

# THE BRIGHT SIDE OF DESIGN: PROCESSES THAT CAN LEAD TO THE INCLUSION OF USERS

*Inclusion4EU Consortium, 2024*

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**Inclusion4EU**, an Erasmus+ project, investigates Co-Design as a method to make software development processes more inclusive, starting with the education of future Computer Science professionals. It researches co-design methodologies in European universities, develops open-access teaching resources, collaborates with marginalized groups to co-design inclusive software practices, and provides training courses for teachers. The project partners are Technological University Dublin, Mälardalen University, Télécom SudParis, Informatics Europe, and SAP.



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## Contents

Introduction.....	4
Part 1. Design for Inclusion: Key concepts, tools and approaches.....	5
1. Design Models.....	5
2. Design Processes.....	11
3. Technology Ramps.....	17
4. Conclusion.....	22
Part 2. Best Practice Examples of Inclusive Design.....	23
5. Case studies of good practices in inclusive design.....	23
Part 3. Intervening with Inclusive Design: Reflections from Practice.....	31
6. Case Study 1: Inclusive intervention - Inclusive, Blended Programming Module for Non-Traditional Students in the School of Computer Science at TU Dublin.....	31
Guidelines for Using Co-Design in Module Development.....	33
7. Case study 2: Creating an Accessible Co-design Toolkit for Co-designers with Intellectual Disabilities and Computer Science Students at TU Dublin.....	34
Key Recommendations to Create Accessible Digital Applications.....	38
8. Case study 3: Arthritis Ireland Easy-to-Use Certification – Inclusive Design “in the wild”.....	39
Recommendations for Using Co-Design for Design of Accessible Products in the field.	41
9. Summary Recommendations and Learnings from Case Studies.....	43
Part 4. Guidelines for Authentic Inclusive Co-Design.....	44
References.....	48



## Introduction

This report explores some of the strengths and benefits of inclusive design (which is the design of systems to make them easy-to-use for as wide a range of people as possible), as well as presenting some examples of best practice using inclusive design. It is divided into four main parts:

1. *Design Practices*: This part is divided into three main sections, the first one looks at inclusive design models, the second one is a review of two key design processes that focus on including users as part of the design, and the third one looks at the use of technologies to help make digital content more accessible and understandable.
2. *Case Studies*: This part looks at best practices for involving end users in software design processes, from the literature.
3. *Reflections*: This part looks at best practices for involving end users in software design processes, based on reflections by practitioners.
4. *Guidelines*: This part collates all the lessons learned from the previous sections, and creates a series of guidelines of best practice for the use of inclusive design.

In addition to literature and case studies, a series of interviews were undertaken with interviewees including a person with a disability, industry professionals with expert inclusion knowledge, industry professionals with non-expert inclusion knowledge and an assistive technology expert.

The overall goal of the report is to introduce the notion of Inclusive Design, and particularly how it can apply in the field of software development, as well as to outline some of the potential benefits of this approach, and some suggestions as to how it might be incorporated into existing practices.



## Part 1.

# Design for Inclusion: Key concepts, tools and approaches

## 1. Design Models

There are a range of design models reviewed and presented as part of this research, including Accessible Design, Inclusive Design, Universal Design, and Design for All. Although these terms are used interchangeably, they represent distinct philosophies of design, with different origins, application domains and disciplines. They are all focused on a design process that includes the consideration of people with a wide range of abilities, capabilities, preferences and needs

### 1.1. Accessible Design

Accessibility refers to the practice of ensuring any individual can access content or technology in an optimised way, regardless of whether the individual has a disability or not (Armitage, 2016)). The most effective, simplest and least expensive way to build in accessibility is when it is done from the beginning of the design process (Kalbag, 2017). There are a variety of potential accessibility issues that a user may have, such as visual issues, auditory issues, cognitive limitations, limited movement, speech disabilities, neurological limitations and temporary/environmental issues (Barrell, 2020). In the early days of the World Wide Web, Berners-Lee (1997) stated that *“it is critical that the Web be usable by anyone, regardless of individual capabilities and disabilities”*. Web accessibility is concerned with ensuring that websites, tools and technologies are designed to be usable and accessible for all users, regardless of ability. The Web Accessibility Initiative (WAI) have developed a variety of guidelines to promote web accessibility:

1. Web Content Accessibility Guidelines (WCAG) describe how to make Web content and Web sites accessible for users with disabilities. The initial version was developed in 1999 with the latest version, WCAG 2.2 was released in October 2023 (WAI).
2. Authoring Tool Accessibility Guidelines (ATAG) are used to guide web authoring tools used to create the content.



3. User Agent Accessibility Guidelines (UAAG) are used for the tools used to access that content (e.g. browsers and media players).

Historically, these guidelines have been based on four design principles (Brown and Hollier, 2015):

- *Perceivable*: e.g. provide text alternatives for non-text content, create content that can be presented in different ways.
- *Operable*: e.g., make all functionality available from a keyboard, help users navigate and find content.
- *Understandable*: e.g., make text readable and understandable, help users avoid and correct mistakes.
- *Robust*: e.g., maximise compatibility with current and future user tools.

## 1.2. Inclusive Design

An inclusive design strategy requires an understanding of diversity within the population and responding to the identified diversity with knowledgeable design decisions that address the needs of as wide a range of people as possible. There is general agreement amongst researchers that it is very important that inclusive design is incorporated into the overall design process from the initial concept stage, and all decisions throughout the development process should include the users' feedback to ensure the final product is a usable product for a wide range of people (Waller *et al.*, 2015).

Joyce (2022) describes inclusive design as “*methodologies to create products that understand and enable people of all backgrounds and abilities*”. Inclusive design may address a wide range of diversities, including things such as: age, culture, economic situation, education, gender, geographic location, language, race and accessibility.

From an accessibility point of view, inclusive design has taken a different strategy to earlier approaches when designing for people with a disability. Recent international trends towards the integration of people with disabilities into the mainstream of society, has been reflected in the inclusive design process (Clarkson & Coleman, 2015). Whilst accessibility design is focused on users with disabilities, inclusive design has a much wider focus as it involves all aspects of diversity, including older people, people, linguistic and cultural diversity, as well as those with diverse learning styles (Joyce, 2022).

Narenthiran, *et al.* (2022) explored the use of mixed methods to understand how users adapted their personal workspaces during the COVID lockdown, to help develop more inclusive workspaces. To achieve this an exploration of the literature was undertaken, followed by a survey, circulated to students and staff at a large university in the UK, with the aim of understanding how people had adapted their home spaces during COVID lockdown and to explore what barriers they continue to face. An analysis of the outcomes resulted in extracting key performance-based goals (e.g., productivity and focus within a study space) and prescriptive design features (e.g., lighting, furniture, and thermal comfort), whilst also considering the inclusivity of these features. The key conclusion of this research was that it is important to work with end users to understand their specific needs and identify creative and inclusive solutions.

### 1.3. Universal Design

The term “universal design” was created by American architect Ron Mace in the mid-1980s (Mace, 1985) to describe a new philosophy of design that highlights the development of products for as wide a range of people as possible. Mace had already made significant contributions to accessible architecture, including helping create the first building code for accessibility in the United States in 1973, that first became mandatory in North Carolina, and they quickly spread to all other states. He defined “Universal Design” as “*the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design*” (Dolph, 2021).

Mace helped create the Center for Universal Design at North Carolina State University which defined seven principles of universal design (Story, *et al.*, 1998):

1. *Equitable Use*: The design is useful and marketable to people with diverse abilities.
2. *Flexibility in Use*: The design accommodates a wide range of individual preferences and abilities.
3. *Simple and Intuitive Use*: The use of the design is easy to understand, regardless of the user’s experience, knowledge, language skills, or current concentration level.



4. *Perceptible Information*: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. *Tolerance for Error*: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. *Low Physical Effort*: The design can be used efficiently and comfortably and with a minimum of fatigue.
7. *Size and Space for Approach and Use*: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

O'Leary and Gordon (2009) argue that the first of the seven principles represent the overriding philosophy of universal design, and that the next four principles provide suggestions as to how to achieve that philosophy, whereas the last two principles are domain-specific, and are most relevant for the design for physical products and the built environment and may find less relevance in other domains such as software design. Moore, *et al.* (2022) undertook a national study to explore the extent to which universal design is implemented from the perspectives of playground professionals in the Republic of Ireland. Using a cross-sectional online survey they discovered that playground professionals recognise the importance of universal design for planning, designing, and providing public playgrounds for inclusion. They also found that these professionals implement universal design in various ways, but there is still a lack of knowledge of good practice guidelines, and this constitutes a significant barrier to a more widespread implementation of universal design.

Watchorn, *et al.* (2021) developed a systematic review of current literature regarding applications of universal design to Built Environments. They used the person–environment–occupation (PEO) model as a theoretical framework for the review, which found 33 key peer-reviewed journal articles. Those articles are generally focused more on description, discussion, and commentary rather than empirical approaches; although, a combination of quantitative, qualitative, and mixed methods approaches is employed in many papers. They conclude that including a wider range of perspectives (occupations, social participation, multi-disciplinary and trans-disciplinary collaboration, and multicultural perspectives) in the ongoing discourse around UD would enable the concept to reach its full potential as a medium for social justice.



#### 1.4. Design for All

The term “Design for All” is a similar notion to universal design, but its focus and origins are more closely related to the development of technologies that are usable by all (Burzagli, *et al.*, 2009), as opposed to the built environment. It is not intended to be a design approach to develop a single solution for everybody, but instead as a user-centred approach to providing products that can automatically address the possible range of needs, as such is it often characterized as a “Swiss army knife” approach to design (Nordby, 2004).

