Part I

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ICCHP-AAATE 2022 Open Access Compendium
"Assistive Technology, Accessibility and (e)Inclusion"

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Aim and scope: To communicate and complete knowledge on ICT, AT and Accessibility for/with people with disabilities and older adults and connect research in these domains with the necessary practical background and user related aspects.
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Editorial

Welcome to our Open Access Compendium “Assistive Technology, Accessibility and (e)Inclusion” published on the occasion of ICCHP-AAATE 2022.

The first Open Access Compendium was published for the ICCHP 2020 conference and its added value became immediately clear, just as the wish to continue what hopefully will become a long series of significant resource publications for the community of AT and accessibility researchers and wider stakeholder.

That first edition which came under the title “Future Perspectives of AT, eAccessibility and eInclusion” included 29 peer reviewed papers. The one we present today includes 78 contributions. that together present a 360° view on AT, Accessibility, ICT with and for people with disabilities and older adults.

The decision of AAATE and ICCHP to join forces for the organization of a major conference in 2022, provided an excellent opportunity for innovation. It was decided to create and offer a new venue for researchers and practitioners in assistive and access technologies, to showcase their work and mingle together.

After almost two years of living through a pandemic, during which AAATE 2021 had to be canceled and ICCHP 2020 was held online, the best way forward was to merge the individual bi-annual conferences for 2022, providing a single platform for exchanging ideas, stimulating conversation, and facilitating networking– at the Polo Territoriale of the Politecnico di Milano in Lecco, close to the most beautiful shores of Lake Como.

So, the Compendium got a brand-new name, highlighting this new, additional perspective. Its scope was broadened to include topics closer to the AAATE community and the conference themes. Each of the extended abstracts submitted underwent a rigorous review by at least 3 experts, making up the selection presented in this second edition.

Representing a multidisciplinary, multifocal approach was made easier by bringing the AAATE and ICCHP communities together to explore the common threads linking policy, practice, research and advocacy for people living with disabilities, as well as working together for a more equitable, and inclusive future.

The ICCHP-AAATE 2022 joint conference was open to everyone interested in new and original ways to put technology at the service of people living with a disability. Together with the traditional Young Researchers’ Consortium, this joint conference was a unique ecosystem for networking, exchange and connecting researchers and developers in all our field(s) to a stronger community.

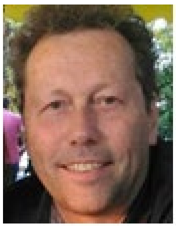
This universal approach that has characterized the conference is also reflected in the different publications available: Technological-scientific conference proceedings published with Springer Lecture Notes in Computer Science; the scientific, more open and broader designed Open Access Compendium “Assistive Technology, Accessibility and (e)Inclusion”; and the ICCHP-AAATE Book of Abstracts collecting all submitted abstracts and additionally the descriptions of policy sessions and panel discussions, educational sessions; and the brand new Innovation Area with product presentations, demonstrations and poster sessions.

We hope this edition of our Open Access Compendium delivers memories, knowledge and also new insights to you – and is an incentive to join our future conferences.

Looking forward to meeting you 2023 at AAATE in Paris, France and at ICCHP 2024 in Linz, Austria.

Linz / Lecco, July 2022

Andrea
Petz



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Content

Digital Solutions for Inclusive Mobility: Solutions and Accessible Maps for Indoor and Outdoor Mobility

UniMaps - An Accessible Mobile Indoor Navigation App

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Abstract. UniMaps is an accessible mobile application for indoor and outdoor navigation on Campus Bielefeld. This position paper describes the development and issues we faced and how we tackled them. UniMaps was initially developed in a student competition and has since then been further developed by students as an official university project. The development is done after the Universal Design principles and with the involvement of people with disabilities. The first issue we faced during the development was the large-scale indoor map data acquisition. We created a semi-automated approach which correctly reconstructs about 80% of the rooms and we are currently further improving it. The second issue which we faced was the indoor navigation. An indoor GPS localization is not possible and WiFi and bluetooth beacons allow only a coarse localization. In a current bachelor thesis, a step counter is implemented which uses the gyro sensor and is also compatible with wheelchair users. With a combination of the step counter and the different current coarse localization options we want to implement fine localization which allows an intuitive navigation. The last big issue was the visualization of maps. There are different map styles from the OSM community, but as far as we know there is no map styles which is accessible. In the future we are planning to design a map style which is accessible by design.

Keywords: unimaps, accessibility, mobile application, indoor navigation, osm.

1 Introduction

UniMaps [1] is an accessible indoor and outdoor navigation app. It provides a seamless room-to-room navigation between buildings on Campus Bielefeld. UniMaps was developed after the “Universal Design” principles. Therefore, the application is compliant with Web Content Accessibility Guidelines (WCAG) 2.1 [2] at AA-level and attempts to provide barrier-free navigation on campus. Beside the WCAG criteria’s, we added more accessibility features like help-overlays which provides the user with information about the current view or a less detailed map. This reduces the map style to a minimum for users who are easily distracted. Beside the accessibility related features, we also integrated the person and facilities catalog. This allows navigation to a person or facility without knowing the exact location. Other features are the reporting and avoidance of barriers, saving of custom linkages, and an integration of the canteen plan as well as the tram schedule.

In the following section we will explain some aspects of the development of UniMaps that were important to us and what problems we encountered. Three of these issues will be described in more detail. The first issue is the indoor map data acquisition, followed by the indoor navigation and finally the visual representation. At the end a conclusion about UniMaps and its challenges during the development will be given.

2 UniMaps

2.1 Development

The development of UniMaps started in summer term 2017. In contrast to the usual development processes, where a few university members decide what kind of app they want and a tender company develops it, UniMaps has gone a different way. In a student competition 112 students in 12 teams from the Faculty of Technology got the task to develop an accessible indoor navigation app with the "Universal Design" principles [3]. The idea behind this process was that most of the app users will be students and that they know best what their needs for such an app are. The two requirements, indoor navigation and accessibility with the "Universal Design" principles ensured that first the requested app was developed and second that the app was developed for anyone and not just for students. This means that the students had to put themselves in the position of others which may not have the same physical abilities. They also got in contact with people with disabilities to understand their needs. In this competition 12 prototypes of android applications were created.

In 2018 the winning app was used as a base for the development of the application and since 2019 the development is done as an official university project by the Accessibility Services (ZAB – Zentrale Anlaufstelle Barrierefrei) [4]. The development continued with students after the idea behind the completion worked well. In 2019 the first version of UniMaps was released in Google Play Store [5]. The close connection with the research and teaching of the university was deepened in a project where students evaluated the best way to create an iOS app when an android app already exists. In this project a way was found where most of the code basis could be reused although both apps were developed as native applications. A barrier we faced in the iOS development was the lack of a map render library which met our requirements. For this reason, we decided to extend an existing map rendering library to have offline maps that do not take up much memory. This was done as part of a bachelor thesis [7], which implemented a parser for mapsforge map files in the map rendering library CARTO [10].

With the availability of the map rendering library the iOS app was released at the end of 2021. Since then, three more bachelor theses and a student project were done or are ongoing. Some of them will be mentioned later.

2.2 Indoor Map Data Acquisition

One key point during the early development was the map data acquisition. As the Bielefeld University is one of the largest contiguous buildings in Europe a manual data acquisition was not possible, and an automated process had to be developed. As we decided for a map render engine which uses OpenStreetMap (OSM) [6] based maps, we had to find a process of converting existing building data into the OSM standard. As a data source we got the CAD data of the buildings from the university. The data is in the DWG file format and was converted to DXF for a simpler parsing. We developed a tool to convert the DXF files into OSM files for visualization and into a graph on which the navigation is done.

For the *OSM* generation we detected all nodes in the *CAD* which correspond to a room. For each of these nodes we shot rays into every direction and recorded the intersection with walls. Afterwards the room was reconstructed with the walls which intersected with the rays. In general, about 80% of the rooms in our maps were correctly reconstructed by this technology. However, this approach also has its limitations. One of them is that the quality of the *OSM* file highly depends on the quality of the *CAD* data. For example, a misplacement of the room node was one common issue we faced in our data. As soon as the room node is not in the room anymore, the room creation fails. However, these cases can be easily detected by a manual postprocessing as the rooms were extremely big when these nodes were placed outside the building or really small when the room was placed in the wall between two rooms.

During the development we also faced the issue that the *OSM* indoor and accessibility schema was not sufficient to cover all our needs. Therefore, we had to use custom tags which do not comply with the *OSM* standards.

An ongoing bachelor thesis tries to improve our current approach. It is based on the work of Domínguez et al. [11] who presented a method for semiautomatic detection of the topology of building floors. At first glance the solution presented in the bachelor thesis seems to overcome some of the issues we were facing in our current approach.

2.3 Indoor Navigation

Another issue we faced is the indoor navigation. Normally navigation apps make use of GPS to localize the user. In our case this method fails most of the time as there is no or just an inaccurate GPS signal inside the university. The only other data sources we can obtain in the building are Wi-Fi and the data from the smartphone's gyro sensors. Because the exact place of the access points was not recorded during placing, we can only detect the coarse location of the user via the Wi-Fi signals. For a localization in the navigation the Wi-Fi signals alone are not exact. A bachelor thesis evaluated the usage of bluetooth beacons for localization [8]. With the size of the building only low costs beacons were financial suitable. Unfortunately, with theses beacons the localization had an error of multiple meters. Because of the lack of localization options, we decided that the user can see the way he has to take on the map but must check off when he completed an instruction. We used the inbuild android step detection to estimate the way he went. We update the map accordingly but once again due to inaccuracy the user must check off the instruction once completed. A bachelor thesis implemented a step detector which has an accuracy of 72% [9]. The algorithm also aimed to detect the movement of wheelchair users and achieved an accuracy of 100% if the smartphone is carried in front of the chest. We also want to publish the results of the thesis in a separate paper.

The process of manually checking of the instructions is not ideal and in the current time not intuitive anymore. People are used to instructions that automatically update and not to instruction lists. Therefore, we want to automate this with the algorithm which was developed in the bachelor thesis and a combination with the Wi-Fi signals.

2.4 Visual Map Representation

One issue which we are currently facing is the accessible visualization of map data. In the *OSM* community different map styles exist like *Openstreetmap Carto*, *mapnik* or *pioneer.* These map styles try to meet the requirements of all users, while other map styles like *CyclOSM* were designed for specific groups like cyclist. But as far as we know there is no map style which is especially designed for accessibility. An accessibility problem which all of these maps have in common are the various different styles of roads and areas. These many different styles can overwhelm or distract people with mental disabilities. As our map is based on such a default map style we introduced a less detailed map, which removes many impressions and simplifies the environment to a simple black and white map. But for us, this solution is not good enough. Therefore, we already got in contact with the Bielefeld University of Applied Sciences and the Faculty of Design. In a course the students designed prototypes of alternative map styles which face accessibility while still looking appealing. In the future we want to redesign our current two map style system and possibly replace it with a single map style which is accessible by design.

3 Conclusion

In this position paper we presented UniMaps, our accessible navigation app for the Campus Bielefeld. The app is developed by students and provides a barrier-free navigation. We presented our development process which tries to be as close as possible to the users of the application und uses the potential of the students. Three issues which we faced and are still facing were described in more detail. The first issue was the map data acquisition which we automated to a large extend. The second issue was the indoor navigation which is a challenge due to the lack of GPS signal and for us still an issue which we tackle. At last, the visualization of the map, which is something that till now has not been done in a fully accessible way.

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Implementation and Innovation in the Area of Independent Mobility through Digital Technologies

An Architecture of Deep Neural Networks for Expiry Date Recognition System

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Abstract. Visually impaired people want to know about expiry date of perishable foods during shopping and they want to enjoy shopping without help of others. In this paper, we propose a system which recognizes the expiry date in the image automatically and tells them the recognized date. The system is divided into two parts. At first, the system detects the expiry date region from the input whole image. Then, it recognizes the date from the region of the image. In this paper, we focus on the latter part of the system. It consists of a neural network (NN) which inputs the image and outputs the expiry date. The NN consists of 4 convolutional layers, 2 max pooling layers and 5 fully connected NNs. We devise the output layer to prevent the output of impossible dates. We corrected 140 images of expiry dates and used 100 images for training and 40 images for testing. The number of the images was not enough for training; therefore, we increased the training images by synthesizing the image. We created total of 100,000 synthesized images and used for training and validation. We input 40 images which was not used in training. The result shows that 39 of 40 images were correctly recognized.

1 Introduction

Shopping for daily necessities in supermarkets is inconvenient for the visually impaired. When shopping, they cannot easily obtain product information. From the results of an interview of 14 visually impaired individuals regarding shopping [1], they can go to the front of the product shelves by themselves, because they remember the arrangement of the shelves in the supermarket. However, they cannot obtain the name, price, or expiry date of perishable foods. They want to enjoy shopping without help of others. In this paper, we focus on automatic recognition of expiry dates.

Expiry dates are often written as dot matrix characters. Such characters are represented by a set of dots, as shown in left image in Fig. 1. In order to recognize them, Ashino and Takeuchi are proposed an automatic recognition system using combination of deep neural networks [2]. Visually impaired people can take an image of a product by their camera or smartphone, and the system recognizes the expiry dates in the image automatically and tells them the recognized date. The system can recognize each single digit; therefore, it requires additional process to concatenate digits to date. Figure 1 (a) illustrates this process.

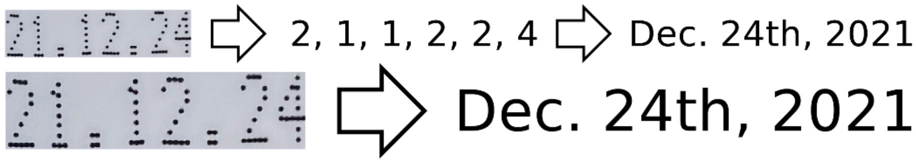


Fig. 1. a) Traditional system b) Proposed system of process of expiry date recognition: Expiry dates in the left images are written in 'Year.Month.Day' format.

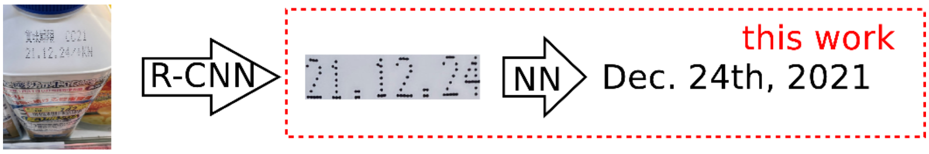


Fig. 2. Flow of proposed system

In this paper, we propose a system to recognize an entire expiry date of perishable foods, not each digit of the date. Figure 1 (b) illustrates the proposed process. It can recognize the expiry date directly and does not require additional processes. In order to do this, we propose a date recognition neural network (NN) which can recognize a date from an image.

Tanaka et al. proposed a system for recognizing expiry dates [1]. Their experimental results indicated that the accuracy of their method for recognizing the expiry dates in drink packages was only 43%. Hosozawa et al. proposed an erosion and dilation procedure for dot matrix characters [3]. However, they did not give the recognition accuracy for this procedure. Zaafouri et al. proposed an automated vision approach for recognizing expiry dates using a multi-layer NN [4]. Gong et al. proposed a DNN for localizing the expiry date in an image [5]. The last two studies did not consider dot matrix characters.

Our proposed system is divided into two parts as shown in Fig. 2. At first, the system detects the expiry date region from the input whole image. This can be achieved by region-based Convolutional NN (R-CNN) [6]. Then, the system recognizes the date from the region of the image. In this paper, we focus on the latter part of the system.

With this system, the visually impaired people can read expiry dates without the need for assistance. They can also read the expiry date of products they bought earlier at home.

2 Expiry-Date Recognition from Image

We propose a system to recognize expiry date from the region of the image. The system consists of NN which inputs the image and outputs the date.

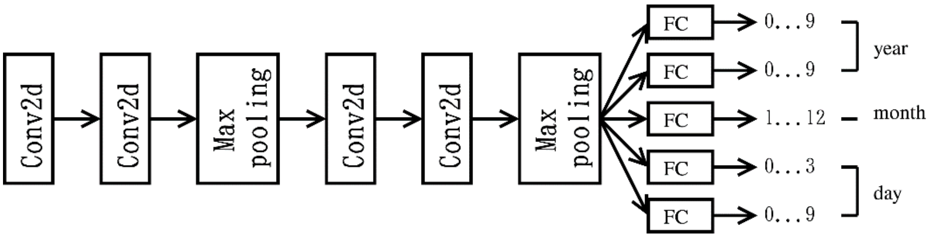


Fig. 3. Architecture of the date recognition NN

Fig. 4. Synthesized expiry date image for training

We devise the output layer to prevent the output of impossible dates, e.g. 13th month or 43 day.

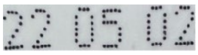
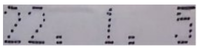
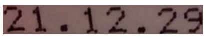
The NN consists of 4 convolutional layers, 2 max pooling layers and 5 fully connected NNs (FC) as shown in Fig. 3. At first, the image is input to two convolutional layers which has 32 channels and 3x3 kernel size. Then, the output is subsampled by a max pooling layer of 2x2 size. Again, the output of max pooling layer is input to two convolutional layers and a max pooling layer. Finally, the output is input to five fully connected NNs, which has one hidden layer with 256 neurons. The first two NNs are used as year-recognition. The output of each NN has 10 neurons which represents the digits of tens or ones place of the year. The third NN is used as month-recognition. The output has 12 neurons which represents the month. The last two NNs are used as day-recognition. The outputs have four neurons for the tens place of the day and 10 neurons for the ones place of the day.

3 Experimental Results

We corrected 140 images of expiry dates and used 100 images for training and 40 images for testing. The number of the images was not enough for training; therefore, we increased the training images by synthesizing the image. We clipped each digit in the image and synthesized the image of random date as shown in Fig. 4. Since zeros in the tens place of month or day may be omitted, we randomly selected either a 0 image or a blank image. We created total of 100,000 images and used 90,000 images for training and 10,000 images as validation. Using theses images, we trained NN in 10 epochs.

In order to test the system, we input 40 images which was not used in training. Table 1 shows some of the input images and the recognition results. 39 of 40 images were correctly recognized, i.e. the recognition rate was 97.5%.

Table 1. Samples of the input images and the recognition results

Input Image	Recognition Result
	220502
	220105
	211229
	220123

4 Discussion

The system was able to achieve high recognition rate of 97.5% because we synthesized many images and used them for training. The only failure example is shown at the end of Table 1. This should be recognized as '220103,' however it was recognized as '220123' by the system. We investigated the output of each neuron of the tens place of the day and found that the value of the 2's neuron was 0.76 while the 0's neuron was 0.16. However, for the ones digit of the day, the value of the 3's neuron was almost 1, while the value of the second largest neuron was 5.0×10^{-10}. If we calculate the measure of reliability, e.g. entropy, then the system rejects the unreliable recognition results. The entropy of the tens place of the day in the last image in Table 1 has the largest value. Therefore, we can reject this recognized date successfully in this experiment. The number of test samples are small, so we have to increase the number of the test samples and choose the entropy threshold carefully. If the recognition result is rejected, the system will ask the user to take the image again.

5 Conclusion

In this paper, we proposed a system to recognize an entire expiry date of perishable foods expiry date from an image. The system was able to achieve high recognition rate of 97.5% because we synthesized 100,000 images and used them for training.

As a future work, it is necessary to conduct more experiment using other test images. It is also necessary for visually impaired people to use the system and give feedback on it. We plan to implement the proposed system in a smartphone application.

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H-H and H-M Communication with and among Disabled Persons in Public Transport

TRIPS Deliverable D3.3 Report on Accessibility Standards and Legislation

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Abstract. This contribution deals with human communication aspects with and among persons with disabilities (PwD – also involving their carers and accompanying persons) increasingly assisted by ICT devices/tools. Under eInclusion aspects public transport plays an important role for them to fulfil their aspirations of self-determined and as much as possible independent living including moving around in one's own vicinity as well as travelling to other locations – even abroad. The eAccessibility of communication content can be a big barrier to such aspirations. The EU project TRIPS (TRansport Innovation for disabled People needs Satisfaction) addresses a broad range of issues in this connection. The low degree of content harmonisation across communication systems and platforms has been identified as a serious development gap in TRIPS Task 3.3 Report on Accessibility Standards and Legislation. This refers to both content entities (mostly of the microcontent type) and the methods to process and manage them.

Keywords: Comprehensive Content Interoperability, Multimodal Communication Content in Public Transport, EU Project TRIPS, controlled interhuman communication, microcontent.

1 Communicating with Disabled Persons in Public Transport

In H-H and H-M communication flaws or even outages can happen which is especially detrimental in ambient assisted living (AAL) environments. This not only can cause dissatisfaction, but worse (even in barrier-free) public transport leaves the user stranded causing frustration or complete discouragement. Needless to mention that such flaws and outages can also occur in M-M communication geared towards assisting users if the content communicated – mostly one or the other kind of microcontent entity (microCE) – is not comprehensively content interoperable. Such advanced content interoperability (contentIOp) includes the necessary requirements for communication with and among persons with disabilities (PwD). In any larger city in Europe there are several language communities and PwD with different needs. The share of the latter is increasing due to demographic reasons, such as aging society causing the increase of the number of persons with multiple impairments. There is a high percentage of PwD who like to travel or just visit friends or relatives in the same geographic area – and there are lots of cities with foreign visitors or tourists. Thus, travelers also include PwD with (temporarily or permanently) acquired or congenital impairments, many of whom can travel thanks to modern AT devices. They have special needs with respect to interhuman communication, shared to some extent by their carers or social company.

The importance of interhuman communication is often underestimated. It can only be replaced to a certain degree by information and communication technologies (ICT). In public transport with its special forms of "controlled communication" a lot of – usually not unified – microCEs occur, for instance in the form of messages, announcements, user instructions and the like. Given the situation outlined above, the *Recommendation on software and content development principles 2010*[1] increasingly gains importance. It "defines as basic requirements for the development of fundamental methodology standards concerning semantic interoperability the fitness for multilinguality (covering also cultural diversity), multimodality and multimedia, eInclusion and eAcessibility, multi-channel presentations. These requirements must be considered at the earliest stage of the software design process, and data modelling (including the definition of metadata), and hereafter throughout all the iterative development cycles". This refers not only to methodology standards, but also to the standardization and harmonization of the respective microCEs themselves.

2 Microcontent and Microcontent Entities

In connection with the above, there is scientific and technical R&D dealing with "microcontent" (also referred to as structured content, or structured information, or structured data and often used interchangeably) which "seems to be the most appropriate term [for] entities of structured content at the level of lexical semantics" [1] – in line with Dash's [2] definition whereby microcontent indicates content that conveys one primary idea or concept. When referring to microcontent design, several authors agree on five main characteristics of microCEs, namely format, focus, autonomy, structure, and addressability. Experts largely agree that comprehensive contentIOp in principle can be achieved more easily at the granularity level of microCEs than between larger content entities. However, recent studies point to the fact that a minimum of metadata must be used in data modelling of microCEs at this granularity level, otherwise they are not sufficiently qualified to achieve comprehensive contentIOp.

By means of the above metadata, the respective concept or idea of the microCE is "represented", i.e., uniquely identified and described. However, the "presentation" of that representation can vary broadly with respect to different languages used (and

[1] Accessible under: https://aaate.net/recommendation-2016-concerning-standards-on-eaccessibility-and-einclusion/

synonyms available), cultural differences, different communication modalities, and the technical possibilities of the output devices used. This variation of presentations can be confusing to anybody, but particularly to PwD. Under the perspective of comprehensive contentIOp and controlled interhuman communication this variation needs to be reduced for the sake of unimpeded communication. This reduction in fact is carried out by means of standardizing the representation as well as presentations of microCEs in the form of content or data standards. For applying unified principles and methods to this end methodology, standards are developed. In some fields extensive standardization activities are taking place for the unification and harmonization of microCEs.

3 Need for More Standardization and Harmonization

The above also applies to the communication with AT devices, or with larger information systems informing or assisting travellers. Despite of the above-mentioned high-level recommendation in the field of standardisation the requirement to consider multilinguality, multimodality, and PwD's needs in all content development and management still is not sufficiently met. This also refers to internationally harmonised principles and methods to achieve comprehensive contentIOp. Applications and devices/tools where microCEs must be reusable or even re-purposable are increasing, such as in user-interface design of technical devices/systems, data repositories in the public domain, eLearning (especially microlearning), smart city conceptions, public transport, etc. Thus, standardization activities are increasing concerning the requirements of comprehensive contentIOp.

Already since around 1990, industry became aware of the need for multilingual and multimodal content (beyond written and spoken) and developed standards for the localization of products, goods, services, and the respective documentation. Technical committees dealing with data (such as in product master data management) in eCommerce/eBusiness/eTrade have developed whole series of standards containing standardized microCEs and the respective standardized methodology.

Given the growing needs for all sorts of microCEs and the increasing requirements for their development, approaches for ICT-supported cooperative content creation are emerging. In addition, microCEs in some application fields, such as public transport, fall under the category of "critical communication", which on all accounts requires stricter standards and new standards concerning the requirements of "comprehensive content interoperability". Demands for content quality and enhanced content reusability are growing. Under this perspective, harmonizing the wording of dialogues across different information platforms and using controlled communication in different languages and modalities would strongly support content eAccessibility not only public transport, but in many situations for many needs.

In the field of Assistive Technology (AT) the user interfaces for communication can occur in nearly all technical applications for verbal and nonverbal communication in next to all possible communication modalities. While the technology is highly advanced, the harmonization of content – mostly in the form of controlled communication – across systems/platforms and languages is not always considered an issue. As a result, users are faced with too many kinds of "presentation" of the same content in different locations with same or different systems or tools.

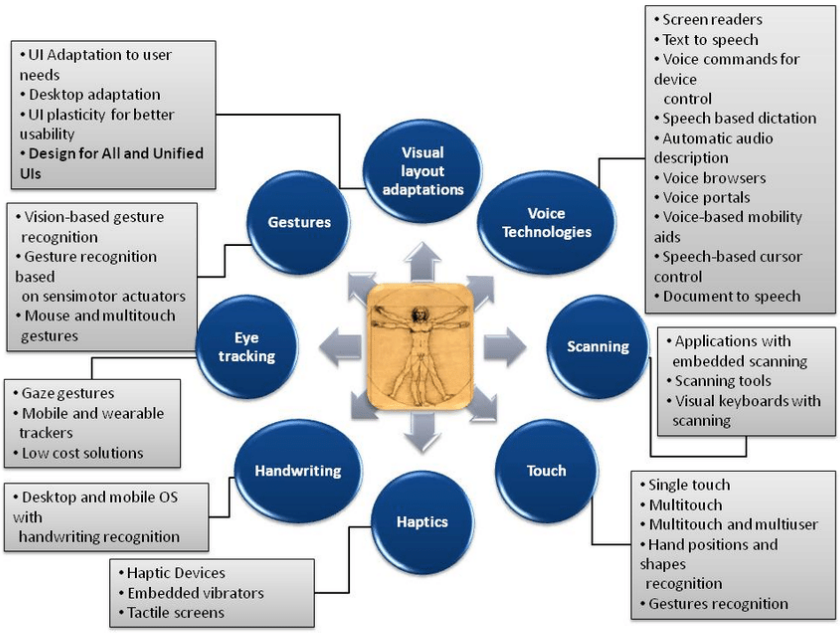

Fig. 1. Human communication aspects everywhere[2]

The above figure reveals that the AT field would be in a unique position to lead the field with respect to methodology standardization

4 Microcontent in Public Transport

For content development to be used in accessible public transport, standards on web content accessibility [3] and Design for All [4] are fundamental but need to be extended by further methodology standards and standardised microCEs. In the light of the increasing mobility of people outlined above, the respective content management must consider content multilinguality, multimodality, and user needs under eAccessibility and eInclusion requirements. This development requires a high degree of international harmonization both in terms of methodological approaches and content – first micro-CEs.

TRIPS deliverable D13 provides in depth information on efforts to coordinate standardisation activities falling under the scope of the project. The investigation extends towards harmonised or non-harmonised use of controlled (written or oral) communication across platforms, extended towards non-linguistic forms of communication (icons, cartoons, etc.) and potential communication barriers to certain user groups. It also

[2] https://www.researchgate.net/figure/Assistive-technology-categories_fig3_288274418

considers different types of microCEs, some of which are not directly necessary for individual users, but maybe necessary as sort of meta-content, such as classification schemes, thesaurus entities, user ontologies, etc. In this connection, the metadata used for the data modelling of microCEs are a kind of microCEs.

In the framework of "Smart Cities" cooperation, the MIM (minimal interoperability mechanisms) approach [5] provides clues for revising existing or developing new standards in various fields of microcontent that comply with current and future requirements – fully considering "comprehensive contentIOp" as well as economical aspects. Different kinds of microCEs can be made highly interoperable at the place and time and to the degree necessary if their different communicative roles are duly indicated.

5 Overcoming Flaws in and Breakdown of Communication

Depending on the type of content, potential flaws in H-H and H-M communication can be different. Besides, unexpected interruption of ICT-assisted communication and accidental outages in public transport operation can occur. To overcome the problems faced by disabled persons in such situations, new kinds of commercial and non-commercial communication services, for instance in the form of an extension of existing language services could be envisaged. Such services also should work complying with the respective standards. The quality of the services – from the point of view of personal skills of the service providing persons to the appropriateness of the systems used – could be certified based on standards.

6 Final Observations

The TRIPS deliverable D13 also provides latest information on efforts to coordinate standardisation activities falling under the scope of TRIPS. It explains the intricate interrelationship between accessibility related legal regulations or standards and informs on the coordination of standardisation activities. The document comprises an overview on the state of the art of legislation (especially laws referring to standards), existing formal and informal standards and ongoing standardisation activities, as well as of pertinent (preferably standards-based) certification schemes.

The methods, microCEs and tools to support communication could be used in other environments, such as smart cities, all kinds of work environments, pertinent language/communication services.

This contribution is based on the results – particularly on Deliverable D13 Report on Accessibility Standards and Legislation – of the EU project TRIPS (TRansport Innovation for disabled People needs Satisfaction) which has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement no. 875588.

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Emerging Technologies and Access to Mobility through Public Transport

A Review of Potential Impact upon People with a Disability

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Abstract. This paper explores the outcomes of a series of co-design workshops targeting the development of innovative concepts to address barriers to mobility. The workshops were developed as part of the TRIPS project funded by the European Commission. The workshops identified that not all problems required big ideas to resolve. A series of innovations were imagined by people with a disability to reduce barriers to travel. Some built upon new technology, whilst others took existing ideas and added an inclusive twist. The series of co-design workshops featured people with a disability, transport operators, and assistive technology specialists. In each workshop, emerging technologies was introduced to panels. Each panel prepared simple design concepts that sought to outline incremental or disruptive innovations to address one or more barriers identified throughout a journey. Designs were prioritized according to feasibility and impact, and a final list was prepared. These were divided into incremental innovations that addressed specific barriers and disruptive innovations that addressed the entire basis of travel and mobility. Often, the most popular and desirable innovations were incremental, building upon current technologies but applying them in new ways. Finding new ways to apply those technologies demonstrated that much was possible. In the examples of incremental innovation, the technology was not a barrier if the will to change was in place. The workshops also explored how to increase access to transport by asking participants to dream and think about "big" ideas that would address many of the barriers they faced.

Keywords: Mobility, universal design, innovation, emerging technology, co-design, transport

1 Introduction

Not all problems require big ideas to solve. Here are five innovations imagined by people with a disability that would reduce barriers to travel. Some build upon new technology, whilst others take existing ideas and add an inclusive twist.

In a series of co-design workshops held by the Trips Project, featuring people with a disability, transport operators and assistive technology specialists, a range of emerging technologies were introduced to panels. Each panel prepared simple design concepts that sought to outline incremental or disruptive innovations that could address one or more barriers identified throughout a journey. These designs were then prioritised according to feasibility and impact, and a priority list of innovations was prepared.

2 Methodology

At the heart of the co-design methodology was the careful selection of stakeholders who would bring diverse perspectives to the workshops. Once stakeholders were identified, in order to build a methodology upon which co-design could take place, the project team undertook a review of the range of ways public transport and mobility could be framed. It was clear from early feedback that passengers were concerned that we investigated the full journey chain from pre-journey planning to the safe arrival at home after travelling. After reviewing the options, the project chose to adopt the journey framework developed within the Whole Journey Guide produced by the Australian Government.

Alongside this, the project undertook to determine the range of emerging technologies impacting upon the development of products and services for mobility. These technologies included Robotics, the Internet of things, augmented reality, wearables and artificial intelligence.

With this information acting as a framework for design and discussion, the project established a series of co-design workshops. These drew together stakeholders to produce a series of imaginative design concepts that were tested and validated using SWOT and PEST tools which led to a prioritised list of ideas.

3 Findings

The workshops identified a series of innovations that could address one or more steps in planning and taking a journey. These innovations were divided into incremental innovations that sought to address specific travel barriers and disruptive innovations that often addressed the entire basis of travel and mobility.

In most cases, the most popular and desired innovations could be defined as incremental building upon current technologies on the market but applying them in new ways. These include the most popular solution that people with a disability suggested was for accessible and inclusive Travel planners. Often those with disabilities found that information about a journey was held in multiple locations, with a bus company, the city and some with NGOs. As transport is a single process, there was a strong desire that planning technologies should reflect the need for a seamless process. The development of a website or application to plan travel for people with disabilities, recognising that the barriers to mobility vary from person to person, would appear to have significant benefits bringing greater autonomy and information. Pulling together data such as access to stations, accessible routes to stations, accessibility on board, and what to do when things go wrong would help people with disabilities and anyone with additional needs on a journey.

For many, this included connectivity to the transport or vehicle itself, showing when an accessible vehicle will arrive and the current waiting time. Additional information such as how crowded the next vehicle is might also benefit those who are neurodiverse and want to avoid congestion, which might trigger pain or discomfort. Above all else, such an application would make journeys more manageable and comfortable with less time spent thinking about travel and more time enjoying the journey. Others suggested variations on such an app, feeling that an app that guided them to accessible parking spots updated in real-time would help make journeys less anxious whilst reducing air and noise pollution rates through less traffic in city centres.

Increasing confidence through access to information was also part of improved Voice or Speech assistants during travel. Access to spoken information was welcomed by those with limited sight and those who found it challenging to read signage as it changed or because it was blocked from view, such as those viewing from the height of a wheelchair. Such technology would offer more than stop announcements. Still, it would also include live information about congestion and the surrounding area with suggestions for the best way to leave the vehicle or station integrated for those with limited mobility. One user described this as a little like an audio description for the real world, delivered through a mobile phone to a headset, reducing disturbance to other passengers when travelling.

These speech assistants could be built upon wearable technologies for travellers with a disability, and the use of Smart bracelets, a wristband allowing users to pay for travel upon boarding and then communicated to any vehicle that a longer boarding time was seen as offering great potential. Such bands have been available in some locations already, and both reduce the problems of accessible ticketing systems. Users are charged as they board and disembark a vehicle and do not have to deal with the difficulties of accessing kiosks or ticketing systems. As with other technologies, any user could benefit by reducing the risk of missing journeys or travelling illegally due to unintended errors when booking. One application of wearable technology was such a personal wearable linked to an account and credit card to approve payments based on passing a gate or beacon at the beginning and end of a journey. A second was using the same wearable to facilitate access to the vehicles themselves. This might allow a wearer to open the vehicle's doors or activate a powered ramp to board or leave, especially during an emergency. It might link to the "audio described" assistants but offer the same information in text on a screen or by vibrating to tell someone to leave the vehicle at the next stop. Wearable technology could be the basis of knowledge and a means of communication, notifying the driver or vehicle manager that a disabled user is boarding and ensuring they are aware of what accommodations they should make.

Thinking to the future, new forms of wearable were seen as providing new opportunities for people with a disability; Smart Glasses could still further facilitate access to vehicles by providing additional information about the vehicle and its facilities. For example, smart glasses could be used to help find accessible spaces onboard a train, locate accessible toilets or show the location and direction of approaching transport as you wait. In addition, all the forms of wearable offered control to engage remotely controlled powered ramps to help board vehicles on demand. Whether by selecting a command to deploy the ramp or using location information to deploy ramps automatically, the system would allow users to access when they are near a door to enable self-boarding and exit, offering independence and less reliance on additional assistance staff.

Some of the wearable technologies discussed draw upon opportunities offered by augmented reality applications. Such applications could greatly benefit people with entirely different needs, including physical, sensory or cognitive needs. AR would help enhance the physical world rather than isolate the user from that environment. The more information a person has, in as digestible a form as possible, the greater their confidence in the journey ahead.

Many of these incremental ideas build upon current technologies. Finding new ways to apply those technologies demonstrated that much was possible. In the examples of incremental innovation, the technology was not a barrier if the will to change was in place.

The TRIPS project workshops also explored how to increase access to transport by asking participants to dream and think about "big" ideas that would address many of the barriers they faced. Some of their answers were fascinating, and whilst some verged upon science fiction, others were technically feasible based on emerging technologies entering the marketplace.

One of the first concepts suggested that wheelchairs users imagined a "Levitating" wheelchair, a wheelchair that could fly at low altitude and avoid traffic jams and obstacles. Imagineers indicated that this would mean there was no need for other means of transportation, as it could go anywhere, and provided them with complete autonomy. Whilst it seemed to be fantasy, the idea was based on the growth of drones and robotics, including flying delivery vehicles being trialled in some parts of the world. As a solution, it offered the opportunity to go anywhere and be flexible, easily avoiding obstacles. However, teams recognised barriers to overcome, a need for some parts of the vehicle to act autonomously, providing safety and protection for travellers and those around them. In addition, it was suggested that finding ways to avoid adverse weather might make for a more comfortable journey.

Some of the features of this concept can be seen in a design for an autonomous car that could be rented for individual use. People with a range of disabilities envisaged an autonomous smart car without any driver, rented for personal use. The technology could be tailored to an individual's needs by establishing a user profile engaged when the user entered the vehicle through face recognition. Reducing dependency on drivers and shared transport appeared to offer a way to improve the independence and autonomy of persons with disabilities when travelling, especially where the interface to give instructions to the vehicle was fully accessible, making a massive difference to the time taken planning a journey. The autonomous cars would include a user-friendly flexible booking system, adaptive features for multimedia usage and rolling information systems about the environment as we travel, making a journey both functional and a pleasure.

Those imaging this vehicle recognised how combinations of emerging technologies such as AI, the Internet of Things, wearables could offer automated and intuitive guidance and transport wrapped up in a universal design approach.

Autonomous robotics were also at the heart of a third idea for creating assistive buddy robots when travelling. A travel buddy robot was a concept of a robotic device that follows the traveller carrying luggage and could support you with information, providing support in case of the need to transfer from one position or vehicle to another. It felt both futuristic and feasible to our Imagineers with value to people with disabilities and lone and older travellers with bags and feeling overwhelmed as they travelled. This added a level of confidence and security to the journey and a social aspect of not feeling isolated while travelling. Some shared how the concept might enable them to walk home freely after shopping or while starting/ending a long journey. They liked the idea of being able to book such a “buddy” in advance on a pay as you go model allowing the robot to return to a charging station after use.

An entirely different approach was envisaged by one group that created a design concept for cities based on Mobile walkways across a city network. They developed a city-wide network of rapid mobile walkways concepts where people can automatically get on and off safely. By building a system for all travellers that had benefits for those with disabilities, there was a strong sense of inclusivity in this concept; it built upon existing technology found in airports and metro stations and felt friendly and straightforward to use. Added value was seen in the opportunity to reduce traffic congestion and associated pollution in cities, creating a healthier and more pleasant environment for all.

A final idea came from a group conscious of how travel could be impeded by small obstacles that significantly impacted. They imagined the creation of a LIDAR 3D reconstruction of the environment. Using wearable and portable personal technology sensors, they envisioned a reconstruction of the environment using LIDAR. The obstacles could be identified, and the traveller warned and guided to avoid them. Participants liked this idea as it was wearable and not bulky, allowing those with a visual impairment to reconstruct the external environment precisely. The sense of confidence and safety was shared by many. This technology seemed to offer a means to navigate the built environment to access transport safely, interchange vehicles, and disembark readily and smoothly. Envisaging the technology, the team imagined smart glasses equipped with a LIDAR sensor with headphones for sending alerts. As they walked, the glasses could transmit what was detected through LIDAR to the phone, process the information, and send the alerts and advice to the headphones. Third-party developers could offer extra information with apps that interface with the glasses to suggest additional information based on what the user wanted and needed.

4 Conclusion

The most important emerging technologies highlighted by the workshops, with the potential for impact upon travel and mobility in the short, medium and long term, were

- Artificial Intelligence to analyse needs, anticipate problems and recommend solutions
- Internet of Things – communicating needs and requirements for travel to the vehicles
- Wearable technologies – reducing the need to address inaccessible sources of information and ticketing
- Robotics and Drones to create new forms of vehicles that utilised AI and the IoT for autonomous travel

- Natural interfaces to simplify the interaction with infrastructure and systems

It has been said that the most significant barrier to inclusion is awareness, and perhaps with the growth of new technologies, we need to include imagination and creativity as a barrier to overcome. Using a co-design methodology, the workshop participants demonstrated that ideas would flow in an open setting given time and space. By using well-formed tools to analyse ideas, priorities could be identified that could provide the basis of a business case for further investment to impact upon a diverse range of travellers.

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Haptic and Digital Access to Art and Artefacts

Introducing Art to People with Visual Impairment through Tactile Pictures

A Survey of Art Museums in Japan

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Abstract. Since the Act for Eliminating Discrimination against Persons with Disabilities came into effect in 2016 in Japan, the environment surrounding people with disabilities has improved. However, there are still many improvements that need to be made with regard to art appreciation by people with disabilities. The aim of this study is to investigate the current state of art appreciation for people with visual impairment at art museums in Japan, especially focusing on the use of tactile pictures in art museums. The study conducted questionnaire surveys targeting art museums across Japan and interviewed four individuals with visual impairment. The study claims that the popularization of a tactile image maker and a layered-type tactile picture among art museums will promote art appreciation for people with visual impairment.

Keywords: Tactile Pictures, Layered-Type Tactile Pictures, People with Visual Impairment

1 Introduction

Support for people with disabilities has improved in Japan since the Act for Eliminating Discrimination against Persons with Disabilities (Act No.65 of 2013) came into effect in 2016. The Japanese government also introduced the Act on Cultural and Artistic Activity of Persons with Disabilities (Act No.47 of 2018) in 2018, which promotes support for art appreciation for people with or without disabilities. However, the art environment for people with disabilities in Japan still lags behind that of other countries ([1], [2], and [3] among others).

In Europe, the Typhlology Museum which is one of the first museums dedicated to people with disabilities opened in 1953 in Zagreb, and, with a gradual increase in the number of such kind of museums, tactile appreciation began to spread to museums in the 1990s [4]. The widespread use of tactile pictures in museums has increased the number of people with visual impairment who are proficient in tactile appreciation. What is more, coupled with an inclusive education system, it has also advanced support for art appreciation for people with visual impairment at educational institutions [5] .

In contrast, very few art museums in Japan offer tactile appreciation of art, including tactile pictures, and only a few museums work in cooperation with special needs schools for the visually impaired[3]. Therefore, in order to promote art appreciation for people with visual impairment in Japan, we must first investigate the actual status of support for art appreciation for people with visual impairment at art museums in Japan and clarify the opinions of people with visual impairment and the problems faced by art museums.

The purpose of this study is to investigate the current state of art appreciation for people with visual impairment at art museums in Japan. The study specifically focuses on the use of tactile pictures, as a way to promote art appreciation for people with visual impairment. We conduct questionnaire surveys targeting art museums across Japan and interviewed four individuals with visual impairment. Based on the survey, we claim that the popularization of a tactile image maker, such as PIAF, among art museums will promote art appreciation for people with visual impairment. We also argue that a layered-type tactile picture will provide an effective means to promote art appreciation in terms of an educational, welfare-supporting, and artistic perspective for people with visual impairment.

2 Questionnaire Survey

2.1 Materials and Methods

A questionnaire was used to gather data about (i) the current state of art appreciation and the use of art museums by people with visual impairment, (ii) the number of tactile pictures owned by the art museums, and (iii) problems when providing tactile pictures. The survey questionnaire was distributed in 404 art museums, of which 401 were the members of the Japanese Council of Art Museums and 3 were related museums working to support people with visual impairment. The questionnaire was administered between July and August 2021. Both mail and web responses were accepted.

2.2 Results

Among 404 art museums' directors/employees, 211 (52% of the whole) responded.

(i) We asked them about the number of visitors with visual impairments, in 2018 before the spread of the COVID-19. A total of 202 art museums responded, of which 53 and 111 responded with "0" and "unknown," respectively. Only 38, or 18% of the respondents, had a number for visitors with visual impairment, which ranged from "1" to "about 100".

(ii) The number of museums that owned tactile pictures were 22 (out of 211), which was only about 10% of the total number of museums that responded, and all of these museums had over 30,000 visitors per year. Tactile pictures in these museums,

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[3] Hino clarified the actual situation of art education at special needs schools for the visually impaired in Japan, and argued the importance of art appreciation in the education of visually impaired children [6]. Introducing art appreciation by people with visual impairment in Italy, Ouchi et al. also claimed the necessity of incorporating appreciation activities in the education of the visually impaired in Japan [7].

mostly (67%) used capsule paper (a tactile picture on a capsule paper) dot diagrams (14%), tactic drawings with resin (10%), and other similar products (7%).

(iii) When the 22 respondents from museums with tactile pictures were asked about their concerns about the tactile pictures, 19 of them were concerned about understanding of people with visual impairment on the composition of the tactile pictures, 14 were unsure about how to explain it to people with visual impairment, and 10 had doubts about whether the intention of the artist was conveyed.

With regards to the opinions of museum visitors with visual impairment, most of them felt that it was good to have something to touch when appreciating pictures. However, preferences varied depending on the degree of disability. For example, people with acquired visual impairment preferred hearing about the art, while those with congenital blindness preferred touching tactile pictures.

3 Interview survey

3.1 Materials and Methods

Based on the results of the questionnaire survey, we asked four university students with different degrees of visual impairment and visual experience (Table 1) to examine different types of tactile pictures. Their responses were used to identify the kind of tactile pictures that are easy to understand and the best ways to make them accessible.

Table 1. Four university students with different degrees of visual impairment and visual experience

Student A: Low vision, cannot see outlines but can see objects with clear contrast. Cannot read letters. Has memory of visual information (used to be able to see a little better than now). Experienced tactile perception of tactile diagrams. Used to draw and make pictures, but now rarely draws. Art appreciation is limited to textbooks.
Student B: Severe amblyopia, no visual acuity values with manual valve (just enough to understand hand movements). Has memory of visual information as former mild amblyopia. Used to draw and create pictures, but has had little experience with art education since losing sight.
Student C: Totally blind, no light perception (no light/dark perception), no experience of seeing. Had tactile experience with tactile diagram at a special school for the visually impaired but had little experience of art appreciation of tactile pictures.
Student D: Totally blind, no light perception (no light/dark perception), no experience of seeing. Not much experience in tactile drawing or art education.

We selected a copy of “Sankahakuu” by Hokusai Katsushika as an original painting to make tactile pictures, as its composition is easy to understand. Three types of tactile pictures were made: a complex tactile picture close to the original painting (Fig.1), a simplified tactile picture (Fig.2), and a layered-type tactile picture[4] (Fig.3). The layered-type tactile picture consists of several tactile papers, each of which depicts a part of a painting. It allows people with visual impairment to gather information about the paintings in a step-by-step, countable manner; the first tactile paper is the simplest one, and the last tactile paper is the complex one close to the original painting. We modified the tactile pictures according to their opinions and asked for their impressions again.

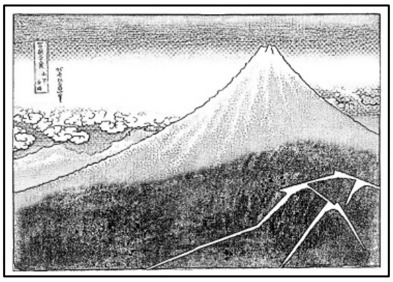

Fig. 5. Complex tactile picture close to the original painting

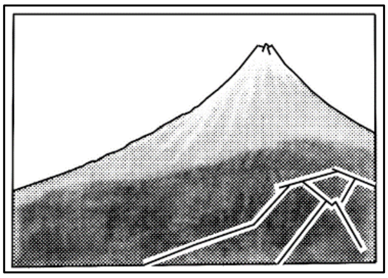

Fig. 2. Simplified tactile picture

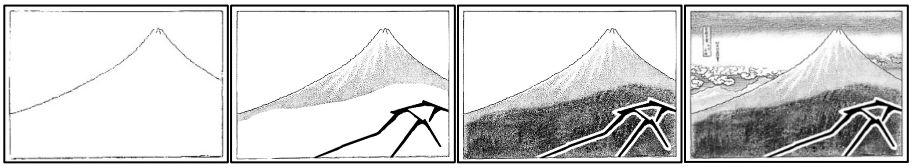

Fig. 3. Layered-type tactile picture of "Sankahakuu"

Well-known methods of presenting diagrams and pictures to the visually impaired include point diagram (Fig.4), capsule paper (a tactile picture on a capsule paper) (Fig.5), thermoform (plastic sheet) (Fig.6), and UV-cured resin ink (Fig.7). Of these, point diagram and capsule paper are considered relatively easy to implement in terms of cost and technology for production, and are widely used by educational and support institutions. In this study, we used capsule paper since its initial cost is relatively low and it is capable of expressing the finest details of a painting.

[4] The layered-type tactile picture of "Sankahakuu" used for this survey was a reprocessed version of the one created in 2013 based on an original drawing in the collection of the Yamanashi Prefectural Museum. See [8] for further information on layered-type tactile pictures.

Fig. 9. Point diagram

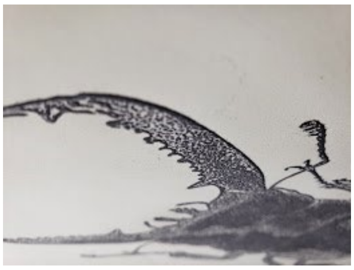

Fig. 9. Capsule paper

Fig. 7. Thermoform

Fig. 7. UV-cured resin ink

3.2 Results

While the four interview participants had different preferences about how they wanted to experience art in detail, all had requested for an explanation of the original painting at the beginning of their art appreciation. Regarding tactile pictures, all participants wanted to appreciate both the complex tactile picture, close to the original, and the simplified tactile picture. They also agreed that the layered-type tactile picture was easy to understand, as it provided the information about the paintings in a step-by-step, countable way. Moreover, they all preferred the following order of presentation: the tactile picture closest to the original, the simplified tactile picture/the layered-type tactile picture, and again the tactile picture closest to the original.

The modified tactile pictures, which were reworked according to their opinions, were easy to understand and appealed to their aesthetic senses. For instance, we made following modifications for each request on the tactile pictures of "Sankahakuu" so that they can appreciate the pictures more easily (Table 2, Fig. 8). Feedbacks on the modified tactile pictures were that they were easier to understand, matched the image, and all participants enjoyed the details.

Table 2. Requests and Modifications

	Requests	Modifications
(a)	More clearly contrasted tactile image	Dots on the rock surface were enlarged.
(b)	More space between the clouds and the rock surface	The space between them were doubled.
(c)	Make the area where the setting sun shines on the mountainside concave	The rock surface was concaved.
(d)	Make the snowy area more raised, but dots on the snowy area would diminish the image of pure white snow, so nothing should be drawn on the snowy area	Both the mountain surface and the snow were concaved, leaving the border between the snow and the mountain surface raised.

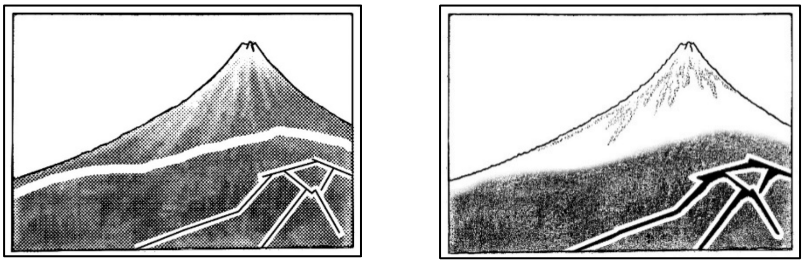

Fig. 810. Samples of modifications – left: (a)&(b) right: (c)&(d)

4 Discussion

Museums that own tactile pictures were those that had more than 30,000 visitors per year. These museums most probably have the necessary income and labor required to support art appreciation for people with visual impairment. Furthermore, it was found that the overwhelming majority of tactile pictures owned by them were tactile pictures on a capsule paper. This could be because tactile image makers are easier to adopt, relatively inexpensive and do not require extensive technical knowledge to produce. Therefore, the key to promoting art appreciation for people with visual impairment may be popularizing tactile image makers among art museums.

Our findings about the participants' preferences for the order in which tactile pictures are presented and the types of the tactile pictures are valuable. These results can be considered a reference for creating a manual for providing tactile pictures at museums. We also found that by modifying the tactile pictures, we could create tactile pictures that not only provide compositional information of paintings, but also appeal to the aesthetic senses of people with visual impairment. This opens the possibility of appreciating paintings through the sense of touch.

The layered-type tactile picture can provide both compositional and aesthetic information on paintings. We claim that it can be used in three ways: educationally, appreciating tactile pictures in a step-by-step manner can improve art literacy; welfare-support, with audio guidance, it enables people with visual impairment to appreciate art without any special support from other people; and artistically, since the layered-type tactile picture made it possible for people with visual impairment to appreciate a complex tactile picture close to the original painting.

5 Conclusion

This study investigated the current state of art appreciation for people with visual impairment in Japanese art museums. Our findings indicated that popularizing tactile image makers and the layered-type tactile picture would promote art appreciation for people with visual impairment and lead to the improvement of the quality of art appreciation for people with visual impairment.

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Effect of Visual and/or Haptic Experience on Haptic 3D Model Recognition

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Abstract. Our research question is whether there is any difference in haptic recognition, i.e. understanding what the 3D models represent by the sense of touch, between early blind and late blind people. To investigate it, we took the opportunity of a Zoom symposium on our 3D model making and delivering service. Prior to the symposium we sent out two 3D models to 48 blind and visually impaired attendees without telling what they were. After the symposium, we emailed a questionnaire to them on the understanding of the models and the attributes of the attendees, and received the answers from 32 people. The average correct rates for each model were 75% and 50%. The effect of visual, tactile, and hearing experience as well as the age and usage history of hearing and/or tactile senses on the correct rates were examined, but their effects were not explicitly shown by the numbers because of the inadequate research design. Rather, their comments on the grounds for recognition suggest that recognition of 3D models is the conclusion logically drawn by combining a few shape features, and finding these features relies more on prediction than the ability of tactile sense.

Keywords: Haptic Recognition, 3D Model, Early Blind, Late Blind.

1 Introduction

For blind and visually impaired people to understand the shapes of things that they want to know, we are doing a 3D model making and delivering service using 3D printers to their demands [1]. While doing this service, questions were raised as to whether there is any difference between early and late blind people in haptic recognition of 3D models. It is generally assumed that early blind people are better at haptic object recognition than late blind people because they have used haptics for long times in their everyday lives [2]. On the other hand, late blind people have had the experience of seeing actual objects, which may be useful for recognizing the shapes of the models. If there are differences between them in the way they understand 3D models through the sense of touch, then it may be necessary to modify the way in which models are created and presented to them.

The researches on the effect of visual experience on haptic shape recognition focused on the orientation in which the objects were presented. The sighted participants' performance deteriorated when the objects were presented in non prototypical orientations whereas that of early blind participants was unaffected [3], [4]. These researches used geometrical shapes either embossed or made of blocks. However, we want to know the effect of visual experience on recognizing real objects which can be found in everyday life, including on TV and on Web. We therefore decided to investigate the effects of different attributes of blind people on haptic recognition of 3D models.

2 Method

2.1 Zoom Symposium on 3D Models

Since 2020, we have held Zoom symposiums every half a year on our 3D model making and delivering service [1]. The numbers of the symposium audience exceeded 100, and more than half of them were blind and visually impaired people. Before each symposium, we sent one or two 3D-printed models to the blind and visually impaired audience who had requested them. We used one of these symposiums to investigate the research question.

2.2 Procedure

Prior to the symposium that was held on August 8, 2020, two 3D models were sent out to each blind and visually impaired attendee. The models sent were a coronavirus and either one of two sizes of sphinx: large (140 mm L × 58 mm W × 83 mm H) and small (half these dimensions), or a snail (77 mm L × 32 mm W × 33 mm H). The 3D data of them were downloaded from a 3D data site, Thingiverse and put to a 3D printer, Ultimaker S3, with PLA white filament (Fig. 1).

Of the three kinds of models, the coronavirus was named as such when sent. The other model was unnamed and sent without telling the recipient what it was. The large sphinx was sent to 17 people, the small sphinx was sent to 9 people, and snails were sent to 23 people (Small size sphinxes were made to shorten the time to print). In all, models were sent out to 48 people.

The recipients were finally told what models they had been sent at the symposium on August 8. However, by this time some of them appeared to have already been told by their sighted family members what these models represented.

On September 4, after the symposium, we emailed a questionnaire to the 48 people to whom the models had been delivered. They were given a week to email back their replies. The contents of the questionnaire related to haptic recognition were as follows.

1. What model did you receive in addition to the coronavirus model?
2. What did you think this model represented before being told?
3. What features of the model led you to the answer you gave to question 2?
4. Had you ever seen the actual object (sphinx or snail) depicted by the model, or a photograph of this object?

5. Had you ever touched the actual object (sphinx or snail) depicted by the model, or a model of this object?
6. Had you ever read or heard about the object (sphinx or snail) you received?
7. When did you start getting information from the outside through your sense of hearing or touch (rather than sight)? Answer in any way you like, for example "since birth", "since primary school", "since I was X years old", or "since X years ago".
8. Please state your age and gender.

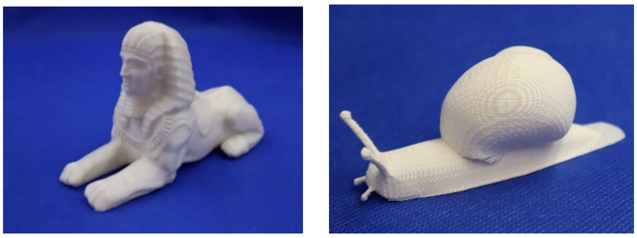

Fig. 1. Two of the models that were sent to the attendee (left: sphinx, right: snail).

3 Results

3.1 Respondents

We received responses to the questionnaire from 32 people (67% recovery rate). One of these respondents was a sighted person, whose answers were excluded from the analysis. The respondents consisted of 22 males and 9 females in age groups ranging from 10–19 up to 80–89. Most of the respondents were in their 50s, 20s and 60s.

16 respondents received the snail model, and 16 respondents received a sphinx model (large or small). One person received both models, so the total number of models is higher than the number of respondents because this person was counted twice.

3.2 Correct Answer Rate

Figure 2 shows the numbers of people who correctly identified the snails and sphinxes. The correct answer rate for snails was 75% (12 people), and the correct answer rate for sphinxes was 50% (8 people). It is possible that differences in the size of the sphinxes affected the percentage of correct answers. Of the eight respondents who correctly identified the sphinx, seven had received the larger model and only one had received the smaller model. But on the other hand, of the seven respondents who failed to identify the sphinx, four had received the larger model and three had received the smaller model, so it cannot be said that people responded incorrectly because they were given smaller models. Wrong answers for the snail model included insect (2 people) and ammonite (1 person). Wrong answers for the sphinx included lion (3 people), animal (2 people), and dog (1 person).

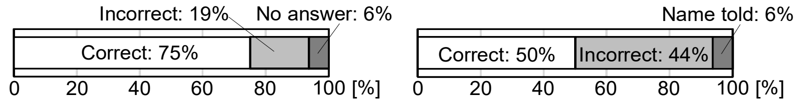

Fig. 2. Correct answer rates for model recognition (left: sphinx, right: snail).

3.3 Grounds for Recognition

We asked the respondents to describe which characteristics of the model provided the basis upon which they recognized it as a snail or sphinx. Of the twelve people who had correctly identified the snail, six attributed their success to the combination of the shape of the rounded or coiled shell and the two protuberances, two mentioned that they had also recognized the body in addition to these two features, and another three only mentioned the shell. On the other hand, two of the people who incorrectly identified the snail as an ammonite mentioned only the round shell part. The two who identified it as an insect only mentioned the protuberances.

Six of the eight people who identified the sphinx correctly said they recognized that it had an animal's body and a human face. Some of them even mentioned the hair behind the face, the beard at the bottom of the head, its ornaments, and its rolled-up tail.

3.4 Effect of Visual, Tactile, and Hearing Experience

People who had previously seen a real snail or a photograph of it achieved a better correct response rate (100%) than people who had not (25%) (Fig. 3, left). However, the ratio of correct and incorrect answers in the recognition of the sphinx was the same regardless of visual experience (Fig. 3, right).

In the recognition of snails, the correct answer rate was higher for respondents who had previously touched a real snail or its model (88%), but even respondents with no such experience achieved a high correct answer rate (71%) (Fig. 4, left). In the recognition of the sphinx, the numbers of correct and incorrect answers were almost the same regardless of experience (50% and 53% respectively, Fig. 4, right).

In the recognition of snails, respondents who had previously read or heard about their shape achieved a high recognition rate (80%), but so did respondents with no such experience (80%) (Fig. 5, left). In the recognition of the sphinx, respondents who had previously heard or read a description of it achieved a higher recognition rate than those who had not (60% and 40% respectively) (Fig. 5, right).

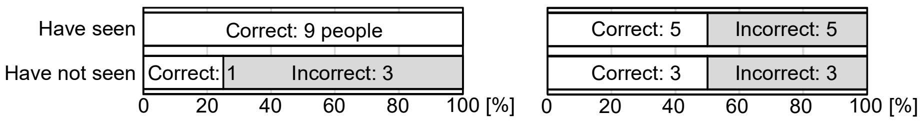

Fig. 311. Effect of visual experience on model recognition (left: sphinx, right: snail).

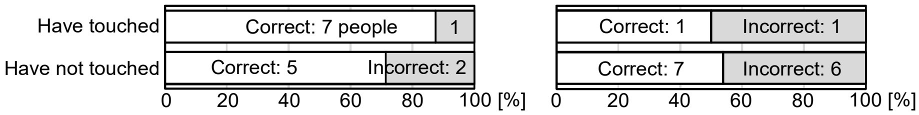

Fig. 4. Effect of tactile experience on model recognition (left: sphinx, right: snail).

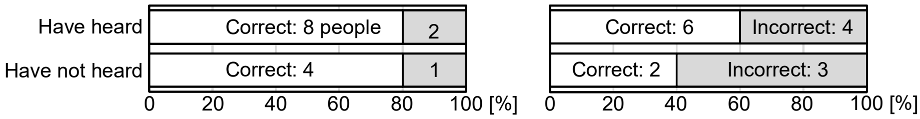

Fig. 5. Effect of hearing experience on model recognition (left: sphinx, right: snail).

3.5 The Effects of Age

For both the snail and the sphinx, the average age of correct respondents (46.2 years and 67.4 years respectively) was higher than the average age of incorrect respondents (20.0 years and 37.6 years respectively) (Fig. 6).

The question "When did you start getting information from the outside through your sense of hearing or touch (rather than sight)?" substantially asked the age of onset of blindness. The chronological age minus the age of onset of blindness makes the main usage history of auditory and/or tactile senses. Respondents who correctly identified the snail had a longer usage history of auditory and/or tactile senses than those who did not (correct: 26.4 years, incorrect: 18.7 years). However, this is reversed in the recognition of the sphinx (correct: 25.0 years, incorrect: 27.3 years) (Fig. 7, right).

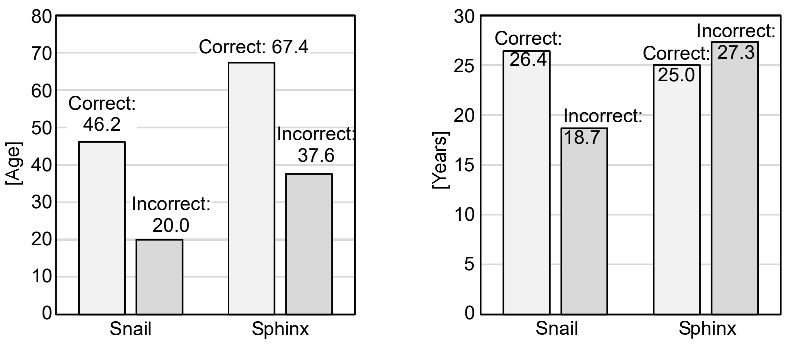

Fig. 6. Average age (left) and average use history of auditory and/or tactile senses (right) of the respondents divided by the correctness of their answers.

4 Discussion

We will first consider the limitations of this survey. This questionnaire was aimed at symposium participants, which made it impossible to impose controls on parameters such as their age or their history of visual impairment. It is not possible to consider interactions between visual, tactile, and hearing experience, age, and history of information acquisition. There were also two types of model sent to the questionnaire respondents. Thus, the effects of the visual and/or tactile experience were not explicitly shown by the numbers.

Within these limitations, we will describe the impressions we gained through compiling the questionnaire results. In order to recognize an object by touch without being told what it is, it seems that it is essential to have had prior experience of seeing or touching the object, or having it described in some way. From a comparison of the characteristics of respondents providing correct and incorrect answers, it seems that the correct respondents arrive at their responses by grasping a number of characteristics that lead towards a logical result, while the incorrect respondents only had a partial grasp of these characteristics. It seems that the inability of incorrect respondents to identify other characteristics was not caused by a lack of tactile ability, but by a lack of top-down information telling them that something should be there. Whether the face of the sphinx was recognized as a human face or as a strange animal face seems to have depended on whether or not the respondents were expecting to find a human face there.

The average age of correct respondents was higher than that of incorrect respondents. The average ages may have been influenced by data from the extreme ends of the age range (with one respondent aged from 10–19 and one aged from 80–89), but if the age difference is meaningful, then perhaps older people have had more opportunities to access various kinds of information, and this knowledge may have assisted in their recognition of the items. Two of the respondents who failed to identify the sphinx correctly were in their 20s and 30s, and had no prior experience of seeing, touching or learning about the sphinx.

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Cognitive Disabilities and Accessibility

"InfoBase"

Design a User-Friendly Online Database to Support People with Autism

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Abstract. "InfoBase" is an informative database for the Hungarian National Autistic Association (HNAA). The aim of the InfoBase is to provide parents, professionals, and those interested with fast, accurate information about HNAA services and other professional information related to autism from one place. Currently, the database provides information to be uploaded in three categories: HNAA services, autism-related movies and books, and autism-specific methods and tools. It is possible to filter the display of data, and it is possible for users to expand this database with administrative management. This paper shows the design, development, and results of the testing of "InfoBase".

Keywords: Autism, Database, Assistive technology.

1 Introduction

The autism spectrum disorder is a developmental disorder of the nervous system. People with autism show a very diverse range of behavioural patterns. What is common in this diversity is that we find qualitative differences in social communication and mutual social interactions, as well as narrow, repetitive patterns of behaviour, interest, or activity. [1,2] The incidence of autism is over 1% [3], which can directly affect hundreds of thousands of people and their families in Hungary.

The idea of developing an "InfoBase" for the Hungarian National Autistic Association (HNAA) [4] was born after our accession to the European Cooperation in Science and Technology (COST) Research Group in 2020 [5]. The main aim of this COST Action is to build a cross-sectoral pan-European and non-sectoral network to improve social inclusion and the quality of life of people with autism, with 31 countries participating in this 4-year joint research. Our work presented in this paper unifies two of the narrower goals of COST [6]: (1) evaluating the development of new Assistive Technology (AT) by ensuring interdisciplinary and cross-sectoral collaboration between all stakeholders to develop standardized practical guidelines for the design, development, and deployment of AT, (2) building knowledge by providing a database of current AT technologies and adapting them to the employment and educational environment for users with autism and their families. [3]

Autism-specific support is framed by a form of autism-based planning that is based, among other things, on an understanding of the specifics of autism and common needs and 'arranges' both the physical and social environment so that the common world is understood, become predictable, giving the people involved the opportunity to experience mutual understanding, to act independently, and to experience success in different areas of life. [7] Over the last fifty years, the use of a number of methodologies, strategies, and tools has proved successful in scientific research and has become widespread in practice [6], such as various information and communication technology (ICT) tools, including assistive, prosthetic, and educational tools and technologies. [9] Skill development, along with direct, targeted, and individualized support for people with autism are essential, however, reliable information of different focus and depth is also necessary for the family, professionals, and even for the wider community supporting these people.

2 Method

The development process consisted of two major, separable tasks: the exploration any analysis of the literature and similar pre-existing contents; the design, development, and testing of the Hungarian database.

2.1 Literature Review

We began our work by exploring the literature with the goal of finding out if a new database was needed at all. The following international projects and databases have been reviewed.

In the WHO-coordinated Global Cooperation on Assistive Technology (GATE) project [8], we did not find a database that matched our ideas. EASTIN [9] is an excellent database, but difficult for a "layman" to use (details of assistive technology devices need to be known, e.g. serial number, manufacturer name, or ISO category), but serves as an excellent example for our development. AT-INFO-MAP, an African AT database [10] is practically unusable in a domestic environment. Techmatrix [11] is an assistive and educational technology tool and resource to support the learning of students with disabilities and their classmates. Both keyword and category search are available here, albeit only in English. Atvisor [12] aims to connect people with solutions. Their strength comes from sharing knowledge. The common disadvantage of international databases is that they are written in English, so the information is not easily accessible to Hungarian parents and professionals, or the lay community in general. Analysing the range of available international and domestic projects and databases, there was a need for a freely accessible, systematically structured, and professionally controlled database with comprehensive content, tailored to user needs. The authors, as members of Faculty of Engineering Informatics (University of Pannonia), have contacted the experts of HNAA and Eötvös Loránd University to ask for suggestions as to what people with autism and their family members would need. Our analysis in several online consultations have also revealed which technologies and what features would be needed.

2.2 Development of an Online Database

Based on the analysis above, the development was in PHP, a common server-side scripting language for creating dynamic web pages using Apache HTTP Server, an open-source web server application. It aims to create, maintain and develop a web server program that meets rapidly changing requirements, is secure, and suitable for business, enterprise, and free use.

We considered it a functional requirement to be able to search by keywords and categories for assistive technologies, books, films, and assisting organizations (which we later narrowed down to HNAA advocacy services). Furthermore, there was a consensus that users could be suggested in the above fields in an input field that could become public after administrative review and, if necessary, change. As a non-functional requirement, we set design principles guaranteeing that it would be easy to understand and use for anyone (including users with autism), ensuring clarity, transparency, and simplicity.

The database table for uploading new items contains the following: the name of the new item, category, keyword, description, source, image name, image description, image source, and the e-mail address of the person submitting this new item.

3 Results

In this section, we briefly present the InfoBase [13] database developed for HNAA, which is available on the Internet and can accept suggestions. InfoBase is a clean, easy-to-use WEB application with a freely accessible and closed administration interface.

On the home page of the public interface, it is possible to search for information with the "Search for information" button and to send a suggestion with the "Send suggestion" button. When searching for information, the user has the following options: (1) category selection, (2) search in the title, i.e. as if it were a keyword search, (3) search in the description, i.e. free text search. When submitting new item, the user has the opportunity to submit the following information in the category of support methods and tools: (1) name of the tool / method, (2) keywords, (3) free text short description (4) additional sources (5) image (with name, source) (6) own e-mail address. Similarly, the user can suggest a book or a movie. Submissions will be reviewed and approved by the administrator. In the main menu of the password-protected administration interface, the administrator can use the following functions: (1) manage existing content (view, edit, delete) (2) add new content (3) manage suggestions (view, edit, delete), acceptance).

3.1 "Internal" Testing

The monitoring of the InfoBase took place in two phases, the first phase of which was the technological “internal” testing of the information portal. Although the participants worked closely together during the development, we considered it reasonable that one of the HNAA staff members and two members of the special education group should test the various functions of both the admin and the public user interface before public testing would commence. Taking the needs of the testers fully into account, which were mostly related to the structure and ease of use of the interface, the IT team prepared both interfaces for public testing from a technological point of view.

3.2 Test Page Content Preparation for Public Testing

One of the guiding aspects of the preparation of the test page contents was to fill the Infobase with records that are limited but as diverse as possible, thus indicating to the testers that the thematic diversity of the database is prepared. As an example, various genres of films/books were included (from authors worldwide) among the records displayed on test page, focusing on different age groups and parts of the autism spectrum. Comprehensive descriptions have been prepared for the records that provide basic information in a concise and easy-to-understand manner, and references to literature books, works of fiction, films, and videos have been added, providing a more nuanced and thorough understanding of the subject. The keywords have 4-5 words and phrases that summarize the content of the description, helping to highlight the essence, as well as providing clues for the search, orientation. On the one hand, the images are also intended to make it easier to navigate the database, also providing an overall visual impression of the topic of the description.

3.3 Public Testing Feedback Questionnaire

After preparing the InfoBase for public testing both technologically and in terms of content, we compiled a feedback questionnaire to be completed by the testers, which can be divided into four main sections. In the first (introductory) section of the questionnaire consisting of six items, respondents must report demographic data such as age, gender, and place of residence. This part of the questionnaire also collects data about the respondent’s relationship to autism (in the form of a multiple-choice question), the frequency of use of each platform, the tools to seek information about autism (in the form of a five-point scale), and the role of databases in information seeking.

The next part of the questionnaire, which deals with the user interface of the InfoBase, examines the reactions to the technological aspects of the information portal on a 10-item, five-point Likert scale (the System Usability Scale - SUS) [14], and an open-ended question. This section of the questionnaire examines the assessment of the content of the InfoBase, which the testers have to mark on a five-point scale consisting of 12 statements, and it is also possible to formulate content-focused feedback and recommendations in response to the open question.

The third unit of the questionnaire - which contains a similar five-point scale of 4 elements and an open-ended question - is intended for those who, as an HNAA employee, test not only the user but also the admin interface.

The final question of the questionnaire encourages all testers to make further comments and suggestions about the information portal as a whole.

Public online testing of the information base began on October 18, 2021, and ended on November 8, 2021 by using online common space. The target group of the testing was reached through the Facebook social media platform and the official profile of HNAA. The only condition for participating in the testing was a thorough review of the InfoBase interface and testing of its functions, no other selection criteria, such as connection to autism or age, prevailed during the testing. A separate pop-up window on the Info Base page drew attention to the fact that this is currently a test page and that the testers should complete a feedback questionnaire after the review.

3.4 Main Results of Public Testing

The mean age of the 64 subjects in the test was 42.34 years (standard deviation: 8.97), with the youngest being 11 and the oldest being 64 years. The gender distribution of the sample is also uneven: 87% of respondents were females, 11% were males, and 2% did not specify their gender. The place of residence of the participants by type of settlement shows that 37% of the sample live in a city, 33% in a (county) capital, and 30% in the municipality. The highest proportion of testers described their association with people with autism as parents (37%) and professionals (31%). There were significantly fewer respondents who selected HNAA as an employee (13%), a university student (9%), another family member (4%), a person with autism (4%) or a person not in direct contact with people with autism (2%) participating in the testing phase. The picture is further nuanced by the fact that 64 respondents gave 95 answers to this question, i.e., each tester found two or more of the above-mentioned answer options to be a characteristic of themselves. For example, 8 identified themselves as parents and professionals, whilst 2 identified as parents, professionals and HNAA staff simultaneously.

The most commonly used tool to search for information about autism in this sample is a computer and a mobile device, as 63% of respondents use these tools for this purpose every day or several times a week. While lectures and courses are the least accessible source of information for respondents, 89% of the sample attends lectures and courses related to autism no more than 1-2 times a month. Significantly more respondents use different surfaces of social media, such as websites, books and specialist books, to inform and acquire knowledge about autism. In addition to these tools and platforms, there was a person who learns about autism primarily in person at the HNAA office.

Autism-related websites are visited by 36% of testers several times a day or a week, 49% a week or 1-2 times a month, and 15% of those who complete them visit them no more than once a year. Thirty percent of the testers had previously used a database to search for information on autism. One respondent named not only domestic but also databases operated by organizations of English-speaking nations (National Autistic Society, Autism Speaks). However, for a nuanced interpretation of the results, it is important to note that 37% of the respondents who did not use the database did not indicate the database they used.

Based on the evaluation of the answers to the questions, the testers' perceptions of the InfoBase contents are presented below. 76% of testers fully prefer and 12% prefer to recommend InfoBase to professionals and parents. Also, 72% of respondents fully agree and 17% agree that InfoBase (especially) provides useful content for families with a recent diagnosis and novice professionals. 68% of participants fully agree and 17% prefer to recommend the site to people with autism and autism.

71% of testers think the site is completely useful for finding methods / tools, movies / books, and advocacy services. However, several testers find it appropriate to designate additional subcategories within the 3 main categories for greater transparency and structuring, for example, it is suggested that the book subcategory be broken down into literature and fiction. Many testers suggest further expansion of the existing 3 main categories: testers would add an institution and / or service (6 proposals) and / or a specialist (3 proposals) search engine to the InfoBase, covering the entire country and all aspects of the care system. 3 testers call for the creation of a category that informs about the laws and regulations in force, as well as about the benefits and discounts that can be used.

Of all the items in the content scale, the highest proportion of participants - 80% of the participants - fully agreed with the statement that in order to ensure the reliability and accuracy of the content, the page needs to be constantly checked and expanded. According to one of the respondents, during the continuous professional check, special attention should be paid to ensuring that the same content does not appear in the database more than once. 55% of respondents found it completely useful to submit suggestions from the user. According to the comments, the lack of confidence in the submission of items may be due to the fact that it is not clear to several respondents that an item will be entered into the InfoBase only after the admin has approved it, and that the uploader you will receive feedback via email. 51% of the participants fully agreed that the descriptions are traceable and sufficient, in connection with which the testers recommend a more transparent division of the descriptions, spell checking, and a more specific and explicit formulation of the purpose and function of the database.