Harper (2007) explored *Design for All* in the context of the World Wide Web, arguing that it proposes that every web page should be designed so that as many people as possible can access it, regardless of any sensory or cognitive impairments. However, he observed that the concept means different things to different people, and this creates a barrier to full implementation of it. He notes that for some people it is a broad notion that impacts society at large, by referencing socioeconomics, ethics, and issues of general discrimination, while others see it only as a technological issue and a problem to be solved.

Jankowska (2020) explored some of the legislation and regulations by both the United Nations and the European Commission concerning the accessibility of products and services by persons with disabilities using a Design for All approach. She argues that the COVID 19 pandemic drew greater attention to existing barriers that exist in online services for persons with disabilities. Key legislation reviewed includes:

- The EU New Consumer Agenda, which was enacted on 13th November 2020 and stated that “*European consumers rightly expect to benefit fully from the single market and to be empowered to make informed choices and play an active role in the green and digital transition whenever and wherever they are in the EU*”. It also highlights the importance on ensuring that all consumer groups can access these services.
- The EU Digital Education Action Plan 2021-2027 emphasises the need to promote the necessary education and training to address the digital skills knowledge gap, as older people and those with disabilities are often excluded from everyday activities or interactions, because of inadequate accessibility of education.
- The EU Charter of Fundamental Rights in Article 1 sets forth that “*Human dignity is inviolable. It must be respected and protected*”, and it notes in respect to the rights of disabled people in Article 26 that “*the EU recognises and respects the right of persons with disabilities to benefit from measures designed to ensure their*



*independence, social and occupational integration and participation in the life of the community.”*

- The United Nations Convention on the Rights of Persons with Disabilities is acknowledged as the first legally-binding international human rights instrument, and in Article 1 it states that all persons, including those with disabilities, such as long-term physical, mental, intellectual or sensory impairments, should not be hindered from full and effective participation in society on an equal basis with others.

Ermacora, *et al.*, 2020 looked at Design for All from the perspective of using technology in education, and specifically focusing on addressing the problem of social exclusion for people with disabilities. Using a combination of coding, digital fabrication, STEM education and disability, they developed a new framework called “Design for ALL.L”, to create social inclusion through project-based learning programs. It helps guide the development of educational programs to foster awareness and empowerment for people with disabilities at different levels.

### 1.5. Summary of Design Models

	<b>Accessible Design</b>	<b>Inclusive Design</b>	<b>Universal Design</b>	<b>Design For All</b>
<b>Original Discipline:</b>	Disability Studies	Ergonomics	Architecture	Computer Science
<b>Aimed at:</b>	Specifically focused on people with disabilities.	Marginalised Groups (including age, size, and ability).	Marginalised Groups (including age, size, and ability).	Everyone, and a wide range of technologies as well.
<b>Principles:</b>	W3C/WAI Guidelines including WCAG and ARIA.	Inclusive Design Research Centre guidelines.	CAST Principles of Universal Design	All of the design principles from the other models of design.

<b>Key Conclusion s:</b>	Accessible Design is governed by a number of design principles.	inclusive design has a wide focus that involves all aspects of diversity.	Universal Design has clear principles, but they have variable relevance in different design situations.	Design for All focuses on the users, and the key aim is to identify their barriers and challenges.
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*Table 1. Summary of Design Models*

These four models are not only representative of some of the key models of inclusion, but they were also extensively discussed by the participants of the interviewing process in the Interviewing Report (WP2A). In terms of Accessible Design, some of the key points mentioned by the interviewees include the fact that accessible design leads to better design, that there are good software tools to help, and that it's important that there are processes and procedures in place to support accessible design. In terms of Inclusive Design, some of the key points mentioned by the interviewees includes the fact that inclusive design can be easily misunderstood by technologists, that there is an economic case to be made for it, and that a big challenge with this sort of design is the availability of suitable users, so organisations need to rewards innovations in Inclusive Design. In terms of Universal Design, some of the key points mentioned by the interviewees includes the fact that universal design is sometimes unintentional, but software can be used in ways that the designers did not intend, again the fact that designers need to be exposed to as wide a range of users as possible to understand their needs, and to engage with their lived experience rather than a superficial engagement. In terms of Design for All, some of the key points mentioned by the interviewees include the fact that in Design for All it is important not only to consider the needs of the users, but also the types of devices that the users have, and the level of support they have for those devices.



## 2. Design Processes

The models described above require detailed processes to be associated with them to achieve their intended goals. Specifically, those models ask that the designers should take a wide range of users into consideration when creating their designs, and to help achieve that goal, design processes that explicitly incorporate the potential end-users in the design teams are considered below.

### 2.1. The Changing of the User

Design In technology, the idea of the “user” is central to the historical evolution of computer interfaces and the very existence of the field of human computer interaction (HCI) (Cooper and Bowers, 1995). While early “users” of computer technology in the 1950s were engineers and programmers the emergence of new “end users” marked the historical beginnings of interface design and the wider context of users and their interactions with technology but also with each other (Grundin, 1989). Defining “the end user” is another large part of the theory of Human Computer Interaction and interaction design and there has been much work in identifying barriers and designing for diverse user groups. The term “User Centred Design” is associated with Donald Norman (1986) who outlined an iterative approach to technology design centred on understanding end users’ contexts, specifying their requirements and designing technology iteratively to meet their needs. Norman since progressed the ideas in user-centred design to “Human-Centred Design” where rather than focusing on a “target user” should understand the problems that people face and design technology or systems to address them using an iterative problem-solving approach. Techniques such as empathetic user research, rapid prototyping, iterative testing with users are core to Human-Centred Design but they also overlap with the tools and techniques of Design Thinking (Johannesson and Perjons, 2014). Norman has since proposed a more recent incarnation of human centred design referred to “Humanity Centred Design” where he posits that we should look beyond trying to solve the problems of individuals but rather we should aim to design for societies to solve complex global issue. While user/human/humanity centred approaches to design require user engagement the extent to which users are involved in design and decision making varies considerably according to researchers and practitioners. User participation in research, design, development and production phases of human centred systems can vary from sporadic consultation with key stakeholders to full collaborative design and development partnerships. Some of the participatory methods presented below can be classified as Human Centred Design however participatory methods are not a prerequisite for Human Centred Design.



## 2.2. Participatory Design

Participatory Design is a design approach where designers and non-designers (including customers, researchers, and other stakeholders) actively participate together in the design process (Ehn, 1992; Spinuzzi, 2005). The “nothing about us without us” motto of the disabilities rights movement and person-centred approaches to care (Kitwood, 1997) have progressed previous standard clinical medical models of social research and care for older adults and people with disabilities. Within this context, significant developments in the fields of disability studies and inclusion research have advanced approaches to care, technology and policy making are “person-centred” and “participatory”.

There is a collection of methodologies that are associated with participatory design, which emphasizes not just consultation, but active, meaningful participation of the non-designers, that aims to create a sense of ownership and empowerment. Typical tools include using games and “game languages”, walkthroughs and workshops, workplace microethnographies, card-matching exercises, prototyping sessions, mock-ups, prototypes, and scenarios (Holtzblatt and Beyer, 1997).

Bratteteig and Wagner (2016) explore the outcomes of a participatory design, as well as looking at some barriers to achieving those outcomes. The researchers explored a number of pre-existing participatory design projects, and identified the following challenges.

- Designers and non-designers facing issues that are difficult to negotiate and change.
- Difficulties in making conflicting perspectives in a project heard and in ‘managing’ them.
- Complexities that emerge in real use and cannot be met by the designed IT artifact.
- Complex distributed processes and competing design considerations that make it difficult to consistently apply participatory design methods and techniques.
- Speaking to highly specific and diverse non-designer needs.

Sanders, *et al.* (2010) explored a range of participatory design methods looking at case studies from a range of disciplines, and a range of methodologies, and they categorised them based on either their purpose or their modality of interaction, as follows:

1. Making Tangible Things (including 2-D Collages, 2-D Mappings, and 3-D Mock-ups).
2. Talking, Telling and Explaining (including Stories and Storyboarding, Diaries, and Cards).
3. Acting, Enacting and Playing (including Game Boards and Games Pieces, Props and Black Boxes, Participatory Envisioning and Enactment, and Improvisation).

Delgado, *et al.* (2022) discuss processes associated with wider participation in AI design. A specific case study is discussed, called the TREC Legal Track, it is an AI system that has been trained to explore legal issues, and it relies on a range of participatory approaches to facilitate the design and evaluation of new computational techniques, specifically, for automating attorney document review for civil litigation matters. This case used an interactive simulation methodology to allow computer scientists and lawyers to work together.

### 2.3. Co-Design

Co-Design is a term that refers to a design process where designers incorporate input from non-designers (including customers, researchers, and other stakeholders) in the process. The nature of the collaboration will vary widely from project to project, and the designers and non-designers may not have an equal say in the design outcomes (Zamenopoulos and Alexiou, 2018). Co-Design comprises a wide range of approaches, from research-oriented ones (e.g., applied ethnography) to design-oriented ones (e.g., using generative tools), and with a focus on user involvement, ranging from approaches in which designers move toward non-designers (e.g., usability testing) to approaches in which non-designers move toward designers (e.g., participatory design). Thus, it is a complex and multi-faceted process to categorize (Steen, 2013).

Slattery, *et al.* (2020) reviewed the literature of co-design in healthcare using a systematic literature review. The search strategy encompassed three academic databases, three grey literature databases, and a hand-search of the journal *Research*



*Involvement and Engagement.* The outcome was a total of 26 records that met the inclusion criteria, and they identified positive and negative outcomes associated with co-design.

The research also provided recommendations for conducting research co-design, including:

- Training participating end-users in research skills.
- Having regular communication between researchers and end-users.
- Setting clear end-user expectations.
- Assigning set roles to all parties involved in co-design.