84% of testers rated keywords as completely or more important and appropriate; in the answers to the open-ended question, the respondents argued about the usefulness of the keywords. The scale shows that the significance and applicability of the additional resources were assessed by the respondents in the same way as the keywords, and in the comments, the sources are listed, and the testers suggest that the sources provide information on the possibilities of accessing, purchasing and renting devices, films, and books. Testers have a positive view of the images, according to one respondent; they can help people with autism in particular, but at the same time, participants suggest adding images to the title, enlarging them, and uploading videos where appropriate.

3.5 Results of the System Usability Scale Test

The System Usability Scale (SUS) [14] is a ten-question Likert-scale questionnaire, which measures the overall usability of the system. There are five possible answers to each question. The answers range from "Strongly Agree" to "Strongly Disagree", meaning that "Strongly Agree" corresponds to five, and "Strongly Disagree" corresponds to one. The evaluation of the questionnaire took place in the following picture: a suitable value can only be obtained where all ten questions have been answered by the respondents. Of the sixty-four respondents, only fifty-four completed all ten questions, so we could only rate their answers. To calculate the SUS score of the targeted websites from the questionary-based user feedback, first, we calculate the score of the odd number of questions, $Qscore(Odd) = Xn - 1;\ where\ n = 1{,}3{,}5{,}7{,}9$ and then we compute the score of the even number of questions, $Qscore(Even) = 5 - Xn;\ where\ n = 2{,}4{,}6{,}8{,}10$. Then we calculate the SUS score through equation 1.

$$SUSscore = \sum_{n=1,3,5,7,9}(Xn - 1) * 2.5 + \sum_{n=2,4,6,8,10}(5 - Xn) * 2.5 \text{ -----------[1]}$$

To determine the quality of the websites, we set six quality parameters based on the SUS score, shown in table 1. Based on the quality parameter, we evaluate the websites according to their SUS score that shown in Table 1.

Table 1. Quality assessment parameter

SUS score	Quality assessment
90-100	Best
80-89	Excellent
70-79	Good
50-69	OK/Fair
30-49	Poor
1-29	Worst

Based on this, the score of SUS questionnaire is 79.49, because the numbers of quality assessments are: 20 best,13 excellent, 7 good, 11 "still" are correct, and 2 worst ratings.

3.6 Summary of the Test Results

From the first moment of the development of the InfoBase, we strived for user-centric design. As part of this, with the help of this small-sample, data-collecting questionnaire, our goal was to assess the needs, aspects, and suggestions of the users during the development, thus helping to ensure that the completed database really responds to user needs. More than 80% of the sample would recommend the use of the site, in whole or in part, to parents, professionals, and stakeholders alike, so it seems that our preliminary goal of making the InfoBase was offering a wide range of content to the target audience. Based on the feedback, mostly all three categories offer relevant content to users, however, there is a significant demand for additional subcategories and main categories among testers. The starting point for the development of InfoBase was that the information portal should provide professionally verified, up-to-date content so that it could be continuously expanded in response to emerging needs. The importance of our former endeavour was fully confirmed by 80% of the respondents, while the assessment of the possibility of expanding the content from the user side is divisive, being a result of the uncertainties and misunderstandings related to the assessment of user suggestions. Based on the feedback, it would be justified to formulate the purpose and function of the database in an even more specific and clearer way, while in the case of descriptions, additional sources, and images, several formal changes are needed. We will build on the results of the evaluation of the questionnaire in the further steps of the database development: we plan to discuss the results together with all partners involved in the development, with a special emphasis on HNAA representatives.

4 Conclusion

We have created InfoBase, in which users can search for HNAA services, films and books related to autism, and autism-specific methods and tools in Hungarian in a user-friendly way. The information on the site can be searched, expanded, and modified with administrative supervision. The "InfoBase" is currently being tested from several perspectives: its content usability issues with the System Usability Scale (SUS), and its content usefulness with a questionnaire compiled by experts form the HNAA and participated universities. The development and the detailed results of the testing will be presented at the conference.

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13. Assistive Technology Within Reach – Atvisor: https://www.atvisor.ai/en
14. InfoBase (in Hungarian): http://segito.aosz.hu/
15. System Usability Scale: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

Shall the Easy-to-Read Adaptation of Micropoems Affect Emotions?

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Abstract. People with cognitive disabilities present difficulties in reading comprehension. This obstacle affects their interactions with creative documents such as literature texts. To reduce these barriers and to improve their daily life, documents can be manually adapted following the Easy-to-Read (E2R) Methodology. As part of our research, a tool that automatically suggests E2R adaptations of micropoems has been developed. In this context, a two-phase user study has been performed using original micropoems in the first phase and their E2R adaptations provided by the aforementioned tool in the second phase. Participants in the study responded a collection of questions of different nature. Since reading causes in general a specific effect in readers, e.g. an emotion, a memory, or a judgement, one of these questions was devoted to know which emotion provokes, on the one hand, the original and, on the other hand, the adapted micropoem. In this paper we present an early analysis of those emotions in order to know whether the E2R adaptation of micropoems has any influence on readers' emotions.

Keywords: Emotions · Easy-to-Read Methodology · Micropoem in Twitter.

1 Introduction

Language is the intrinsic human capacity to communicate. It is a direct tool for transforming abstract thought into concrete production. In this sense, since emotions[5] are abstract and socially produced, they have a close relationship with language and communication [12]. Naming emotions squeezes complex feelings into something compact, i.e. a word; complex feelings, once labelled, are more visible, and thus more easily and readily accessible than in the absence of the word [3].

Reading can imply a direct consequence in the reader related to a severe and temporary mood disturbance, pleasant or painful. This effect is known as emotion and is central to reading experiences [9]. When people read a story, they construct a kinematic

[5] For the purposes of organization and exposition, we will use the term emotion as an umbrella term to include both emotions and feelings.

model of the scenes and events that it depicts. Hence, readers can have sympathy for characters and empathize with them [4].

Zooming in on a specific literary genre, it is also true that reading poetry evokes basic and complex emotions, much as if readers were experiencing the events for themselves. Emotions thus can be seen as the effect of the reader's reflection on the poem style [8].

Besides of the content of the poem itself, its prosodic cues such as meter, rhythm, and rhyme, affect on how the reader feels the poem. The music of poetry in its prosodic features can elicit particular free-floating emotions [7]. For instance, long metrics with a slow rhythm can provoke sadness, while shorterverses with a lively rhythm radiate more joy.

Poetry is important because it helps us understand and appreciate the world around us and it appeals to our emotions and feelings [10]. On this account, cultural materials, in general, and literary materials such as poetry, in particular, should be accessible for all, including people with reading comprehension difficulties.

For such a reason, the Easy-to-Read (E2R) Methodology was created [1, 6] with the aim to present clear and easily understood contents to different sectors of the population that include persons who present cognitive impairments or low literacy skills, among others.

People with disabilities have the right to participate in the activities of the society in the same way as others[6]. Putting the emphasis on culture, people with disabilities have the right of taking part on an equal basis with others in cultural life[7]. In that sense, the process of adapting literary texts, such as poetry, into E2R versions consequently helps enhance the linguistic ability, leading to a better emotional understanding, but also to a better social competence [11].

As part of our research, a tool that automatically suggests E2R adaptations of micropoems has been developed. In this context, a two-phase user study has been performed using original micropoems in the first phase and their E2R adaptations provided by the aforementioned tool in the second phase. One of the questions the participants were asked was devoted to know which emotion provokes, on the one hand, the original and, on the other hand, the adapted micropoem.

In this paper we present an initial analysis of emotions when reading micropoems[8] extracted from Twitter, in order to find out whether the E2R adaptation of such micropoems has any influence on reader's emotions. The rest of the paper is organized as follows: Section 2 is devoted to (a) describe the user study we conducted to validate our tool, and (b) put forward the outcomes we found regarding the impact of the E2R adaptation of micropoems on readers' emotions.

Finally, we show some conclusions and future work in Section 3.

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[6] Ley General de derechos de las personas con discapacidad y de su inclusión social. Versión en lectura fácil. (Diciembre 2015).

[7] Article 30: https://short.upm.es/au078

[8] Poems characterised by their extreme brevity, generally limited to 140 characters because they are usually published on online platforms.

2 User Study: Question about Reader's Emotions

The E2R Methodology [1, 6] heavily relies on manual adaptation of documents, a highly time-consuming task. In order to help in the labour-intensive and costly process of adapting documents to E2R guidelines, our research line is currently focused on applying different Artificial Intelligence (AI) methods and techniques to (semi)-automatically perform the E2R adaptation of texts. One of the attempts we are working with is the development of SUPER (SUggesting microPoems in E2R) [13], a tool that automatically suggests an E2R adaptation for micropoems.

As we mentioned before, in order to validate the aforementioned tool, a twophase user study has been performed using original micropoems in the first phase and their E2R versions in the second phase. To perform this study, we decided to involve stakeholders, in particular E2R validators. The sample of participants consisted of 7 persons with intellectual disabilities who had already evaluated easy-to-read texts in the past. Therefore, we launched a survey, using a questionnaire[9], in order to compare pairs of micropoems (the original text and its E2R adapted version provided by SUPER) in terms of reading comprehension.

Participants in the study responded a collection of questions of different nature; one of these questions was devoted to know which emotion elicits the original and the adapted micropoem. Participants were asked what they felt when reading the micropoem, so they had to choose one of the eight emotions given as an option: joy, sadness, illusion, calmness, nervousness, rage, anger, and other. The main topic of the micropoems was love, since if there is an emotion that is the most commonly used in these 500 years of history of writing, that is love [2].

In this section we present the initial analysis of those emotions in order to know whether the E2R adaptation has had any influence.

2.1 Key Findings

At first glance, we did not hypothesise that the adaptation based on the E2R Methodology would have an impact on the evocation of emotions. However, of the 20 pairs of micropoems used in the study, 6 had opposite emotions in the adapted version. That is, 30% of the adapted micropoems evoked a polarised emotion to the original micropoem. In these six pairs of micropoems that have undergone change, the pattern is repeated: in the original micropoem participants felt joy as the main emotion (accompanied, in some cases, by related emotions as calmness or illusion), while the adapted micropoem evoked sadness or nervousness. Given that, we decided to identify a possible relationship between the sub-topic (love vs. lovelessness) and readers' emotions. Upon such an analysis, we noticed that out of the 20 micropoems in total, 14 revolved around love and the remaining 6 were about lovelessness issues. Once adapted, only 2 out of the 14 love micropoems presented a change in readers' emotions, whereas in the case of lovelessness micropoems, readers felt a polarized emotion in 4 out of the 6 proposed. This

[9] The questionnaire is written in Spanish and implemented as a Google Form. It was launched in July 2020 through mailing lists of E2R experts in Spain.

means that there is a potential trend on the part of our current readers to feel a polarized emotion (from joy to sadness) when they read the original and the adapted version of the lovelessness-related micropoem. As an illustrative example, Figure 1 shows the comparison between the number of micropoems in which participants suffered a polarized change in their emotions when the adaptation is done. Each bar in the graphic shows the total overall of micropoems for each sub-topic (love and lovelessness).

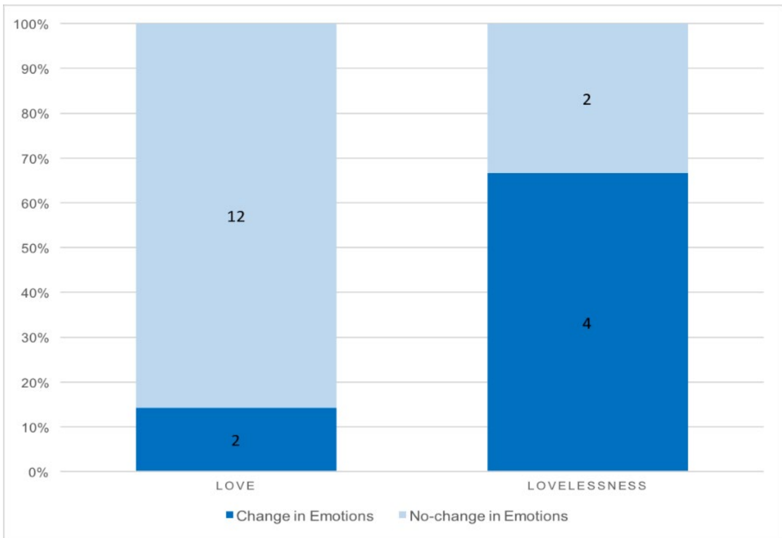

Fig. 1. Number of micropoems of each sub-topic (love and lovelessness) which evoked a change in readers' emotions when adapted into E2R versions.

It is also worth mentioning that the changes provided by SUPER in the E2R adaptation only cover formal aspects (abbreviations, punctuation marks ortypographic symbols), i.e. they do not affect the semantic content itself (see Appendix10 to compare the six original micropoems to their E2R adaptations.). Furthermore, since the set of micropoems does not follow any established prosodic structure (verse and rhythm are free), we cannot infer that those changes in emotions are also due to changes in prosody, as [7] claimed.

However, as the adaptation of the six micropoems addressed abbreviations (e.g. TQ instead of the complete structure Te quiero ('I love you')), lack of punctuationmarks (e.g. full stops, commas), and typographic symbols (+ instead of más ('more')), we could interpret those contrasts of emotions from the point of view of the so-called rhetorical-emotive punctuation [5], a system that is taking shape in electronic text in which converge expressing elements such as abbreviations or emoticons used in social networks. Following this path, punctuation marks are ideographic marks, i.e. they are carriers of meaning. This implies that the content of the message is created with punctuation marks, and not independently of them [5]. For such a reason, a text structured with

[10] https://short.upm.es/0l6t0

logical-semantic (or normative) punctuation will produce a certain impression on the reader, whereas the same text defined with rhetorical-emotive punctuation (non-normative use of punctuation) will produce a radically different impression on the same reader [5].

Taking that assumption into account, the use of rhetorical-emotive punctuation in the original poems (abbreviations, typographic symbols and the lack of punctuation marks) may elicit a different emotive impression compared to the normative use employed in the adapted micropoems.

Hence, based in this very first study, to the best of our knowledge data reveal that an E2R adaptation of micropoems by means of expanding abbreviations and typographic symbols can affect the elicited emotions on the reader, either due to (a) the topic or subtopic of the micropoems (as we see in the particular case of the four lovelessness-related pairs), (b) the fact that the so-called rhetoricalemotive punctuation is admittedly carrier of meaning, or (c) both premises at the same time.

3 Conclusions and Further Research

It is widely acknowledged that poetry evokes emotions. Considering that, in this work we investigated whether the adaptation of micropoems from Twitter into E2R versions has any influence on readers' emotions. The user study we launched in order to achieve our aim suggests that participants have experimented changes in their emotions when reading the adapted micropoem. For the best our knowledge, these changes can be motivated by (a) the sub-topic of the sample of micropoems, since lovelessness-related micropoems evoked more changes in readers' emotions than the set of love-related ones; (b) the so-called rhetorical-emotive punctuation [5], which claims that the use of a non-normative use of punctuation in social networks, such as expressive elements (e.g. abbreviations, emoticons or symbols) will produce a radically different impression on the reader compared to the same text written with normative punctuation; or (c) both assumptions at the same time. Nevertheless, since data comes from only seven participants, it could be worthwhile, as a further research, (a) having a large amount of participants to prove (or not) the hypothesis, (b) increasing the set of micropoems, and (c) considering more topics besides love.

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Virtual Reality for Students with Special Needs

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Keywords: intellectual and developmental disabilities, autism spectrum disorders, virtual reality, special education, classrooms, design thinking, accessibility, inclusive education

1 Introduction

While virtual reality technology is already widely used in business and culture for immersion in new worlds of experience, virtual reality (VR) in the field of special and inclusive education is still not widespread. Students with intellectual and developmental disabilities (IDD) are often externally determined to various degrees in their lives. To cope with everyday life independently, practicing action skills is necessary. In a real-world physical environment, this is not always easy. Virtual reality offers a possibility to acquire skills without restrictive conditions.

Within the project "Virtual Reality for Children with Special Needs" the potentials of virtual reality for students with IDD are explored. This research and development (R&D) project is a collaborative effort of the University of Applied Sciences (ZHAW Winterthur), the University of Teacher Education in Special Needs (HfH Zürich), and Vivala as the Foundation which supports persons with intellectual and developmental disabilities.

2 The Aims of the Project

The aim of this mixed method study is to work out a connection between the degree of immersion and the degree of action competence imparted. To this end, we can draw on about 20 students as testers, who will test out three use cases and their variants. Two of the three use cases use special peripheral hardware to enhance the immersive experience. The exemplary and participatory testing, evaluation, and individualization of virtual reality applications for students with disabilities to promote their participation and self-determination in mobility, education and everyday culture is the focus of the research project.

The aims of the research and development project are:

1. Exemplary testing, evaluation, and individual adaption of three VR uses cases in the areas of 1st mobility, 2nd safe leisure activities, and 3rd communication and cognition.
2. Empowerment of students with IDD in the definition and implementation of their needs for individualized VR solutions
3. Transferring the design thinking approach to another technological field of application.
4. A possible quantification of the goal formulated above could be how many of the participants would like to repeat the VR experiences they have had.

The research questions are:

RQ1. Which drivers and barriers support and hinder the use of immersive VR for students with disabilities? A special focus is on the use of a treadmill and a motion simulator.
RQ2. Which use case do the students mostly use? And why?
RQ3. How can the experiences of Vivala as the future competence center for VR for students with IDD be transferred to other institutions?

We want to explore, how do students report the physical experience, enjoyment and potential and of three different VR devices and uses cases. How do individual adaptions can lead to strengthen action skills in the areas of mobility, safe leisure activities for students with IDD and around communication and cognition for students with autism spectrum disorders. We have designed three use cases that are characterized by the fact that they teach action skills. These support the goal of strengthening self-determination and participation.

In iterative cycles three use cases are successively tested by students with disabilities.

1. *Mobility training* for electric wheelchair users by a physical motion simulator: practice using the joystick safely, visit and experience any places.

Fig. 1. The used Yaw VR Chair[15]

2. *Safety training:* Safely dealing with routine daily tasks involving walking: exploring places on one's own and solving adapted tasks, safe exploration of water bodies.

Fig. 2. The used Kat VR Treadmill[11]

3. *Recognition and communication training*: Practicing recognizing emotions on humanoid avatars to facilitate communication for students with autism spectrum disorders.

Gamification as a means to enhance motivation is meaningful and is applied for all the three uses cases.

The CRPD assigns a key role to information and communication technology (ICT) in achieving social participation. In addition to Article 9 – "Accessibility and usability" Article 28 – "Adequate Standard of Living and Social Protection" - is of relevance for the project: "To ensure disabled persons access to affordable ... equipment and other assistance for needs related to their disability." [14, p. 21]. At its core, this is about empowerment to support the overwhelming aims of the project: self-determination and participation.

3 State of the Art

VR as a technology and applications of immersive VR in various domains have reached a stable stage of development. This project is not about developing technologies further. Rather, it is about the effect of VR on the user. There are three core matters of the project.

3.1 Drivers and Barriers for the Use of VR by Students with IDD

First, it is about the effect of immersion on the teaching of action skills. In the literature as well as in practice, this connection has already been addressed and investigated [4, 7]. We have already conducted field experiments on this topic with students in the upper school [8]. However, with students from mainstream schools, it is easy to assume that motor and cognitive skills are to be expected, which facilitates the design of VR apps.

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[11] https://miro.medium.com/max/1400/1*ZMqCHXREbZ3Ntf_XSbVPHw.png

For our application context, this is not the case. Newbutt et al. [7] reported that head-mounted displays are enjoyable, physically and visually comfortable, easy to use, and exciting for students at the autistic spectrum.

Although many experiments are available as scientific articles, no generally valid rules can be derived from them [e.g. 7, 4, 13]. Therefore, from a scientific point of view, the main question is how the immersion (and thus the sensory stimuli) must be adapted and aligned to the individual abilities so that the positive effect of immersion on the teaching of action competencies is achieved. We want to address this question on the basis of the above-mentioned use cases by conducting a long-term field study with Vivala.

In a preliminary research project an immersive VR app was developed simulating a large train station including moving trains and walking passengers. The aim of this virtual train station was the training of a standard situation for students with disabilities. The students were confronted with several tasks within this immersive virtual world including interacting with virtual objects, finding places, e.g., toilets, within the train station and walking to the platform to enter the correct train leaving for a specific destination [1].

3.2 VR in Classrooms

The recent state of the art shows that there is value to the use of VR regarding increased student motivation, interest levels, and collaborative learning opportunities [13]. Holly et al. [6] emphasise the overall advantage of a hazard-free and repeatable environment in which learners can safely learn through trial and error. An additional aspect is the option to visualise unseen phenomena and virtually added hints [6 p. 114] which bear potential support elements in creating VR environments for students with intellectual or physical disabilities.

As Hellriegel & Čubela [5] state the presumed potential of VR media for positive learning outcomes for young learners needs to be promoted (p. 1). The same applies for special education issues as Lipinski et al. [9] state as well. Accordingly, VR can serve as a medium to stimulate an inclusive attitude [9. p. 18]. And it can facilitate the establishment of barrier-free and safe learning experiences for students with disabilities.

3.3 Individualized VR Solutions: Empowerment by Design Thinking

The importance of participatory design of VR solutions for students is already broadly discussed and tested. But so far there is little experience in participatory design and evaluation processes with students with disabilities. There are some results for students with autism spectrum disorders [e.g. 10] but just a few studies with participatory research approaches involving students with IDD [13]. Within the broader field of special education Lipinski et al. [9] describe how a prolific teaching scenario with VR as a low-threshold entrance to a self-contained approach with VR, based on experiences in psychomotricity education programs can be established. This serves our project as an example of how the implementation in a special school might work. Furthermore, the first author already showed how participatory research with persons with IDD can be successfully installed in technical engineering processes [2]. Likewise, the developed participatory design thinking approach for 3D-printing with persons with IDD shall be adopted for VR.

4 Methodology

Regarding the methodology the prototype development is based on an iterative research- and development cycle, often used in the context of social innovation, and adapted for people in the project SELFMADE by the first author [2, 3]. The methodological findings generated in the context of a project on the self-determined production of aids using 3D printing "SELFMADE" can be transferred to "Virtual Reality for Children with Special Needs". Thus, the method is also oriented towards self-determination and participation of persons with disabilities [2, 3].

Each of the uses cases is identified on the basis of a needs analysis. In the needs analysis the project uses a User Centered Design approach, which is linked with a Design Thinking process. This allows to identify, test and adapt the uses cases in a Co-Creation process by students with disabilities for students with disabilities. During the process experiences, gained while developing each prototype, are considered in the design of the derived prototype. Overall 20 students test the three use cases and their variants. The prototypes are developed in an iterative cycle, based on the principles of Design Thinking.

In order to address individualization and adaption of VR artifacts, the following steps of design thinking can be used:

- Understanding: The first step focuses on the understanding of the problem, this leads to an appropriate question, which defines the needs and challenges of the project. Data sources: photo documentation and written collection, composed from workshops.
- Observation: To gain important insights and to define the status quo an intensive search and field observation follows. Data sources: field notes and written collection, composed from workshops.
- Point-of-view: the individual needs are clearly defined in one question: Data source: documentation of the brainstorming question.
- Brainstorming to develop and visualize different concepts. Data source: think aloud.
- Prototyping: To test and to demonstrate the ideas, first adapted virtual reality. Data source: individualized products and think aloud.
- Refinement: Based on the insights gained from the prototype, the concept is further improved and refined until an optimal, user-centered product is developed. This iteration step can be applied on all previous steps. Data sources: individualized products [12].

This approach is particularly attractive for virtual reality companies because it has the potential to reach new target groups by making it as accessible and usable as possible.

Design methods are already well established in co-creation contexts. Among other benefits, some of them improve development processes by bringing in a user-centered perspective. This specific approach is a good entry point for an inclusive development process. A user-centered approach makes it possible to take into account the perspective and thus the needs and abilities of the target group of a solution.

In the first stage, all stakeholders are introduced to the design thinking process, which is adapted to the needs and abilities of students with IDD or austism spectrum disorders.

Technically the design thinking process represents a prototyping approach. Each iteration in the design thinking process is accompanied by an iteration in the prototyping of the use cases. The evolving experimental prototype is then used as an input for the next iteration in the design thinking process.

From a technological point of view, we use Unity as game engine and development environment. We have evaluated the Oculus Quest 2 as VR goggles. YawVR and KatVR are used as further peripheral devices. The product includes one VR app per use case for the Quest 2.

5 Prototyping Environment

The prototyping environment is based on the Unity Development Environment (version 2020.3). Key design constraints are platform independence and multi-device deployment. The interaction concept aims at using hand and finger tracking by visual means. The use of controllers is discouraged because it is not intuitive and to various degrees complex depending on the functionality of the joystick and the additional available buttons. Both main head mounted display manufacturers, i.e., Vive and Oculus, support visual hand tracking but to various degrees. A rather practical design constraint concerns the avoidance of cabling. Again, headsets from both Vive and Oculus support wireless connections. However, this constraint conflicts with the additional peripheral hardware used for two of the three use cases. Both the treadmill (KatVR) as well as the motion simulator (YawVR) need to be connected by cable to the gaming Laptop and the network, respectively.

6 Preliminary Results

Due to the fact, that the project started in February 2022 and runs until the end of April 2023 it is not yet possible to present results. At the conference we will present preliminary results. The focus will be placed on the first experiences with the tested VR prototypes and on the development and adaption of the design thinking process.

The prototyping process foresees up to four iterations with students in the Mixed Reality Lab at the ZHAW where all the equipment is available for testing. At the time of writing three iterations have been completed. The enthusiasm, interest and joy of the involved students was very impressive. In short, the following main challenges during the first iteration have been identified by the students:

- The walking on the treadmill is different from the natural walking on ground. The difference is mainly in the body posture and the walking is rather a shuffling. This

posed a challenge to various degrees for the students. Hence, they proposed to start with a simple exercise to just learn the walking without any head mounted display.
- The virtual room was perceived as too versatile and deviated the focus of the students. Hence, a simpler virtual world was suggested.

The above suggestions have been implemented for the second iteration. Again, in short, the following perceptions were made by the students:

- The quality of the visualization was criticized. The problem was caused by the used air link communication which was disturbed and caused a low frame rate.
- The newly developed walking exercise was perceived as very helpful but nevertheless still considered as demanding.
- As part of the walking exercise a very simple game was implemented consisting of collecting points. This feature was considered as very motivating and fun.

Furthermore, the first steps for the development of a competence center for Virtual Reality for students at the Vivala Foundation will be presented at ICCHP-AAATE with the focus if the use of VR can “push” the inclusive education of Vivala through a special attractiveness.

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Are Online Offers in Easy-to-Read Language Attractive?

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Abstract. This article uses tracking data to show the extent to which online services in easy-to-read language are used. It also focuses on the user behaviour of online services by people with intellectual disabilities. Finally, alternatives to easy-to-read language as online services for people with intellectual disabilities and their feasibility are described.

Keywords: easy-to-read language, user behaviour, people with intellectual disabilities, Barrier-Free Information, literacy rate of people with intellectual disabilities

1 Introduction

The Institute for Employment Research (IAB) is a special service of the Federal Employment Agency and is subject to the requirements of the Barrier-Free Information Technology Ordinance [2].

The IAB offers BITV-compliant services in German easy-to-read language on its website. It was not yet known to what extent the IAB's online services in easy-to-read language are used. The evaluation of tracking data allows insights into user behaviour. The focus of the evaluation is on quantitative user behaviour.

1.1 Possibilities and Limits of Tracking

Tracking involves recording user behaviour on websites. This takes place in the background, i.e. it is not visible to visitors to the website. The IP address plays a special role in tracking. Every smartphone, tablet, laptop and other internet-enabled devices has an IP address. IP is the abbreviation for Internet Protocol. With the IP address, the device can identify itself in a network and connect to other devices in the network. IP addresses usually consist of four number blocks. These number blocks are separated from each other by dots.

Since the IP address can be used to draw conclusions about the specific end device, only the first two number blocks of the IP address are stored at the IAB for reasons of data protection; they are thus the basis of the data stock. It is not possible to tell from the IP address whether a human or a bot has visited a website.

Depending on the software used for tracking, the number of page views, the click paths or the time spent on the respective page can be documented, for example. The length of stay was not tracked during the survey period.

An analysis of the click path to the offer in easy-to-read language cannot be expected to yield any insights at present, because the offer in easy-to-read language must be directly accessible from the respective homepage (cf. [2]). Consequently, it cannot be assumed at present that click paths will yield relevant information about user groups of services in easy-to-read language.

1.2 The IAB Forum

The IAB Forum is part of the IAB's online offering and has the information required by the BITV in easy-to-read language. Until 2017, the IAB Forum was mainly available as a print magazine. Since then, the IAB Forum has been available exclusively online. The IAB Forum provides scientifically sound, quality controlled and carefully edited contributions from the entire range of IAB research free of charge (cf. [6]). The topic dossiers and series have been enhaced by personal portraits and interviews. The target group of the IAB Forum is the professionals and other interested parties Since the IAB Forum is not primarily aimed at researchers and has the central concern of offering information in comprehensible language, this online offering was selected for the analysis of the use of easy-to-read language.

1.3 The IAB Forum is Subject to the BITV

Public authorities in Germany are obliged to make their websites barrier-free. The accessibility of internet offers is controlled with the monitoring procedure described in § 13 BGG and § 8 BITV (cf. [1,2]).

Accessibility includes, that various topics are explained in easy-to-read language, for example:

- Information on the main contents of the website,
- information on navigation,
- Explanation of the main contents of the accessibility statement,
- references to further information available on the website in easy-to-read language (cf. [2]: §4).

In accordance with these requirements, the online offer of the IAB Forum has several pages with the required information in easy-to-read language.

2 Analysis of Accesses to the IAB Forum Website

In the calendar year 2021, there were a total of 1 954 485 hits on www.iab.forum.de. The entry page of the easy-to-read language offer https://www.iab-forum.de/leichte_sprache/ had 698 hits in the same period.

The sub-page "How to use this site" (https://www.iab-forum.de/leichte_sprache/so-koennen-sie-unsere-internet-seite-benutzen/) of the easy-to-read language offer had 257 hits in the same period.

Another sub-page of the easy language offer (https://www.iab-forum.de/leichte_sprache/diese-informationen-bekommen-sie-im-iab-forum/), which describes the information provided on the homepage, had 245 hits during the survey period. This sub-page has the descriptive title "You can get this information in the IAB Forum".

Calculating the percentage of page views of the offers in easy-to-read language in relation to the total page views of the homepage gives these results:

The accesses to the homepage in easy-to-read language amount to 0.0357 percent of the accesses to the IAB Forum. The percentage of hits on the subpage explaining in easy-to-read language how to use the site is 0.0131 percent of the hits on the online offer of the IAB Forum. The sub-page describing the actual information of the online offer of the IAB Forum in easy-to-read language has a percentage access share of 0.0125 percent.

Table 1. Accesses to selected pages of the IAB Forum

	Accesses	%-Share
Homepage IAB-Forum - of which:	1.954.485	
Entry page for easy language	698	0,0357
Subpage "How to use our website"	257	0,0131
Subpage "You can get this information in the IAB Forum"	245	0,0125

This means that the accesse to the easy-to-read language offers of the website www.iab-forum.de are at a minimal range.

In further research projects, it should be clarified to what extent the offers in easy-to-read language are accessed on other websites subject to the BITV and whether the contents in easy-to-read language specified by the BITV are relevant for people with intellectual disabilities. Furthermore, it should be evaluated which topics people with intellectual disabilities would like to obtain information about.

2.1 Internet Use by People with Intellectual Disabilities

The primary target group of easy-to-read language is people with intellectual disabilities (cf. Inclusion Europe 2009). The study "Media Use by People with Disabilities" shows that 48% of the people with learning disabilities surveyed use the internet at least several times a week (cf. [4]).

"People with learning difficulties are among those in Germany for whom one can still speak of a gap in terms of access to digital media. Only half of the respondents have a computer or laptop with internet access in the household, a good third owns a smartphone, only one in ten a tablet PC" ([4]: 100). The study also shows that the equipment of people with intellectual disabilities is significantly worse than for the average of the entire population (cf. [4]: 100). Two thirds of the respondents use moving images/films on the internet (cf. [4]: 101). Younger people use the internet more often than older people. The different prevailance of smartphone access is considered a main reason. 42% of people with intellectual disabilities aged 14 - 49 own a smartphone, but only 25% of the people with intellectual disabilities surveyed who are at least 50 years old also own a smartphone (cf. [4]: 99).

The authors of the study point out that the reading ability of people with intellectual disabilities has a significant influence on their media use.

A study by Koch showed that only 24% of pupils with intellectual disabilities reach the level of alphabetical reading (cf. [8]: 14).

2.2 Target Group Specific Internet Offers for People with Intellectual Disabilities

The BITV-compliant offerings on the IAB website are texts in easy-to-read language, like many other BITV-compliant offerings. These texts comply with the conventions for the creation of texts in easy-to-read language. In the chapter "Internet use by people with intellectual disabilities", it was shown that the primary target group of easy-to-read language offerings prefers to consume films on the Internet. This fact leads to the conclusion that the text offerings in easy-to-read language do not correspond to the primary usage behaviour of people with intellectual disabilities.

Future internet services for people with intellectual disabilities should therefore consistently be either films or podcasts. Up to now, people with intellectual disabilities have not been sufficiently perceived as a target group for podcasts. Since 76% of the people surveyed in the above-mentioned study listen to the radio at least several times a week (cf. [4]: 98), people with intellectual disabilities are obviously familiar with auditory media.

It is essential that when creating film and audio material for people with intellectual disabilities, their disability-specific limitations must be considered. To be more specific, this means that the speed of moving image material must be adjustable on the end device, just as is possible with speech output devices for blind people.

Text content must be easy to understand on morphological, syntactical and lexical levels. Here, recourse to rules for easy-to-read language (cf. [7]) as well as aspects of reading comprehension and literacy (cf. [9]: 14 ff) is urgently required.

2.3 Feasibility of Target Group-Specific Internet Services for People with Intellectual Disabilities

It has already been stated that the mandatory offers in easy-to-read language do not fit the internet usage behaviour of people with intellectual disabilities. well documented from their use of the internet by people with intellectual disabilities that offers are used that provide information as moving images or films.

A high proportion of people with intellectual disabilities listen to the radio. Podcasts, similar to radio, offer information that is recorded auditorily.

Provided that people with intellectual disabilities gain access to the internet, more target group-specific video and audio offerings need to be be developed.

This presents public authorities subject to the BITV with additional tasks that most probably cannot be mastered with the resources existing today . The easy-to-read language texts are building blocks in the creation of videos and podcasts. However, creating videos and podcasts is considerably more time-consuming than creating easy-to-read language texts.

3 Conclusion

In summary, it must be stated that the online offers in easy-to-read language, as far as data are available, are only used to a minimal extent. Possible reasons for this could be the low literacy rate of people with intellectual disabilities and their restricted? access to the internet. In addition, the content that must be provided according to the BITV mainly relates to the accessibility and use of the online offer. Information on factual topics does not have to be provided in easy-to-read language.

A rethink seems indispensable here. On the one hand, framework conditions should be created to enable public authorities that are subject to the BITV to prepare and provide information in channels to fit to the internet usage behaviour of people with intellectual disabilities. On the other hand, online services should also offer factual topics in easy-to-read language that are in the context of the daily life of people with intellectual disabilities.

Easier and improved access to the internet for people with intellectual disabilities is indispensable. To make this successful, further research projects (see above for initial tracking results) about the target group are necessary.

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Towards a Mobile Application to Support Pre-school Teachers Observing Early Signs of Autism Spectrum Disorder

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Abstract. This contribution provides an overview of the activities conducted within the Erasmus+ Project NeMo (NEw MOnitoring guidelines to develop innovative early child education teachers curricula) aimed at developing a digital toolkit to enable pre-school teachers observe signs of autism spectrum disorder (ASD) in their pupils as well as design teaching activities to address the main social and developmental challenges related to ASD. The development process was carried out in three phases (1) requirement gathering and systematic review, (2) conceptualization, and (3) pilot testing, of which the first two have been concluded and the last one is currently ongoing. The first phase (requirement gathering) comprised an online survey that involved 434 pre-school teachers in five European countries: Italy, Spain, Cyprus, Slovenia, and Sweden. Based on the survey results, the first version of the toolkit encompassed a web application that implements an educational network allowing teachers to create custom educational activities tailored on students' needs and keep tracks of student progress. Pilot testing is currently ongoing in five countries to gather preliminary information on its feasibility and acceptability. The final results of the pilot trials will provide further indications about the feasibility of implementing such device in early educational settings. Results will help bridging clinical services with educational services to promote more timely and integrated ASD care pathways.

Keywords: Autism Spectrum Disorder, Early Intervention, Early Child Education and Care, Assistive Technology

1 Introduction

Autism spectrum disorder (ASD) is a category of neurodevelopmental disorder characterized by persistent deficits in social communication and social interaction across multiple contexts as well as restricted, repetitive patterns of behavior, interests, or activities [1]. The care and social needs of preschool children with ASD (typically up to six years of age) are significant, usually extend to parents and siblings, and require substantial community resources. In response to these needs, early detection of ASD has become a priority for primary care and other community settings to provide early intervention services and to improve outcomes [2].

There are limited screening tools developed for pre-school teachers, despite their importance as informants of ASD children's social behaviors compared to their normative peer groups. As mobile, interactive, and smart technologies (e.g., smartphones, tablets, robots) are becoming increasingly available in educational settings to foster children's learning and creativity, teachers can be trained to use them also to contribute to the screening of young children, thus providing valuable information on children's behavior in socially rich environments (e.g., kindergartens; primary schools) [2].

In light of these considerations, the aim of this contribution is to report on the development cycle of a mobile application, i.e. the NEMO Toolkit, to enable pre-school teachers to observe early signs of ASD in their educational settings as well as delivering educational activities to foster inclusion of pre-school children with ASD. The mobile application has been in part developed within the Erasmus+ Project NeMo (NEw MOnitoring guidelines to develop innovative early child education teachers curricula) and involved five European countries: Italy, Spain, Cyprus, Slovenia and Sweden [3]. The design of the mobile application involved three consecutive phases: (1) a systematic review of the literature on ASD early screening; (2) requirement gathering from pre-school teachers, and (3) pilot testing of the app in early child educational settings. The results of the systematic review have been published elsewhere [2]. The reviewed evidence suggests that mobile applications are the most promising and cost-effective solutions to both implement ASD screening strategies and design educational activities for children with ASD. The present contribution extends the findings from the systematic review by reporting on the results of the requirement gathering phase across the five European countries involved in NeMo as well as the design of a first version of the mobile application. An overview of the future piloting activities is also provided.

2 Method

2.1 Requirements Gathering

An online survey conducted on Qualtrics has been carried out among ECEC teachers in Italy, Spain, Cyprus, Slovenia and Sweden to explore the characteristics of the educational contexts in which the NeMo toolkit could be implemented. The key information collected through the online survey included (a) experience in ASD teaching ("Have you ever had in your classroom a child with a diagnosis of autism?") and screening ("Have you ever received formal training in recognizing signs of autism in your students?"); (b) ECEC teachers' attitudes toward technology ("How would you rate the usefulness of the following technologies for your teaching/educational purposes?" and "Which of the following technologies would you feel more comfortable with if used with children with autism spectrum disorders?"); and (c) Resources available ("How much do you think would be the budget considering the amount of funding usually available?").

2.2 Conceptualization and Prototyping of the NeMo Toolkit

The results of the systematic review and the online survey were discussed among the team members of the NeMo project to identify any possible solution capable of integrating ASD screening and teaching activities into a single digital eco-system. Discussions were carried out over a series of iterative rounds and involved final end users (i.e., ECEC teachers) to ensure that the solution could be as much as possible centered around the needs of the key stakeholders.

2.3 Pilot Testing of the NeMo Toolkit

Once consensus has been achieved on the most adequate solution for the toolkit, a series of pilot tests was planned to assess the first version of the NeMo Toolkit in all five participating countries. In each country, one pre-school teacher was trained in the use of the application and asked to use it for four weeks. At the end of the 4-week experience, teachers were required to answer a brief evaluation questionnaire addressing three main dimensions of use: (1) Usefulness ("e.g., Do you think the NeMo Toolkit may be useful in your daily practice? Please explain why yes or not"); (2) ASD Applications (e.g., "Do you see any possible applications in your daily context in case of children with a diagnosis of ASD?"), (3) Barriers (e.g., "What are the main barriers to its use in your daily context?"), and (4) Improvements (e.g., "What other functionalities would you like to find in this toolkit?").

3 Results

3.1 Requirements Gathering

In total, 380 ECEC teachers in Italy and 54 pre-school teachers across Spain (n = 10), Cyprus (n = 15), Slovenia (n = 12), and Sweden (n = 11) responded to the survey. Due to differences in the number of respondents across participating countries, descriptive analyses were carried out for Italy separately from the other countries (hereafter, EU). With reference to teachers' experience with ASD, the percentage of those who did report to have no experience in teaching to ASD students was 54% for EU respondents and 71% for Italian respondents. Half of EU respondents and 60% of Italian respondents, however, reported to have received some training in recognizing signs of ASD. With reference to teachers' attitudes towards technologies, very similar responses were provided by the two groups (see Fig. 1), with the Laptop/PC and the mobile devices (i.e., smartphone and tablet) considered the most useful solutions by teachers.

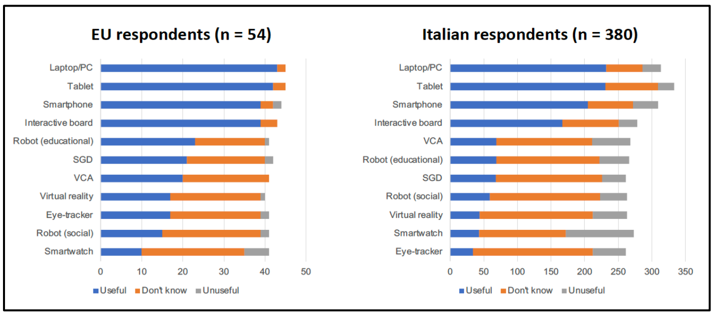

Fig. 1. Answers to the question: How would you rate the usefulness of the following technologies for your teaching/educational purposes? (cumulative responses). VCA, voice-base conversational agent; SGD, speech-generating device.

On a similar vein, teachers in the two groups provided also comparable answers to the question about which of the products they would be more confident with in case of ASD, indicating both laptop/PC and tablet in the top positions (Fig. 2).

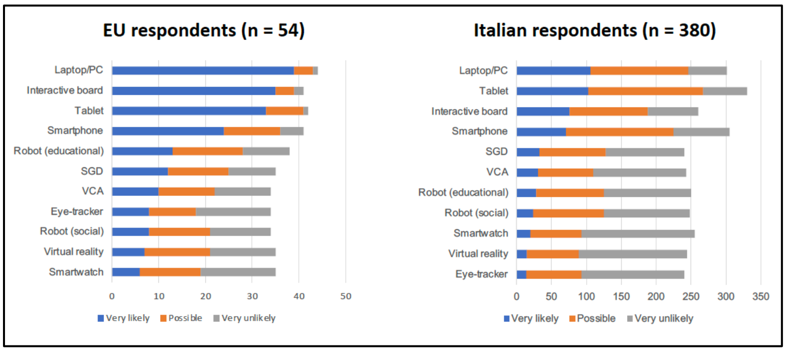

Fig. 2. Answers to the question: Which of the following technologies would you feel more comfortable with if used with children with autism spectrum disorders? (cumulative responses). VCA, voice-base conversational agent; SGD, speech-generating device.

Lastly, considering the budget available for the two groups, most EU (43%) and Italian (44%) respondents indicated a range of 50-300 euros as the maximum possible amount of funding they could obtain to buy a digital solution.

3.2 Conceptualization and Prototyping of the NeMo Toolkit

Overall, the online survey confirmed that, across countries, tablets and PCs can be the preferred technological solutions within which implement the toolkit. Furthermore, to be accepted by teachers, the survey stressed that the technologies included in the toolkit must be affordable. Based on these results, a mobile application was adapted to the scope of the current project with a view to provide teachers with both an ASD screening tool and a platform to design teaching activities. After analyzing various technological proposals currently on the market, based on discussions among team members and other stakeholders, it was decided that the central element of the NeMo toolkit would be based on VIVO [4], a web application that implements an educational network allowing teachers to create custom educational activities tailored on students' needs and keep tracks of student progress. Activities in VIVO are structured in form of task analysis, that represents an effective and widely used educational strategy, commonly used for learning multistep activities, even with people with ASD [5]. Based on VIVO, some extra development was required to improve usability and user experience for the NeMo target group. The resulting app is a forked version of the original VIVO.

As a screening tool, the first version of the NEMO toolkit was endowed with the EDUTEA questionnaire [6]. EDUTEA is a multi-language teacher-reported questionnaire to screen for early signs of ASD. The NEMO toolkit has been also conceived as an application to assist pre-school teachers to easily design educational activities for children tailored on their needs. As educational activities we mean both task analysis activities and quiz activities. Teachers have the possibility to keep track of the activities executed by each child and monitoring their progress over time. Furthermore, just like the original version of VIVO, it is possible to share the created activities among other teachers within the same country.

3.3 Pilot Testing of the NeMo Toolkit

Due to the containment measures to prevent the diffusion of COVID-19 virus, the piloting activities are still ongoing. Only Slovenian partners almost completed the pilot test study, involving N teachers and N pupils. For the scope of the present contribution, we can only provide a summary of their feedback. With regard to the learning curve of the toolkit, significant differences have been noticed between teachers in relations to their age and digital competences. In particular, for younger teachers there were almost no difficulty in learning how to use the app; on the other hand, older teachers with less digital skills, needed to be guided a little more in the usage of the app. All the partners agreed that the best way of exploiting the potential of the toolkit is to introduce it gradually to teachers, with a set of training session in which they could be gain confidence in using the tool in a learning-by-doing process and overcoming potential bugs and technological problem. Concerning the age of the children, all partners consider the app suitable for 3 to 6 years old pupils. One of the most liked characteristics was the flexibility of the application in terms of creating custom content from scratch about any subjects. As a matter of example, Figure 3 represents a screenshot of a quiz based on learning emotions from images, while Figure 3 is a part of an activity based on washing hands. Considering the proposed features, the possibility of having a speech synthesizer was highly appreciate so much that some of the teachers involved built an activity based on learning the word of a song through the speech synthesizer. The mobile version of the application was the most liked one.

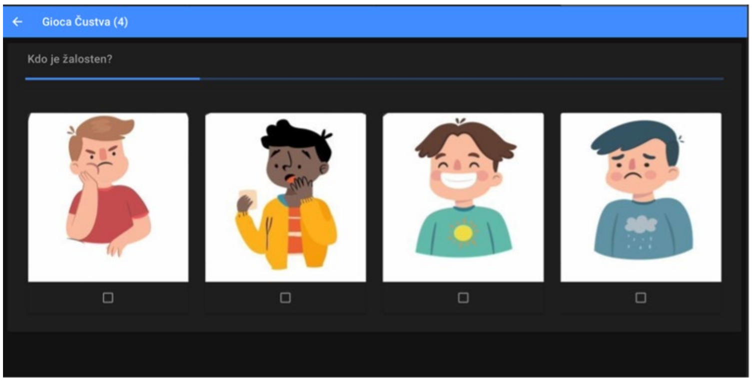

Fig. 3. An example of Quiz Activity. "Who is happy?"

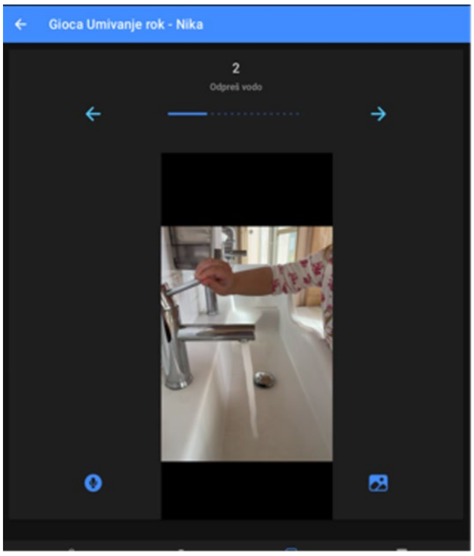

Fig. 4. An example of a step of the "Washing hands" activity.

4 Conclusions

The NEMO toolkit has been one of the first attempt to provide ECEC teachers with a tool to involve them in the clinical as well as educational interventions to foster the development of students at risk of ASD diagnosis. The final results of the pilot trials will provide further indications about the feasibility of implementing such device in early educational settings. Results will further help bridging clinical services with educational services to promote more timely and integrated ASD care pathways.

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User Requirements for an e-Counselling and e-Learning App for Parents with Children with Attention Deficit Hyperactivity Disorder

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Abstract. In Austria, attention deficit hyperactivity disorder (ADHD) affects the lives of approximately 5.2% of children. The main symptoms of ADHD are attention deficit, hyperactivity and impulsivity, which lead to difficulties for the children in coping with everyday life. In addition, the behavioural problems of affected children also have an impact on the well-being and functioning of the entire family. Due to the dysfunctional family life, parents experience a high stress level. Therefore, parent counselling and family-centred work are of great importance to support families in coping with problematic situations. However, there is a lack of occupational therapy-based support in the home environment for parents of children with ADHD. The study points to the need for an e-counselling and e-learning app that meets the demands for appropriate support in the daily life of parents of children with ADHD. Interviews with nine parents of children with ADHD, one focus group with seven paediatric occupational therapists and two workshops with twelve children with ADHD show the need for an application that supports parents in daily routines even prior to occupational therapy intervention as well as complements occupational therapy with recommendations for everyday life. Parents and occupational therapists particularly welcome tips for everyday life, information about ADHD and contact addresses for help. Children stated that improving the skills of preparing meals, doing homework, getting up and going to sleep is most important to them. The content should predominantly be low-threshold with professional videos, photos and images with a limited amount of text.

Keywords: ADHD, e-counselling, parents, user needs, occupational therapy based application

1 Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common mental disorders in childhood and adolescence and often continues into adulthood as a partial or full syndrome [1]. In Austria, approximately 89,000 children (prevalence of ~5.2%) meet the diagnostic criteria of ADHD [2]. Only licensed physicians may diagnose

ADHD by interviewing the parents and/or the affected children to document the criteria for the disorder [3]. The main symptoms of ADHD are attention deficit, hyperactivity and impulsivity [1, 4]. Attention deficit manifests itself, for example, in many careless mistakes in schoolwork, in the difficulty of organising oneself or generally in the rapid distractibility by external stimuli. Hyperactivity becomes evident, among other things, in the difficulty of playing quietly and in an irrepressible urge to move. Impulsivity is shown by excessive talking or impatience, to give an example. This leads to a high stress level for parents and the family environment in everyday life [5]. The CDC (Centers for Disease Control and Prevention) recommends combined treatment of medication and behavioural therapy for children with ADHD at the age of six [6]. Therefore, occupational therapy and family-centred work are of great importance to support families in coping with problematic everyday situations. Occupational therapists working with children provide family-centred care to enable the child and the family to manage everyday life successfully. The systematic review of Nielsen et al. [7] examined the evidence of occupational therapy interventions for children with ADHD. It summarises that the interventions focus on play to improve playfulness and interpersonal skills, on motor performance in everyday activities and cognitive skills. The Cog-Fun (Cognitive-functional intervention) was identified as a manualised intervention. The Cog-Fun targets emotional, cognitive, and environmental barriers to successful participation in daily activities through the acquisition of executive strategies (inhibit-, effort recruitment-, monitor-, and planning strategies) [8]. Ianni et al. [9] surveyed Canadian occupational therapists and asked what interventions they use with children with ADHD. More than 50% of the respondents reported that they work on school achievement, sensory processing, fine motor skills, emotion regulation and activities of daily living.

As the literature shows, occupational therapy programs support children with ADHD. However, there is a shortage of occupational therapy services for children in Austria [10] as well as for occupational therapy-based support in the home environment for parents of children with ADHD. Therefore, the aim of the project is the development of an e-counselling and e-learning app for parents of children with ADHD, which provides evidence-based occupational therapy content. The present paper focuses on the user needs and requirements for such an app.

1.1 State of the Art

There are already several apps for adults and children with ADHD. The systematic review by Păsărelu et al. [11] examined 109 ADHD apps and found that the majority of the analysed apps were aimed at assessment or treatment. In addition, it has become clear that despite the existence of mental health apps, more collaboration is needed between experts who plan and professionals who develop mental health apps. Currently, low participant numbers, missing valid outcome measurements and psychoeducational aspects characterise research on ADHD apps and technologies for children and adolescents [12]. To get an overview of offered apps for persons with ADHD, the researchers of the present study screened 15 apps in German and English. The analysis of the apps followed the usability evaluation according to Nielsen & Mack [13]. In addition, the provided content was analysed. The target groups of the evaluated apps are either children with ADHD, adults who are affected by ADHD and seek advice for the handling of the symptoms, or parents who would like to discover whether their children are affected by ADHD or not. The analysis shows that most of the apps are designed for self-diagnosis. Some of the apps provide pedagogical content on the importance of consistent educational behaviour for parents, whereas others aim to improve cognitive functions through cognitive training and games. Children can thus enhance their memory, concentration and coordination. Several apps have limited content such as music for relaxation or a diary for daily structure. The app "ADHS-Kids" is most similar to the planned app and contains activities around daily life. It focuses on educational topics, i.e. parents learn to formulate rules for the most common everyday problems.

The literature and the app analysis illustrate that most apps are designed for self-diagnosis. Only a few contain concrete evidence-based occupational therapy contents that can be integrated into everyday life.

1.2 Objectives

The qualitative user study aimed to assess user needs and requirements in order to develop an e-counselling and e-learning app for parents of children with ADHD that encourages the quality of life and caring skills of the affected families. The study focused on the user needs of parents as the main target group and on the views and expectations of occupational therapists and children.

2 Methods

The present paper examines the following research question: *What content and features are needed for an e-counselling and e-learning app for parents of children with ADHD for support in everyday life?*

The methodological approach to answer the research question follows the concept of user participation applying qualitative methods. In eight interviews with parents of children with ADHD (9), one focus group with paediatric occupational therapists (7) and two workshops with children with ADHD (12) participants were asked about problems children and parents face in daily life, previous solutions in dealing with these challenges and needs regarding the content and features of an e-counselling and e-learning application.

2.1 Data Collection, Participants, Data Analysis

The participants of the survey were recruited through the strategy of gatekeeping [14]. To recruit parents of children with ADHD, emails and messages with an information letter were sent to occupational therapists and psychotherapists in Upper Austria and Vienna and to the social media platform Facebook (group ADS/ADHS Kids in Österreich). Occupational therapists and children with ADHD were recruited with the support of therapists. Prior to the interviews, a focus group and workshops took place, the interviewers assured the participants of data anonymity and confidentiality. Subsequently, the participants gave their written consent. Written parental consent was obtained for the workshop with children [15]. Interviews and the focus group were conducted during February and March 2022 via the video-conferencing tool Zoom or in person and were recorded. The workshops, which took place on the premises of a therapist in April, were also recorded. The interviews lasted for about an hour, the focus group for about two hours and the workshops for about half an hour. The researchers created appropriate semi-structured interview guidelines for each target group on the challenges in daily life, previous solutions in dealing with challenges and user needs in relation to the planned app. For the workshops, seventeen Kids Activity Cards [16] (cards with pictures of everyday activities based on the topics: self-care, rest, leisure and productivity) were prepared for collecting children's answers on a poster. The children determined easy tasks and those that require some or a lot of support. Furthermore, they performed four guided exercises for activation and centring, which were modifications from activation and centring activities by Winter & Arasin [5].

The socio-demographic data show that seven mothers and two fathers interviewed were aged 28 to 63 years. Six female and one male occupational therapists had 2 to 28 years of professional experience and were aged 24 to 49 years. Only boys between 7 and 12 years participated in the workshops. Generally, boys are more likely to show obvious symptoms such as hyperactivity; they are therefore more likely to be in therapy, which is also confirmed in the literature [1, 4]. The data transcription and the analysis of the interviews, focus group and workshops are based on the structuring qualitative content analysis according to Kuckartz [17]. The objective was to extract and summarise specific topics, contents and aspects. The categories were formed both inductively and deductively, and super- and subtopics were created in MAXQDA 20.0.0 [18].

3 Results

The analysis of the collected data resulted in five categories, which are described in the following paragraphs: challenges in everyday life, useful app content, information and features, simply prepared and personalised content and general tips.

3.1 Challenges in Everyday Life

The analysis of the data of the focus group with occupational therapists illustrates that parents often seek therapy for their children because of the children's low self-organisation, aggressive behaviour, interaction difficulties, self-esteem problems, sibling rivalry and problems in doing homework. In addition, parents described challenges in self-composure and self-care as a parent, time management, risk of injury of the child, medication management, children's difficulties adapting to new situations, and the high potential of disputes in the family system. Most parents stated that everyday life is challenging because the child needs constant attention and help. Their children apparently struggle with depth perception, fine or gross motor functioning, high distractibility, planning action steps in simple activities such as teeth brushing, making friends or difficulties when participating in family or leisure activities. In the interviews, parents were asked about previous solutions concerning these daily challenges. They stated that clear daily routines and patience are most helpful. Other strategies such as not engaging in discussions with the child or a stopwatch for certain activities like dressing in the morning are strategies parents developed to manage the day. In the workshops, children most frequently reported difficulties and the importance of improving in preparing meals, in writing and doing homework, playing board games and in getting up or going to sleep. According to the occupational therapists, the most common therapy goals are independent care (e.g. dressing independently), being able to eat in peace with the family at the table, starting and completing homework independently, completing tasks without distraction, staying on task and anger control.

3.2 Useful App Content

Occupational therapists indicated that parents of children with ADHD often take little care of themselves. Therefore, the new app should contain tips on how to facilitate parental self-care. They also noted the need for tips on how to deal with the respective mood of the affected child in everyday life (e.g. the child can be massaged when he or she needs rest, or they have a pillow fight when the child needs movement). The children tried out exercises for activation and centring in the workshops and mentioned that they would like to perform them at home with their parents or at school with friends. According to occupational therapists and parents, the app should also contain suggestions for everyday life (e.g. how to take breaks, how to tidy the desk, how to organize learning material, how to get the evening and morning routine going). Some parents welcome a diary function in the app that enables them to write down special events or to reflect on the day's events together with the child in the evening. In addition, some advice such as the rev counter (alert program) for the whole family to identify what everyone actually needs, a checklist of how a child's desk should be organised or sayings and songs to accompany everyday activities were mentioned by occupational therapists as useful content. Further needed content relates to communication between parents and child, such as increasing physical contact if the child simply does not listen.

3.3 Information and Features

Parents are interested in information about ADHD, as they sometimes know little about the clinical picture. Further information about medication, a healthy diet and organisations that parents can contact if they are in need of assistance should be provided. Occupational therapists mentioned that push notifications should prompt parents to think of positive experiences with their children. Parents indicated that push notifications should inform about content-related issues such as new activities. The frequency of push notifications should be individually adjustable. In terms of gamification, parents suggested features such as a point system where children can achieve individually determined rewards or praise notification when a goal is achieved. Another feature welcomed by parents is an avatar as a guiding figure that accompanies parents and children through the app and can be customised.

3.4 Simply Prepared and Personalised Content

According to the occupational therapists, for low-threshold communication, the content should be provided more through pictures and videos and less by text. The parents also welcomed video content and few technical terms. The app should not be overloaded with content, as this would overwhelm the already burdened parents. Parents and the occupational therapists noted that the app should explain in advance how much time is required to get essential tips. Furthermore, the interviews and the focus group show that the app developers should take into account that not every family needs all the content and that parent should have the possibility to choose the content they want and need. For this purpose, questions should be asked at the beginning of using the app to find out which content should be provided.

3.5 General Tips

The occupational therapists agreed that the app cannot replace occupational therapy and that specific exercises require guidance from a trained expert. However, all participants stated that an app could be a useful and innovative addition to therapy.

4 Discussion

The user survey and the app analysis revealed similar results to those described by Păsărelu et al. [11] in their systematic review. There is a gap between user needs and features and content implemented in existing apps. Accordingly, the aim of the research and development of an e-counselling and e-learning app for parents with children with ADHD is to fill in the gap to provide professional occupational therapy-based recommendations for parents for daily use. For the development of the app, the findings of the user study and the user requirements will be discussed in a multidisciplinary team with experts from occupational therapy, sociology, nutritional sciences and technology to ensure that the user needs are met in addition to an attractive design and an intuitive use of the app.

The findings of the user survey and the literature [19] illustrate that one of the greatest challenges is doing homework. The participants of the user survey ask for suggestions such as how to tidy the desk or how to organize learning material. Pressman et al. [23] stress that parents should support their children with homework by providing a fixed time and a quiet place to work. Metacognitive strategies are part of many therapeutic approaches for children with ADHD [5, 7, 8]. These structured procedures can be applied to different situations, including doing the homework. Children learn to first "stop and think" what the assignment is and prepare all their materials, then "start and keep going" and later "check" if they have done all their tasks and finally "praise" themselves for finishing. As the homework example shows, various sources, especially literature on evidence-based occupational therapy approaches, will be considered when developing the app content. Another important point in the interviews with occupational therapists and parents was that each family faces individual challenges in everyday life. Faraone et al. [3] state that therapeutic treatments for ADHD are multifaceted and have a different focus depending on the symptoms and age of the individual. Accordingly, app content should be offered in a comprehensive, easily understandable and customisable way to cover the different needs of families based on the challenges in their daily life. Comparing the results of the user research with the Cog-Fun intervention in occupational therapy [8] confirms that it would be effective in helping children acquire executive strategies (inhibit-, effort recruitment-, monitor-, and planning strategies). As one possible solution, the app could support parents to organise activities together with the child and subdivide them into minimal steps.

Limitation. The main symptoms of ADHD attention deficit, hyperactivity and impulsivity as well as the challenging situations described for the target groups can also be part of everyday life in families with children without ADHD. However, they differ in duration and intensity and only occur temporarily. For this reason, it is important to note that ADHD symptoms are strong and permanent and that the app will be specifically developed to support parents with children with pronounced ADHD symptoms.

5 Conclusion

Attention deficit hyperactivity disorder (ADHD) is one of the most common mental disorders in childhood. For the development of an e-counselling and e-learning app for parents with children with ADHD, the user needs were collected in interviews with parents of children with ADHD, a focus group with occupational therapists and workshops with children with ADHD. It can be concluded that the intended app might serve as a supplement to therapy with recommendations for everyday life. It should contain activities with tips for everyday life such as taking breaks, tidying the desk for homework, and getting the evening and morning routines going. In addition, information about ADHD and contacts for assistance should be provided. Push notifications should remind parents, for example, to praise their children. The content is planned to be low-threshold with professional videos, photos and images, and little text. Due to the different challenges and manifestations of ADHD symptoms, the app should allow personalisation of the content needed. Overall, the user research perceives an app as a useful and innovative supplement to therapy.

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Promoting Labour Market Inclusion

A Review of Assistive Technologies for Workers with Autism Spectrum Disorder

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Abstract. Persons with autism spectrum disorder (ASD) can be efficient workers. Despite the increasing recognition of their potential contribution in the workplace, they continue to experience many challenges entering and maintaining employment. Overcoming these challenges can be achieved by resorting to specific assistive technologies (ATs) which can play, if properly chosen, a strategic role in allowing persons with ASD to compete with all others in accessing, hiring, maintaining employment. It is in the light of these considerations that this contribution aims at deepening knowledge in this field by investigating which ATs can be used in the workplace to support the labour market inclusion of persons with ASD. This study provides a focused systematic review of 27 studies identified within the literature. Results analyzed the ATs that can be used for supporting the labour market inclusion of persons with ASD, the skills they help to develop and the work activities they can support.

Keywords: Assistive Technology, Autism Spectrum Disorder, Labour market inclusion

1 Background

Persons with autism spectrum disorder (ASD) can be efficient workers [3,4,9]. Several research carried out on the employment of these persons revealed that, despite the difficulties connected to this neurodevelopmental condition disorder, they are able to tolerate repetitive tasks for a short time, carry out the assigned jobs with a high degree of precision, and accuracy, maintain high levels of attention for long periods and be particularly precise in the technical field. [3,19,24]

Despite the increasing recognition of the potential contribution that persons with ASD can bring in the workplace, they continue to experience many challenges entering and maintaining employment [11,12]. Higher unemployment rates comparing to those of persons with other types of disabilities, high percentage of temporary contracts, works in positions below their qualifications or skill level, working reduced hours and lower rates of pay than their co-workers in comparative positions represents some of the main features characterizing the labour market of persons with ASD [15,12,25,23,10,17].

The lack of social and communication skills, poor time management, inappropriate commenting, poor hygiene, deviating from routine, difficulties with reasoning, decision-making, mastering the job application process, remembering and following instructions, interacting and communicating effectively with co-workers and integrating into the workplace culture are some of the main barriers that hinder or prevent persons with ASD to enter the labour market, to find and maintain a job, to be included workplaces [14,19].

These barriers can be overcome by introducing in the workplace specific reasonable accommodations; these undoubtedly include assistive technologies (ATs) which can play, if properly chosen, a strategic role in allowing persons with disabilities to compete with all others in accessing, hiring, maintaining employment, in carrying out the assigned job duties and in career advancement [6].

Despite the growing recognition of their strategic importance, there are still few research that have investigated the field of ATs for persons with autism spectrum disorder in the workplace [23].

The scarcity of studies in this field entails, in several countries including Italy, the persistence of a non-use or under-use of the potential of ATs for workers with ASD and other kind of disabilities [6]. Research conducted in this area shown that employers' workplace ATs knowledge is rather poor [13,16,17,7,20] and many of them have the perception that ATs for workers with ASD are excessively expensive and complex to adopt and manage [17].

All these factors often lead employers to look at ATs with distrust and to be hesitant about their adoption [7]. In some cases, they can also lead to making bad choices and moving towards ineffective solutions to meet the needs of people with ASD and the needs of work contexts [20].

It is in the light of these considerations that this contribution aims at deepening knowledge in this field by investigating which assistive technologies can be used in the workplace to support the labour market inclusion of persons with autism spectrum disorder.

2 Method Used

To compose an overview of the state of the art of ATs for persons with autism spectrum disorder (ASD) in their day-to-day work a systematic review was conducted in November 2021. The electronic databases *Psych INFO*, *Education Resources Information Centre* (ERIC), *Scopus*, *Psychology and Behavioral Sciences Collection* (EBSCO) were investigated using the following keywords: *assistive technolog* AND employment AND worker* with autism spectrum disorder OR worker* with autism*. No time limit was entered. The title and abstract of retrieved studies were then reviewed for inclusion using the following inclusion/exclusion criteria: (a) the study must have included worker(s) with ASD; (b) participants, with a diagnosis of ASD, must have been 18 years of age or older; (c) the study must have reported AT(s) for promoting/managing employment/job tasks; (e) the study must have been published or accepted for publication with online availability in English within a peer-reviewed journal. Each included study was then summarized using a reading form to collect information about: (a) AT used; (b) developed skills; (c) related work activities/job tasks.

3 Results and Discussion

A total of 1216 articles was retrieved; of them 27 met the inclusion criteria for the review (see Fig. 1).

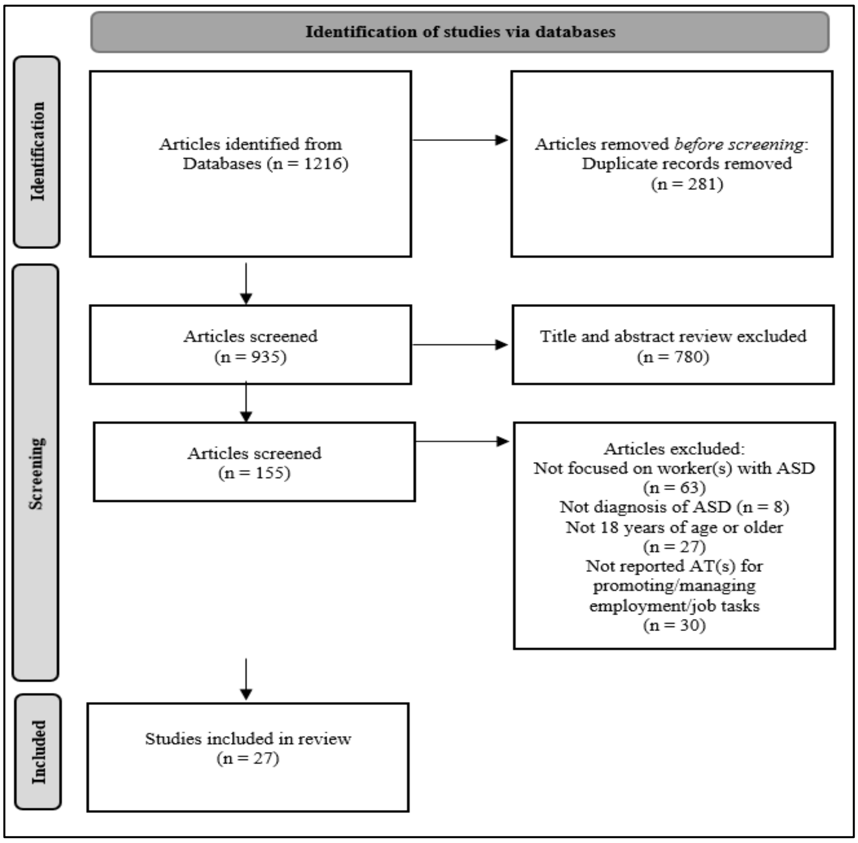

Fig. 1. Search process flow diagram

The included articles[12] were published from 2003 to 2021; most of them (20 out of 27) was in the time frame from 2012 to 2021, highlighting a growing interest and development in this field especially in recent years.

[12] The references of the included articles are: [3,5-7,10-15,17-21,23-29,32-36].

3.1 ATs Used

Table 1 provides an overview of the founded assistive technologies.

Table 1. Assistive Technologies reported in the included studies

Technology	Number of studies	References
Radio and headset	1	[3]
iPod, iPad, iPhone	13	[5,10,13-15,19-21, 24, 33-36]
Tablet	3	[6,14,17]
Laptop computer	6	[7,12,23,26,28,29]
Pocket PC	1	[32]
Virtual reality	2	[18,27]
Wearable	1	[25]

Radio and headset are used in the covert audio coaching (CAC). This is a method for giving antecedent prompts and performance feedback using a pair of two-way distance radio. This implies the presence of a job coach or a mentor providing assistance, job explanations and feedback [3].

Although only a paper reported this technology, CAC can be used in various work environments where the use of radio technologies (headsets, etc.) is increasingly frequent; it lends itself well to concise messages such as instructions and timely feedback that are useful for learning the skills necessary to carry out work tasks, reduces the dependence of the person with autism on the presence of a specific operator and the risk of misrepresenting forms of non-verbal communication that characterize communicative exchanges in presence [3].

iPods, iPads, iPhones (13 out of 27) are the most frequently found technology in the included studies. Their portability and ease of use makes them increasingly popular within work contexts and as part of job training and internship programs for workers with autism spectrum disorder [10,24]. However, what makes these mainstream technologies assistive are the different and more and more numerous software that can be installed allowing iPod, iPad, iPhone to become Personal Digital Assistants (PDAs) [5,36].

PDAs are conceived to provide the person with stimuli, prompts for the note, of a visual, auditory, or combined nature [25]. These stimuli can reproduce specific sequences of actions or be memoranda that serve the person to learn, or remember, all that is necessary to perform one or more work tasks or to develop skills and competences to interact with work colleagues or participate in conversations and conferences [34]. PDAs are pocket-size, easily accessible, and economical when compared to other solution, and allow workers with ASD to acquire skills to carry out tasks autonomously, progressively reducing the dependence on personal assistants [11].

PDAs represent one of the most common interventions to support workplace inclusion of workers with ASD [5].

PDAs can also be composed through PCs and tablets even if their use is limited and were found in few of the studies included in this review. Their reduced diffusion is mainly attributable to their size which makes them less portable than iPod, iPad, iPhone which can be held in the hand or inside clothing pockets. For this reason, their use is limited to work situations characterized by a sedentary lifestyle such as office work at the computer or at a desk.

In addition to these ATs, a promising approach is the possibility of customizing workplaces, thanks to information communication technologies (ICT) and the internet of things (IoT) expanding the still untapped potential of virtual reality and wearables such as smartwatches [18,27,25]. This approach represents a fascinating perspective on ATs but is still too complex and expensive [30].

3.2 Developed Skills

In the selected studies, assistive technologies were used to support the development of different kinds of skills in workers with autism spectrum disorder.

Specifically, three macro types of skills can be identified: 1) pre-vocational skills, namely «the basic skills and abilities essential for employment in any field, such as following directions and being punctual»[13] (e.g., social skills, communication skills) [32-34]; 2) generic on-the-job skills (e.g., participating to a job interview, preparing a job application) [18,27]; 3) specific on-the-job skills (e.g., answering the phone, photocopying) [19,24,18,27].

The assistive technologies identified can support the development of these skills by 1) teaching to workers with ASD through video modelling [32-34]; 2) supporting the memorization of the sequences of actions necessary to carry out a work task providing auditory and visual antecedent prompts [19,24]; 3) giving job performance feedback [3]; 4) simulating job situations and work tasks using virtual reality [18,27,25].

Although the different assistive technologies can all be functional to the development of the different types of skills mentioned above, some possible trends in the choice of assistive technology in relation to the skills to be developed in the worker with autism spectrum disorder seem to emerge from the literature in this field.

Tablet and Laptop computer on which various types of software can be installed, appear to be useful for supporting, through video modelling, the development of prevocational skills. iPod, iPad, iPhone, Wearable are used, always in combination with software that make them Personal Digital Assistants, to support the development of specific on-the-job skills. The same happens, but without the use of software as they make use of the remote presence of a tutor, using Radio and headset. Finally, the use of virtual reality production systems appears to be of growing interest to support development of generic on-the-job skills.

3.3 Related Work Activities / Job Tasks

Within the articles included in this review, assistive technologies were used to teach workers with ASD to carry out different jobs or labour market related activities (i.e., participating a job interview).

[13] APA Dictionary of Psychology (https://dictionary.apa.org/prevocational-training) [21/01/2022].

It should be noted that the studies mainly referred to the use of assistive technologies for workers with ASD in the fields of public administration, office work [7,12,23].

The analysis of the different studies highlighted how the use of assistive technologies to support the labour market inclusion of persons with ASD requires that each job task be carefully analyzed and divided into specific and detailed sequences of actions. This is a fundamental step as it allows you to identify the appropriate auditory and visual prompts, plan feedback and program video modeling software [3] [25].

4 Conclusions

This systematic review allowed to deepen the ATs knowledge for workers with autism spectrum disorder. Expanding knowledge in this field is strategical for supporting the labour market inclusion of persons with ASD, especially in Italy.

In fact, in our country, the absence of a national database collecting and disseminating the different ATs and reasonable accommodations adopted by employers, make workplace assistive technologies a hard-moving universe, unlike other countries where some national databases in this field are operational, such as the Job Accommodation Network in the United States.

However, a further element for reflection must be brought to attention: an in-deep knowledge of assistive technology itself is not enough to achieve workplace inclusion. In fact, ATs represent a useful tool that can unfold its potential if properly selected and inserted within a personalized workplace inclusion project, integrated with the broader life project of the person with disabilities [1,2,8].

This requires companies to have an in-depth knowledge not only regarding disability, assistive technologies, labour laws, reasonable accommodation, but also related to humanities like pedagogy and psychology.

It is an indispensable knowledge to allow companies to define objectives, strategies, activities, appropriate tools, and evaluating methods for designing a project capable of responding and balancing the needs of the person with ASD and those of the workplace, so to improve their labour market participation and inclusion.

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Living at Home with Dementia

A Multi-Stakeholder Perspective on Challenges During the Night

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Abstract. An increasing number of people with dementia live at home, despite psychosocial and medical conditions, with an increasing burden for the informal caregivers as a result. Behavioural changes, such as wandering, sundowning, and agitation, are important predictors for caregiver burnout, with institutionalization of people with dementia as a result. The aim of this study was to gain insight into the challenges people with dementia living at home and their informal caregivers experience during the night, that can contribute to the development of technological interventions. Semi-structured interviews with people with dementia and their informal caregivers were combined with a focus group with formal caregivers, resulting in an empathy map of people with dementia and their informal carers. Improving the knowledge about the importance of good sleep and opening up the discussion about sleep will increase the potential for tackling problems related to sleep for both people with dementia and their carers. Structure in day and night activities, both physical and mental, seem crucial for sleep quality. Also, a person-centred approach in dementia care is evident. Personal habits and behaviours of people suffering from dementia must be collected and well-documented in time, and shared with those involved in determining the person-centred dementia care, and developing supportive technologies.

Keywords: Dementia, Sleep, Empathy Map, Gerontechnology.

1 Introduction

As an increasing number of older adults choose or are forced to live independently in their homes for as long as possible, many people with dementia live at home, despite psychosocial and medical conditions. As dementia is characterized by deterioration in cognitive, neuropsychiatric and functional skills, the burden for the informal caregivers increases over time. Caring for a person with dementia becomes more difficult due to Behavioural and Psychological Symptoms of Dementia (BPSD) and sleep disturbances [1]. Sleeping patterns of people living with dementia have been reported to be shorter, lighter and more easily disturbed [2], with more fragmented sleep-wake cycles, more sleep during the day and less at night [3] than can be ascribed to normal ageing. These behavioural changes, such as wandering, sundowning, as well as related agitation, are important predictors for caregiver burnout and subsequently some of the major causes of institutionalization of people with dementia [4-5].

Many studies have been conducted on the needs of people with dementia living at home, and how to support dementia care at home. The focus has been mainly on difficulties in ADL. However, less emphasis has been on the needs of the informal caregivers, and challenges during the night, while the effect of sleep and sleep quality on social, mental and physical health becomes more and more evident [6]. At the same time, insights into what influences a good quality of sleep is increasing [7]. The aim of this study was to better understand the challenges people with dementia living at home and their informal caregivers experience during the night. The goal was to actively involve people with dementia, informal caregivers, as well as formal caregivers to gain insight into a multi-stakeholder perspective. These insights can contribute to the development of technological interventions that support people with dementia and their cares in a good night's sleep.