Chauhan, *et al.* (2021) looked at optimising co-design with ethnic minority consumers. The study observed that ethnic minorities are a diverse population and the diversity between and within these groups need consideration for optimising their participation in co-design. They looked at consumer engagement strategies to improve patient safety in cancer services and identified three key aspects of the co-design process pertinent to the involvement of this population;

1. Starting at the pre-commencement stage to ensure diverse, seldom heard consumers are invited to and included in co-design work.
2. Considering logistics and adequate resources to provide appropriate support to address needs before, during and beyond the co-design process
3. Supporting and enabling a diversity of contributions via the co-design process.

#### 2.4. Participatory methods beyond Co-Design, Co-Researchers

There is a growing body of research exploring methodologies for a co-researcher approach in the areas of developing age-friendly concepts, (Buffel, 2015; Egan *et al.*, 2014). Buffel (2015) adopted an ethnographic co-researcher approach within a community of older adults in Manchester. This study illustrates how a participatory methodology can promote ownership of research, challenge ageist beliefs and enhance participation through skills and knowledge.



2.5. Summary of Design Processes

	<b>User/Human Centred Design</b>	<b>Co-Design</b>	<b>Participatory Design</b>
<b>Original Discipline:</b>	Computer Science	Design Science	Political Science
<b>Participants:</b>	Designers and non-designers (including customers, researchers, and other stakeholders)	Designers and non-designers (including customers, researchers, and other stakeholders)	Designers and non-designers (including customers, researchers, and other stakeholders)
<b>Locus of control:</b>	The designers have control of the situation and may take as much feedback from the non-designers as they deem suitable.	The designers have control of the situation and may take as much feedback from the non-designers as they deem suitable	The designers and non-designers are partners in the design process, and the non-designers meaningfully participate in all design decisions.
<b>Philosophy:</b>	Human Computer Interaction	General philosophy of Design Science	Human Centred Design
<b>Goals:</b>	User Centred Design processes should seek to identify a wide range of non-designers, including those who are not traditionally consulted, and there should be resources allocated to allow these processes to support in the design. Methods may include user interviews,	Co-Design will seek to identify a wide range of non-designers, including those who are not traditionally consulted, and there should be resources allocated to allow these processes to support in the design. Methods may include user interviews,	Participatory design provides a number of process and tools, including walkthroughs, workshops, workplace microethnographies, card-matching exercises, co-design sessions, mock-ups, rapid prototyping, and scenarios. Some of these methods may overlap with user centred design tools and techniques but the key difference is in the level



	observations, evaluations etc.	observations, evaluations etc.	of involvement of researchers in the design process.
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*Table 2. Summary of Design Processes*

These design processes are not only representative of some of the key processes of inclusion, but they were also discussed by the participants of the interviewing process in the Interviewing Report (WP2A). In terms of Co-Design, some of the key points mentioned by the interviewees includes the fact that co-design must include (and appreciate) the perspectives of a range of stakeholders, but this is not always practical in a working environment, and it is important that participants have a shared understanding of their goals, and are using terminology in the same ways. In terms of Participatory User Centred Design, some of the key points mentioned by the interviewees includes the fact that user involvement should not be unfairly burdensome on the users with disabilities, that there are challenges recruiting and keeping participants, therefore, organisations need to support these processes, and reward both the end-users and their own employees to ensure that this is a sustainable approach. Specific advice regarding co-design includes the fact that participants should focus on using visual content, including visual prototypes and ideas so that they can be shared more easily. It should be noted that this advice was given by an expert practitioner working with co-designers with intellectual disabilities, but a visual approach may not work for all designers particularly those with visual impairments. It is also essential that an empathetic environment is developed between all participants, and it is also vital that a safe space is created to develop empathy among team members supports good co-design.



### 3. Technology Ramps

In the same way that ramps make buildings accessible to people who use wheelchairs, some technologies can help make digital content more accessible or understandable. In this section we will look at two technologies, one to make content more understandable (Explainable AI), and one to make content more inclusive (Inclusive Design Patterns).

#### 3.1. Inclusive Design Patterns

A software design pattern is a reusable general solution to a specific type of software problem, but it is not a finished design that can be transformed immediately into a computer program, instead it provides a template through which a complete solution can be reached (Johnson and Vlissides, 1995). The notion of design patterns originated in 1966 as an architectural concept (Alexander, 1966), and in 1987 Kent Beck and Ward Cunningham began experimenting with the idea of applying the idea of design patterns to computer programming (Beck and Cunningham, 1987). Since then, their use has become more widespread in programming, and they have been shown to provide high-quality solutions to difficult technical problems (Wang and Huang, 2008).

Given the success of design patterns, accessibility advocates have begun to leverage this approach by incorporating inclusive design approaches into new design patterns, so that developers will create software applications that will already have accessibility features in-built. Some examples of inclusive design patterns are presented below:

- Sanchez-Gordon *et al.* (2019) developed a series of four new accessibility design patterns in the software implementation process specifically for web applications. In their research they defined four accessibility design patterns which they named as: Authentication Adapter, Blindness Adapter, Dichromatic color vision Adapter, and Blurry vision Adapter.
- Gomes, *et al.* (2021) developed a set of design patterns specific for the design of mobile and web-based user interfaces for autistic users. In this paper the researchers explored relevant literature to develop quality user interface attributes specifically for people with Autistic Spectrum Disorder (ASD). Based on these attributes, the researchers created a set of four (4) inclusive design patterns.
- Valtolina and Sisto (2022) looked at the development of a complete design pattern language to address the development of accessible interfaces for websites, mobile apps or conversational Interfaces (chatbots or voicebots). This pattern



language allows developers to create technical solutions based on good evidence.

- Piro (2023) explored the development of a series of design patterns for the development of inclusive Conversational AI systems. To achieve this the researcher analyzed a number of card toolkits and guidelines for the development of Conversational AI systems, and for each toolkit and guideline, the researcher explored whether or not they could be considered inclusive guidelines, to create these patterns.
- Zaina, *et al.* (2022) looked at accessibility barriers that occur in pre-existing design patterns for building user interfaces of mobile apps. They did this by conducting a gray literature review in professional forums and blogs to reveal the difficulties developers face when using mobile user interface design patterns. They identified nine (9) user interface design patterns with barriers, and create a set of guidelines to prevent the problems in those patterns.

### 3.2. Explainable AI

Explainable AI (XAI) is any Artificial Intelligence (AI) system where the users or developers of that system have a clear understanding of how it reaches its decisions (Héder, 2023). The challenge of being able to understand the exact mechanics of how AI systems reach decisions is as old as AI systems themselves. Since the development of Artificial Neural Networks (ANNs, which are computer programs designed to simulate how the human brain operates) in the 1950s (Yadav, *et al.*, 2015), the question of what *exactly* these systems are learning, and how they are making decisions, has been an abiding one. It was in 1962 that Frank Rosenblatt coined the term “*Black Box AI*” (Rosenblatt, 1962), to describe the phenomenon whereby developers of ANN systems could see the inputs to the system, and see the outputs of the system, but the inner workings of the system may as well have been covered in a black box, since they are totally opaque in terms of understanding how the system is working. As AI systems have become more and more sophisticated, the issue has become increasingly obfuscated, to such an extent that Héder (2020) introduced the term “*epistemic opacity*” to describe the lack of understandability of AI system decisions, and in particular, as this relates to the occasional unexpected behaviours (or decisions) of AI systems.

This lack of clarity of how AI decisions are taken is becoming an increasingly serious issue as more and more aspects of human life are governed by AI systems, including areas such as healthcare, financial services, economics, legal and judicial matters, engineering, journalism, politics, social sciences, and even humanities and the arts (Emmert-Streib, 2021). If these systems are implemented using Black Box AI, users cannot get answers to important questions, such as:

- Why was I refused a bank loan that I applied for?
- Why can I see some social media posts and not others?
- Why was a specific medical treatment recommended for me?
- Why did the airbags deploy in my car when there wasn't a crash?

If a user cannot get answers to these questions, then they cannot remedy the situation if an incorrect decision was made, and this poses very serious ethical questions that need to be addressed (Gordon, *et al.*, 2021). Thus, the goal of XAI is to try to address this significant ethical issue, by requiring that AI systems are designed in such a way that it is always possible to understand how these systems come to decisions. To help enforce such an approach, governments are beginning to develop legislation to help regulate the use of AI. In 2016, the European Union enacted the General Data Protection Right (GDPR), which introduced a “right to explanation” - a right to be given an explanation for an output of an algorithm or AI system. However, it is worth noting that this right is not absolute, and is limited to the use of AI systems in very serious decision-making arenas, such as in the legal sphere (Wachter, *et al.*, 2017). In the domain of financial services, in the United States of America, the 1974 Equal Credit Opportunity Act (ECOA) retrospectively grants a similar right to explanation on all decisions made about credit scoring (Krippner, 2017). In France the 2016 *Loi pour une République numérique* (2016 Digital Republic Act) grants subjects the right to request and receive information pertaining to the implementation of algorithms that process data about them (Malgieri, 2019). Most excitingly, by the end of 2023, or early in 2024, the European Union will introduce the most comprehensive legislation yet to regulate the use of AI systems (including Generative AI), this *AI Act* will categorise AI systems as being: unacceptable-risk AI, high-risk AI systems and minimal-risk AI, and will provide a framework for dealing with (and remedying) the ethical considerations raised in this section (Cox, *et al.*, 2022).