2 Method

2.1 Interviews During Home Visits

Semi-structured interviews were conducted with people with dementia and their informal caregivers to gain insight into their problems and challenges during the night in relation to sleep and sleep quality. The interviews were held from December 2021 to February 2022, during home visits, so the respondents could stay at home in their familiar environment, and people with dementia were accompanied by their family carers. Due to Covid-19, it was also proposed to have an online or telephone meeting. The research population consisted of people with dementia, living at home, preferably with partner (informal carer), experiencing difficulties or challenges during the night, and being able to participate in a conversation with the researcher and the informal caregiver.

Participants were found within the network of the project consortium. The consortium partners contacted potential participants by telephone or face-to-face. In case a person was interested in participation, more information on the research was provided by means of an information letter. By giving informed consent, the participant confirmed being informed, agreed upon free participation without obligations, and agreed on being contacted by the researchers to set a date. They were also asked to keep a sleep diary for 2-7 days, based on the NHG (Dutch College of General Practitioners) guideline [8], before the visit. During the visit, open questions were posed, using topics based on literature and the guideline 'Care for Healthy sleep and sleep problems' [9], regarding day/night rhythm (including daytime napping, activities during the day, eating patterns; difficulties during the night); evening routine (including eating and drinking patterns in the evening, screen usage, need for sleep); causes and effects of sleep disturbances (including health situation, medication, physical condition of bed room, daytime functioning, mood, and fatigue).

2.2 Focus Group

In addition to the home visits, a focus group with formal caregivers was organised. The goal was to extent or confirm the results of the home visits from a multi-stakeholder perspective. The research population consisted of formal caregivers with experience in dementia care and sleep disturbances. Participants were again found within the network of the project consortium. The recruitment process was comparable with the home visits. The focus group was organised in February 2022 online, due to Covid-19 restrictions, using MS Teams for video conferencing and Mural (www.mural.co) for online collaboration and discussion.

2.3 Data-Analysis

Both home visits and focus group were recorded. The interviews were transcribed. The results of the focus group was captured in Mural. The aim was to develop an empathy map. An empathy map is a collaborative visualization used to articulate what we know about a particular type of user, in this case people with dementia and their carers [10]. Two researchers analysed the transcripts and the notes in Mural separately, using the themes of the empathy map: thought process (think & feel); influences (see); discussion (hear); decision / action (say & do); pains; and gains. In collaboration, the researchers structured the results in two final empathy maps.

3 Results

3.1 Participants

Eleven people were interviewed in this study. Three women suffering from dementia [59-83; mean age: 75], five informal caregivers [1 male, 4 female; 74-86; mean age: 82] and three formal caregivers [all female]. Two informal caregivers did not agree on including their relative with dementia in the interview. One woman suffering from dementia did not involve an informal caregiver for the interview. Two interviews were made during home visits, others by telephone. Interviews with formal caregivers were realised by means of MS Teams video calling. Three formal care givers participated in the focus group: a dementia care coordinator; a nurse / care center consultant; and a nurse specialist [all female].

3.2 Empathy Map of People with Dementia

People with dementia have difficulty in accepting the loss in abilities. “To admit that it no longer is allowed and possible, that’s kind of… eh…well it’s okay now, but in the beginning…” [R1]. It results in worries, that effects a good night sleep. Upcoming daily activities may also trigger those worries. “Tomorrow home care will come; she comes early… but their timing changes constantly, so I have to keep an eye on that” [R1]. They have learned to listen to their body, in what is possible, and what is not. Making notes may help to reduce the worries and thoughts.

Participants indicate that having a planning with activities helps to sleep better. However, some people with dementia mention a lack of activities. “I’m older and alone, and

I only have the television and my books" [R2]. Going to bed at a fixed time, having a normal nap during the day, not drinking more than normal supports a good sleeping rhythm. Also, a convenient and fresh bedroom contributes to a good night sleep (see Fig. 1).

Fig. 1. Empathy Map of People with Dementia.

The 'pains' people with dementia experience are the limitations in physical activities (outdoors) due to dementia and ageing; the physical restrictions by others for safety reasons (e.g. locking doors); and difficulties in understanding technology.

3.3 Empathy Map of Informal Caregivers

Informal caregivers feel tired and powerless, not knowing what is best for their loved ones. "Each day is different" [R4]. Some indicate that they sleep lightly, being afraid something might happen during the night. Others deliberately sleep in separate beds or with separate mattresses, to maintain their own sleep quality. "I have to take care of my own rest; otherwise I won't make it during the day" [R6]. A walk with volunteers or other daytime activities for the person with dementia during the day helps the informal carer to recharge. However, informal cares feel uncomfortable in transferring the care for their loved one to other people (e.g. relieve care services) (see Fig. 2).

Main 'pains' experienced by informal caregivers are: the right timing for institutionalised care; the separation from their spouse; and bad night sleeps. 'Gains' can be found in attention for their own rest; contact between fellow-sufferers; and a sympathetic ear by professionals.

Fig. 2. Empathy Map of Informal Caregivers.

4 Discussion

Due to Covid-19 home visits were not always possible and desirable. Therefore, recruitment was difficult and the semi-structured interviews were not as 'person-centred' as intended. Besides, informal caregivers of people with dementia often felt too much burden to participate in research. As a result, formal caregivers were also involved in the interviews.

Although using the empathy map as a data-analysis tool is unconventional, it appeared to be an efficient method to come to multi-perspective results and insights.

Despite the original focus on ethnical and sociocultural diversity within participants, this was not accomplished in this study. However, cultural differences are prevalent in acceptance and confirmation of suffering from dementia [11]. Also in the caregiving process cultural differences are highly important, in order to be able to provide person-centred care, especially in dementia care, where people suffering from dementia are even more relying on cultural and ethnical habits and needs.

5 Conclusion

There is still a lack of attention for quality of sleep and sleep disturbances, especially in dementia care. Improving the knowledge about the importance of good sleep and opening up the discussion about sleep will increase the potential for tackling problems related to sleep for both people with dementia and their carers.

Besides increasing the knowledge about sleep and sleep quality, and how to improve this for people suffering from dementia, structure in day and night activities seem crucial. Activities, both physical and mental, during the day influence the need for sleep during the night.

Due to the multi-stakeholder approach in this study, the relevance of a person-centred approach in dementia care became evident. Therefore, it is important that personal habits and behaviours of people suffering from dementia are collected and well-documented in time, and shared with those involved in determining the person-centred dementia care, and those developing supportive technologies.

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Augmentative and Alternative Communication (AAC) Emerging Trends, Opportunities and Innovations

Evaluation of STT Technology Performance for Spanish Dysarthric Speech: Description of a Pilot Experiment

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Abstract. Automatic Speech Recognition (ASR) systems might be especially beneficial for people with physical disabilities. However, people with functional diversity usually present difficulties in speech articulationtoo, one of the most common being dysarthria. Existing commercial ASR systems are not able to correctly understand dysarthric speech, and although some investigation tackling this issue has been conducted, an optimal solution has not been reached yet. Some commercial ASR systems, such as Microsoft Azure Speech to Text, offer a customization interface where users can train a base model with their speech data and thus improve the recognition accuracy. This paper evaluates the performance of this commercial ASR system when exposed to Spanish dysarthric speech. Results show that, overall, the customized models outperform the basemodels of the system. However, the results were not homogeneous, and even though the recognition accuracy improved considerably, the results were far from being as good as those obtained for typical speech.

Keywords: automatic speech recognition, dysarthria, intelligibility

1 Introduction

Automatic Speech Recognition (ASR) is a technology that enables the recognition of spoken language and converts it into text. We can find it implemented in Environmental Control Systems (ECS) or in Virtual Assistants (VA), among others. A group that can especially benefit from these technologies are people with physical impairments or reduced mobility. However, many people with disabling conditions also present a disordered speech, such as dysarthria, associated with neuromotor conditions. This obstructs the accurate recognition of their speech for ASR systems, which have not been trained to recognize non-typical voices. In order to develop an ASR system, there is a need to have big amounts of speech data; however, recording processes can be challenging for people with speech difficulties. The currently existing dysarthric speech databases are mostly in English, and have not been collected for the purpose of ASR system training. Besides, even if dysarthric speech databases existed, each person with dysarthria presents his or her own speech features and pronunciation difficulties. Therefore, it is very difficult to create a homogeneous dysarthric speech database that can be used to train

ASR systems. However, some commercial speaker-independent ASR systems provide their users with a customization interface; a small amount of data from the future user is collected and used to adapt the speaker-independent model. Our approach has been to use the Microsoft Azure Speech to Text speaker-adaptive ASR system with the aim of evaluating its capacity to be personally and individually adapted to people with dysarthria.

1.1 What is Dysarthria?

Dysarthria is a speech disorder caused by disturbances in neuromuscular control of the speech mechanism. It does not affect the creation of grammatically correct sentences, but it leads to a more imprecise articulation of words. Different types of dysarthria can be categorized depending on the affected area of the neuromotor system. Symptoms may also vary depending on the type of dysarthria.

2 Related Work

There are already some services that have been specifically designed for people with dysarthria. In the case of ECS, we can find the STARDUST project [12] or the homeService project [5]. When it comes to Speech-Generating Devices (SGD), there is the Voice Output Communication Aids (VOCA) [6] and the Voice-Input Voice-Output Communication Aids (VIVOCA) [9], the ModelTalker project [3], the AhoMyTTS initiative [8], or Voiceitt [11].

To the best of our knowledge, there are no available databases of dysarthric speech in Spanish. Besides, the existing databases in English or other languages have been designed as part of diagnosis tests, but not for ASR or VA; also, samples were collected in a professional setting.

Different evaluations have measured the accuracy of ASR systems when exposed to dysarthric speech [1, 2, 4, 7, 10]. Most of them have been carried out in English, and with speaker-independent systems. On the other hand, those studies that trained a system with the users' speech obtained high accuracy rates in clinical environment. However, they are not likely to be replicated in non-clinical environments.

In our approach, we use an adaptive speaker-independent ASR system. This consists of using a speaker-independent system that can be customized for different speakers with a minimum amount of speech data. Microsoft Azure was thought to be the most adequate ASR commercial system for our experiments, as it provides a customization interface for language and acoustic models and the chance to use different base models for customization.

3 Database

3.1 Description of Participants

C1 is a 13-year-old girl who has congenital cerebral palsy. She has a slow speech rate, her voice is breathy with high volume, and she produces long syllables. Sometimes she introduces pauses between syllables.
M1 is a 51-year-old male who has congenital cerebral palsy. His speech is slurred and somewhat nasal. Sometimes introduces pauses between syllables.
F1 is a 59-year-old woman whose dysarthria is due to a brain anoxia. She has a short speech and presents difficulties to sustain sounds. Her vowel sounds are not very clear.
R1 is a 26-year-old woman with typical speech, that is, a speech with no pathologies. The results obtained by this speaker are a reference of what Azure Speech to Text is capable of. Results obtained in the R1 models should be considered a goal for the rest of the models.

3.2 Recording Process

The recording process involved the recording of 10 different sessions. Each session was composed by the corpus of 21 commands. Therefore, we ended up having 210 audio recordings from each speaker (10 times each command). We obtained the same amount of data from the reference speaker. The order of the commands that were to be recorded was altered from session to session; this way, we avoided the predictability effects. All recordings were performed in a home environment, so that the system was trained in the real future environment. This also maximized the subjects' comfort, as they did not need to attend recording sessions in remote locations. Besides, each individual decided the duration of each recording session. Enrolled subjects were asked to conduct their recording sessions in different days and at different times of the day. This way, the variability of the speech would be greater and the system would not be customized based on a single recording session. Hence, the recording sessions are spanned across the period of days or weeks, and the recording sessions can have any duration.

4 Experiments

The experimental evaluation has three main sections: automatic evaluations, human evaluation and evaluations through an app. They are described in the following subsections.

4.1 Experiment I: Azure Custom Speech to Text

Azure Custom Speech to Text is the name of the interface of Azure to customize the user's models. It offers 4 versions of the base model. We conducted a preliminary test with all of them to evaluate them without additional training.

In all cases, the best results were obtained by base model 20201015. We chose this model to train it and to conduct all our experiments. To train the model, we used audios, orthographic transcriptions and related text (a text containing the vocabulary of the audios). We used the jackknife or leave one out method to get cross-validation results. Therefore, we always trained the model with 9 different audio sessions and then tested it with the tenth session. Some experiments also included a finite state grammar, which limited the recognition to the words included in it. We have used four different models per speaker: base model (*B*) (provided by Azure), base model with grammar (*BG*) (not acoustically trained but using vocabulary restrictions), custom model (*C*) (acoustically adapted with audios from the user) and custom model with grammar (*CG*) (acoustically trained model also using vocabulary restrictions). For the adaptation of the models, we used audios, orthographic transcriptions and related text (the finite grammar). In this experiment, we evaluated the learning performance of the customization interface. We trained the base model provided by Azure and measured the Accurately Recognized Commands (ARC) and the Word Error Rate (WER).

4.2 Experiment II: Human Evaluation

In order to see whether humans were able to understand our participants, we conducted a perceptual test in which each person would have to listen to 30 commands uttered by each speaker. They had to transcribe what they understood and then indicate the perceived difficulty of understanding, rating it from 1 to 5 being 1 very easy and 5 very difficult to understand. We also calculated the ARC and the WER for the human evaluation (*HE*) based on the answers we got.

4.3 Experiment III: Implementation

We built an online site where the speakers tested the trained models with live input from the microphone. The base model was trained with all the available recorded audio data (that is, 210 audios for each speaker). No finite grammar was included in the testings, as it was not feasible to use it with live input.

5 Results

5.1 Experiment I: Azure Custom Speech to Text

Accurately Recognized Commands. The ARC represents the commands that have been recognized without any errors. The graphics below (see Fig.1, 2, 3 and 4) show the mean average results (after cross validation) for all 3 speakers with dysarthria. In green, we have the correctly recognized commands, in red the commands recognized with one or more errors and in blue the not recognized commands (that is, when the system output a blank space because it not understand anything). The models with the highest ARC were the custom models with grammar (*CG*). The models with the lowest ARC were the base models (*B*). In the case of **R1**, the system performed perfectly in 3 cases, and it only failed 3 commands when using the base model. Although the results for the speakers with dysarthria were not perfect, there was a relative improvement over the base model. The highest ARC (after training) was obtained by **M1**, followed by **C1**, while the lowest was obtained by **W1**.

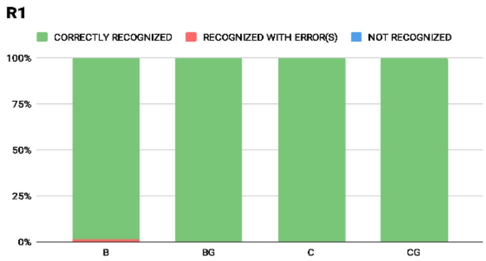

Fig. 1. Percentage of ARC for speaker R1.

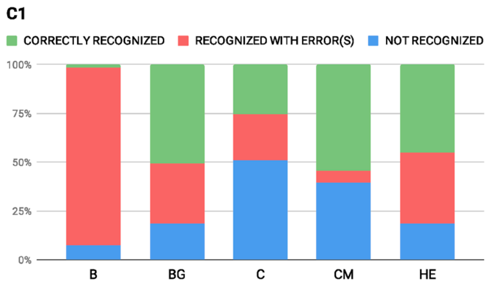

Fig. 2. Percentage of ARC for speaker C1

Fig. 3. Percentage of ARC for speaker M1

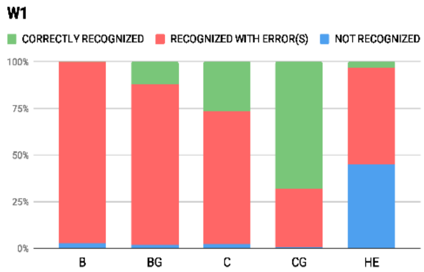

Fig. 4. Percentage of ARC for speaker W1

Word Error Rate (WER). The WER represents the total number of wrongly recognized words. The lower the value is, the better the output has been. The lowest value possible is zero. The types of error that compose the WER are substitutions (a term is replaced by a different one), deletions (words that have been omitted and not replaced by another one), and insertions (words that have been added to the reference). The highest WER was always obtained by using the base models (B); however, the lowest WER was obtained with different models, depending on the tested speaker (See Fig. 5).

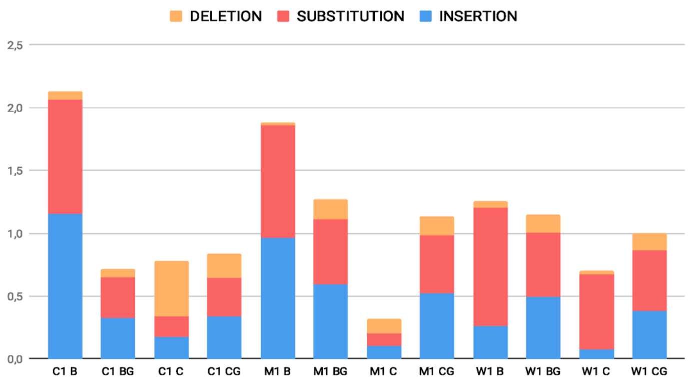

Fig. 5. WER per speaker and model

5.2 Experiment II: Human Evaluation

A total of 85 people took part in the perceptual test, 10 of which had experience in talking to people with dysarthria. We concluded that this previous experience was not relevant in the results. The ARC was not as good as those of the custom model with grammar (see Fig.1, 2, 3 and 4). Results showed that the higher the WER obtained in the transcriptions made by the evaluators, the higher the perceived difficulty of understanding (see Table 1). Therefore, there is a relation between the errors made in the transcriptions and how difficult the speaker was to understand.

Table 1. Human evaluation total WER and perceived difficulty (P.D.) with their standard deviations.

Speaker	WER	P.D.
C1	0.635 (± 0.689)	3.685 (± 1.302)
M1	0.749 (± 0.692)	3.880 (± 1.283)
W1	1.095 (± 0.443)	4.540 (± 0.801)
Average	0.827 (± 0.646)	4.030 (± 1.210)

Most Difficult and Easiest Words. We calculated the number of times a word was correctly or incorrectly recognized using each model. There was a relation between the personal pronunciation difficulties of each speaker and the final output of the speech recognizer. Apart from this, the easiest and most difficult words coincided with those subjectively perceived as easy and difficult by the human evaluators.

5.3 Experiment III: Implementation

Regarding the online site results, the ARC was not as good as with pre-recorded data for any of the speakers (see Fig. 6). In this case, there is no "not recognized" category, the system always recognizes something. Regarding the WER results (see Fig. 7), the distribution of the types of error is very similar to those for the pre-recorded data.

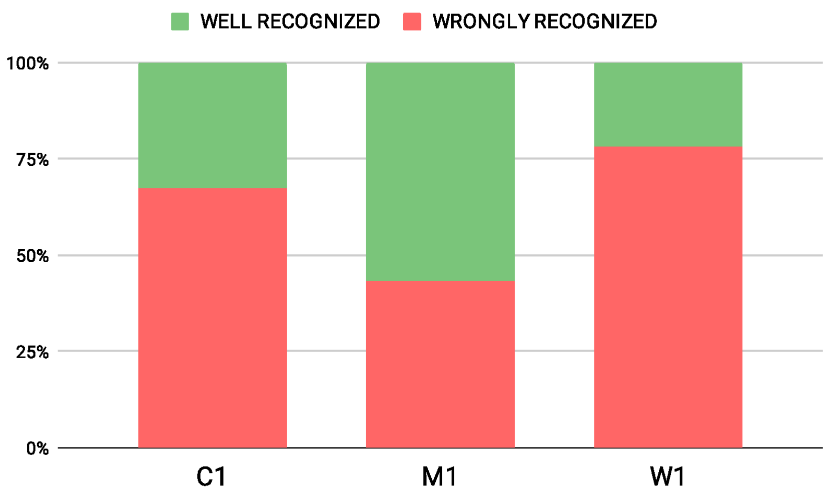

Fig. 6. Percentage of ARC of online site

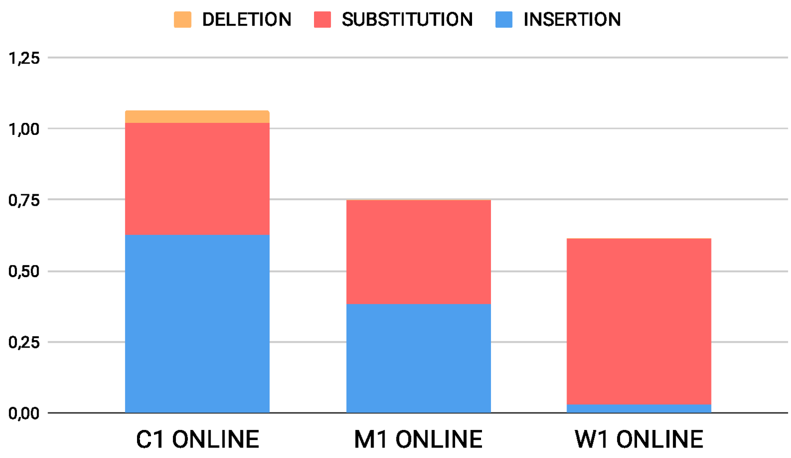

Fig. 7. Online site WER per speaker

6 Questionnaire for Participants

The participants filled a questionnaire about their experience. They claimed that they did not struggle to perform the recordings and found the website easy to use. They also agreed on the fact that there are currently not enough adapted speech technologies, and provided some implementation ideas. For example, they would like to use speech technologies in their home and social environments, or to control their personal computers.

7 Discussion and Conclusions

Although speaker-adaptive ASR systems appear as an attractive option for dysarthric speech recognition, our experiments show that there is still room for improvement. We chose a commercial ASR system which has demonstrated a very good performance with typical speech, but the results when adapting the system to dysarthric speech are disappointing, even after adaptive training.

Besides, the system itself has limitations. It is not feasible to include a finite grammar in the online site experiments. On the other hand, the customized models cannot be embedded for local use in Windows applications. The lack of dysarthric speech databases is also a huge disadvantage over typical speech.

The results obtained varied among our speakers; they are only based on three people with dysarthria, and we did not find any common patterns among them.

There is a clear need and demand for speech technologies for people with speech articulation difficulties, and having access to these technologies would greatly improve their quality of life.

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Analysis of the Communicative and Linguistic Functions of some Alternative and Augmentative Communication Software for the Italian Language

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Abstract. CAA supports communicative interactions, and its use enables communicative exchanges. Some research has shown that people who use AAC have difficulties mastering the rules and conventions of the language (Binger et al., 2011). Few studies have investigated language development in AAC users: it is, therefore, urgent to reflect on whether and how AAC systems support communication at a pragmatic and semantic level and allow users to be exposed to correct and complex linguistic input. Selecting different language components and identifying their diversity of word class and syntax, morphology, and grammar requires AAC developers to have «an in-depth knowledge and understanding of the underlying grammar structure language, as well as typical age and development path in which specific words and linguistic structures are found acquired and used» (Soto & Cooper, 2021:7). This paper intends to compare some AAC software tools developed for the Italian language at a double level, pragmatic/semantic and morphological/syntactic, using an analysis tool specifically developed for the Italian language and based on the Graphic Symbol Utterance and Sentence Development Framework (Binger et al., 2020). The comparison of AAC software shows that they allow and facilitate communicative exchange, but as the complexity of the linguistic components increases, several limitations emerge.

Keywords: Alternative and Augmentative Communication software, Checklist, Language development

1 Background

Alternative and Augmentative Communication (AAC) is widely acknowledged to support communicative interactions for persons with complex communication needs (CCN) due to limitations in their communicative abilities because of speech, language, physical or cognitive impairments [3].

Using AAC allows communicative exchanges, but some recent research has shown that people utilizing AAC present several difficulties in mastering the rules and conventions of the language (mother tongue or foreign language) [4] [5]. This can lead AAC users to poor linguistic production, with errors or inaccuracy at the morpho-syntactic level hindering the understanding and correct carrying on a conversation with other interlocutors [18], the achievement of the school academic requirements [13], and the employment maintaining [2].

Therefore, it becomes urgent to reflect on whether and how AAC systems represent tools for supporting communication and instruments allowing users to learn the language and its rules in all their complexity and richness.

The few studies that have investigated language development in AAC users have found that there are several variables affecting the path of language acquisition [19]. Among these two are of particular importance: the AAC software used, which undoubtedly represents a language learning environment different from that of spoken language, and the way with which the system is used [18].

Typically, the AAC software organizes and presents the different language components (e.g., nouns, verbs, adjectives) in specific communication boards. These are designed by the software developer and give AAC users the opportunity to customize them.

Selecting, organizing the different language components, identifying which of them to propose within the communication boards requires the developers of the AAC systems to have «an in-depth knowledge and understanding of the underlying grammar structure language, as well as typical age and development path in which specific words and linguistic structures are found acquired and used» (pg. 7) [18].

Software for AAC must make communicative exchanges possible and support the acquisition of language, its semantic richness, and the mastery of its complex morpho-syntactic and grammatical rules.

The literature highlights how few studies have been conducted so far regarding the linguistic aspects of AAC software and those carried out are oriented to the English language, while those that have considered other languages, those of Latin derivation such as Spanish and Italian, are limited [18].

Considering these considerations, this paper presents the results of an analysis conducted on some AAC software for the Italian language to investigate to what extent they are configured as tools for communicative exchanges (pragmatic level) and as tools to support language learning.

2 Method Used

With this aim, we developed a specific tool (Evaluation Questionnaire) for the Italian language based on the Graphic Symbol Utterance and Sentence Development Framework [6]. It describes the typical broad movement from the pragmatic and semantic level to the morpho-syntactic and grammar one adapting it for AAC English users with CCN (see Fig. 1).

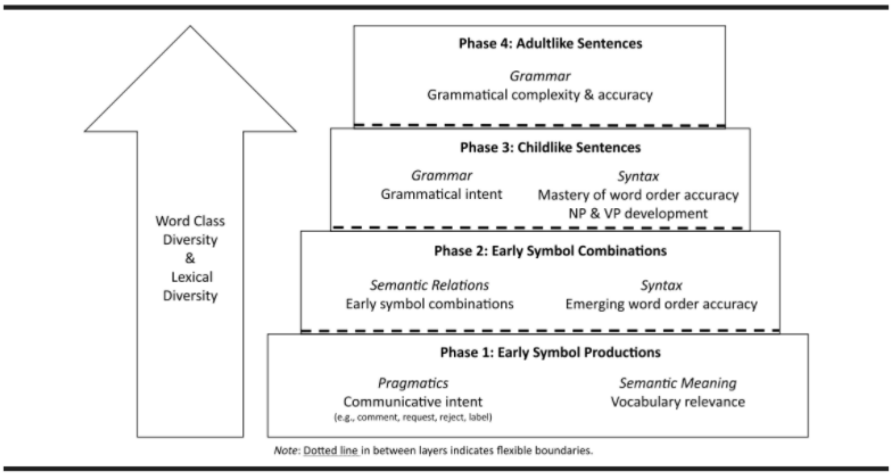

Fig. 1. Graphic *Symbol Utterance and Sentence Development Framework* (Binger, Kent-Walsh, Harrington & Hollerbach, 2020:320).

Our tool is composed of 12 questions aimed at evaluating whether different AAC available software for the Italian language helps children to move beyond early pragmatic and semantic development and acquire grammatical skills along the path to meeting typical language milestones and becoming sophisticated communicators.

The linguistic components characterizing each of the four phases of the Framework were deeply analyzed, re-arranged for the Italian language and specific indicators were exploited to develop a new checklist composed of 12 items. The tools explore the following areas and subareas: communicative intent (pragmatics & vocabulary relevance), vocabulary meaning (semantic relation), word class and lexical diversity (word class & lexical diversity), syntax, morphology, and grammar (word order accuracy, type of sentence & inflectional morphemes) (Table 1.).

Table 1. The developed Evaluation Questionnaire

Level	Components	Questions
Communicative intent	Pragmatics (communicative intent)	*Does the software provide options for requesting, rejecting, obtaining attention, and commenting?*
	Vocabulary relevance	*Does the software allow the user to select vocabulary relevant to the context?* *How does the software store and organize the symbols used for AAC?* *Does the software storage system allow choice?*

Vocabulary meaning	Semantic relation	*Is the software storage system of symbols designed to serve the user?* *Is the software storage system designed to display symbols as the user's level of mastery increases?*
Word class and lexical diversity	Word-class	*Does the software offer a wealth of word-class diversity both close word classes (determiners, pronouns, prepositions, and conjunctions) and open word classes (nouns, verbs, and conjunctions)?*
	Lexical diversity	*Does the software offer a wealth of word class diversity of open word classes (synonyms of nouns, verbs, and conjunctions)?*
Syntax, morphology, and grammar	Word order accuracy	*Does the software guide the user in the correct arrangement of the words respecting the syntactic order of the language (such as the disposition subject + verb + object)?* *Does the software provide feedback to the user regarding the incorrect syntactic arrangement of words in a sentence?*
	Type of sentence	*Does the software allow the user to construct the different types of sentences specific to the language, declarative, interrogative, coordinated and subordinate of various types and degrees?*
	Inflectional morphemes	*Does the software allow the user to use the different inflectional morphemes of his language?*

The following applications were then purchased and analyzed: Clicker 6, Mind Express, Symwriter2, The Grid 3, Verbo, LetMe Talk, AAC Talking Tabs, Dialogo AAC, Go Talk Now, Widgit Go It, Parla con Me. For each of them, the Evaluation Questionnaire prepared was completed.

3 Results and Discussion

Below the main results obtained using the Evaluation Questionnaire are presented and discussed.

3.1 Communicative Intent (Pragmatics & Vocabulary Relevance)

All the selected software provides options for requesting, rejecting, obtaining attention, and commenting thus fulfilling the pragmatic function of communication-related to basic needs or simple choices. They also offer a rich vocabulary to support daily communicative interactions.

According to Drager et al. (2006), AAC can increase some functional communication skills as the expression of needs and wants (e.g., requesting, rejecting, making choices), the development of social closeness, the exchange of information (e.g., play activities, social routines), and the fulfillment of social etiquette expectations.

3.2 Vocabulary Meaning (Semantic Relation)

All software, except Dialog AAC, allow users to easily reorganize the vocabulary categories. Most of the software follows the logic of the velcro of the PECS. The result is a predominantly denominative approach, although it is possible to construct some simple sentences.

The possibility for the user to be able to reorganize the vocabulary is an element of extreme importance in the AAC as it allows him/her to use the semantic relations he/she possesses or that are processed during language learning [14]. Furthermore, a personalized reorganization of the vocabulary directly influences his/her ability to foster early language and communication development [9].

3.3 Word Class and Lexical Diversity (Word Class & Lexical Diversity)

All software offers a wealth of word classes and lexical diversity. They range from neighboring word classes (determinants, pronouns, prepositions, and conjunctions) to open word classes (nouns, verbs, and conjunctions). However, not all the linguistic components are reported in the communication boards, except Parla con Me which provides a vocabulary chosen based on linguistic studies of the high-frequency vocabulary of spoken Italian.

In a software (Clicker 6) it is possible for the user to create semantic links between the various words. This is a positive aspect, but it could also generate semantic confusion also in relation to the different CCN.

Vocabulary selection represents one of the most critical components of AAC because the chosen vocabulary influences language and communication development. Historically, AAC focused on nouns [1]. This may be because many concrete nouns can be represented with high iconicity relative to other word classes, using symbols [16].

Recently research have highlighted that this overreliance on nouns has decreased favoring the diffusion, within the communicative tables, of verbs [11]. This enrichment in the communicative table’s design is important because the inclusion of other word classes, in addition to nouns, enables children with CCN to communicate across different contexts and for various reasons [17].

3.4 Syntax, Morphology, and Grammar (Word Order Accuracy, Type of Sentence & Inflectional Morphemes)

Most of the software (7/11) allows users to compose sentences respecting the correct positioning of diverse linguistic components. Only AAC Talking Tabs provides a rigid system (e.g., the subject precedes the verb) not responding to the flexibility and complexity of the Italian language. In addition, Widgit Go It does not present inflectional morpheme options.

Lastly, through the different configuration levels (from beginner to competent and advanced), only Parla con Me appears the most complete from the morpho-syntactic level for the following reasons: 1) the variety of synonyms and vocabulary sets much more extensive than other series of board created with both Grid 3 and other software; 2) more than 20 categories and 80 sub-categories composed by an average of 50 words; 3) more than 1000 fully conjugated verbs (in other software those who create/modify the boards must insert the various verb forms themselves).

The richness of Parla con Me at the morpho-syntactic level is extremely important for the development of language and communication skills and responds to recent literature evidence. For example, Savaldi Harussi et al. (2017) underline that the number of conjugated verb forms that a software possesses is necessary for creating clauses.

It should also be noted that the acquisition of intransitive verbs appears to be important for supporting children's transition from single word to multiword utterances [10]. This may be because intransitive verbs do not take or require a direct object to form a grammatical sentence, whereas transitive verbs require a direct object [10]. As for vocabulary acquisition, children with CCN need additional exposure and more opportunities to practice using target grammatical constructions [8].

4 Conclusion

The comparison between the 11 AAC software conducted with the Checklist is not so faithful to the complexity and richness of the Italian language. All allow and facilitate the communicative exchange (*communicative intent*), but as the complexity of the linguistic components increases, various limitations emerge. This urges for a deeper understanding in the AAC area and a preliminary linguistic awareness of the software developers on the different linguistic components delivered by the boards. The research has made it possible to highlight how important it is to consider both the communicative and linguistic components to fully exploit the potential offered by the AAC and at the same time, to promote the acquisition of more sophisticated morphosyntactic skills in children with CCN.

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Participation of Stakeholder in the Design of a Conception Application of Augmentative and Alternative Communication

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Abstract. The objective of this paper is to describe the implication of an interdisciplinary team involved during a user-centered design methodology to design the platform (WebSoKeyTo) that meets the needs of therapists to design augmentative and alternative communication (AAC) aids for disabled users. We describe the processes of the design process and the role of the various actors (therapists and human computer researchers) in the various phases of the process. Finally, we analyze a satisfaction scale of the therapists on their participation in the codesign process. This study demonstrates the interest in extending the design actors to other therapists and caregivers (professional and family) in the daily life of people with disabilities.

Keywords: user-centered design, stakeholders, participation of therapist, satisfaction.

1 Context

Assistive technologies for communication and home automation allow people with disabilities to be autonomous and better social participation. However, many of these assistive technologies are abandoned [1] because they do not sufficiently take into account the expression of the needs of these people. In order for these technologies to meet the needs, it is important to involve, in user-centered design, occupational therapists and psychologists who can complement or express the needs of people with disabilities as part of their ecosystem [2]. Moreover, their expertise allows them to evaluate the abilities of the disabled person to better adapt the assistive technologies to their needs.

In previous work [3], experts in human-computer interaction developed AAC with the SoKeyTo platform [4] based on the needs expressed by therapists. It consists of a page and button editor for the use of AAC designers.. It consists of a page and button editor for the use of AAC designers. The editor allows defining the morphology and the contents of the buttons (text, picture and sound), the visual and sound feedback and the type of associated function (simple communication function, call of an application, sending of messages according to protocols to restore an oral message with a text-to-speech system) and the structuring of buttons in page. The SoKeyTo platform editor allows the customization of the AAC interface and the connection of several input interaction modes (pointing device, eye tracker, joystick, speech recognition, on/off switch). SoKeyTo also allows various control modes to be configured (pointing, time delay click, scanning system) according to the abilities of disabled people.

Calmels et al. [4] reported the limits of the design of AACs by human-computer interaction engineers (difficulty in understanding the needs given by the therapists; longer design time and availability of AAC due to numerous exchanges between designers and therapists; impossibility to test AAC adaptations online). This study also demonstrated the crucial role of occupational therapists in the learning phase and the adaptation of AAC to abilities and behavior of the disabled person. Indeed, occupational therapists and psychologists have knowledge and know how to do for adapting and personalizing AAC during the occupational therapy sessions.

Numerous studies have addressed the issue of end-user participation in the codesign of applications. Gibson et al. [5] give recommendations to overcome barriers on how to better support people with disabilities to engage in codesign. Dijks et al. [6] have proposed participation methods that empower people with impairment to actively take part in the design process. Ambe et al. [7] presents codesign fiction as an approach to engaging users in imagining, envisioning and speculating not just on future technology but future life through co-created fictional works. These studies show that different methods of codesign are invented to overcome barriers in order to facilitate the participation, the expression of needs and the proposal of solutions by end users.

Participatory design with therapists without experience of user-centered design method poses challenges for researchers and designer due to the differences in their mutual experiences and knowledge. In this paper, we firstly highlighted the methodological approach adopted for the codesign of WebSoKeyTo, taking into account the experiences of using AAC produced by SoKeyTo. Then, we report the satisfaction questionnaire about the participation of the therapist in the design process of the WebSoKeyTo platform.

2 Codesign of the WebSoKeyTo Platform Using a User-Centered Design Method

Figure 1 describes the different phases of the user-centred design methodology [8] of the WebSoKeyTo platform for designing alternative augmentative communication aids. The team consists of six therapists (4 psychologists, 2 occupational therapists) and 5 human-computer interaction researchers (3 senior researchers and 2 students). The six therapists had never participated in a focused design method before. One of the therapists has a dual background (psychologist and computer specialist). The following section describes the phases of the implementation of the method. A satisfaction questionnaire on the participation of the therapists ends this design cycle.

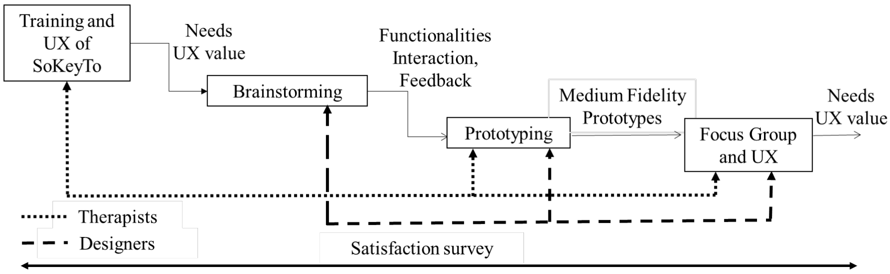

Fig. 1. Different phases of the design of the WebSoKeyTo platform.

2.1 Training and Evaluation of SoKeyTo

We first trained the six therapists to use the SoKeyTo [3] platform by demonstrating all the features in a practical way as reported above. Five users had never used another AAC design tool before and one is expert in the use of SoKeyTo. These six therapists were invited to use the SoKeyTo platform for two months: firstly, a scenario imposed by the SoKeyTo platform designers for one month, and then a free scenario for the design of an AAC for a disabled person. These therapists could benefit from the help of the SoKeyTo designers in case of bugs or difficulties of use. At the end of this trial phase of the SoKeyTo platform, we proceeded to the evaluation of the usability of this platform by means of the USE (Usefulness, Satisfaction, and Ease of use) questionnaire [9] on a Likert scale from 1 (strong disagree) to 7 (strong agree).