Explainable AI (XAI) can be extremely helpful in the development of Inclusive Design practices by providing transparency and understanding of how AI systems make decisions. XAI techniques make AI systems more understandable to a wider audience,

including people with disabilities. Since they provide explanations in formats like text, visualizations, or even audio, it ensures that everyone can access and comprehend the insights derived from AI models. They can also help in bias mitigation by identifying and mitigating biases within AI models by revealing how decisions are made. This transparency allows designers to detect and address biases that could disproportionately affect certain groups (Hamid, *et al.*, 2024).

### 3.3. Active Inclusion for the Design of AI Systems

Many Artificial Intelligence (AI) systems work by learning from a large collection of data, called a dataset, for example, if there is a large collection of data concerning people's spending habits in the local butcher shop, the AI system will learn about all the different kinds of people who shop there, and may identify common characteristics of most customers, and may create a representation of the "typical customer", in other words, the AI system will create a model of the relationships between the features of the data. However, if the data being input into an AI system has some degree of exclusion in it, then the model that the AI system will produce may also have that exclusion in it, so in the example above, looking at customers in the butcher shop, we know that all vegans and vegetarians will be excluded from this AI system, as they will not feature in the dataset. The exclusion could also be based on age, culture, economic situation, education, gender, geographic location, language, disability, race or any combination of these. In some cases, the AI system may even exacerbate these existing inequities, therefore, it is essential to address this issue, and an inclusive design approach may offer a potential remedy to this bias.

Presented below is a review of a series of papers that looks at both how AI systems can exacerbate this exclusion, and also how inclusive approaches can ameliorate these issues, but in turn how this approach may result in further complex ethical issues.

Trewin, *et al.* (2019) explore the issue of AI fairness as it relates to people with disabilities. They argue that AI systems are taking on increasingly important roles in decision-making and interaction in society, and that they have the potential to impact people with disabilities either positively or negatively. They look at four domains in society that are growing in terms of their use of AI systems: Employment, Education, Public Safety, and Healthcare. The researchers used focus groups of people with a range of disabilities to explore these domains, and to identify pre-existing discriminatory practices in each of them. They further explore how AI systems are perpetuating, replicating, and, in some cases, exacerbating these bad practices. They argue that the inclusion of diverse users is needed in the development of new AI systems, using an Inclusive Design approach. They also argue that existing AI systems need to be



reviewed for their potential impact on disabled users, and these systems should offer opportunities for users with disabilities to identify and redress perceived errors, and raise fairness concerns. They also highlight, that people with disabilities should be involved in the sourcing and reviewing of datasets used in building AI models, and they should also be involved in testing, to create more inclusive and robust systems.

Chan, *et al.* (2021) explore the issue of AI systems and digital exclusion in the context of global inequality. Western corporations dominate the development and proliferation of AI, and that may result in explicit forms of bias towards countries and peoples in the Global South. The researchers cite numerous examples, including in image datasets where people from the Global South are underrepresented, and even if they are present, they are labelled in different ways than their Global North counterparts. The researchers point out ways that the labelling of datasets is restricted in ways that exacerbate this digital divide; and large organisations have different standards of privacy and consent in the North and South of the globe. Many of these corporations have recognised this as a serious issue, and have tried to involve more diverse groups in the development of their systems, including hiring foreign labour and establishing extra-national data centres and laboratories.

Porayska-Pomsta and Rajendran (2019) discuss the importance of diversity in the development of AI systems to help reduce the impact of bias and discrimination in those systems. They argue that AI systems have acutely exposed biases that already exist in all social systems, and in this way, they act as a mirror to expose the differences between our aspirations for an inclusive society and the realities of systems governed by stereotypical thinking, prejudices, and ultimately ignorance. The researchers present a number of examples of bias (from their own research, and elsewhere) in communication tools, medical tools, games, legal tools, and educational tools. They discuss the notion of accountability and how it is a more complex proposition when dealing with Artificial Intelligence, for example, if judicial datasets have a significant racial bias, and these datasets are used to train an AI system, then the models that are created will have that same bias, and if that AI system is used to determine the outcome of a legal proceeding (with any questioning or intervention by a human being), there is a chain of responsibility for this scenario. Those who are accountable could include the judge for not questioning the decision of the AI, the programmers for creating the biased AI models, the Data Scientists for failing to correct for the bias in the dataset, and the broader society as well as each judicial decisions that led to the creation of the biased dataset in the first place. Thus, what is required is a broader and more flexible definition of accountability, and the researchers argue that the key change that is needed to address these challenges is to include a more diverse range of users in the design and redesign stages of the development of AI systems.



Helm, Michael and Schelenz (2022) discuss the development of a chatbot that incorporates an inclusive design philosophy to enable their system to be easily used by disabled and vulnerable users. The researchers argue that technology is not value-neutral, and therefore it is essential that one of the values that these systems embody in them is an inclusive perspective. However, there is a balance to be struck between inclusion on the one hand, and protecting people online on the other. There is a danger in exposing vulnerable users to hate speech, disinformation or other upsetting content, therefore, using a combination of Scenario Analysis and Value Sensitive Design, they incorporated a range of user perspectives in their design process. The researchers ultimately felt that although the primary goal of their system was to ensure user agency, they had to use AI techniques to enforce a series of safeguards to prevent the users for interacting with distressing content. These safeguards are relatively static, and do not take into account specific contexts, they are therefore also potentially enforcing conformity, and may be antithetical to contemporary ethical philosophy which highlights the importance of context in judgements. They conclude that there is a tension to be managed between the rigid nature of AI systems with the desire for inclusion and diversity; and ultimately there is a need to incorporate diverse voices in the entire lifecycle of AI systems.

#### 4. Conclusion

This section looked at some of the key concepts, tools, and approaches in the design of inclusive technology. The section begins with a review of four key design models - these are *Accessible Design*, *Inclusive Design*, *Universal Design* and *Design for All*. The overall goal of all these models is to widen the range of potential users that could use a particular technology. The models do differ in regard to their guidelines and the composition of the intended audience, but they do have a great deal of overlap, and the model names are often used interchangeably. The next part of this section looks at two design processes that can be used to achieve the goals of the previously discussed models - these are *Co-Design* and *Participatory Design*. The two processes advocate a design approach for the designers of a new technology to work with non-designers to get feedback as early as possible. They differ in the degree to which the non-designers have authority to make decisions about the design, and (as before) the process names are often used interchangeably. The final part of this section looks at some technologies that can be used to assist in the development of inclusive technologies. These technologies include:

- *Inclusive Design Patterns*, which are software blueprints for creating more inclusive technologies.

- *Explainable AI*, which is software tools that provide decision-making processes with a clear explanation as to how decisions were reached.
- *Active Inclusion for the Design of AI systems*, which looks at approaches to prevent AI systems from replicating existing digital exclusions in human-based decision-making.

The overall goal of this section is to describe some of the key theoretical concepts related to creating more inclusive technologies, and from that, in the next section, we will review a number of case studies that explore some of the more practical challenges encountered when creating inclusive technologies.



## Part 2.

### Best Practice Examples of Inclusive Design

#### 5. Case studies of good practices in inclusive design

This section presents a collection of case studies of good practices in inclusive design, and exemplars of user involvement. Each case study is presented by highlighting the challenges encountered, as well as some of the key successes that can result from including the user into the design practice. The case studies in this section are a combination of existing case studies from literature, whereas the cases studies in Part 3 are based on reflections from practitioners of inclusive design practice.



## 5.1. Case Studies from Literature

<i>Case Study: An Inclusive Model of UX Design</i>	
<b>Participants:</b>	<ul style="list-style-type: none"> <li>• California State University Long Beach, USA</li> <li>• Leeds Beckett University, UK</li> </ul>
<p>The case study focuses on a new approach to making User Experience Design research more inclusive by using an approach called the “Connectivity Model” to more easily include persons with autism in the participation process. User Experience (UX) Design is the process of designing a product or service so that a user has maximum satisfaction in using it, through user research, usability testing and iterative design. Using an inclusive design approach is an important step in achieving that goal, but the inclusion of persons with autism in participating group can sometimes be challenging, potentially due to their lack of sufficient cognitive ability or language skills to participate in the research process in meaningful ways. Further, lecturers and teachers may be reluctant to include such persons due to institutional regulations and ethical concerns.</p> <p>The “Connectivity Model” avoids the requirement for complex ethical clearance by facilitating observations via recorded videos. It analyses user behaviour looking at social, emotional, behavioural, physical and motivational needs, and considers constraints such as ability in the areas of physical, cognitive, and developmental areas.</p> <p>This approach was used as part of the Play•IT project to design an educational game that mediates social interactions between children, and specifically between children who on the autism spectrum and those who are not. The emphasis is on co-creating a solution that addresses the social, communication and behaviour skills needed by children on an equal basis. The approach was considered successful as all designers were able to conduct the UXD research and apply it to their designs.</p>	
<b>Reference:</b>	<p>Satterfield, Debra, and Marc Fabri. "User participatory methods for inclusive design and research in autism: A case study in teaching UX design." In <i>Design, User Experience, and Usability: Theory, Methodology, and Management: 6th International Conference, DUXU 2017, Proceedings, Part I 6</i>, pp. 186-197. Springer International Publishing, 2017.</p>

*Case Study: Using Inclusive Design to Increase Sales***Participants:**

- Cambridge Engineering Design Centre, University of Cambridge, UK
- Unilever, Leatherhead, England, UK

The case study focuses on exploring the benefits of using an inclusive design approach to drive an increase in sales. It looks at activities that were conducted with Unilever to improve the visual layout and content used in their e-Commerce systems. Specifically, the ice cream brand, Magnum, is one of Unilever's billion-dollar brands that implemented this inclusive review on their e-Commerce websites. Before this process, the default form of product images was a photograph of the product where it was difficult or impossible to discern key information from these images, particularly when they were being displayed on a small mobile screen. With an increasing amount of e-Commerce transactions being conducted on mobile devices, this is an increasingly important issue. This issue is further exacerbated for people with any degree of vision loss including age-related long-sightedness.

The process involved developing guidelines for new sales images, and their layouts. These new images are digitally enhanced product images, specially designed for mobile e-commerce. They use digital representations of the product, sometimes enhanced with off-pack communications such as a square containing the product information. To choose the correct images and layouts a number of user trials were undertaken, resulting in over 3000 users being consulted in total.

To assess the effectiveness of the final chosen visual content, an 8-week live trial was conducted, comparing the old and new visual layouts, and the new one experienced a huge sales increase of 24% compared to the old one. This leads to a

three-pronged approach to help advocate for the use of inclusive design practices in corporate settings. Those three elements are:

1. Develop a proof-of-concept prototype of a better solution that demonstrates in a tangible way that something better is possible.
2. Enable business stakeholders to experience the issue, and the difference that the prototype solution makes for them.
3. Quantify the number of people that the issue affects, and quantify the extent to which the solution could reduce this number.

**Reference:**

Goodman-Deane, J., Waller, S.D., Bradley, M., Clarkson, P.J. and Bradley, O., 2018. "Using inclusive design to drive usability improvements through to implementation". In *Breaking Down Barriers: Usability, Accessibility and Inclusive Design* (pp. 65-75). Springer International Publishing.



*Case Study: Co-Designing Interactive Apps with Adults with Intellectual Disabilities***Participants:**

Queensland University of Technology, Brisbane, Australia

The case study focuses on the use of participatory design practices to provide opportunities for people with intellectual disabilities (IDs) to contribute to the conversation in how technologies can best support them and their individual needs. This process involved a co-design exercise aimed at designing a mobile application to support people with IDs when using public transport. The process involved an exploration of the literature on inclusive design and universal design in mobile apps to create an initial prototype, which was brought to three exploratory group meetings engaging the participants with IDs in evaluating, modifying and updating the initial prototype. These group interviews also included stakeholders of the system (i.e. researcher, moderator, participants, carer/teacher).

Following this a more detailed one-hour interview was undertaken with each participant, in the first half hour, the interviewer concentrated on engaging with the participants, getting to know them, and gaining knowledge about their current experience with public transport and mobile applications. During the interviews, the participants were presented with hypothetical scenarios exploring how they would cope with unexpected situations that can arise during journeys (such as getting lost or missing a bus). In the second half hour, the interviewer introduced the project design and let participants engage with either a paper-based prototype or a digital prototype, where they were regularly asked to use the "think aloud" protocol to share their insights and envision their own ideas. These interviews resulted in enormous insight, and more improved design.

The key steps of the process in order to deepen the engagement of participants, were:

1. The use of concrete initial digital prototypes as "probes" to initiate conversation.
2. A non-finished feature designed for appropriation and to encourage user creativity.
3. The explicit inclusion of carers as both proxies for communication but also co-designers.



4. The use of easy-to-use development/prototyping tools to encourage co-development of changes during the sessions.

**Reference:**

Sitbon, L. and Farhin, S., 2017. "Co-designing interactive applications with adults with intellectual disability: A case study". In *Proceedings of the 29th Australian conference on computer-human interaction* (pp. 487-491).

5.2. Case Studies from Practitioners

*Case Study: Ryanair-improves-industry-leading-customer-service*

**Participants:**

Ryanair

Ryanair have a stated aim to reach 225 million passengers by 2026 [1] and a key part of achieving that goal is to improve their digital offerings [2]. A key part of this process is the role of Ryanair Labs, the technology Hub of Ryanair [3]. Ryanair was known in the past for its poor website [2]. Colin O'Brien head of QA at Ryanair Labs identified this as a key reason for growth not breaking through the 80m barriers [2], and this resulted in a major re-think about digital strategy. This produced a renewed emphasis on redeveloping digital services. Led by Ryanair Labs user experience (UX) is at the heart of this re-design. An extensive process of user feedback is built into development and deployment strategies. Activities include [3]

- User Testing
- Empathy maps
- Contextual Inquiries
- Job to be Done Interviews
- Competitor Reviews
- Benchmarking
- Surveys
- Intercepts
- Polls
- Shadowing
- Diary Studies
- Card Sorting



Development involves a Five-stage process Research, Design, Prototype, User Testing and Develop and launch, [3]. Users are heavily involved in the Research, testing and Deployment phases. Ryanair continues to grow its digital offering and has added services like a Day of Travel App and Digital Wallet. An important initiative in meeting its goals is its use of a customer panel. By driving a user lead policy Ryanair is on its way to achieving its 225 m passenger goals.

#### Citations:

[1]

<https://corporate.ryanair.com/news/ryanair-improves-industry-leading-customer-service/>

[2] <https://www.thechatshop.com/article/ryanair-better-customer-experience>

[3] <https://diggintravel.com/ryanair-ux-research/>

#### *Case Study: CSIRO Integrated Research*

##### **Participants:**

Commonwealth Scientific and Industrial Research Organisation

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) [1] is an Australian Government national science agency responsible for scientific research. Their research focuses on the biggest challenges facing the nation. They also manage national research infrastructure and collections. CSIRO carries out research in many domains from Natural Environments to Medicine.

A key challenge of their work is how to work with many stakeholders from different disciplines. One example is the Bluelink project [2], whose aim is to understand and predict ocean conditions which is essential for those working in the marine environment. The constantly changing nature of the ocean brings considerable risk and uncertainty to marine industries and operators, such as fisheries, maritime transport and the Navy. The ocean, however, is complex, difficult to predict and very large. These factors make getting reliable information about current and future ocean conditions a challenge.

There are many stakeholders involved from many different domains. These include

- the Royal Australian Navy (RAN)
- maritime transport providers
- the fishing industry
- tourism operators
- marine managers.

The project also needs input from many different skillsets including, Advanced ICT, Sensors and Control Engineering, Oceanography, Meteorology, Data Science and so on. To address complex problems, for example to understand and manage cumulative impacts and uncertainty for socioecological systems research, and to facilitate multisector and multi-jurisdictional decision-making integrative practices are needed. CSIRO calls this requirement of multi-disciplinary teams and multiple stakeholders working together, integration research [3] CSIRO has been building capacity in this aspect of complex societal projects. and has been developing best practice and frameworks around integrated research. [4] The necessity to work together and when to engage both users and developers and other stakeholders have resonance for many similar projects. As the internet of Things grows integrated, ICT projects, for example, in healthcare will become the norm Key topics include Communication, Knowledge Brokering, Project Governance, Integrated Research Practices [3] and Co-Design [5]. CSIRO bring these approaches together in an approach called Co-3D [6]. This looks at the 3 aspects of combined stakeholder development, namely Co-Design, Co-Creation and Co-deployment. The research group have created detailed recommendations as part of their CO 3D (Co Design Co-Development and CO Deployment) model in how to address working across integrated interdisciplinary and transdisciplinary teams [7]. They highlight an important distinction in understanding expertise for participatory processes into 'knowing-that' and 'knowing-how'. According to the authors 'knowing-that' involves understanding what is required to deal with complex societal and environmental problems in an integrated way, whereas 'Knowing-how' involves knowing which methods or processes to use in a particular context.

#### Citations:

[1] <https://www.csiro.au/en/>

[2] <https://www.csiro.au/en/research/natural-environment/oceans/Bluelink>



[3] <https://research.csiro.au/integration/understanding-integration-research/>

[4] G rigg, Nicky; Mokany, Karel; Woodward, Emma; Pirzl, Rebecca; Fletcher, Cameron; Ahmad, Maryam; Lemon, David. CSIRO's integrated national prediction, foresighting and scenarios capability. CSIRO: CSIRO; 2020. csiro:EP206017. <https://doi.org/10.25919/gvcm-zg09>

[5] Robert, G., Locock, L., Williams, O., Cornwell, J., Donetto, S., & Goodrich, J. (2022). *Co-Producing and Co-Designing* (Elements of Improving Quality and Safety in Healthcare). Cambridge: Cambridge University Press. doi:10.1017/9781009237024

[6] <https://research.csiro.au/integration/tools/>

[7] <https://research.csiro.au/integration/co-3d/>

### 5.3. Summary

The case studies in this section highlight the importance of user involvement throughout a technology design and development lifecycle from research to design, development, testing and deployment

- Common UX instruments used to leverage user feedback include surveys, interviews, empathy maps etc.
- Use of a dedicated User Experience Team (i.e. Ryanair Labs)
- Collaboration between teams in an organisation i.e. Design Team worked with the Ruter research lab to conduct focused testing, and spent time on the street for guerrilla testing with a wide range of travellers.
- Real Time engagement with users to make features more usable and accessible
- The final CSIRO case study highlights the need for interdisciplinary teams to address and design for complex challenges.



## Part 3.

## Intervening with Inclusive Design: Reflections from Practice

## 6. Case Study 1: Inclusive intervention - Inclusive, Blended Programming Module for Non-Traditional Students in the School of Computer Science at TU Dublin

In **March 2015** the School of Computer Science of the **Technological University of Dublin**, decided to develop an inclusive degree programme for non-traditional students - those who couldn't attend a full-time schedule of classes. The entire staff of the School of Computer Science (approximately 35 staff members) were involved in the design of the programme, including experts in accessibility and usability, and they spent about four months working on the design of this new programme.

## Context

In the first year of the programme, the students undertake a year-long module entitled "Programming and Algorithms" which is the focus of this case. The programme was redesigned as a blended programme, with some modules in the classroom, some online, and some a mixture of both, to make the experience more inclusive for students.