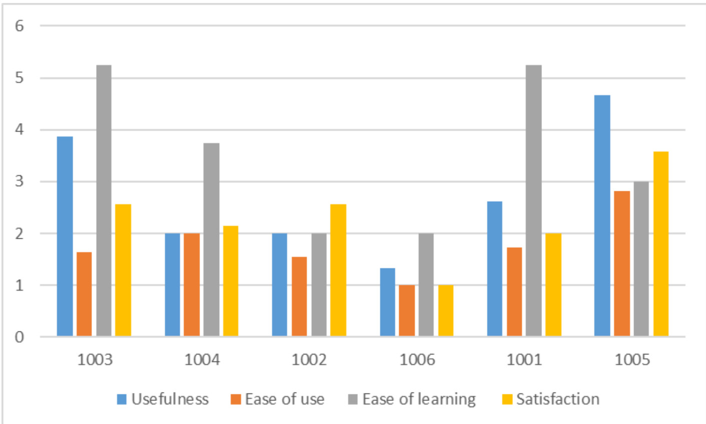

Fig. 2. Score of the USE questionnaire for each therapist.

Figure 2 shows the results of the five USE indicators for each of the therapists. We note that professional 1006 (psychologist and former computer scientist) rated the SoKeyTo platform very negatively. However, two other therapists mentioned its ease of learning and three others its ease of use.

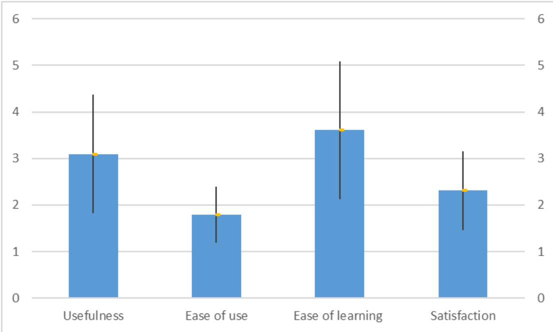

Fig. 3. Mean and standard deviation of USE criteria.

Figure 3 shows a very poor score for the criterion “Ease of Use” (mean :1.8 ; standard deviation (SD) :0.6) and for the criterion “Satisfaction” (mean :2,3; SD :0,85. The criterion “Ease of learning” (mean :3,6 ; SD 1.4) and “Usefulness” (mean: 3; SD: 1,3) are just average. Difficulty of understanding (concept too computer-oriented and not professional) of the functionalities, SoKeyTo oriented towards computer use, lack of essential functionalities (undo, overview of the AAC structure, pictogram editor, etc.), bugs, poor ergonomics, aesthetics to be reviewed are negative points reported by the therapists.

The therapists reported positive such as functions to run applications or web links from the buttons, customization of the AAC interface, possible interaction with different switches, high creative potential to create an AAC.

At the end of the SoKeyTo use phase, the six therapists participated in a focus group to express their feedback on the use of SoKeyTo and their needs. Therapists reported mainly the lack of ergonomics of the SoKeyTo editor's interface and lack of functionality. They also expressed additional needs: a Web version of SoKeyTo (WebSoKeyTo), the possibility to share their resources (pictures, pages, AAC interface, ...), a user interface of page and button editor more user-friendly including menus, functionalities, and buttons more accessible for therapists. The therapists have ranked their needs after a consensus between them. Then, the needs were discussed with the whole codesign team. Therapist 1006 played an important role in clarifying the needs in terms of software functionality.

2.2 Brainstorming

From the user feedback obtained through the questionnaire and the feedback on SoKeyTo, the design team used this base to design a solution closest to the therapists’ needs. The design team set up two brainstormings through several low-fidelity mockups. The purpose was to propose a new friendly user interface and a redesign of functionalities available on SoKeyTo more accessible to therapists.

We performed two different ones. The first one concerns the specification of AAC buttons (morphological and functional characteristics) and the specification of the scanning strategy (parameters of scanning strategy) of AAC.

The second one is about the navigation of pages. A page is a set of navigation and communication buttons that can be grouped into categories. This idea came from therapists' activities with communication books used by disabled persons to communicate within their human environment.

2.3 Medium Fidelity Prototype

We set up an alternative sequence of prototype design and focus group for the three prototypes (specification of buttons, of scanning system and navigation of pages, see Figure 4).

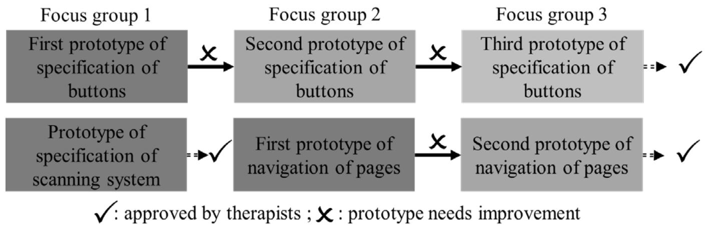

Fig. 4. Focus group and prototyping cycle.

The design team set up focus groups to collect feedback from the therapists on the prototype and new functionalities that allow them to carry out their activities. Due to COVID pandemic, all focus group were performed by videoconferencing. The design team show prototypes using case studies. Then, design team and therapists shared their point of view about prototypes. The both skills of the focus group proposed some adjustments or improvements. At the end of the focus group, if there was no agreement to validate the prototype, it was modified and presented again a week later until consensus.

The first iteration was to present the prototypes on specification of buttons and specification of scanning system. The feedback was very positive, but the therapists wished more concrete examples to have a better overview. The scanning strategy prototype was validated during the first focus group, as it corresponds to the expectations of the users due to its affordance (choice of strategy parameters through visual representations).

The second session was about specification of buttons prototype and navigation of pages. Therapists highlighted their wish to group some functionalities to have an easier control on WebSoKeyTo application for the specification of button. For the navigation of pages prototype, therapists asked to have a more developed case studies to see the envisaged result for a large number of pages. The CCA described in [4] consists of 53 pages. They also suggested modifications concerning the use of a color code to differentiate the category of pages from each other, The last iteration allowed to validate the two prototypes after some minor modifications following the therapists' remarks.

The therapists are testing the prototype of the button specification. They greatly appreciated being able to use it and adjust their needs in terms of feedback and interaction on the buttons. The development of scanning and page navigation strategies is still in progress.

3 Study of Therapists' Satisfaction with Their Participation

The therapists were heavily involved throughout the design process.Our objective was to evaluate the satisfaction of participation of 5 therapists (3 psychologists and 2 occupational therapists) in the codesign phase of the WebSoKeyTo platform by means of a questionnaire (See Table 1).

Table 1. Satisfaction questionnaire on the involvement of the therapists.

Number	Questions
Q1	Do you feel that you are involved in the codesign?
Q2	Do you feel that your design proposals have been taken into account in the medium proposals?
Q3	Do you feel that your design proposals have been taken into account in the V1 WebSoKeyTo platform?
Q4	Do you feel that your professional skills were taken into account in the codesign?
Q5	Were your proposals taken into account quickly? Why or why not?
Q6	Do you think you had difficulties in expressing ideas?
Q7	Do you think you had difficulties in expressing solutions (concrete proposals)? Why or why not?
Q8	Are you satisfied with the way consensus was reached? Why or why not?

We used a Likert scale with five values (strongly disagree, disagree, neutral, agree, strongly agree). Figure 5 shows that therapists globally appreciated their participation in the design process (Q1 to Q4, Q8). However, the answers to Q6 and Q7 show that two therapists had difficulties due to the lack of practice and the need to share a common language to express needs and solutions.

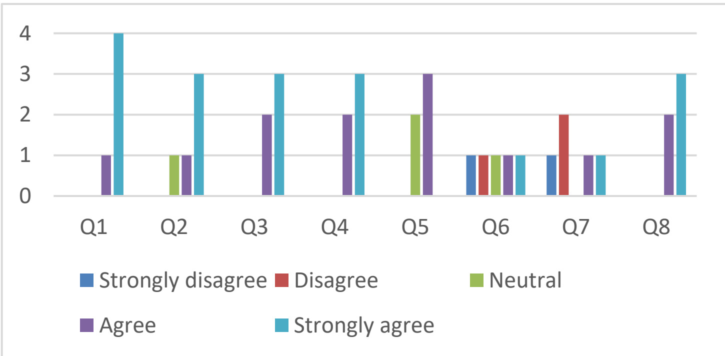

Fig. 5. Frequency of responses from the 5 therapists

All of them underline the listening skills of the design team. The proposals discussed between the therapists, the regular and numerous exchanges allowed to find consensus between the needs formulated by the therapist and the functionalities and interaction proposed by the designer team. Sometimes a psychologist, ex-computer scientist, facilitated the understanding of the therapists' proposals.

4 Discussion

This questionnaire shows that therapists are satisfied with the way their needs were taken into account and how the design consensus was conducted. However, to the question "which other stakeholder" should be consulted for the design of the WebSoKeyTo platform, the therapists suggest integrating speech therapists specialised in language, psychomotor therapist who could have another point of view. They also suggested that daily carers (specialised educational monitors, educational and social carers, carers, etc.) as well as family members could be involved in the adaptation of AAC, including functionalities/pictograms related to life books. To the question, "how do you improve your involvement in the design of WebSoKeyTo"? Assistance in the testing phases, better explanation of the expectations of the design team are requests expressed by the therapists. They also recommended that a greater immersion of the designers with the professionals could have been beneficial.

We implemented the method of codesigning the WebSoKeyTo platform with two therapists' skills. The discussions show that the people who accompany the disabled person in their daily lives should also be involved in the design process. The therapists suggest that Fablabs could also be involved in the modelling and manufacturing of the control devices. This shows that the therapists are already planning to use the AAC designed by the WebSoKeyTo platform.

5 Conclusion

This paper describes a search for an appropriate approach for involving therapists in the design of the WebSoKeyTo platform. None of the therapists had been involved in a design methodology and three of the five researchers were partially aware of the needs of therapists. Firstly, the version used by the engineers underwent training for therapists, followed by two months of use and user experience. This evaluation clearly demonstrated the need to improve the ergonomics, the logic of the AAC design interface and its affordance. This discovery of the SokeyTo platform was essential for the therapists to mature their needs. To do this, we implemented a cycle of codesign tools (focus group, brainstorming, prototyping). This study showed the need to develop a common language and a total immersion of the researchers to understand the therapists' needs. Conversely, the therapists had to take into account the technological and ethical constraints of their request. This study therefore demonstrated the need of a close collaboration and various exchange to find consensus for the WebSoKeyTo design. The medium fidelity prototypes also showed their limitations. Indeed, therapists would have liked to manipulate these prototypes with more representative case studies. The satisfaction questionnaire also shows that the stakeholder needs to be extended to other everyday professionals, especially for the adaptation of the AAC by them. The question of reinventing design methods in the form of method stories [10] or codesign fiction approaches [7] used for the participation of people with disabilities arises for this design context.

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Augmentative and Alternative Communication for Individuals with Autism

Additional Considerations

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Abstract. Augmentative and alternative communication (AAC) is often recommended to support the inclusion of autistic individuals who have complex communication needs. This conceptual paper discusses commonly used theoretical frameworks which are utilised to make clinical decisions to match AAC systems and devices, and the implementation of these on an individual level. The purpose of this paper is to explore the utility of these existing frameworks for autistic individuals. This paper describes issues that are specific to autistic individuals which may impact the AAC clinical decision making process with a specific focus on sensory processing differences. The hypothesis of this conceptual paper is that the sensory processing differences commonly found in autistic individuals impact the AAC clinical decision making process and should therefore be considered when making AAC decisions to ensure optimal AAC assessment and interventions. The authors suggest adaptations to existing frameworks which can accommodate these differences.

Keywords: AAC, autism, sensory processing.

1 Introduction

Augmentative and alternative communication (AAC) refers to a range of systems and strategies that are used to support communication when natural speech is impaired and does not meet the person's needs [1]. Generally, AAC can be classified as aided and unaided. Unaided systems of AAC e.g. manual signing, do not utilise any equipment external to the body. Aided AAC systems, on the other hand, consist of equipment such as communication books, mainstream tablet technologies with AAC specific apps, and dedicated devices specifically designed to support communication. Aided AAC systems can therefore be considered to be assistive technologies (AT). As technologies progress, AAC is increasingly used to support inclusion in a range of activities and environments including education, employment, the home and leisure [2]. Multi-modal communication involving a combination of aided and unaided AAC is often utilized by individuals with complex communication needs. In this conceptual paper we explore how the characteristics of individuals with autism may influence the process of AAC assessment and interventions leading to some suggestions for adaptations to existing models of AAC assessment and intervention.

2 Using Theoretical Models to Provide AAC Assessments and Interventions

The Human Activity Assistive Technology (HAAT) model is frequently utilised to guide assessment and evaluation of AT use [3]). This is a transactional model which seeks to capture the experience of an individual while engaged in activities. Furthermore, in doing so, this model supports the understanding of how the individual is able to participate in that activity as enabled by the AT. In the context of this paper, the activity of interest is communication, considered to be one of the major activity domains in the International Classification of Functioning, Disability and Health's (ICF) classification of activities [4]. The use of aided AAC therefore refers to the AT that is used within the activity of communication and this may be used in multiple contexts; be it physical, social, cultural and institutional. The HAAT model also, in tandem with the ICF classification of body structures, provides a framework for understanding the human user of AT. This includes mental, seeing, hearing, voice and neuromusculoskeletal functions as well as additional sensory functions.

While it is possible to utilise the HAAT model to support decision making of AAC, it does not fully cover all possible AAC solutions. Unaided AAC does not fall under the umbrella of AT since the use of gesture, signing and vocalisations do not make use of any equipment external to the body. This is particularly important because many autistic individuals use multi-modal communication which consists of both aided and unaided communication [5]. Since 2004, however, the American Speech Hearing Association has recommended the use of the Participation Model [6], originally proposed by Rosenberg and Beukelman in 1987, as a theoretical framework for AAC clinical decision making. This model, which has been revised since, is designed to provide a systematic process for carrying out AAC assessments as well as planning for intervention in order for the individual to participate in multiple contexts. Furthermore, the model supports the need to evaluate the effectiveness of interventions, thus it is cyclical in nature and recognises the life span of the user. It therefore acknowledges that learning to use AAC is a process which requires re-evaluation to ensure that the AAC system and strategies continue to meet the individual's communication needs in a range of environments with multiple communication partners. In this model, the AAC assessment process commences by assessing the individual's participation patterns and communication needs. Environmental supports and opportunity barriers are also assessed e.g. facilitator skills, knowledge and attitudes as well as policy and practice. The model also includes assessment of the individual's capabilities and access barriers which include motor, cognitive linguistic, literacy and sensory perceptual skills. While the process appears to consist of a two-step process whereby the individual is assessed followed by intervention, it has been suggested that the processes of assessment and intervention should be intertwined from the outset [7].

3 AAC for Individuals with Autism

In recent years, the population of individuals for whom AAC is considered has changed to include those with autism [8]. Autistic individuals present as a heterogeneous group with approximately 30% of autistic children likely to require AAC as they may fail to develop sufficient speech to support their participation in family, educational and community contexts [9]. As children become adults their communication needs change as it the need for information exchange and social closeness become more prominent therefore AAC is of great importance in achieving inclusion [10]. The negative effects of failing to develop a formal communication system on education, employment and independence outcomes are well documented and it is therefore of great importance that AAC assessments and interventions are provided for autistic children as early as possible to ensure their inclusion [11, 12]. As mainstream technology has brought AAC to the public domain, families of autistic individuals have become more accepting of the use of aided AAC systems to support communication [13]. There is evidence to demonstrate that the implementation of AAC for this group of individuals is effective to highly effective, particularly for supporting requesting [14]. Donato et al. [15] have, however, identified a number of barriers to the successful implementation of AAC by autistic individuals. These include barriers in how services are provided, the AAC systems themselves, facilitator barriers including both parents and other communication partners, and factors related to the individuals themselves which included lack of attention and motivation to use AAC systems to communicate.

Loncke [7] questions whether autistic individuals should be considered as a specific group with their own AAC needs and whether they therefore require different AAC approaches to assessment and interventions when compared to other populations such as those who have primary motor and or cognitive impairments. This could be considered because autism is described as a neurodevelopmental disorder with deficits in the area of social communication likely to impact motivation to communicate and or the ability to interact with AAC devices and systems. This is distinct from other individuals who require AAC, e.g. individuals who have cerebral palsy, who may not have social communication challenges and are potentially more motivated to communicate. Furthermore, social communication deficits may impact the individual's ability to engage in spontaneous communication [15]. Repetitive behaviours and restricted interests which may include sensory processing differences are also present [16]. Schaaf [17] notes that sensory differences may affect participation and inclusion in daily activities. In fact the presence of sensory responsiveness has been recognized by the DSM-5 as a relevant diagnostic feature for autism. There is also a growing body of literature that indicates that differences in sensory processing may contribute to difficulties in social communication within individuals with autism [12, 18, 19].

4 AAC Assessment and Autism

Assessment of AAC is a complex process as it requires gathering information across many domains [6]. From a user perspective, it requires the utilisation of a number of performance components to be able to access an AAC system and to use it to communicate efficiently. These include visual and hearing skills, motor coordination skills, sensory processing skills, the ability to sequence and organise movement (praxis), oral motor skills, language and cognitive skills, visual attention, and literacy skills (if available to the individual) [3, 6]. Consideration of all of these components during the AAC assessment process for an autistic individual is therefore important. While the Participation Model covers a range of areas, including vision and hearing under sensory perceptual skills, it does not refer to the sensory processing component. On the other hand. the HAAT model does refer to the importance of considering the implication of sensory processing and praxis when assessing or evaluating for AT, and the role of these skills to help an individual organize behaviour and learn [3].

5 Sensory Processing

Sensory processing refers to the way that information, which comes through the senses, is managed in the brain in order to enable purposeful adaptive responses to the environment and to participate in meaningful life activities [21]. This is based on the evolving theory of Sensory Integration proposed by Ayres [22, 23]. This theory is frequently used in interventions with autistic individuals as they often encounter difficulties with integrating sensory information and this is hypothesised to have an effect on their learning, behaviour, attention, social interactions and engagement in activities of daily living [17]. Attention deficits and challenging behavior have been cited as potential barriers to learning to use AAC [15].

In the literature, sensory processing differences in autistic individuals have been broadly categorised into three patterns; hypo-responsiveness, hyper-responsiveness and sensory seeking e.g. Feldman et al. [20]. Hypo-responsiveness refers to a lack of or reduced response to stimuli while individuals who are hyper-responsive may display exaggerated or defensive behaviours when presented with stimuli [17] Sensory seeking behaviours are associated with the need to work actively to gain sensory stimulation and this could be the result of hypo-responsiveness or poor perception of sensory input [17]. Recent research is continuing the process of elucidating whether specific sensory responsiveness patterns are more likely to impact the development of communication skills e.g. Feldman et al. [20] and Watson et al. [19]. Other patterns of sensory integration dysfunction such as somatodyspraxia have also been associated with difficulties in social interaction and imitation e.g. Haswell et al. [24]. Moreover, it has been reported that fine motor impairments which may have an underlying sensory processing difficulty are prevalent in individuals with autism [reference]. Research has identified that fine motor coordination difficulties may have an effect on social communication skills e.g. Bremer & Cairney [25]. When evident, these may also present a barrier to learning to use AAC [14]. This evidence, coupled with prevalence rates of between 40 and 90% of children diagnosed with autism who are likely to present with sensory processing differences, supports the importance of considering sensory processing during AAC assessment [26].

The Participation Model does refer to motor skills when describing what should be assessed under the individual's capabilities, however it would be beneficial to view these motor capabilities through a sensory processing lens. Moreover, only one published study, by Lund et al. [8], which compared the assessment of a child withcerebral palsy to a child with autism, referred to the need to include occupational therapists to evaluate sensory processing skills for the child with autism although this was in relation to eating and drinking and not to its impact on AAC. The authors do conclude that it is possible that some aspects of the Participation Model require greater emphasis when considering the individual with autism although no specific reference is made to the inclusion of sensory processing assessment. This is consistent with Dietz et al. [27] who suggest that consideration of diagnosis should be given attention when planning the assessment forAAC.

To further support this argument, the ICF's classification of body structures can also be considered. This classification includes the category of additional sensory functions. Moreover, the HAAT model makes reference to this when describing the Human User. The Participation Model could therefore be extended to include sensory processing. Consideration of sensory processing patterns could lead to improved matching of AAC to the individual with an impact on the intervention strategies which are chosen to reflect this. A further point is the need to also consider the individual's communication partners and their knowledge of the individual's sensory processing as this may impact how interventions are provided.

6 AAC Interventions for Autism

The Participation Model includes planning of interventions both at the time that assessment is carried out, and also for the future. With particular reference to autism, Beukelman and Light [6] note three key considerations. The need to promote social communication, the need to provide interventions across the lifespan and the need to use effective intervention techniques. This raises the question of how these strategies might be chosen. Research has indicated that differing sensory processing patterns may impact communication development e.g. Patten et al. [12] and Watson et al. [19] whose findings suggest that children who present with hypo-responsiveness and sensory seeking are more likely to experience difficulties developing verbal language and social communication. Provision of sensory processing interventions and accommodations may therefore also need to be they put in place to support other intervention strategies chosen to implement AAC systems and strategies [28].

A further consideration is whether those in the environment have the skill and knowledge to implement those intervention strategies. Training is one way of addressing the needs of communication partners although Kent-Walsh et al. [29] note that the difficulties with socio-communication may impact on how effective partner training is. This is consistent with Donato et al.'s [15] research which specifically identifies barriers to communication partners who may not have the knowledge or skill to implement the requisite intervention strategies to ensure successful learning of AAC with individuals who require AAC. Many individuals with autism do not display the ability to initiate communication or may not respond to the communication of others which means that the skill level of others must be considered [15].

7 Conclusions

The assessment and intervention of AAC is a complex process which draws on the knowledge and expertise of a range of professionals. While the AAC systems themselves are of importance, careful selection of the AAC system must be done with individual characteristics in mind. This may require adjusting of existing frameworks or the creation of a new one. This paper outlined some of the specific issues relating to AAC for individuals with autism with a proposal to consider sensory processing difficulties as a part of the process. Further research is required to build evidence on the long-term impact on the use of AAC when rich sensory experiences are provided during the continuous implementation of AAC in different settings

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Language Accessibility for the Deaf and Hard-Of-Hearing

Environmental Sounds Recognition System for Assisting Deaf and Hard-of-Hearing People

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Abstract. Deaf and hard-of-hearing (DHH) people cannot recognize the sounds of daily life. These sounds are called environmental sounds (ES), and DHH people find it difficult to live without them. Therefore, hearing assistance dogs and products are used to support DHH people. However, no adequate system to recognize ES, which can be handled for anyone, anywhere, and at any time, has been developed. The aim of this study is to improve the quality of life of DHH people by assisting in ES recognition in various situations. In this study, six types of sounds were used for recognition: two types of water flow, a car horn, fridge alarm, engine idling, and none. None is a sound that does not have a specific ES; however, it contains noise such as the natural sounds of daily life. Feature extraction was conducted by focusing on the value of the spectrogram, and each ES type was discriminated using a support vector machine (SVM), Euclidean distance (EUC), and Mahalanobis distance (MH). Among the six ES, SVM had the highest average discrimination rate (83.3%), followed by EUC (41.2%) and MH (43.3%). In addition to the high discrimination rate, SVM was able to discriminate all six types of sounds, which was not possible with the EUC and MH.

Keywords: Deaf and hard of hearing people・Environmental sounds・Support vector machine

1 Introduction

The number of deaf and hard-of-hearing (DHH) people, including the elderly, is approximately 14 million [1]. This number is expected to increase in the future, owing to an aging society. DHH people cannot recognize the sounds of daily life, such as door chimes. These sounds are called environmental sounds (ES), and DHH people find it difficult to live without them [2]. In addition, unawareness of ES may lead DHH people to dangerous situations. Therefore, hearing assistance dogs and products, such as blinking door chimes, support DHH people. Two types of studies have been conducted previously: analysis of ES features [3] and the effect of ES on DHH people [4]. However, the findings of these studies are still insufficient for assisting DHH people.

The aim of this study is to improve the quality of life of DHH people by assisting them in ES recognition in various situations. The specific objective is to develop an ES recognition system specialized for DHH people. Two novelties were achieved in this study: creating a data set specialized to meet the needs of DHH people and building a system that recognizes several sounds in various situations.

2 Methods

2.1 System Configuration

The proposed system configuration can be divided into two phases. During the first phase, acoustic features were extracted as numerical values of the ES. The extracted features were then divided into training and testing data for discrimination performed using supervised machine learning. In the second phase, we plan to use these discrimination results to define the discriminated ES, either visually or through vibration. In summary, the final goal is to convert ES information into visual information or vibrations and present them to DHH people. In this paper, we discuss the first phase.

2.2 ES Selection

It is important to know which kind of ES is truly required for recognition by DHH people in daily life. To determine this, a preliminary questionnaire survey was conducted with 50 DHH students to select the ES for recognition in the system. In the questionnaire, 30 ES were presented using a five-grade evaluation approach. The 30 ES presented here can be divided into three groups: 19 indoor sounds, assuming a situation in which the respondents spent time alone, 8 outdoor sounds, assuming a situation where the respondents were going out alone, and 3 sounds of animals and babies. The details for these ES are listed in Table 1. For each ES, the respondents were asked, 'Do you think this ES is important enough to notice?' As an answer, five levels of agreement were provided, as shown in Table 2. In the five-grade evaluation, a score was assigned to each level of agreement. Table 2 lists the levels and points of each. According to this table, the total points were calculated by multiplying the number of respondents at each level by the number of points and summing them up. The maximum total points were 200 when all 50 respondents answered with "Very," which has a value of 4 points.

Table 1. The 30 presented ES in the questionnaire

Indoor sounds		Outdoor sounds	Animals, Baby
Alarm clock	Bee buzzing	Ambulance siren	Dog barking
Fire/Gas alarm	Thermometer	Fire engine siren	Cat meowing
Calling of intercom	Vacuum cleaner	Police car siren	Baby crying
Door knock	Ventilation fan	Bicycle bells	
Bathtub alarm	Running water	Car approaching	
Kettle alarm	Wind	Car klaxon	
Glass breaking	Dropping a coin	Train departure	
Earthquake warning alarm	Dropping a smart phone	Train approaching	
Microwave beeping	Door alarm of refrigerator		
Washing machine alarm			

Table 2. Levels of agreement, and the points for five-grade evaluation

Level of agreement	Not at all	Not so much	Slightly	Well so	Very
Points	0	1	2	3	4

The results are presented in Fig. 1. The "sound of running water" was rated the most important to satisfy the need for "notice when people forget to stop the water supply." In terms of the points, "Fire, gas alarm," and "Sound of a car approaching," got the highest points, followed by the "car klaxon" and "door alarm of refrigerator," in this order.

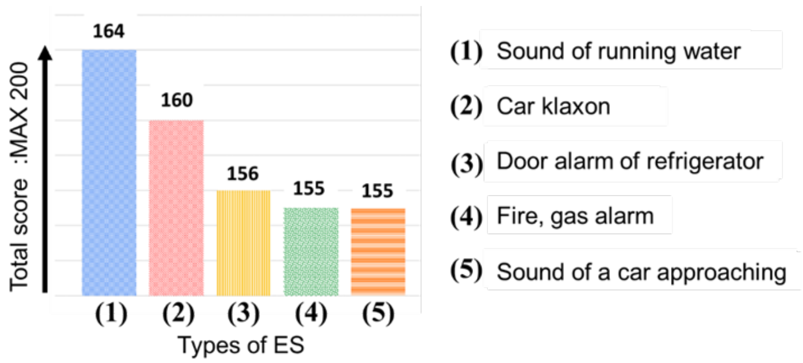

Fig. 1. Result of questionnaire survey

The ES used in this study was determined based on these results. Two types of sounds were used for running the water: dripping flow ("dripping") and constant flow ("high"). A dripping sound occurs when the tap is not completely closed, and a louder sound occurs when the tap is open to its maximum. In addition, we focused on the following ES according to the results of the questionnaire: car klaxon ("car horn"), door alarm of a refrigerator ("fridge alarm"), and sound of an approaching car ("engine idling").

Furthermore, it is necessary to have information on when a particular ES does not occur to determine whether an ES is occurring. Therefore, a sound that does not have a specific ES but contains noises, such as the natural sounds of daily life, was defined as the sound “none.” Finally, we decided to discriminate six types of sounds, including “none,” and the five ES mentioned above.

For high, dripping, fridge alarm, and none, self-recorded sound sources are used. The target ES were recorded using a TASCAM linear pulse-code modulation recorder, and the voice memo function of the iPhone8. The recorded sound files of the dripping and fridge alarms include the time when the respective ES is not sounding. The sound files of none were created by extracting the time when the sound of the dripping and fridge alarm was not sounding.

For car horn and engine idling sounds, the existing datasets UrbanSound8K, and ESC-50, were used. UrbanSound8K is a dataset containing 8732 labelled sound excerpts of urban sounds from 10 classes: air conditioners, car horns, children playing, dog barks, drilling, engine idling, gun shots, jackhammers, sirens, and street music [5]. The ESC-50 is a dataset consisting of 2000 labeled environmental recordings equally balanced between 50 classes (40 clips per class). These 50 classes can be grouped into 5 main categories: animal sounds, natural soundscapes and water sounds, human (non-speech) sounds, interior/domestic sounds, and exterior/urban noises [6].

2.3 Feature Extraction

The sound waveform was converted into a spectrogram using a short-time Fourier transform and the average value for each frequency was extracted as the feature value. Nine intervals between frequencies of 0, 50, 100, 300, 700, 1500, 3000, 6000, 12000, and 15000 Hz were extracted as nine channels. For the high and engine idling sounds, which did not change with time, 0.1 second in an arbitrary range of extracted. For the other four ES, each feature was extracted for the number of seconds in which the sounds occurred. Finally, 100 sets of training and testing data were prepared for the discrimination of each of the six ES types mentioned above, for a total of 600 sets each. All the feature extraction processes were performed using MATLAB.

2.4 Discrimination Methods

In this study, the correct answer was prepared in advance using the sound data of each ES as a feature value. Therefore, supervised machine learning was used for the discrimination. For comparison purposes, three types of supervised machine learning were used as discrimination methods, that is, support vector machine (SVM), Euclidian distance (EUC), and Mahalanobis distance (MH), were applied using MATLAB. For the SVM, “LIBSVM,” an open-source SVM library, was used, and the selected kernel was the radial basis function kernel.

3 Results and Discussion

In Fig. 2 and Fig. 3 show the waveforms of the high and fridge alarm sounds, respectively, and an example of the spectrogram. There was no significant change in the spectrogram value at high (Fig. 2). In contrast, for the fridge alarm (Fig. 3), the waveform amplitude increased at 1.3 and 2.1 s, and the spectrogram value also increased, indicating that the fridge alarm sounded twice. The change in the value of this spectrogram was used as the feature value.

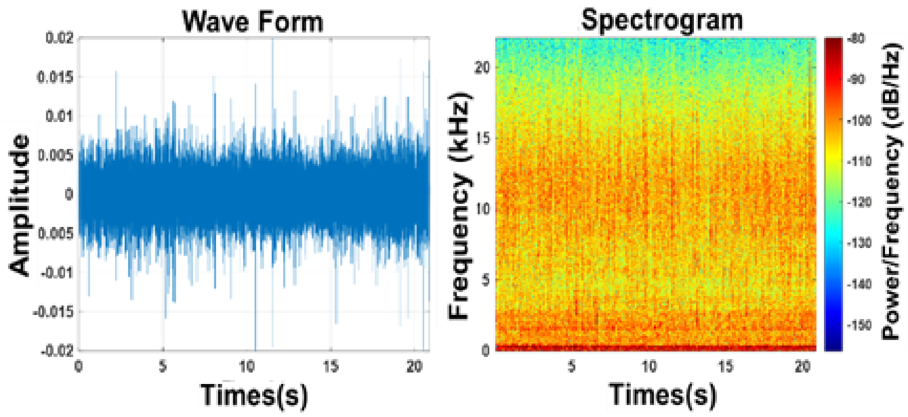

Fig. 2. Waveforms and spectrograms of high

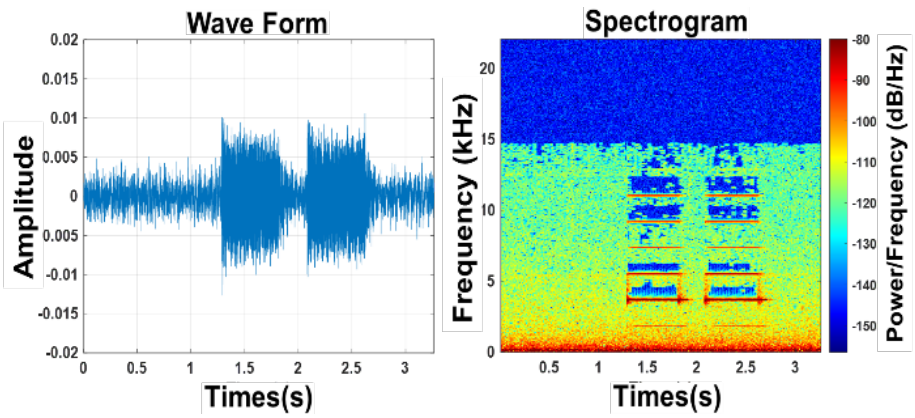

Fig. 3. Waveforms and spectrograms of fridge alarm

The features extracted from the six types of sounds were input into the SVM, EUC, and MH for discrimination. The results of discriminating the 100 test data points for each are shown in Fig.4. The average discrimination rates for the high, dripping, car horn, fridge alarm, engine idling, and none sounds for each discrimination method were 83.3% for SVM, 41.2% for EUC, and 43.3% for MH. SVM had the highest discrimination rate and could discriminate between all six types of sounds. However, it was impossible to discriminate between none in the EUC. For MH, in addition to none, dripping and fridge alarms could not be discriminated.

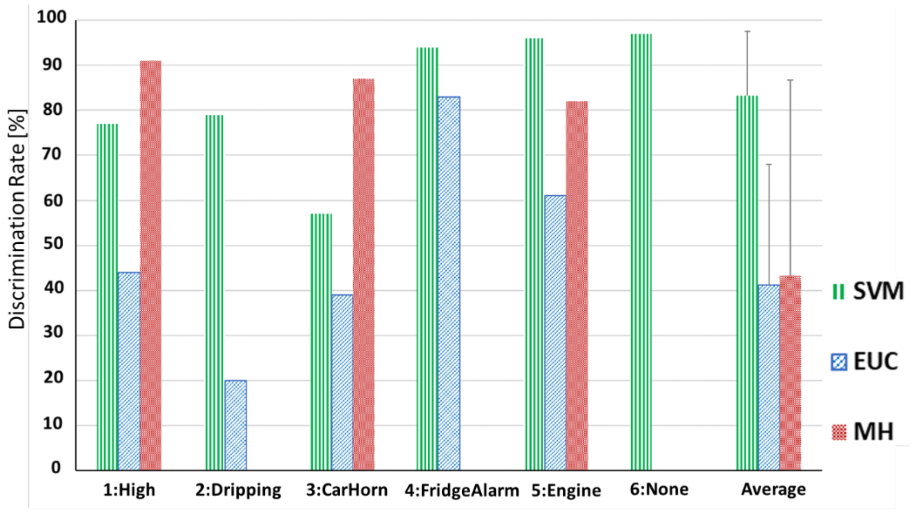

Fig. 4. Results for six classifications

4 Conclusions and Future Work

Six types of ES were converted into a spectrogram, and it was confirmed that the features could be discriminated using the SVM with an average discrimination rate of 83.3%. In future studies, a deep learning method should be considered for discrimination; and an original dataset with a wide variety of ES should also be established. In addition, this study only discussed the first stage of the system configuration; and the second phase should be discussed in the future with the aim of developing a recognition system.

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Modern Communication Technology, Assistive Technology, and Hearing Impairment

How Do They Go Together?

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Abstract. This work sheds light on the experiences of hearing-impaired individuals with communication and assistive technology nowadays, primarily for the contact with public entities, including the health sector. We used an online survey and 12 in-depth interviews to collect statistics and narratives and analyzed the answers. Our findings draw a picture of technology as an enabler and life-saver with a number of weaknesses, both technical and non-technical. Areas of improvement include the universal design of technical solutions, user journeys for users of assistive technology, technical installation and setup of public and private infrastructure, instructional and educational training, and others.

Keywords: Hearing loss, ICT, AT, public administration, barriers

1 Introduction

More and more of today's societies are to a great extent digital. Communication, be it of private nature or with public entities and administration, is often relying on online services and digital tools. This trend has increased further with the Covid-19 pandemic.

Hearing loss, while being an invisible impairment, is wide-spread in most societies. There are different definitions of "hearing loss" and different statistical approaches of how to quantify it. The estimate for Norway is that roughly 36% of the adult population are affected by hearing loss, which compounds of 20% with a mild impairment and 16% with a moderate or severe impairment [1]. The WHO state that currently more than 5% of the world's population require rehabilitation for a "disabling" hearing loss [2]. The trend is rising, as this number is expected to increase to more than 10% by 2050 [2].

In this work, we focus on the intersection of topics communication technology, assistive technology (AT), and hearing loss in the context of individuals' contact with public entities and the health sector. AT can in turn be viewed as a subset of communication technology. Questions that have guided our research are: How do individuals with hearing loss communicate by means of digital solutions? What are their technological needs, expectations, and preferences? What recent experiences do they have with various communication systems and assistive technology? What are good solutions? What areas of improvement do exist, and what technical (and other) barriers do they encounter?

This work partly confirms previous research and partly adds new details to the overall picture. Its main contributions are novel knowledge regarding the effect of meeting and conference tools for this user group, in particular the advantages of image and video, high-quality audio, sometimes enhanced further by additional microphones, media recording and archiving, as well as of captioning. Another important contribution of this study is to view technology in a greater perspective and in the light of related areas such as AT, installation and setup, instructional training, technical support, organization and administration, as well as consequences of the Covid-19 pandemic.

The work received funding by The Norwegian Directorate for Children, Youth and Family Affairs (Bufdir). Its results were originally published as two scientific reports (both in Norwegian): One covers the in-depth interviews [3], and the other presents the survey and contains the overall discussion of results [4]. The remaining work is straightforward. After the description of the methods used, we present and discuss findings from different data sources before the work concludes.

2 Methods

In order to answer the aforementioned questions, we have used a mixed-method approach.

An online questionnaire with in total 20 questions was sent out in June 2021 to members of the Association of the Hearing Impaired in Norway (HLF). As a quantitative method, the survey's objective was to overview the area and get indications of problematic areas. The answers were subject to a plain descriptive statistical analysis [5]. Almost 380 respondents between 18 and 90 years answered our questions, with an average of 50 years and an approximated normal distribution of ages. It is underlined, however, that the number of answers for each question varies as the applicability of subsequent questions for a particular respondent depends on his / hers previous answers. The use of hearing aids prevails by far (94% occurrence), while the list of other technical solutions with a substantial usage includes hearing loop (T-coil) and Bluetooth streaming (combined 90% occurrence), various microphones (15%), cochlear implants (CI, 6%), and speech-to-text systems (6%). Additional ATs in use are smartphone apps, fire alarms, door bells, alarm clocks, sound streaming units, and a few others. Written interpreters are utilized by 11% of the respondents.

Next, we conducted 12 in-depth interviews with individuals with a hearing impairment, seven women and five men. The informants were recruited from members of the HLF. The aim of this qualitative approach was to focus on individual experiences and narratives, to collect user voices, and to supplement the picture drawn by the online questionnaire. The interviews were conducted either through phone or video call, transcribed, anonymized and then underwent a thematic analysis [6]. The population was on the average 60 years old, with the youngest being 24 and the oldest 83 years. One informant rated their technical skills as low, seven as medium, and four as high.