## Before the intervention

Before the intervention some students were excluded from undertaking a degree, for a number of reasons, including that they were not able to travel daily to university, or they had physical impairments preventing them from accessing the physical buildings, or they needed a lower staff-student ratio to have more one-to-one time with their lecturers.

This new inclusive, blended programme was designed to address their needs. In particular, the pre-existing module was delivered once a week in 3 hours in the evening, from 6:30 pm – 9:30 pm, for 24 weeks. This created a barrier for non-traditional students to attend, and an alternative had to be developed.

## The Intervention

The module was originally divided into two components: online lectures, delivered for 2 hours each week through both live sessions and pre-recorded videos, and in-person labs where students participated in programming practical sessions that were also broadcasted online. After reflection, it was deemed necessary to include face-to-face elements for practical subject support, resulting in the first and last lecture held in person each semester, along with the middle week of each semester (Week Seven).

Creating pre-recorded videos demanded significant organizational support, with additional time allocated to staff timetables for preparation and recording. An Instructional Designer was enlisted to assist in content development and post-production, and a dedicated room equipped with lighting, greenscreens, and



recording equipment was set up for video creation. However, soundproofing was not implemented.

The lecture sequence was adjusted to enhance quality, beginning with Week Three, then Week Four, and finally Week One once issues were resolved. Content was structured into five to seven mini-lessons of 15-20 minutes each, allowing for flexible learning. The advantage of this approach became evident during later content recording, as it improved clarity by revisiting basics in earlier lessons. Online lessons were housed in a Virtual Learning Environment, taking advantage of asynchronous discussions, online compilers, simulators, quizzes, and shared noticeboards. The module spanned two semesters, with nine weeks of online lectures and three weeks of in-person lectures each term, fostering a balanced learning experience.

#### After the intervention

Given that there was a pre-existing course that taught a similar module, it was possible for a direct comparison of outcomes. Since 2016, the students undertaking the blended module achieved a higher average mark on exams (+6%), and a larger percentage of students on the blended module achieved over 70% in this module.

The students were extremely satisfied with the module and rated it highly on their QA feedback, they also developed their own programming projects that they worked on in parallel with their assignments for this module, as they had become extremely engaged in the programming lifestyle.

#### Conclusions

In conclusion, the blended program successfully extended educational opportunities to non-traditional students, with the majority thriving in this innovative learning environment. Moreover, this endeavour yielded a valuable reservoir of teaching assets that can be leveraged not only for further instruction but also for the promotion and marketing of the School and the University.

However, it is important to acknowledge that certain aspects required attention. Some students demonstrated a need for personalized one-on-one support, leading to the organization of additional tutorials. Additionally, a limited number of topics required revisiting during lab sessions to bolster understanding for specific students. The key takeaways from this case study revolve around the motivation of both students and the lecturer, the adaptability of practical subjects like programming to online delivery, the critical allocation of resources and support from the School, and the importance of active student involvement in design decisions, reflecting the power of co-operation in creating an effective and inclusive module.

#### Guidelines for Using Co-Design in Module Development

In order to create an educational module that is student-centric, inclusive, and continually refined based on the insights and collaboration of all stakeholders involved there are a number of key points that need to be considered:



- **Consider motivation** of both students and the lecturer.
- **Evaluate the adaptability of the module**, while practical subjects like programming are adaptable to online delivery others may not be.
- **Ensure the critical allocation of resources and support** from the School.
- **Student Involvement is crucial** - the importance of active student involvement in design decisions, reflecting the power of co-operation in creating an effective and inclusive module.
- **Co-Create Learning Objectives:** Collaboratively establish clear and student-centric learning objectives that align with the goals of the module.
- **Address Inclusivity:** Specifically consider inclusivity within the co-design process, ensuring that the module caters to a broad range of students, including non-traditional learners.
- **Accessibility and Usability Experts:** When relevant, involve accessibility and usability experts to ensure the module is accessible and user-friendly for all students.
- **Allocate Resources:** Allocate necessary resources, such as time, equipment, and personnel, to support the co-design process and the development of the module.
- **Instructional Design Support:** When needed, engage experts or specialists to assist in design and development

### 7. Case study 2: Creating an Accessible Co-design Toolkit for Co-designers with Intellectual Disabilities and Computer Science Students at TU Dublin.

TU Dublin and St John Of God Community Services have run an innovative co-design programme where computer science students work with service users to create digital applications together since 2016 (Bourke, Boland et al., 2018). 3<sup>rd</sup> year students work together with co-designers with Interaction Design to develop digital applications together and find solutions to a problem together. These projects form part of the academic requirements for undergraduate assessment in computer science and co-design participants receive a certificate of participation at the end of the module. This co-design programme and partnership has generated a rich source of tacit knowledge



on specific design tasks, methods and approaches that work well for both students and co-designers with intellectual disabilities.

#### Context

The co-design programme has highlighted a need for accessible design resources and training materials for both students and co-design participants. There are numerous practical resources and toolkits in the fields of design thinking and UX design that support co-design activities. While many of these resources are valuable tools for designers to understand and adopt a participatory approach, the resources are not always accessible or appropriate for designers or co-designers with disabilities. For example, people with intellectual disabilities may have difficulties with literacy and have challenges with tasks and interactions that require reading and comprehension while drawing and graphics-based tasks are not accessible to people with visual impairments. Furthermore, existing resources are not always appropriate for software developers or computer science students without training in the fields of User Experience or Interaction Design.

#### Before the intervention

Before the intervention, we interviewed students, lecturers and co-designers with intellectual disabilities to explore their perceptions and experiences of the co-design process. Participants who engaged in the co-design process reported their experience of the benefits and challenges of this interactive process. For student and co-designers alike communication was reported to be the biggest challenge! Co-designers with intellectual disabilities found it challenging to advocate for themselves and most importantly communicate what they don't like (response bias). Students were challenged to speak colloquially removing their technological jargon when working on co-design tasks.

#### The Intervention: An accessible co-design toolkit.

Based on literature, existing tools and our previous co-design work, a set of tools were created or adapted to create an accessible co-design toolkit. For this adaptation, two overarching principles were implemented:

1. Use of simple English. All text from the tools was reviewed by the user expert from SJOG and was re-written using simple terms and sentences: nouns were avoided, and sentences were broken down into simpler grammatical structures.
2. Providing visual aids. For each tool, every field was supported by an image (photos or icons) to help overcome literacy limitations (see Figures 1 to 3).

#### *Adapted Design thinking tools*

“The Empathy Map” is adapted from the D-School toolkit, includes realistic pictures, simple text and a quadrant layout to make it more accessible for co-designers.

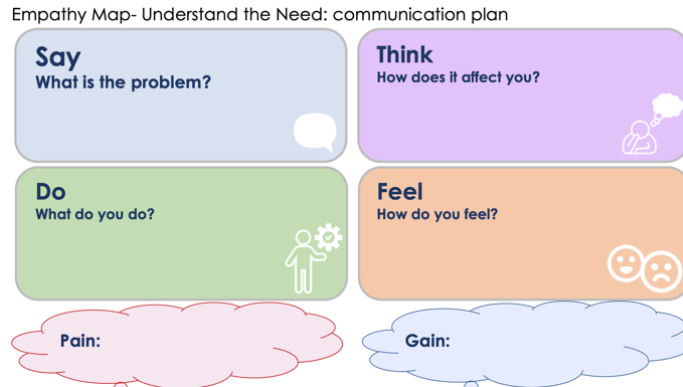


Figure 1. The Empathy Map

“Managing expectations” is following the same design principles, is meant to bridge the gap between what end-users need and what developers (computer science students) are capable of doing. Unrealistic expectations by the co-designers were highlighted as a specific issue by designers and lecturers during individual interviews in a previous study. This tool was implemented to assist in tackling this issue and to assist in providing realistic expectations of the resulting product for the co-designers.

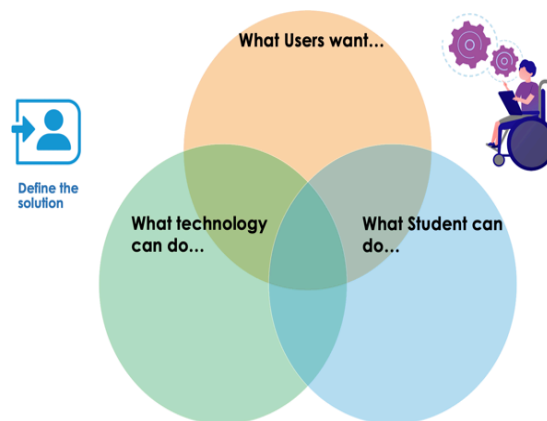


Fig. 2. Managing expectations

“I like, I wish, What if” (Figure 3) adapted from the D-School toolkit, includes realistic pictures, simple and large text to encourage co-designers to give detailed feedback.

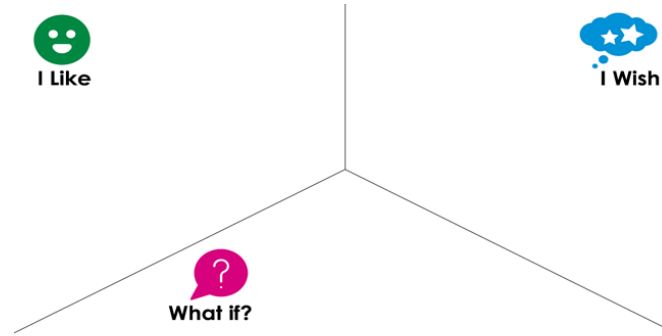


Fig. 3. I like, I wish, What if

*New Tool: “Guessing Games”*

There was also the development of a new form of co-design tool, founded on previous experiences of co-design, that was executed as a “guessing game” (where designers are presented with images and icons, and are asked to guess their meaning) this was an engaging method to extract functional information for the designers (particularly useful for visual or auditory information – which stimuli were clear and relayed the message or meaning the designers wanted e.g., icons – log in/out button etc.), whilst the co-designers were curiously engaged about understanding or “guessing” the images presented sequentially. This provided a non-influenced method of extracting the co-designers' thoughts on items without providing leading information on the item in question.

*New Tool: Facilitator prompts*

A commonly occurring issue in within qualitative data collection is biasing individuals or influencing their answers whether knowingly or not, this can be even more pronounced in more vulnerable populations. One solution to this is to make sure to invite co-designers with intellectual disabilities to offer their opinions and feedback before anyone else to avoid biasing their reactions and suggestions. “Another feasible solution we have found, inspired by the ‘Do-It-Yourself Guide, is an easy-to-use table of neutral-nonbiased questioning methods (see Table below). This can reduce facilitators use of leading questions. Why?” is a really important prompt and design question for facilitators to pose to try to understand co-designers perceptions of early prototypes and to elicit more detailed feedback. Finally, the facilitators found it important to non-bias the initial questions asked to the co-designers. For example, instead of using questions such as "Do you like? / What do you not like?", which can cause a leading answer. A more revealing approach occurred by phrasing the questions as "What do you think?" or "How did you find?"

<b>When this happens:</b>	<b>Try this:</b>
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Co-designers respond “I like it” to the question what do you think of feature X/icon X?	Ask “Can you tell me why you like it” to try to elicit a more detailed response
If co-designers say “I agree with [another person/participant]”	Ask “Why do you agree/disagree”? Or “Can you tell me about why you agree/disagree?”
A participant makes a comment, and you are not entirely sure of the meaning	Rather than inferring or guessing the meaning of what the participants has said, try repeating back their comment to clarify and phrase as a question to try to get more meaning/clarification.

#### After the intervention

From observation of codesign sessions, the tool kit presented above enhanced communication and collaboration between students and co-designers with intellectual disabilities.

The icon guessing games were interactive and engaging and improved communication on the look and feel of the interfaces being designed. The prompts to help computer science students elicit unbiased feedback from co-designers improved communication and also highlighted the importance of “asking the right questions” for computer science students. The tool “I like, I wish what if” was integrated as a regular feedback tool to iterate through design ideas and prototypes.

Some tools such as the enhanced empathy maps were more familiar and perhaps more intuitive for co-designers with intellectual disabilities due to their highly visual nature. This shows the importance of iteratively updating the tools to ensure that they are accessible to all stakeholders.

#### Conclusions

Co-design holds great potential for the creation of inclusive technology but existing toolkits and resources to support co-design are not always accessible to designers, developers and co-designers with disabilities. We need to ensure that the tools and techniques that we employ for collaborative design tasks are in themselves fully accessible to all stakeholders.

#### Key Recommendations to Create Accessible Digital Applications

- **Ensure that tools and techniques are accessible:** Co-design holds great potential for the creation of inclusive technology but existing toolkits and resources to support co-design are not always accessible to designers, developers and co-designers with disabilities. We need to ensure that the tools and techniques that we employ for collaborative design tasks are in themselves fully accessible to all stakeholders. Some of the tools that were created to be accessible for the co-designers with intellectual disabilities were not intuitive to the computer

science students so we need to ensure that processes can be used collaboratively.

- **Set ground rules for working together:** It is important to take time at the beginning of each co-design session to agree on ground rules for working together that ensures an atmosphere of open collaboration and creativity.
- **Consider communication across the design lifecycle:** Time with co-designers and developers is often constrained and communication between design sessions is essential for iterative development that can incorporate feedback from co-designers.



## 8. Case study 3: Arthritis Ireland Easy-to-Use Certification – Inclusive Design “in the wild”

### Participants

- School of Computer Science at Technological University Dublin
- Arthritis Ireland
- Panel of Participants from Arthritis Ireland
- School of Nursing, Trinity College Dublin.

The School of Computer Science at Technological University Dublin, Ireland worked with Arthritis Ireland (a charity that supports people living with arthritis in Ireland) to develop a process to enable the certification of products that are easy-to-use for people with arthritis. The certification process includes product review panels and longitudinal user testing of products. To support this process, a checklist of key considerations was developed. The checklist was refined and redesigned over several months, with help from a number of stakeholders as well as useful existing research models such as the principles of Universal Design. This project was run over several years from approximately 2009 – 2015. In 2016 the Easy To Use (ETU) certification scheme was re-examined as part of an empirical exploration to understand the experiences of the panel members with arthritis with a view to further developing the certification scheme.

### The Intervention: The Easy To Use (ETU) Certification Scheme

The checklist began as a statement of the seven principles of universal design (with their associated guidelines), however it is evident that some guidelines as less relevant to the condition of arthritis, so, for example, the principle of *Perceptible Information* is vitally important in the design of all products but has not specific resonance for those with arthritis. Thus, the principles were recast as questions such as:

- How much strength is needed?
- How much accuracy is needed?
- How can I transport it?
- How can I maintain it?

A scoring process (on a scale of 1 to 10) was developed to accompany this, and a panel of participants from Arthritis Ireland reviewed the approach, and suggested two key changes (1) Further refinement of the questions, and (2) A more simplified scoring mechanism.

The final version of the checklist for the guidelines removed some redundant questions, and recast them into three discrete categories:

- *Personal*: This category determines if the product is usable by all members of the product audience, regardless of their strength, accuracy, grip, handedness, size, and speed.
- *Operational*: This category determines if the product is usable by all members of the product audience, considering each of the following: body position, comfort, repetition, operation time, complexity, and safety
- *Non-Operational*: This category determines if the product is attractive to, and maintainable by all members of the product audience, considering each of the following: appeal, setup, instruction, packaging, transportation, and storage

The scoring mechanism was changed from a '1 to 10' scale to an Honours, Pass, Fail-type criteria, called Levels  $\alpha$ ,  $\beta$  or  $\gamma$ ; where  $\alpha$  [Alpha] is very easy to use,  $\beta$  [Beta] is somewhat easy to use, and  $\gamma$  [Gamma] is not easy to use. Based on feedback from Arthritis Ireland participants, the designations of the scoring criteria were changed to NO BARRIERS, FEW BARRIERS and MANY BARRIERS as it was felt that the Greek letters might prove to be unfamiliar and cause confusion for users of the guidelines. The feedback from the users throughout the design process was essential, and ensured that the checklist was usable by all users involved in the commendation process.

#### After the Intervention – Follow up Study with ETU participants

##### *Participants*

Panel members who had participated in previous iterations of the Easy to Use pilot scheme were recruited through Arthritis Ireland. Eight people (Six female and two male) between the ages of 36 and 69 (Mean: 57 years) took part in a focus group and individual interviews. Four participants took part in a focus group and the remaining four took part in individual interviews.

##### *Key Findings*

- Participants were enthusiastic and positive about taking part in the Easy To Use Scheme. They perceived the initiative as a way to help themselves and others coping with arthritis. It is interesting to note the motivations for joining the ETU panel: some respondents were glad their opinion was valued and that they could help others, some saw this as an opportunity to apply (or continue to apply after retirement) their professional skills, and others joined for the social connection to meet others with the same condition.

- All participants interviewed were interested in products that aim to help with arthritis (e.g. pain relief). Focus group respondents were particularly attracted to the medical products (Medicur Pro, wrist splint and knee support). Many of the participants had multiple health conditions, some very serious, and were interested in products that can improve their day-to-day life.
- In terms of ideas to improve the ETU training in the future, the key message from participants was simplicity.
- Several of the respondents did not remember the details of the assessment very well or what products they tested. Some prepared notes, others just relied on their memory.
- In some cases panellists were allowed to keep products after testing. Some respondents mentioned this could be an incentive to participate in the scheme. However, one respondent noted that she didn't necessarily want to keep all products she tested. Others noted that they would have liked to test different (or more) products.
- All panel members gave their products to family and/or friends to try out in addition to testing themselves.
- Most respondents thought communication could be improved. In particular, they would like a more systematic approach to the planning of meetings and interviews so that they can better fit this assignment around their work and personal commitments. Respondents would have liked information about what happened to the products after the review. Some of them would have liked to buy the products, but could not find them in the shops.

### Recommendations for Using Co-Design for Design of Accessible Products in the field

1. Need for further exploration of participants in future iterations of the Easy to Use scheme. For example should the opinions of family members be captured or excluded? It could be argued that having other people to test products could bias the panellists' answers. Alternatively, if products are meant to be universally usable, including a full household involved could be an advantage.
2. Participants focus on the medical benefit of the products being tested may have clouded their understanding of "ease of use". A revised approach to training may be a solution to this problem, but we must be aware that people will be testing

the products in their homes, alone and with no guidance, so it might be difficult to separate usefulness vs. ease of use.

3. Need to agree set of procedures for handling the distribution and retention of samples if this scheme was to run on an ongoing basis (and possibly provide mechanism to change product sizes during testing if needed, as this was an issue with a number of panellists).
4. Future iterations could include distinct entries in the checklist to control for medical value or usefulness vs ease of use. While this means testers would explicitly look at whether a product is useful for arthritis, at least the expanded checklist would ensure that both variables are captured.
5. Create a communication strategy for all stakeholders at each step of the process.
6. Future iterations could include some kind of digital or written diary to record user's perceptions over time. This would also target issues of learnability and ease of use. To avoid this risk in the future, it may be advisable to provide panellists with brief guidelines on product assessment to act as a reminder during home testing (and to reiterate the difference between usefulness for arthritis (or other medical benefit) and ease of use).