3 Results & Discussion

Subsequently, the findings from both data sources are presented and discussed jointly.

The following communication solutions have been mentioned by the survey respondents (N=378) for contact with public entities, see Table 1. Multiple checkbox ticks were possible. In the "Other" category, the respondents bring up meeting and conference apps like Microsoft Teams and Google Meet, as well as social media. Besides the technical solutions, some have also noted that they prefer physical meetings, a result which is confirmed by a great share of interview informants.

Table 1. Answers to the question what communication technology is in use for contact with public entities.

Answer option	Share
Phone	70%
Web solution	70%
E-mail	58%
SMS	33%
Chat, including chatbot	25%
Other	4%

The bottom line is that people want to use and actually use multiple and preferably text-based solutions. The phone's high popularity can be explained by the fact that, for many, hearing aids in combination with streaming technology / T-coil, and possibly (written) interpreter services gives a sufficient solution, particularly for shorter conversations. This result is confirmed in the interviews. The surprisingly high rating of SMS may to a great extent be due to public entities sending out confirmation and reminder text messages, but that is only a guess. It nevertheless shows that SMS as a technology is important to a significant share of respondents and should hence not be neglected.

Asked for how satisfied they are with technology in the communication with public entities in general, approximately half of the respondents (N=359) answered to be either satisfied or very satisfied, while 30% answered neutrally. See also Figure 1 (left).
If a binary decision is enforced by splitting neutral answers equally into positive and negative sentiments, the result is a majority (64%) of those who are satisfied, while 36% are dissatisfied. Given the fact that the share of those at least satisfied (49%) is more than dobbel of those at most dissatisfied (21%), the overall message here is that the respondents in general have mostly positive experiences with technology. This impression is further confirmed by the answers (N=188) to the question regarding the respondents' satisfaction with AT, see Figure 1 (right). Here, in total 74% said they are satisfied or very satisfied with their AT, which in the given context primarily refers to hearing aids. 16% are dissatisfied or very dissatisfied, while 10% voted for neutral.

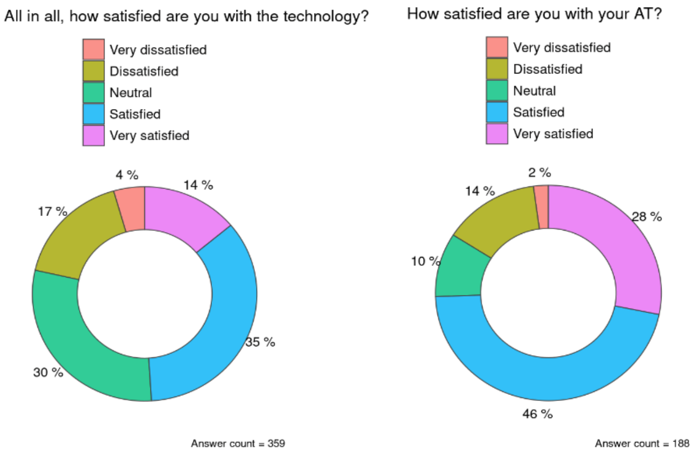

Fig. 1. Pie diagrams detailing the share of answers to the question regarding how satisfied the respondents are with technology in general (left) and assistive technology (right).

The answers to the following two questions, combined with what the informants said in the in-depth interviews, may explain the considerable amount of dissatisfied respondents. Asked for what kind of technical problems they have experienced, a significant share ticked the checkboxes at several of the available answer alternatives, see Figure 2 (left).

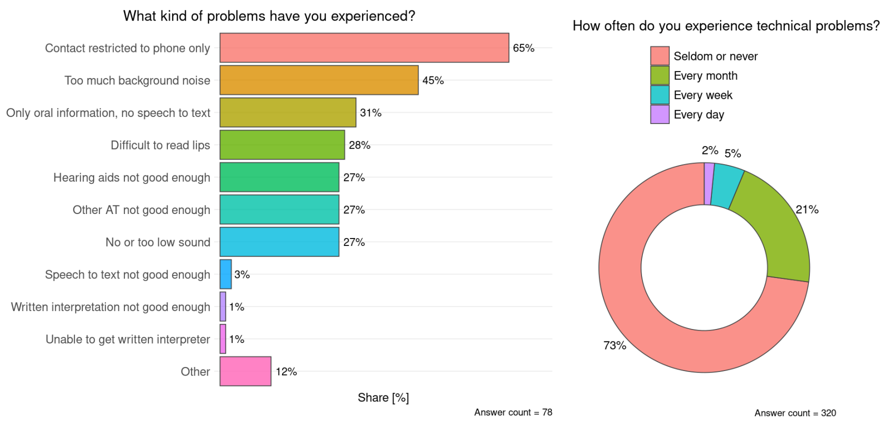

Fig. 2. Bar and pie diagrams detailing the share of answers to the question regarding what kind of problems the respondents have experienced (left) and how often they experience technical problems (right).

Considering AT and related infrastructure, many, in particular elderly, do not know how to use their devices properly, even after many years of use. This points at too complex user interfaces and operation and to a lack of universal design of these devices. Also, hearing aids may not be working optimal in a particular context, such as concerts or seminars. Particularly one-to-many conversations and sounds coming from behind were identified as problematic areas. Others complained about insufficient amplification, amplification of unwanted sounds and noise, and insufficient noise cancellation. Some hearing aids lack T-coil or Bluetooth support, which is viewed as a considerable disadvantage by the majority of informants. It also happens that users do not know whether their devices have support built in, let alone how to use it. Some manufacturers of hearing aids provide mobile apps to control them, and the user interface of these apps may be experienced as too complex, particularly by elderly users. The informants also gave various examples of T-coils not being properly installed or set up or simply not turned on, which of course renders hearing aids with T-coil support useless. The problem of a potentially wrong installation, setup, and operation also applies to fire alarm systems for the home and for hotels. The simultaneous use of many different components / devices and their inter-connection may be difficult to accomplish and cumbersome, partly due to the necessity to manage and organize all these devices with various cables, batteries, instruction manuals, and so on, and partly due to closed and proprietary vendor solutions that cannot be combined.

Also when it comes to generic communication technology, many narratives about technological challenges can be found in the experiences of the informants. The sound / audio in meeting and conferencing apps may be of poor quality due to the lack of insufficient noise cancellation, participants being too far away from the microphone, distortion due to microphone overdrive, a bad internet connection, or because of the lack of support to connect the PC or tablet PC directly to the hearing aids, to name a few. As the vast majority of people with a hearing impairment are lip readers, the quality of visual information is of particular importance. Here, the list of potential technological obstacles includes according to the informants too small video, a poor image quality, frozen video or video which is not in sync with the audio, all of which may make lip reading challenging or impossible. Next, many informants brought up the lack of integrated captions in digital conferencing applications as an area for improvement. At the time of writing, such functionality is available in many solutions, but not all, and not always in all languages. Also, this functionality is quite new, so on the one hand the knowledge about it and how to use it appears to be limited. On the other hand its quality is often experienced as poor still, particularly in languages like Norwegian with many dialects. Recording meetings got many positive remarks, but informants suggested making it “on” by default, such that they always get the possibility to listen to the recording or parts of it later on.

A great deal of obstacles are not caused by the technology itself but rather by how it is organized and used. In many cases, the informants brought up their desire for additional communication channels as alternatives to the plain telephone, such as chat, mail, contact forms, or basically anything text-based. However, many public entities, and in particular the Norwegian health sector, do not offer other contact options besides the phone, according to our informants. Important information, like dates and times for appointments are often given only in oral form. Informants also told us about recordings that did not get properly archived, rendering them basically valueless, and they complained about meeting participants not muting their microphones when not speaking, about participants talking simultaneously with others, speaking unclearly or too fast, or about those covering their mouths. Other examples of barriers we were given are a too small face and incorrect lighting of one's face in the video of meeting software. Not repeating speech from speakers far away from any microphone, such as in lecture and seminar settings, appears to be a frequent problem, according to the informants.

How often are technical problems encountered, and are there nowadays more technical barriers than before? In terms of the first question, an accumulated 27% of respondents (N=320) ticked the "a couple of times each month" checkbox or other alternatives with more frequent occurrence, see Figure 2 (right). This means that the remaining 73% seldom or never experience problems, which mirrors roughly the 74% share of those who are satisfied with the quality of their AT, see the discussion further above. In terms of the second question, 59% of the respondents (N=85) answered that they do not see a change in the situation, 29% said there are clearly more, whereas 12% believe there are less than before. While the large indifferent part is difficult to interpret, the overall trend is that there are more barriers now. However, for a not insignificant share of informants, the Covid-19 pandemic has had a positive impact on their communication. Even though most prefer physical meetings over digital ones, many acknowledge that nowadays there are more and better solutions for video meetings, such as Teams, Skype, Messenger, and similar, which eases lip reading and for many results in better speech audio and less noise, which may partly be due to more disciplined participants. However, while visual communication is received well without exception, there are a few voices that complain about bad audio and bad acoustics in the home, which is due to many being in their home office.

All technical difficulties may have a range of consequences: Many respondents (N=84) said they need more time to solve their problems (67%), while others call help (19%) or simply let those helping solve their tasks (32%). A share of 29% state that they may just give up, which means their problem(s) remains unsolved. It is stressed that multiple alternatives were possible with this survey question. Regarding asking for help, it was striking in the interviews that all informants said they wanted to be as autonomous as possible and tried to solve potential technical issues themselves. Yet, almost all informants admitted to being in need of help from time to the other. This picture is confirmed in the survey. Here, we found that 81% of the respondents (N=16) need sometimes, often, or very often help to communicate, across all ages. This finding is in contrast to the high satisfaction with communication technology and AT as discussed before.

There are two more interesting results from the survey regarding getting instructions for AT and educational training. First, there are many different actors in this field in Norway: Audiologists, audio educators, audio engineers (all of which are related to the health sector), The AT Center of the Norwegian Labour and Welfare Administration (NAV), AT manufacturers, the municipality's hearing contact point, the municipality's adult education, and a few others. This high number of actors makes these waters difficult to navigate for the AT users. Second, as many as 20% of the respondents (N=187) claim that they have not received any instruction at all, and at least 34% think the technology instructing part and training was insufficient. The importance of this demand is raised even further in the interviews, where almost all informants agree that there is a high demand for both better information, better instruction, and repeated training.

When it comes to the list of actors a person with a hearing impairment may have to relate to during their lifetime, the above list of educational actors has to be extended by personal physicians, ear-nose-throat specialists, health nurses, civil society organizations and their hearing peers, interpreting services, and others. Several informants experience it to be challenging to navigate in this jungle of responsibilities, which raises the question of whether there are too many actors. In addition, some of the technical support is organized on a municipality level, and - according to many informants - both service level and competence in Norwegian municipalities regarding hearing loss vary a lot. A superior entity with expert competence and a nation-wide service offer could be a remedy here.

Finally, several informants raised critical voices considering the suppliers of hearing aids. They question the power these suppliers have in the (Norwegian) market, and that the authorities seem to have accepted the lack of interoperability among hearing aids and other assistive devices, such as streaming devices and microphones. As a result, in most cases one cannot combine the solutions of different suppliers with each other. To solve this, it has been suggested to commit the suppliers to the use of joint technical recommendations and protocols, such that interoperability is maintained.

4 Limitations

The validity of this work's results is limited by the following considerations. Both respondents and informants were recruited through HLF's member registry and are thus not representative for the entire population of persons with hearing impairments. An initial N=380 respondents and inter-question dependencies gave (a few) subsets with as low as N=15 for particular survey questions. A larger number of respondents would have been beneficial but was limited by the available project budget. It has also to be kept in mind that the effect of distributing and conducting the survey in a digital manner, and of carrying out the interviews either on the phone or digital meeting tools, may be to give a too positive view of any digital barriers, as both methods of recruiting favor the tech savvy.

5 Conclusion & Outlook

To conclude, we found that our population of people with hearing loss was quite heterogeneous, but they all had in common that communication technology is very important to them. Many informants stated that they are "totally dependent on their hearing aids and AT", and it is not rare even to hear statements that technology "has saved their life". The tremendous recent technical advances targeting hearing impairment have considerably increased the quality of life for a wide range of the population. The survey has shown a number of good technical solutions for many situations and a wide-spread satisfaction with their quality. However, we also have uncovered a number of areas where the technology and related areas can be improved, including installation and instruction, as well as a low degree of universal design of AT.

This picture of technology as an enabler with weaknesses for people with hearing impairments has been confirmed by our interviews. In the opinion of several informants, hearing loss - as compared to other impairments - is once more confirmed as the invisible impairments which - in many cases - does not get the proper attention by the authorities and lawmakers as other impairments do.

Many countries have or are about to incorporate CRPD / the Convention on the Rights of People with Disabilities [7] into national law. In Norway, the current government has expressed their intention to do so in the near future. Incorporation of the CRPD means, among other aspects, to develop universally designed goods, services, equipment and facilities. As the UN's definition of *universal design* particularly includes assistive devices, any system which cannot be combined with AT such as hearing aids is not universally designed. Also, the CRPD applies to basically all aspects of society. This is in contrast to Norwegian legislation, which at the time of writing only requires universal design of ICT for Web, apps, and self-service machines [8], while Norway's Equality and Anti-Discrimination Act [9] mandates the facilitation and adaptation on an individual level. More equality of opportunities and more inclusion could be achieved in Norway and other countries by extending the requirement for universal design of ICT to areas such as working life, the communication with public and private electronic services, and others, and by making facilitation and adaptation the responsibility of the society, not the individual.

Regarding future research, one possibility is to include the experiences, needs and preferences of relatives and caregivers of individuals with a hearing impairment. This was outside the scope of this work but would give additional valuable knowledge about technology. Another possibility is to gain more knowledge about the experiences of hearing-impaired individuals with technology in education- and work-related contexts, as technology and its proper use is crucial in both settings.

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Avatars for Sign Languages

Best Practice from the Perspective of Deaf Users

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Abstract. This paper presents recommendations for the use of Sign Language Avatars that are based on the view of deaf users and deaf and hearing experts. It focuses on three areas: Linguistic aspects of sign language avatars, the aspect of translational competence and ethical issues when deploying avatars. In each of the three areas, criticism and ideas that deaf sign language users stated in focus group discussions are summarized, followed by concrete best practice recommendations that are firmly rooted in our qualitative data.

Keywords: Avatars, Sign Language, Linguistic Accessibility.

1 Background

1.1 Sign Languages and Signing Communities

Most sign languages of the world have a fragile legal status and suffer societal invisibility [1]. Considering that they are fully-fledged, natural languages that have been around for as long as deaf people have been communicating, it seems paradoxical that their power and indispensable role are continuously doubted, to this day – mostly in the fields of education and medicine [2].

Complete linguistic accessibility is only achieved when a natural, high-quality, fully fledged sign language is used. For their entire lives, deaf sign language users rely on dependable and continuous access to professional translation/interpretation services. Without professional and sufficient translation services, their participation in education, society and general social life is not possible (as long as majority members are not sign language competent). Thus, both research and policies have been engaged in finding and creating accessibility for sign language users. One very important effect is the professionalization of the entire field of sign language interpreting [3]. Other attempts that sought both cheap and fast technical 'solutions' were "not always welcomed by Sign Language Communities" [1, and see also 4].

1.2 Sign Language Avatar Research

Avatars that display signed languages can contribute to more accessibility for deaf sign language users. However, when animated avatars are deployed in place of professional human interpreters this is regarded very critically from different perspectives. In that effect, the World Union of the Deaf, together with the World Association of Sign Language Interpreters, issued a statement on signing avatars [5], as well as the Austrian Association of Applied Linguistics [6] and the Austrian Federation of the Deaf with the Austrian Sign Language Interpreters and Translators Association [7].

Research in the field rarely asks deaf users to share their opinions and perceptions and openly discuss possible long-term effects, one recent exception being [8]. Indeed, most research focuses on the technical details and when users are included, on appearance and on legibility of signing avatars but it does not tap into deaf peoples' personal experiences and preferences regarding avatars in general. The huge majority of research so far is conducted either in the form online questionnaires or in lab settings. (Moreover, we noticed that non-signing hearing people and their perception and beliefs about signing avatars are completely absent from research.) And even scarcer are studies where a text that is signed by avatars is compared to a video of the same text translated and presented by professional sign language interpreters.

2 Our Study: Methodology and Data

The data collection for our study took place in two consecutive phases: Focus group discussions and then expert interviews.

2.1 Focus Group Discussions

We conducted 10 focus group interviews, four with hearing participants in German and six with deaf participants in Austrian Sign Language, ÖGS (total: 34 participants between 20 and 85 years of age). In this paper, only the deaf view is presented.

Stimulus Material. On all occasions, the same stimulus material in ÖGS and German was used. The stimuli were specifically put together for these focus groups and consisted of four twin video pairs that each featured an avatar[14] and a professional deaf interpreter. A detailed description of the stimulus material and how it was used is available at https://avatar-bestpractice.univie.ac.at/en/about-the-project/.

Deaf Participants. We conducted six focus groups with a total of 23 deaf participants (13 female, 10 male). They all volunteered to participate, were genuinely interested in the topic and received no compensation. The age groups 20-30, 30-40, 40-60 and above 70 were represented with 4 to 8 people each. The oldest participant was 85 years of age. Regarding their linguistic biography, two participants acquired ÖGS as their first language from their deaf parents. 17 participants use ÖGS in their daily life. And three

[14] Source: SIMAX, see https://vimeo.com/simaxavatar

participants grew up with another sign language than ÖGS, one of them only learned ÖGS a few years ago.

All six groups were moderated by a deaf, signing psychologist, Paulina Sarbinowska. Moderating was her only role and function in this project so she could truly occupy a completely neutral role.

Analysis. All discussions were filmed with three and on one occasion two cameras, then transcribed/translated into German and analyzed. Analysis included isolating all statements, comments and ideas relevant for the topic. These were then thematically grouped, summarized and stylistically unified, resulting in approx. 10 pages of our Draft Best Practice Protocol on the Use of Sign Language Avatars.

2.2 Expert Interviews

This draft was distributed to 10 experts who had agreed to be interviewed. The experts were researchers from the fields of linguistics, computer science, computer linguistics, visual arts, translation studies as well as a deaf community representative, an accessibility advisor and the CEO of a company that develops and commercially markets avatars:

- Sarah Ebling, University of Zurich, Switzerland.
- Nadja Grbić, Department of Translation Studies, University of Graz, Austria.
- Thomas Hanke, Universität Hamburg, Germany.
- Helene Jarmer, president of the Austrian Association of the Deaf.
- Hernisa Kacorri, University of Maryland, College Park.
- Melissa Malzkuhn, Director of Motion Light Lab, Gallaudet University, USA.
- Christian Pichler, Austria.
- Antti Raike, Aalto University, Finland.
- Georg Tschare, founder and CEO Sign Time GmbH, Austria.
- Rosalee Wolfe, Institute for Language and Speech Processing ATHENARC, Athens, Greece.

The expert interviews were conducted in German, ÖGS, English, and American Sign Language and proved to be extremely fruitful.[15] We then reviewed all comments individually and integrated them into one text, thus merging 10 commented versions of the text into one final version of our Best Practice Protocol on the Use of Sign Language Avatars[16].

[15] We would like to thank the experts for the many constructive conversations and their valuable contributions in this collaborative process!

[16] The entire Protocol can be accessed in four languages: https://avatar-bestpractice.univie.ac.at.

3 Findings

In this section, we present our qualitative findings in three thematic fields that emerged from the focus group discussions: linguistic, translational and ethical aspects of avatars for sign languages.

3.1 Linguistic Aspects of Avatars

The avatar deployed in the present research project was not understood by all deaf focus group participants. They criticized lacking facial expressions, imprecise coordination of manual and non-manual components of a sign, missing phrase melody, jerky, hard, mechanical, wooden, robotic, somnolent, unnatural, incomplete signs and missing transitions between them. Furthermore, a lack of mobility of the upper body, shoulders, cheeks, and a lack of or unclear mouthings and also mouth gestures were reported.

In all focus groups it was noted that the avatar "closely follows the German syntax", which was described as unpleasant, tiring, not mature, as a "gimmick", "nice experiment" and even as a "botch-up". The resulting lack of comprehensibility of the avatar demanded maximal cognitive attention and caused viewers to have to "try" or "strain" very hard to follow, calling it a "struggle".

It was also noted that the content provided by the avatar would only be fully comprehensible if viewers simultaneously read captions. However, this carried the challenge of constantly switching languages between written German and Austrian Sign Language (ÖGS). This is in line with the results of the prototype study on SIMAX's avatar which posed follow-up content questions and documented only 52% correct answers by the 247 participants [9].

Our focus group participants criticized that this kind of avatar was completely incomprehensible for people who do not have ÖGS as a first language (people who learned ÖGS later in life, people from migration or refugee backgrounds), as well as senior citizens and people with little formal education and little German competence. It was also criticized that these avatars did not present children with good linguistic role models. (Experts remarked that studies clearly show how Alexa, Siri etc. have an effect on hearing users and their linguistic behaviour.)

Participants demanded full intelligibility of signing avatars used in public and further clarified that they considered it unacceptable to be "informed" by prematurely released (i.e., not fully intelligible) avatars in important areas of everyday life. They discussed the prospect that an avatar could be a facilitator in everyday life by, for example, providing a signed "rough translation" of any text. This would be especially helpful for deaf people with low literacy skills.

Finally, all participants were sure that in the future the quality of avatars would improve significantly and that then they could possibly serve as a valid supplement to interpreters. That would mean more flexibility and independence for deaf people in their everyday life. The question was also discussed whether Artificial Intelligence could contribute to avatars producing authentic, appropriately signed language.

According to one participant, avatars would be "a dream" if there were no qualitative and linguistic differences between the performance of human interpreters and of avatars. Experts remarked that the path to fulfilling this dream may be complicated, non-linear and maybe even ugly.

3.2 Translational Competence and Quality

Many deaf people distrust the quality of avatar translations because, unlike with human interpreters, it is unclear who provided the translation and to which professional code of conduct that person is committed. It would increase viewers' confidence in any longer, complex text signed by an avatar if it were disclosed who did and reviewed the translational work (human-machine, machine-human). It should be clear what language skills or interpreter training and affiliations that person has.

In our focus groups, it was often demanded that commercial avatar products (i.e., videos with an avatar) that are sold and used publicly, should only be released after a thorough quality control by specialists.

Note: Both hearing and deaf focus groups did not differentiate between the quality of translation and the quality of animation/performance. Mostly it was discussed what was seen, and not the quality of the translation.

3.3 Ethical Issues

It was emphasized in the discussions that in terms of participation, deaf interpreters, animators, project managers, as well as the entire deaf community need to be involved in the development and production of avatars. Members of the deaf community should not only serve as study participants or providers of feedback. On the one hand, participants assumed that hearing people were "delighted" with and fascinated by signing avatars. On the other hand, they know that hearing non-signers usually have no competence to assess the intelligibility and the linguistic and translational quality of signing avatars. Furthermore, hearing people usually are so unfamiliar with deaf everyday life that they cannot genuinely understand the needs of deaf people.

It was stressed that not only clients/customers, but also sponsors should coordinate their decisions about avatar projects with the self-advocacy associations of deaf people. Experts remarked that this would also build knowledge within the deaf community about the realities of research and the complicated processes of acquiring funding.

According to the participants it is preferable that "not solely economic interests" are pursued. Trustworthy, seminal research and - in the case of commercial companies - close cooperation with universities and research groups were called for. It would also be desirable for the various researchers and developers in the field of avatars to exchange ideas and learn from each other in a non-commercial setting. This could help raise the quality of avatars to a truly satisfactory level instead of "everyone doing their own thing", as one participant put it. Experts remarked that there was a certain tension between the wish to calmly and cooperatively develop an appropriate quality in sign language avatars and the demand of the market which usually seeks "fast and cheap" solutions. In addition, experts deemed it desirable that research leads to high quality while commercial providers of avatars can conduct their business. Nevertheless, the situation of sign language avatar development cannot be compared with the development of speech synthesis, where in the beginning lesser quality was seen as acceptable and users experienced and accompanied gradual improvements. Since sign languages are minority languages there is the danger that they are negatively influenced (and perceived!) by the spread of bad language data. Experts furthermore remarked that when using language data, the question of ownership and also representation always arises: Who is a good linguistic model? To whom do the data ultimately belong?

Participants remarked that avatar development was one of the few areas where deaf people shall be prioritized for employment. It causes great discomfort when people without sign language expertise determine the quality and use of avatars while they cannot communicate directly with their deaf co-workers.

Furthermore, it was also pointed out that the financial argument (presumably, avatars are cheaper than interpreters) must not be the most important one. Avatars could mislead to the illusion that "everything is now done" for deaf people. However, whether an avatar actually does contribute to more accessibility can only be assessed and decided by deaf sign language users.

Experts remarked that deaf sign language using staff should always be involved in the development and production of signing avatars and should become specialists in these processes so that they can constructively accompany and guide it.

4 Best Practice Recommendations

The following recommendations are firmly rooted in our qualitative data; deaf focus group participants and deaf and hearing experts are the source.

4.1 Linguistic Aspects

1. The linguistic quality of signing avatars depends on the degree of proximity to the human range of movement. Avatars whose primary focus is on the arms, do not provide the means to appropriately and intelligibly display a signed language. In the animation process, the torso, pelvis, shoulders (individually and together), all parts of the face, including the eyes (direction of gaze), and the entire head must be moved completely and appropriately.
2. Signing avatars only deliver high quality linguistic performance if they offer diversity in style and register, as well as linguistic variants within a text. Attention should be paid to diversity within the production team (especially in motion capture technology but also in machine translation).
3. In avatars, special attention must be paid to a precise (frame exact), harmonious interplay of manual and non-manual components of a sign.
4. It is recommended that avatar videos (for example in the area of public transport) also feature pictograms, such as images of buses, platform numbers, and trains.
5. The intelligibility of signing avatars must be granted for all deaf sign language users who depend on the conveyed information. This includes persons with little formal

education, or who did not acquire a sign language as their first language, diverse age groups etc.[17]
6. Avatars are no substitute for captions because captions are needed by all people with hearing impairments who are not sign language competent.

4.2 Aspects of Translation Competence

1. Texts presented by avatars must undergo quality control before they are published/released. This quality control should be conducted by deaf, bilingual specialists, preferably native signers, who are highly competent in both languages (the source language of the text and the language the avatar signs) and who have translation skills and knowledge.
2. It would be conceivable to establish an independent, deaf-led quality control centre where companies can submit their avatars or individual texts presented by avatars to be certified and released by a panel.
3. If the quality control concerns a computer-generated or partially computerized translation, these specialists must be trained and qualified interpreters.
4. An empirically developed set of criteria for quality control of avatar translations is urgently needed (the norm DIN EN ISO 17100 is not sufficient). This generally applicable quality management (for movability, fine motor skills of the animation, ease of perception and translation quality, just to name a few examples) would enable not only developers but also customers and sponsors to assess the product in question.

4.3 Ethical Aspects

1. Sign languages originate from deaf communities and have been preserved by deaf people even in the most hostile conditions. Deaf people helped the language to flourish even under great pressure. The deaf communities of the world wish to see their languages treated with respect. This includes that economic interests are not placed above the protection and preservation of sign languages.
2. Deaf people should never have to choose between avatars and human interpreters. Avatars are not a substitute for human interpreters, they may be an addition.
3. Deaf people must guide the decision where avatars can be appropriately deployed.
4. Deaf people must lead in the creation of sign language avatars, the translation process, and in the quality control (pre- and post-editing) prior to the delivery of an avatar video to the customer.
5. If avatar developers are actually concerned about quality rather than only about profit, they need to cooperate with each other and with the self-advocacy associations of deaf communities.
6. Avatars should be developed and researched in interdisciplinary teams: co-operations are required between visual studies, 3-D animation, linguistics (not only

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[17] Only about 10% of deaf children have deaf parents and thus access to a fully-fledged and fully accessible language. Most deaf people acquire or learn their sign language late and not from their primary caregivers.

computer linguistics) as well as translation studies. Otherwise, avatars will remain gimmicks.

7. The principle Nothing about us without us also applies to the field of sign language avatars. Therefore, the deaf sign language users' perspective (not the perspective of them) should always be central in public relations, in business communication and in marketing.
8. The cost issue must not be the only or the most important decision criterion. Desirable accessibility is a matter of quality; decisions can be taken pragmatically, but still with regard to quality. If an offer is "cheaper" but is neither acceptable for, nor desired by deaf sign language users, then cost saving was prioritized over human/citizens' rights and true accessibility.
9. When public funds are awarded to the development or deployment of signing avatars, the actual needs, desires and perspectives of deaf communities should be the guide.

4.4 Conclusion

Avatars should not be presented, seen or marketed as a "solution" to the "communication problems" of deaf sign language users. Their value is in added entertainment. Deploying sign language avatars must not create disadvantages for deaf people. Avatars should be deployed responsibly in the interests of deaf sign language users. Currently, sign language avatars are by no means an adequate replacement for human interpreters. As long as comprehensibility of avatars does not match those of human signers, avatars should always be used in conjunction with captioning.

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Evaluating Collaborative Editing of AI-Generated Live Subtitles by Non-Professionals in German University Lectures

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Abstract. Subtitles are an important accessibility feature for deaf and hard of hearing students. The automatic generation of subtitles with artificial intelligence provides a fast and cost-effective way to make lectures more accessible. However, automatically generated subtitles are not sufficiently accurate for comprehension. One possible way to increase the accuracy of subtitles in a lecture setting is through a collaborative editing process by amateurs in a live setting. To this end, we conducted a Wizard-of-Oz test to simulate the process of live-editing a university lecture. Participants watched a lecture recording and collaboratively edited AI-generated subtitles in small teams. Subtitles were either presented simultaneously or with a delay that simulated a realistic processing time of the AI. Participants reported their cognitive load and how well they could follow the content of the lecture. The accuracy of subtitles was measured using the Word Error Rate (WER). Manual editing under both conditions reduced the WER of the AI-generated subtitles. Participants receiving subtitles simultaneously achieved a lower WER, reported a lower cognitive workload and could follow the content of the lecture better than those experiencing a delay in the presentation of subtitles. A minimal offset between the audio content and the presentation of subtitles supports amateurs in editing subtitles.

Keywords: Subtitles, AI, Livestream, Collaborative Editing, Higher Education.

1 Introduction

Real-time subtitles are an important accessibility tool for deaf and hard of hearing (DHH) students. Typical problems they face during lectures include a high rate of speech, several people talking at the same time [1] and the inability to lip-read when the lecturer cannot be seen [2]. Subtitles also benefit other students, e.g. non-native speakers [3].

Traditionally, subtitles are created by humans who manually transcribe or respeak the content into voice recognition software. In the context of higher education, tight budgets are prohibitive for this cost-intensive process. Furthermore, not enough professional subtitlers and respeakers are available. With the rise of Artificial Intelligence (AI) technology in the last decade, the quality of automatic speech recognition (ASR) has increased rapidly. Subtitles for spoken language can now be generated fully automatically and almost in real-time. In comparison to manual editing, this process is less cost-intensive and widely available.

Automatic subtitling alone, however, is not sufficient to make lectures or media accessible to DHH students [4–6]. One major problem is the accuracy rate of ASR. A recent comparison of commercial software for English ASR reported up to 94% accuracy for live conversations, however this rate was only achieved with recordings of excellent audio quality [7]. The accuracy rate for more realistic recording conditions that includes some background noise, average recording material, distance and reverberation, is expected to be much lower.

To achieve a sufficient accuracy of 98% [8], manual editing is still required. Crowdsourcing the correction of ASR generated subtitles in real-time is a possible solution without relying on professional services or delays in transcription. Collaborative editing would split the task between a number of people to reduce the individual time and effort. Related studies imply that crowd-editing can improve accuracy [9].

The goal of this research is to evaluate whether students can collaboratively correct AI-generated live subtitles whilst attending a university lecture. We conducted a user test combining all these parameters in a simulated representative environment. We compared the accuracy rates of the AI-generated and user corrected subtitles. Additionally, the participants reported their perceived cognitive workload during the task. This leads to the following research questions:

- Do manual corrections improve the accuracy of AI-generated subtitles?
- Does the time of insertion of the subtitles impact the accuracy of manual corrections?
- Does the time of insertion influence the perceived cognitive workload of the participants?
- Can participants follow the content of the video while correcting subtitles?

2 Related Work

Existing research investigates how the accuracy of AI-generated subtitles can be improved under different conditions. The use of professionals and amateurs for live and asynchronous subtitling is examined.

In order for subtitles to be useful for DHH individuals, they should reach an accuracy of about 98% [8]. Automatically generated subtitles alone do not reach this target. The accuracy of these subtitles can be improved with professional and amateur editing under both live and asynchronous conditions.

Lambourne et al. [10] and Hewitt et al. [11] investigated how live television subtitles generated by respeaking can be improved through subsequent corrections by professional subtitlers. After manual editing, subtitles reached the target accuracy of 98% [10]. Although these studies focused on subtitles generated through respeaking, they show the potential of combining automatically generated subtitles with manual editing.

Takagi et al. [12] evaluated the correction of AI-generated subtitles in company meetings by non-professionals that do not actively take part in the meeting. Their initial results indicated that only very skilled subtitlers correct quickly enough to produce live subtitles. On average, the offset from pronunciation to display of corrected subtitles is 22.8-55.8 seconds, which is not sufficient for live subtitling.

Other studies focus on non-professionals as subtitlers in the context of higher education. Pérez-Martín et al. [13] and Soe et al. [6] investigated whether subtitle creation by students is more efficient and of higher quality when assisted by ASR in a non-live scenario. Their results show that students are able to increase subtitle accuracy [13], and a semi-automated workflow increases effectiveness and efficiency [6].

Wald [5] and Wald & Bain [14] evaluated their developed tool for correction of real-time subtitles in the context of universities. Their participants are non-professionals with different occupations who do not actively take part in a lecture. Their results show that editors can correct an average of eleven errors per minute, which is, according to Wald & Brain, sufficient to understand the subtitles.

A study combining the features AI-generation, collaborative editing, live-subtitling and using a part of the audience (non-professionals) as subtitlers has not yet been conducted.

3 Method

This evaluation is based on a Wizard of Oz approach. To simulate a live lecture, a pre-recorded video is streamed via Zoom. For multi-user editing, Google Sheets is used. The AI-generated subtitles are automatically inserted into the document via a script.

3.1 Procedure

Ten participant groups were randomly assigned to one of two presentation conditions. In one condition, the subtitles were presented simultaneously to the video content. In the other condition, video subtitles were presented at the end of a sentence with an additional delay of one second, simulating the time an external ASR service requires from receiving the audio data to returning the transcription [15]. Every participant joined their group Zoom meeting and their shared document. The video was presented and participants could edit the subtitles until the end of the video. Afterwards each participant answered a questionnaire consisting of the NASA Raw Task Load Index (RTLX) [16] to assess cognitive load, and some test questions about the lecture content to assess retention.

3.2 Participants

30 people participated in the study. About half of the participants were undergraduate Computer Science and Media students, the other half were research staff at the university. Participants were informed about the goals of the study, what participation entailed, and gave their informed consent to take part. The participants were randomly

assigned to one of ten groups. Within these groups of three, participants collaborated to edit the subtitles of the presented video. During the editing process, participants had no means to communicate with one another via chat or video call.

3.3 Video

The presented video was a pre-recorded part of a lecture on "Universal Design for Learning and Digital Accessibility" and had a duration of twelve minutes. We assume that participants were unfamiliar with the topic itself, but it was broadly connected to their area of study. The video-sample was recorded under non-professional conditions with an average audio quality including some background noise. The speaker used naturalistic conversational speech typified by hesitation vowels, unclear pronunciation, incomplete sentences, and grammatical errors.

3.4 Subtitles

To simplify the process, the audio of the video was transcribed with Microsoft Azure in advance of the actual user test. Compared to other commercial solutions from Google, Amazon, IBM, Panopto and Amberscript, it delivered the most accurate outcome for the used recording. The result was not corrected manually. The text was then split into chunks according to WCAG 2.2 [17] guidelines for subtitles where each chunk had a maximum of 80 characters. Each subtitle was extended with timestamps to provide the previously mentioned setups with simultaneous and delayed insertion.

3.5 Interface

The interface is shown in Fig. 1. For collaborative editing of the subtitles, a Google Sheets document was used. It is a robust solution that enables multiple users to edit the same document, to receive real-time content updates, and to track the current position of other users. Following existing solutions like Panopto or the YouTube subtitle editor, the overall text was split into multiple subtitles with unique input fields. This design structures the content logically into small blocks and reduces conflicts from users editing the same sentence or even the same word simultaneously. As soon as a user selects a cell, its border is highlighted in a user specific colour, indicating to others to not modify its content.

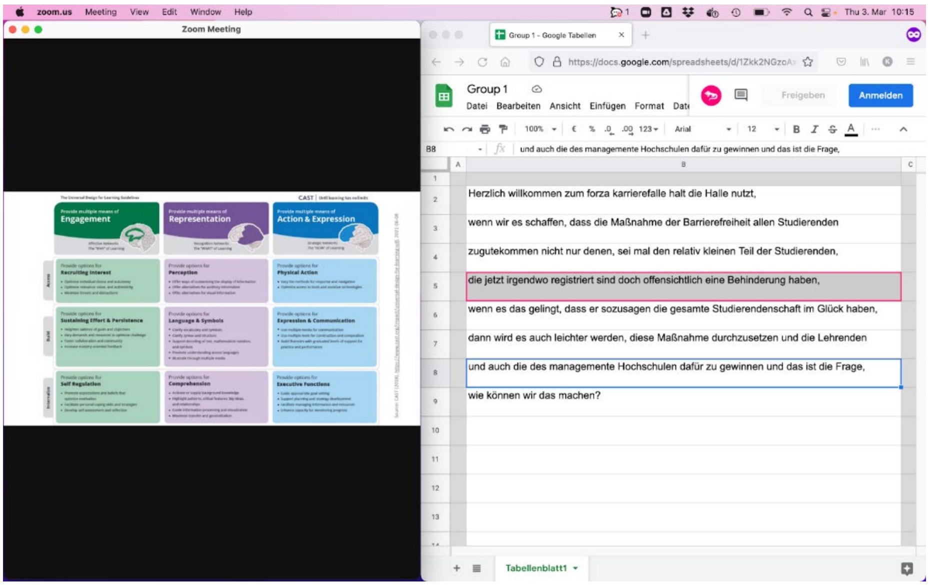

Fig. 1. Interface from participants view

To ensure reproducibility and avoid human errors, the document was controlled through a script accessing the Google API. It ensures that the lecture subtitles are written consistently at a specific time of the video. The sentences are added consecutively and appended below the existing content. The script also starts the video that is streamed to all participants via Zoom screen- and audio sharing. The participants cannot start, stop or rewind the video.

3.6 Metrics

Word Error Rate. To measure errors in transcriptions, the word error rate (WER) is used, with the edited transcript compared with the correct reference transcription. As shown in Eq 1, the WER is computed as the number of substitutions (S), deletions (D) and insertions (I) between the transcriptions, divided by the number of words in the reference (N) and multiplied by 100 to get a percentage value. “WER can be thought of as a percentage approximation of the number of words that need to be corrected in order to achieve the reference transcription.” [18]

$$WER = \frac{S+D+I}{N} \cdot 100 \quad (1)$$

The initial WER of the AI-generated subtitles is calculated and compared to the WER after user corrections against a sample solution by counting the modifications needed to get the solution. Additionally, the modifications done by the participants in comparison to the AI-generated subtitles are counted.