## 9. Summary Recommendations and Learnings from Case Studies

**DIVERSITY:** Different users will have different opinions, even if they have a very similar health condition, disability or lived experience people are individuals and will have different capabilities, preferences and requirements.

**CONTEXT:** To find out if a product is usable, there are limited evaluations to run within few hours, give it to them for a few months, left them take it "out into the wild" test whether it is inclusive in the long term.

**FLEXIBILITY:** A formal process with clear guidelines is fair on all users and product, but the processes are not the centre of the activity, the user must be the centre of the activity, so processes should be flexible to suit the users

**COMMUNICATION:** Communication between stakeholders at all stages of a design life cycle is important for genuine inclusive participation.

**ACCESSIBILITY:** Accessibility of tools and processes for all stakeholders needs to be considered. Tools and processes that are accessible to one group may not be accessible to another.

**USER BURDEN:** Consider the burden on end user participants – is there is an immediate benefit? If not is there payment/compensation? Are the same users burdened with frequent requests for participation?



## Part 4.

### Guidelines for Authentic Inclusive Co-Design

From literature, case studies, interviews and practical explorations we present a summary of guidelines, risks and mitigations for authentic inclusive design.

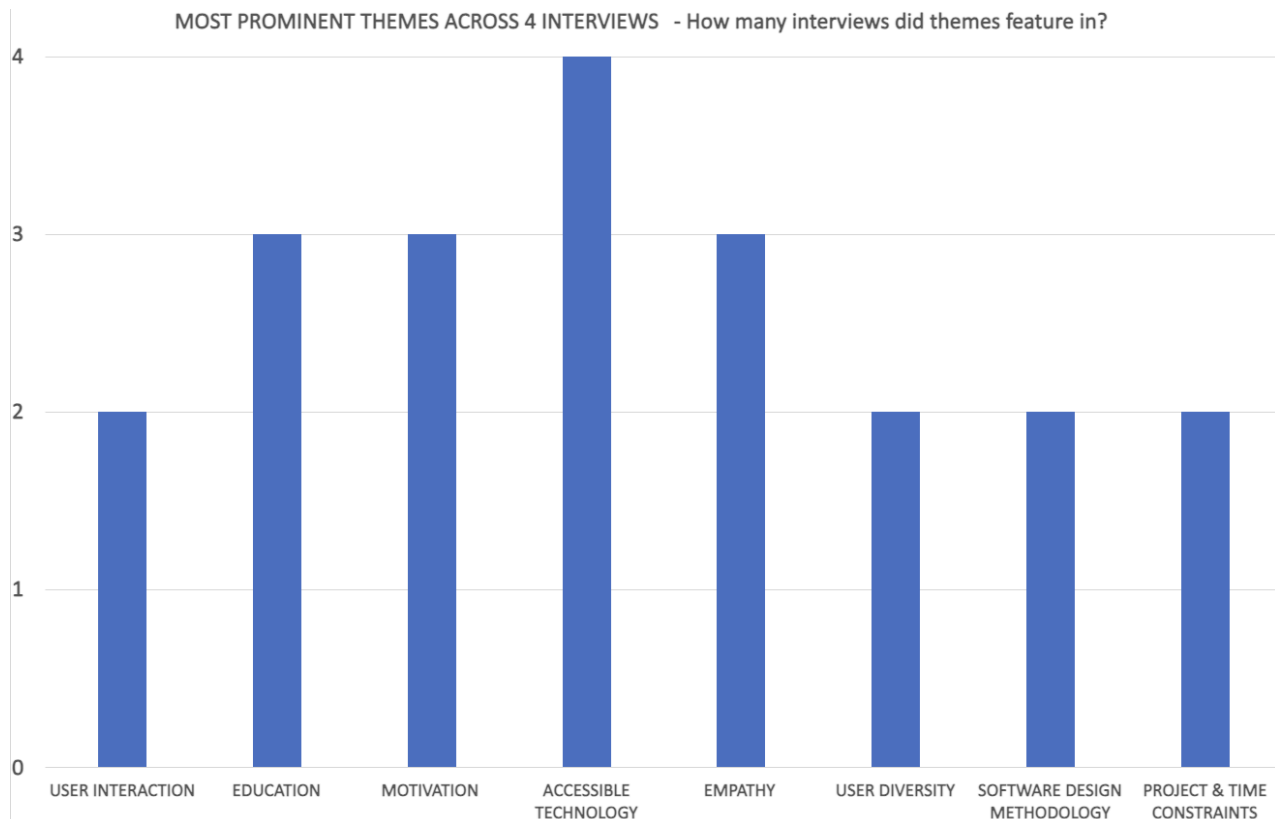
Some of the key themes that are relevant to this section that emerged from the discussions with the participants of the interviews in the Interviewing Report (WP2A) concerning authentic inclusive co-design include the following:

- **USER INTERACTION:** The interviewees indicated that most user involvement takes place in the research and testing phases of the development process. Ideally, if they were using a participatory design approach, users should be involved iteratively throughout the lifecycle of the design.
- **EDUCATION:** Interviewees indicated that it is essential that accessibility is part of all educational courses, and that it is embodied in both the teaching content and the assessment materials. It was also noted that online teaching is often more accessible than face-to-face classroom situations. Education is vital for inclusive practices to become more pervasive in the development lifecycle.
- **EXPLAINABILITY:** Interviewees that motivation is an essential element of inclusive design, and in terms of designers the more they understand the processes and benefits of inclusive design, the more they will engage in it. Additionally, employees should be incentivized to upskill in the area of inclusion by their organisations.
- **ACCESSIBLE TECHNOLOGY:** Interviewees noted that a lot of very commonly used software tools are not accessible and do not work well with assistive technologies. They also noted that designers and developers need to understand there are technology issues beyond disabilities, there may be technology needs that need to be addressed, including access to Wi-Fi, access to the latest software and hardware, and access to support and maintenance.
- **EMPATHY:** The interviewees said that unless employees have access to real users, they will lack empathy during development, and all interactions should be recorded in a variety of different ways for future use. The participants in these design processes also need to have a safe space to embrace their curiosity and share their ideas and feelings, and not be afraid to ask questions.
- **USER DIVERSITY:** Interviewees acknowledged that there are challenges in recruiting real users with disabilities. Their view is that the most excluded users, in general, are the neurodiverse and the blind. They highlighted that users involved in participatory design should be diverse and reflective of the user group



of the design. All aspects of inclusion should be considered e.g., culture, language, accessibility.

- **SOFTWARE DESIGN METHODOLOGIES:** The interviewees suggested that building the system in small chunks (using an iterative or Agile approach) allows for continuous feedback and improvements. This way, issues can be identified and addressed early in the process, and there is no need to retrofit accessibility into the design.
- **PROJECT and TIME CONSTRAINTS:** The interviewees highlighted the pressures and constraints of working on multiple projects, and how challenging that would make it to include users in many of the projects.



The following guidelines have been identified from case studies presented in sections 2 and 3:

#### Engaging Stakeholders:

- **Identify Stakeholder Groups:** Begin by identifying all relevant stakeholder groups affected by the design, development and use of proposed technology.
- **Active Stakeholder Participation:** Encourage active involvement and engagement of stakeholders throughout the design and development process, creating a collaborative atmosphere.
- **Diverse Perspectives:** Ensure that stakeholders represent diverse perspectives and experiences to capture a comprehensive range of needs and insights.
- **Consider Reciprocity:** Ensure that co-designers with specific lived experiences are compensated for their work. Where payment is not possible or appropriate consider short-term benefits for participants such as knowledge or skill swaps across projects.

#### Co-Design Process:

- **Iterative Approach:** Embrace an iterative approach to co-design, where feedback and adjustments are incorporated at various stages to refine the module continually.
- **Design Thinking:** Apply design thinking principles to problem-solving, empathizing with stakeholders' needs and iterating on solutions to create an effective and user-centered module.
- **Flexible Design:** Maintain flexibility in the design process to accommodate changes, evolving requirements, and novel insights from stakeholders.

#### User-Centric Focus:

- **Prioritise End User Feedback:** Prioritize the inclusion of end user feedback, as they are the group (or groups) that need to be able to use the system.



### Accessibility and Inclusion:

- **Address Inclusivity:** Specifically consider inclusivity within the co-design process, ensure that design tools and techniques are accessible to different stakeholder groups.
- **Accessibility and Usability Experts:** When relevant, involve accessibility and usability experts to ensure the design tools, communication methods and resources are accessible and user-friendly.

### Resource Allocation:

- **Allocate Resources:** Allocate necessary resources, such as time, equipment, and personnel, to support the co-design process.

### Continuous Improvement:

- **Reflect and Iterate:** Continuously reflect on the co-design process and module outcomes, making iterative improvements based on feedback and evolving educational needs.
- **Open Communication Channels:** Establish clear communication channels for stakeholders to share feedback, ideas, and concerns throughout the design process.
- **Regular Collaboration Meetings:** Hold regular collaboration meetings to review progress, address issues, and ensure alignment with co-design goals.

### Evaluation:

- **Evaluation methods:** While co-design involves continuous engagement of stakeholders and end users in the design and development of a technology, there is a need for a separate evaluation of the final system. Consider an “in the wild” evaluation in addition to controlled lab based evaluations.
- **Impact Assessment:** Evaluate the impact of the co-designed technology, considering factors such as ease of use, satisfaction, and acceptability.



- **Adjustments and Adaptations:** Be prepared to make adjustments and adaptations to the final version of the technology based on the evaluation results, addressing any identified issues.

#### Feedback and Sustainability:

- **Embed feedback procedures:** Ensure that feedback can be provided by end users beyond the participatory design and evaluation lifecycle to continue to ensure that technology remains accessible and usable.



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