NASA TLX. The NASA Task Load Index (TLX) is a metric used to evaluate the overall cognitive workload of participants during a task [16]. The participants first rate the six subscales (Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, Frustration) on a 20-point-scale. Afterwards they weight the subscales in a pairwise comparison. To minimise the time of completion for participants, the Raw TLX (RTLX) is used, which omits the weighting of dimensions by participants [19].

4 Results

Do manual corrections improve the accuracy of AI-generated subtitles?

Manual corrections did improve the overall text accuracy of the AI-generated subtitles. The initial WER of the AI (8.9%) was reduced to a mean WER of 5.6% for the simultaneous groups and 6.8% for the delayed groups (see Table 1). Across all participating groups, the WER decreased between 1.4 to 4.8 percentage points (see Fig. 2).

Table 1. WER of the corrected versions of the participants in comparison to the sample solution.

Groups	Substitutions	Deletions	Insertions	WER
AI	86	17	18	8.9%
Simultaneous	53.6	9.4	13.8	5.6%
Delayed	59.6	10.2	23.2	6.8%

Capitalisation errors accounted for 0.95 percentage points of the WER of the AI. 1.02 percentage points of the WER of the AI could be attributed to errors in word composition.

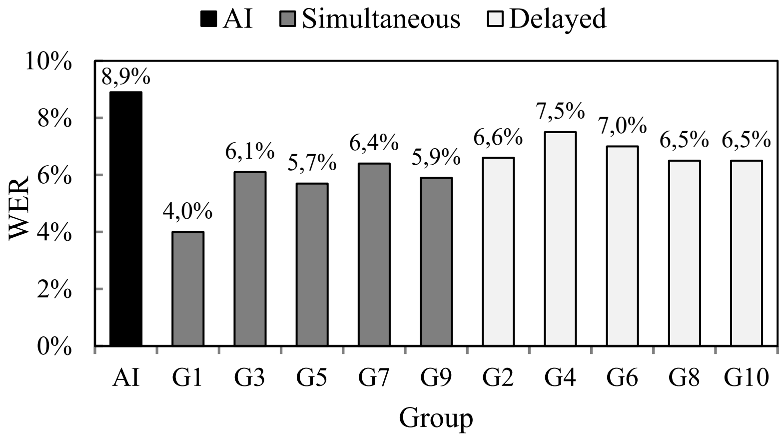

Fig. 2. WER of the AI-generated subtitles compared to the WER of each group after manual corrections.

Does the time of insertion of the subtitles impact the accuracy of manual corrections? A Mann-Whitney-U-Test showed that there was a significant difference ($U = 0$, $p = 0.008$) between the groups receiving subtitles simultaneously and the groups receiving delayed subtitles. The groups who received the text simultaneously to the video reduced the number of errors from 121 errors by the AI to a median of 81 errors, while the groups with delayed insertion reduced the number of errors to a median of 90 errors.

The AI created 123 subtitles in total and 55 subtitles with errors. All subtitles were examined after manual editing and categorised by their modifications or missing corrections (see Table 2). Subtitles with errors that were fully or partly corrected, subtitles without errors that stayed unmodified, and subtitles with additional modifications that had no effect on the WER calculation are categorised as correct. Subtitles that are missing corrections or contain faulty modifications are categorised as faulty.

Not all changes participants made improved the overall text accuracy. Although both groups made a similar number of modifications (delayed 69.6, simultaneous 64.2), the WER of the simultaneous groups was significantly lower. The delayed insertion of subtitles resulted in more faulty modifications. On average, 6 of 123 subtitles (4.9%) were falsely modified in delayed groups and 1.4 (1.1%) in simultaneous groups.

Table 2. Amount of subtitles categorised by correction state

	correct				faulty	
	fully corrected	correctly unmodified	partly corrected	uncounted modifications	missing corrections	faulty modifications
Simultaneous	16.6	63.2	14.2	6.8	20.8	1.4
Delayed	19.6	57.4	9.2	5.2	25.6	6.0

Does the time of insertion influence the perceived cognitive workload of the participants? The time of insertion has a significant influence on the participants' cognitive workload (RTLX) (Welch-Test: $t(20.95) = -3.94$, $p < 0.001$). The average RTLX for participants in the delayed groups ($\bar{x} = 66.9$, $\sigma = 10.2$) is higher than for participants in the simultaneous groups ($\bar{x} = 44.3$, $\sigma = 19.8$).

Can participants follow the content of the video while correcting subtitles? Participants rated how well they could follow the content of the video on a 7-point Likert-scale from 1 ("I couldn't follow the content at all") to 7 ("I could follow the content fully"). Participants in the simultaneous groups (Median = 5) were able to follow the content of the video significantly better than the participants in the delayed groups (Median = 3) (Welch-Test: $t(26.68) = 3.44$, $p < 0.001$).

What subjective impressions do participants report? We analysed participants' answers to open questions in the questionnaire and grouped them by common themes. All participants in the delayed groups perceived the task as either stressful or exhausting. In the simultaneous groups six participants mentioned stress, while seven perceived the task as easy. Additionally, nine participants in the delayed groups reported having trouble remembering the spoken content while they were editing the subtitles. Two participants from each group reported feeling frustrated that they did not do well on the task and could not correct many errors.

Eleven participants in the delayed groups mentioned not being able to follow the content, with four of them explicitly mentioning that they had to skip several lines to catch the spoken sentence again after correcting a sentence.

Six participants found working collaboratively with their teammates helpful. Four participants raised concerns about how to collaborate effectively (e.g. clear indications that teammates correct errors).

5 Discussion

The results of the user-test show that manual correction by non-professionals decreases the word error rate of AI-generated subtitles in a university lecture. The WER for the two experimental groups differed significantly. Although both groups made a similar number of edits, the simultaneous groups produced a significantly lower WER than participants in the delayed groups.

The delay in the presentation of the subtitles seems to impact the rate of corrections negatively. In this condition, which realistically simulates using an external ASR, participants experienced an offset between listening to the audio and receiving the written text. This could lead to corrections or modifications on the basis of the subtitles alone rather than on what was being said.

Participants in the delayed groups reported having trouble remembering the spoken content. This suggests a higher task demand in the delayed condition that impacted participants' ability to correct the mistakes. This is reflected in the RTLX scores. In the delayed groups participants reported significantly higher RTLX scores (66.9) compared to those in the simultaneous groups (44.3). Grier [19] conducted a meta-analysis of the RTLX scores in a number of tasks, arriving at an average RTLX score of 45.29. This provides further evidence that editing delayed subtitles for a live event is a stressful and demanding task for participants.

Participants in the simultaneous group reported feeling less stressed and that they were able to follow the content better than participants receiving delayed subtitles. Not being able to follow the content is a problem for university students who need to actively pay attention to lecture content.

Both groups made modifications to the subtitles that went beyond correcting what was being said. Some of these negatively impacted the WER as they added mistakes. Participants in the delayed groups added more mistakes, suggesting that they edited based on the subtitles alone. Some modifications were motivated by "common sense" and deleted repetitions or mistakes the speaker made. These modifications could potentially be perceived as helpful by DHH individuals. Other modifications were not counted as part of the WER (e.g. correcting punctuation).

In this study, WER was used to compare participants' ability to correct automatically generated subtitles. The requirement for subtitles to be accessible for DHH individuals is an accuracy of 98% (WER $\leq$ 2%). Neither group in this study was able to achieve this level of accuracy. One important question is whether the WER is an accurate measure of the usefulness and accessibility of subtitles. The WER counts mistakes that might not have any impact on the understanding of the text. This is particularly relevant in German where capitalisation or composite words are a source of error. Furthermore, some corrections increase the WER but might make subtitles more usable, e.g. deleting repetitions or incorrect words. A more appropriate measure of whether subtitles were improved by manual correction would be an assessment by DHH individuals. Alternative measures have been proposed (see [20, 21]). Additionally the target WER of 2% or lower must be questioned, as a higher value might also be sufficient, depending on the type of mistakes and their impact on the general understanding of text.

Six participants commented positively on the collaborative aspects of the task. This suggests that sharing the work of editing subtitles positively impacts participants' motivation and makes the task achievable. An open question is how many people in the editing team can work together efficiently.

Participants reported issues in the editing process. The user interface did not fully indicate which subtitles were edited, what corrections were made or when another person can edit a text-unit again. Further user tests are needed to investigate how specialised user interfaces can support collaborative editing.

For live-editing to work, there must be a minimal delay between spoken words and the presentation of the subtitles in an editor. As the AI always requires some processing time, simultaneous editing is impossible. Delaying the video for the editors would synchronise it with the generated subtitles. Adding an even bigger delay to present the video and manually corrected subtitles in sync could be a solution for DHH students and should be investigated in further studies.

6 Conclusion

Non-professionals were able to reduce the WER of AI-generated subtitles for a university lecture. Participants who received audio content and subtitles simultaneously lowered the WER significantly more than those who received subtitles with a delay. In addition, participants who experienced the delay reported a higher level of stress, a higher cognitive workload, and had more problems following the content of the lecture than those in the simultaneous condition. A minimal delay between audio content and the presentation of subtitles is therefore a necessary condition for successful editing. A specific editor for subtitles could improve participants' experience of the editing process and enhance collaboration. Neither group achieved a WER of 2%, the benchmark for accessible subtitles. It is an open question whether measuring the WER is an accurate assessment of subtitles' usefulness for DHH individuals.

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Digital Accessibility: Readability and Understandability

Does Switching between Different Renderings Allow Blind People with Visual Neuroprostheses to Better Perceive the Environment?

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Abstract. Visual neuroprostheses are devices that restore limited visual perception for visually impaired patients. Some of these neuroprostheses, implanted in the retina or the visual cortex include an implant, a computing device and an external camera to capture the scene. An impoverished visual perception is restored when the microstimulation of the retina or the visual cortex activates white spots called phosphenes. However, the resolution of current implants (i.e. the number and spacing of the electrodes) that have passed the clinical trial phases remains low. Such low resolution, coupled with the limited number of different colors rendered by the implants, limits the information that can be transferred. The regular rendering process used with the implants, called Scoreboard, is insufficient to support complex comprehension tasks. To allow the patient to better perceive his environment, ongoing research aims at maximizing the quality and quantity of information provided by the implant. We set up a comparative study between different renderings and we showed that providing the blind with the possibility to switch between different renderings significantly increases the understanding of the environment.

Keywords: Visual neuroprostheses, Interactive rendering, Adaptive rendering, Retinal implant, Computer vision, Blind people.

1 Introduction

According to the WHO [1], 253 million people are visually impaired: 36 million of them are blind and 217 million have moderate to severe visual impairment. Visual neuroprostheses first appeared in the 1960s [2] and have emerged as a promising technique for partially restoring vision in people with visual impairment. Over the last ten years, several implants have been placed on blind people and have been in clinical trials [3]. In this study, we compared three different prosthetic rendering modes: the Scoreboard mode (Control); a combination of semantic object segmentation and scene structure detection called "Combined", similar to a recent state of the art method [6]; and a mode called "Switch" which allows to alternate between the Combined rendering and two other renderings where only objects or only structure appear respectively. The study is based on the analysis of the needs of blind people provided by Ratelle and Couturier [4]. Our hypothesis is that the Switch rendering mode provides a better understanding of the organization of the objects as well as the structure in an external scene than the Control (Scoreboard) and Combined rendering modes. Since it is impossible to perform such tests on implanted patients, the study was performed with a prosthetic vision simulator inspired by clinical reality. Our results, obtained on 20 subjects, show the interest of the "Switch" mode in the understanding of static scenes (images).

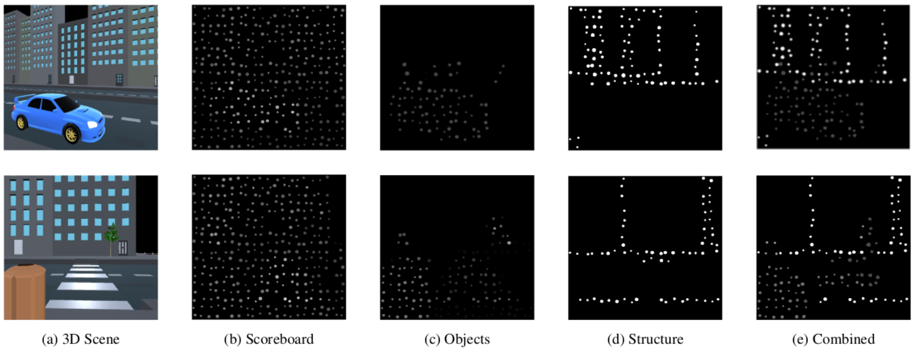

Fig. 1. Examples of prosthetic renderings: (a) shows the initial image in a virtual environment. (b) shows how (a) is rendered with Scoreboard rendering. (c) shows how (a) is rendered with a method that detects only objects, and (d) shows how (a) is rendered with a method that enhances structural information (structure enhancement). (e) is a rendering combining (c) and (d) and called Combined.

2 Related Work

2.1 Visual Neuroprostheses

Visual neuroprostheses are devices designed to restore light perception in people with partial or total blindness. They consist of a portable camera, a small computer and a matrix of electrodes that is implanted in the retina. These implants generate electrical micro-stimulations that cause the appearance of blurred points called phosphenes. Several devices have been developed and some implants have been clinically tested. Existing commercial visual neuroprosthesis systems are based on retinal implantation of a limited number of electrodes (6x10 for the Argus II developed by Second Sight [7], 21x18 for the PRIMA system developed by Pixium Vision [5]). While these neuroprostheses have improved the daily lives of many blind people [8], the restored visual perception is too weak to allow more advanced perceptual or sensorimotor processes such as navigation.

2.2 Different Phosphenic Renderings Depending on the Task

The limitations of current visual neuroprostheses pose significant problems for rendering a scene in a comprehensible manner. The historical method of "Scoreboard" rendering consists in reducing the captured image to the resolution of the implant, then converting the image to grayscale and quantifying the grayscale to the intensity level supported by the implant (Fig. 1B).

However, several studies have shown that specific image processing can improve the performance of subjects in various tasks from perception to navigation [6,9-11]. Specifically, Sanchez-Garcia et al. [6] proposed a rendering that constructs a schematic representation of indoor environments, highlighting the structural informative edges and silhouettes of segmented objects. An example of this type of rendering is proposed on Fig. 1E.

3 Prosthetic Vision Simulator

Due to the difficulty of accessing implanted patients to test different renderings, the use of a prosthetic vision simulator is common in the literature [6,9,10,12]. As its name indicates, the simulator allows to simulate different implants (size, position, resolution) in various contexts (2D or 3D visual scenes, static or dynamic).

3.1 Simulated Implant

We chose to simulate the PRIMA system developed by Pixium Vision (Paris, France), composed of a 21x18 electrodes array. Our choice is motivated by the fact that it is the most recent implant having passed satisfactory clinical trials [3]. It is also one of those that allows a visual rendering with the highest resolution to date. Indeed, the current technical limitations do not allow to have a very high number of electrodes (the Argus II has only 6x10 electrodes [13]).

A dropout rate of 10\% was applied to the electrodes to simulate non-functional or broken electrodes. A Gaussian blur was applied to the generated phosphenes, the size of the phosphenes within the same implant varied between 0.235° and 0.275° of the field of view. The spacing between two phosphenes varied between 0.55° and 0.825° of the field of view.

3.2 Phosphenic Renderings

Scoreboard rendering (Control): The image is reduced to the resolution of the implant. We then quantize the intensity into four levels of gray. Finally, we transform each rectangular area that now represents an implant electrode into a phosphene.

Combined rendering (objects + structure): First, we extract an object segmentation map from the input image, see Fig. 2-1A. As with the Scoreboard rendering, this image is scaled and quantized, see Fig. 2-2A. In parallel, we also extract the edges of the scene structure and then we scale and quantize the image, see Fig. 2-1B-2B. We then combined 2A and 2B into a single image (Fig. 2-3). Finally, we transform each rectan gular area that now represents an implant electrode into a phosphene (Fig. 2-4).

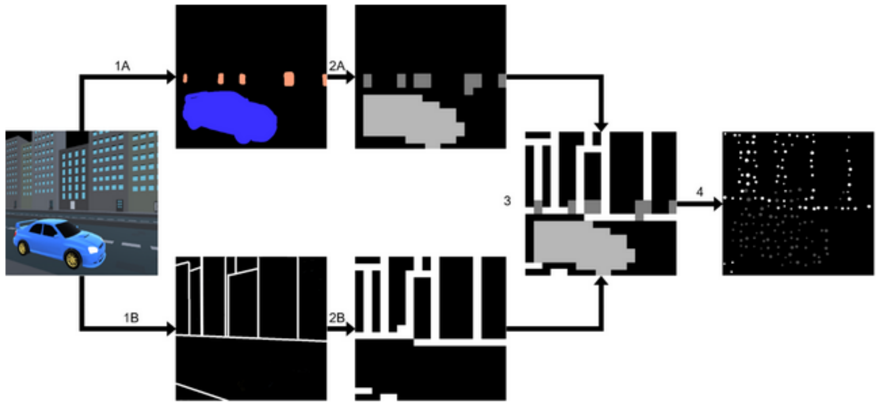

Fig. 2. Generation of the Combined rendering (objects + structure).

Switch rendering: The Switch rendering mode allows the subject to change the rendering at will. In this mode, the available renderings are the Combined rendering, the Objects rendering and the Structure rendering. The Objects rendering is obtained by transforming the image from Fig. 2-2A into a phosphenic version. The Structure rendering is obtained by transforming the image from Fig. 2-2B into a phosphenic version.

4 Material, Methods and Protocol

4.1 Hypothesis, Subjects and Experimental Conditions

We hypothesized that the ability to switch rendering types in real time to perform outdoor visual scene comprehension tasks allows subjects to perform better visually. The subjects were recruited in an engineering school and via social networks (LinkedIn, Facebook). 20 subjects, (11 men and 9 women aged from 17 to 55 years, mean: 25 years, sd: 13 years), participated in the experiment. Each participant had normal or corrected vision. All subjects gave their consent to participate in the study and allow storage of their anonymized data, in accordance with the GDPR. We used the three experimental conditions presented in section 3.2.

4.2 Protocol and Variables Analyzed

The experimental session contained three blocks corresponding to the three experimental conditions. Each block was divided into three parts including familiarization with the rendering used in the block, the test phase, and then a questionnaire regarding the rendering the subject just used in the block. During the test phase, the subject had to answer a series of 15 questions including 5 questions in three categories named "objects", "streets", "doors and crosswalks". Once an answer was selected, users could move on to the next question. The order of the blocks and questions was randomized to limit inter-block or inter-question bias. At the end of each block, subjects were asked subjective questions about the appropriateness of the rendering used in that block. The questions focused on the pleasure experienced and the perceived usability of the rendering used in that block.

To address our hypothesis, we measured, for each subject, two variables: (i) the validity of each answer (correct / incorrect / I don't know), (ii) the response time to each question. To analyze the quantitative results we performed two-way ANOVA tests according to the model (Condition * Task * Interaction), and then used a Tukey post-hoc test to compare pairs two by two. In the figures, we used 95% confidence intervals.

5 Results

Correct answers: The two-way ANOVA showed that the number of correct answers was significantly different by rendering ($F(2,171) = 15.834$; $p < 0.0001$) and by task $F(2,171) = 81.730$; $p < 0.0001$). The interaction was also significant ($F(4,171) = 5.728$; $p < 0.001$). Switch condition is highly effective in identifying objects, but even more in understanding street patterns, see Fig. 3.

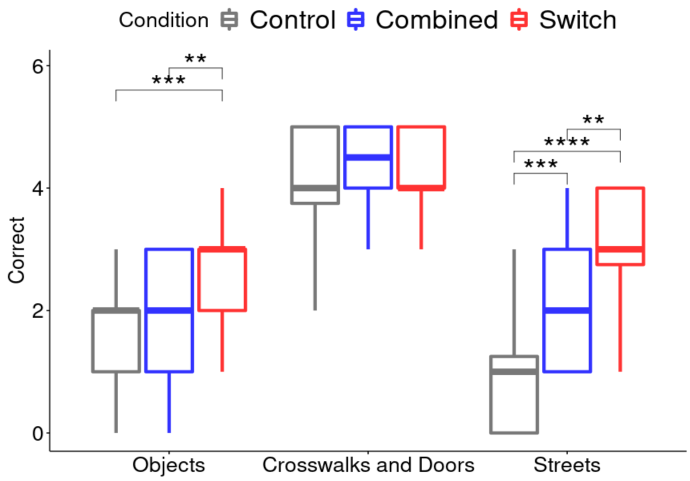

Fig. 3. Average number of correct responses per Render and per Task. Detection of crosswalks and doors is equivalent for all conditions. Identification of objects and street patterns is significantly improved with the Switch rendering. (N=20. Bars indicate 95\% confidence interval. *=0.05 ; **=0.01 ; ***=0.001 ; ****=0.00001).

"I don't know" answers: The two-way ANOVA (Condition * Task * Interaction) showed that the number of "I don't know" answers was significantly different by rendering ($F(2,171) = 10.543$; $p < 0.0001$) and by task $F(2,171) = 5.882$; $p < 0.001$). However, the interaction was not significant ($F(4,171) = 1,909$; $p = 0.111$).

Response time: The two-way ANOVA showed that the response time is significantly different according to the experimental condition ($F(2,891) = 17.245$; $p < 0.0001$) and according to the task $F(2,891) = 14.081$; $p < 0.0001$). However, the interaction was not significant ($F(4,891) = 0.465$; $p = 0.762$).

Subjective questionnaire: Participants were asked to respond with a score between 1 and 7 to a series of questions at the end of each of the three blocks. The two-factor ANOVA (Render * Task * Interaction) shows that the score was significantly different by rendition ($F(2,228) = 11.878$; $p < 0.0001$) and by task ($F(3,228) = 5.604$; $p < 0.001$). The interaction was significant ($F(6,228) = 7.537$; $p < 0.0001$). We observe that in terms of pleasure of use, the Combined and Switch renderings are significantly better rated than the Control rendering (Scoreboard). We can also observe that in terms of difficulty of use, perceived usability and the amount of information presented, the Switch rendering is better rated than the Control rendering. We also notice that the Control and Combined renderings are not perceived with a different level of difficulty. On top of that, for the question: "I found the ability to switch renderings very useful", we obtain an average score of 6.2 +/- 0.52 (out of 7).

Ranking: Subjects were finally asked to rank the renderings in order of preference along four criteria: for identifying intersections and street corners, for identifying objects, for identifying doorways and crosswalks, and overall. Fig. 4 shows these results. We observe that the order of preference for the renderings is Switch, Combined, Control, regardless of the task performed.

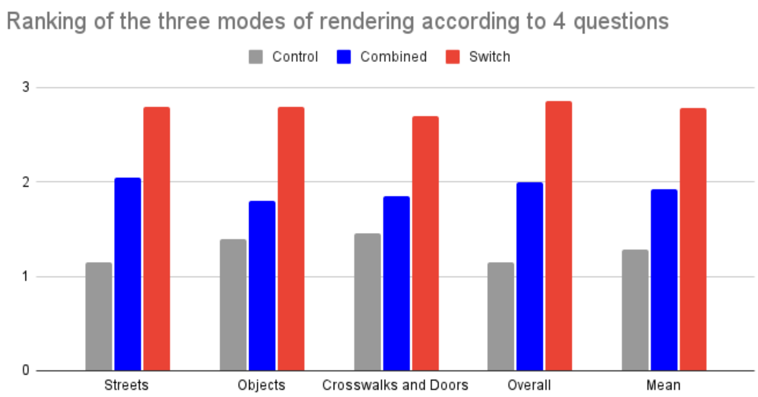

Fig. 4. Average final ranking given by users (N=20). Switch rendering is the best ranked on average, regardless of the task performed.

6 Discussion and Perspective

Our results show that the detection of crosswalks and doors is easy, regardless of the rendering used. This is not surprising because for doors, the rendering is always a white rectangle that is easy to perceive. Crosswalks are less easy to perceive than doors but easier to perceive than other objects because they appear as a succession of parallel rectangles.

On the other hand, the identification of objects and the understanding of the street organization depend strongly on the rendering used. The results show that the Switch rendering is significantly better than the Control and Combined rendering. We observed that the Combined rendering is not significantly better than the Control rendering for object detection. This is not consistent with the study by Sanchez et al. [6]. This distinction can be explained by the resolution of the implants used in our simulator (21x18) which is lower than that used in theirs (32x32). Indeed, according to Cha et al. [14], 600 electrodes with a Scoreboard rendering (Control) are sufficient to obtain an already functional perception. The Control rendering gets more "I don't know" responses than the Switch rendering in the "objects" and "streets" tasks. The Switch rendering is systematically more used in terms of time than the Control rendering whatever the task. It is also more used than the Combined renderer in the "Doors and crosswalks" type tasks. One could imagine that with training, the decision is made more quickly with the Switch mode.

According to the analysis of subjective judgments and ranking of the rendering modes, we highlight that the Switch rendering mode has a clear advantage over the Scoreboard rendering mode in all categories. The final ranking shows that the top-ranked rendering mode is Switch over both Combined and Scoreboard.

Limitations and perspectives: However, we can address the issue of predicting the segmentation and structure images to build the different renderings. In our study, these datas are very easy to obtain because the objects of the scene are labeled. In real conditions, we would have to find another way to recover this information. The addition of neural networks would solve this problem. The prediction of semantic segmentation maps has been widely discussed lately, leading to the birth of neural networks such as EfficientDet [15] which obtain excellent performances. Regarding structure recovery there are also some networks trained to predict this kind of information such as PanoRoom [17]. There are still two problems to manage, the errors in the predictions and the calculation time. It is necessary that the predictions are not too far from reality and that these predictions are produced in quasi-real time.

Another limitation is that our study does not allow us to capture the notion of motion since we use static images. The motion information is a very useful information, so much so that some devices use event-based cameras [16] to create a phosphenic rendering. To push the realism to the maximum it could also be interesting to realize an experiment in real condition. The device could be composed of a virtual reality helmet equipped with a camera that films the scene and a smartphone that takes care of calculating the visual rendering. The interest to make a study in real conditions is double: on one hand we could propose a complete device of study very close to reality, which would allow the future works to be tested on a realistic model. Moreover, we could measure the reaction of the subjects in navigation tasks and not in perception and comprehension tasks.

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Classification of 2D Refreshable Tactile User Interfaces

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Abstract. Enabling blind and visually impaired persons to perceive and interact with two-dimensional data such as graphs, images, tables, flow charts, math formulas, web pages, and floor plans has now become feasible. A radically emerging technology, two-dimensional refreshable tactile (2DRT) displays, can present graphical data to blind persons through refreshable tactile pins (raised up and down) distributed on a two-dimensional surface. While hardware development continuously advances, user interface development has not progressed likewise. To advance 2DRT displays, we performed an analysis and classification of 18 user interfaces based on hardware-software aspects. The comparison is formed in 3 areas, hardware specifications, interaction & software features, and domain coverage. Results show that 2DRT devices differ in hardware-software UI elements by using distinct screen sizes, interaction functions, element operations, finger recognition, and sound support. Conclusions confirm that some developed interesting interactions, but user interface design has not matured yet in this technology field.

Keywords: User interface design · Assistive technology · blind and visually impaired people · 2d refreshable tactile displays.

1 Introduction

The European Blind Union and the World Health Organization estimate that 30 million persons in Europe are visually impaired, where 22.5 million are unemployed due to their sight loss, [17, 8]. A critical factor contributing to the high unemployment of blind people is the access limitless to graphical information in standard user interfaces. Blind and visually impaired people cannot perceive and interact with complex graphical data such as images, graphs, tables, flow charts, formulas, web pages, and floor plans.

Assistive technology has been developed to improve information access for blind and visually impaired people. Single-line braille readers are a specific category of assistive technologies capable of presenting dynamic text information to blind people. However, these are restricted to a single braille line, which cannot convey graphical and two-dimensional data, only braille text information. Braille and swell paper-based graphics are used to present graphical data to blind people, but these can only represent no dynamic data since their tactile modality is not refreshable.

A radical technology, 2d refreshable tactile displays (2DRT), has emerged to surpass this obstacle. 2DRT devices can present complex graphical information to blind persons through refreshable tactile pins(raised up and raised down) distributed on a two-dimensional tactile surface. 2DRT displays are also known as graphical, tactile displays or 2d braille readers. The first state-of-the-art 2DRT display explicitly developed for visually impaired people was the Dot Matrix Display(DMD) 120060 by Metec AG in 1989 [11]. Several 2d refreshable tactile devices came after the DMD 120060, expanding the technology in several domains, orientation and mobility [6], educational systems, word and excel sheets support, graphics and 3D models reading, interactive models, and entertainment.

Since the emergency of 2DRT displays [12], the attention was more on the development and improvement of pin-matrix actuator mechanism and hardware characteristics [7, 15, 16]. While hardware development continuously advances, user interface development has not progressed likewise. Past research, such as the HyperBraille Project [2], addressed a range of user interface challenges. However, user interface contributions are dispersed and not fully mature, and many fundamental design questions remain open [3]. To advance 2DRT devices, it is necessary to fill the research gaps.

This paper aims to advance two-dimensional tactile displays by analysing and classifying the state-of-the-art user interfaces based on hardware and software characteristics. The classification comprises hardware specification, interactions and remarkable features, and domain-function coverage. In total, we explored eighteen 2DRT devices from the market and scientific-research field.

2 Related Work

As 2d refreshable tactile display is a relatively recent emerging technology, related work overviews on this technology are scarce. In 2007-2008, the authors in [7] reviewed the state-of-the-art of devices that presented spatial information to blind users, including graphical tactile displays (2DRT). The devices were classified into mechanical stimulation, focused ultrasound, and acoustic waves. The authors concluded that there was an increasing number of published works on tactile displays. 2d refreshable tactile displays were also already classified in [15]. These were split into two groups, static 2DRT devices (when the finger explores the contours of the screen,) and dynamic 2DRT devices (consisting of a pointer device with a small refreshable tactile display attached, the reading finger does not move.) Once again, the focus was on hardware characteristics, such as refreshing times, resolution, screen size, and other technology remarks.

D. Prescher and J. Bornschein in [13, 4] analyzed and compared more upto-date 2DRT displays. The authors focused their analysis on hardware characteristics such as screen size, number of tactile pins, weight, pin distance, and the mechanism to raise up and down the pins. Other user interface elements (software) were not matched up in these analyses.

3 Methods

3.1 User Interface

To delineate the limit of the 2DRT user interface analysis, it is necessary to define the term "user interface" since it is interpreted differently among authors and researchers. The user interface is assimilated as the device's point of HCI and communication [10], as the set of physical elements for signal transfer and organization between human-machine interaction [9], or does not include hardware elements anywise.

Our user interface interpretation is based on Bødker’s definition [1] where technological innovations, both concerning hardware/software and design methods, are included in the UI. Our interpretation was also based on ISO 9241-220:2019, which states that UI is the set of all components of an interactive system (software and hardware) that provide information and controls for the user to accomplish specific tasks with the interactive system. As part of the UI, we consider all the input and output physical elements of the device (2DRT display) and the software layer responsible for the HCI.

3.2 Procedure

The user interface comparison was based on both hardware and software characteristics of the 2DRT user interfaces. Different from related work, we approached 2DRT user interfaces characteristics on the hardware and software side, including a total of 18 2DRT displays (user interfaces) from 1989 to 2022

Following the set of requirements for optimal 2DRT devices defined in [14, 15, 5] we restricted the range of 2DRT displays analyzed in the comparison to a circle of characteristics. Devices with pin refreshment rates lower than 0.05 Hz were restricted to the analysis since a higher actualization rate does not update the tactile pin surface in less than 20 seconds, making it less practical to present dynamic graphical information. Regarding display size, we consider only devices with a tactile surface bigger than 120 cm2 or with more than 350 tactile pins(taxels.) The technology must support a noticeable difference between raised and non-raised pins. We only consider devices with non-raised pins positioned at least 0.025 mm below the tactile surface, and raised pins positioned between 0.06 mm and 0.09 mm above the surface. Devices with multiple levels of pin elevation (not binary) were also evaluated.

All information was collected from scientific fonts (Research-Gate and Google Scholar) and technical product description documents for devices with no scientific publications. To ensure a rigorous analysis methodology, 2DRT devices without a detailed literature review or available technical reports were not considered for this analysis. The user interfaces were compared at the device level, meaning that each 2DRT display is comprehended as containing only one whole user interface

4 Results and Discussion

The eighteen user interfaces were classified at several levels, hardware characteristics, interaction features and domain coverage (represented in Figure 1).

Fig. 1. 2DRT devices. Photographs and images by each respective owner.

4.1 Hardware UI Classification

We start by looking at the number of tactile pins(taxels) of each 2DRT device's tactile surface (expressed in Figure 2). Based on the collected data, 2DRT user interfaces can be split into two groups, large surface resolution (more than 7000 taxels) and small surface resolution (less than 7000 taxels.) Larger surface resolutions enable the representation of more elements and more detailed tactile graphics. However, higher resolutions imply a better organization of the information since the tactile surface can be overloaded with more tactile elements.

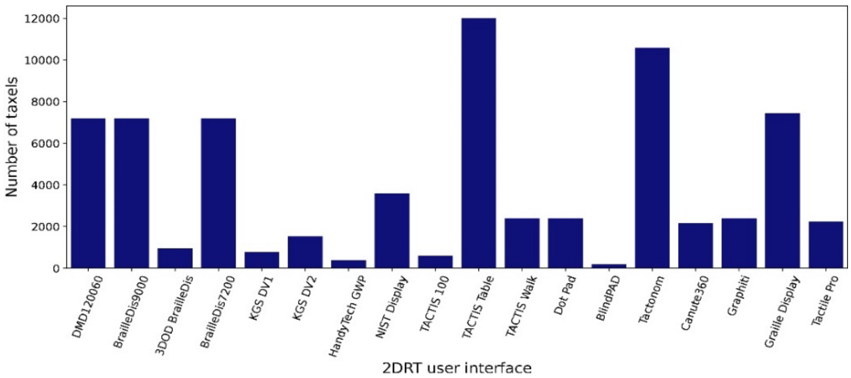

Fig. 2. Number of taxels (surface resolution) of 2D refreshable tactile devices.

It is interesting to look at the relation between the number of taxels and the screen size in square centimeters, since 2DRT tactile surfaces use different spacing distances between pins. A regression line of the previous correlation was drawn in Figure 2. Results show that most 2DRT devices have a very similar relation between the number of taxels and screen size. Devices that use a higher pin spacing distance (Graphiti and BlindPAD) or do not have an equidistant spacing between taxels (Canute360) stood out from the average correlation. It is necessary to have a proper pin-spacing distance (between 2.5 to 3.0 mm) to support braille text presentation, which is used by the other 2DRT devices. Equidistant distance between taxels is necessary to present a larger set of graphics, as conventional screens use.

We also correlated the number of taxels as a function of the refreshment rate of each device (represented in Figure 2). Results show that the BrailleDis devices take an average between 0.2s and 0.05s to refresh their pin-matrix surface of 7200 pins, standing out from the other devices. Some device's pin-mechanisms take up to 10s to refresh the entire screen, limiting the representation of more dynamic information. Still, devices such as the Tactonom and the TACTIS Table stand out positively from the average correlation due to their large surface size.

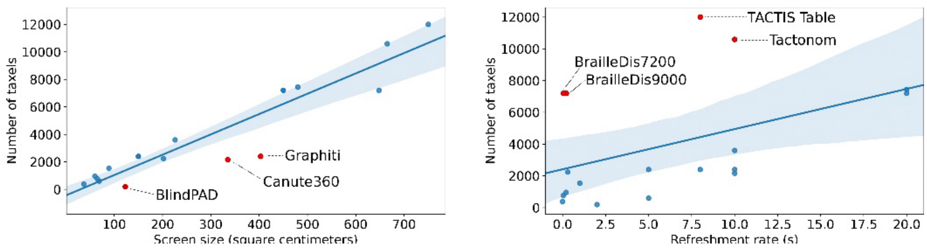

Fig. 3. Left: number of taxels as a function of the screen size in (cm^2) of 2DRT devices. **Right**: Number of taxels as a function of the refreshment rate (s) of 2DRT devices.

4.2 Interaction and Software Features

To compare the software component of 2DRT UI, we have analyzed over eight different remarkable interaction features in each UI. Interactive operations included panning (move current view) and zooming (out and in). Element-level operations such as element routing (change state or content of elements) and highlight support were also considered. Finger detection, gesture recognition, integrated sound support and internationalization support were also evaluated. The interaction features comparison is represented in Table 1.

Results have shown that 12 out of 18 2DRT user-interfaces support panning and zooming operation. Element-level operations, finger, gesture and sound support are not regular in 2DRT user interfaces. These devices stand out since they support these interesting user interface features. Sound support enables devices to present text information by using text-to-speech engines as the Graphiti user interface uses to replace Braille text. Finger detection is interesting since for the BrailleDis devices, the Graphiti and the Tactile Pro devices, a touch-sensitive surface is used, while the Tactonom uses an RGB camera for finger recognition.

Table 1. Interactions and remarkable features analysis of 2DRT UI. In the events with no available information, we assumed that the UI does support the specific feature (No)

	Functions		Element operations		Finger	Gesture	Sound	Inter.
User Interface	panning	zoom	routing	highlight	rec.	sup.	sup.	sup.
DMD 12006	No	No	No	No	Yes	No	Yes	No
BrailleDis 9000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3DOD BrailleDis	Yes	Yes	No	No	Yes	Yes	Yes	No
BrailleDis 7200	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KGS DV1	Yes	Yes	No	No	No	No	No	No
KGS DV2	Yes	Yes	No	No	No	No	No	No
Maple-GWP	Yes	Yes	No	Yes	No	No	No	No
NIST Display	No	No	No	No	No	No	No	No
TACTIS 100	No	No	No	No	No	No	No	No
TACTIS Table	Yes	Yes	No	No	No	No	No	No
TACTIS Walk	No	No	No	No	No	No	No	No
BLITAB	Yes	Yes	No	No	No	No	No	No
Dot Pad	Yes	Yes	No	No	No	No	No	No
BlindPAD	No	No	No	No	No	No	No	Yes
Tactonom	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Canute 360	No	No	No	No	No	No	Yes	Yes
Graphiti	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Graille Display	No	No	No	No	No	No	Yes	No
Tactile Pro PCT	Yes	Yes	Yes	No	Yes	No	Yes	Yes
Total	12	12	5	5	7	4	8	6

4.3 Domain Coverage

Lastly, based on the studied 2DRT user-interfaces, we identified seven context domains, text documents reader, graphic viewer, orientation & mobility (O&M), education, entertainment (including games), drawing support, and internet browser. Each device was analyzed in terms of these domains coverage, represented in Figure 4.

Some user interfaces incorporate more domains and include a system architecture that operates the developed application domains. These 2DRT user interfaces have been classified as operating system-based UI. Another interesting insight is to look at the less incorporated fields in these devices, drawing support, internet browser and mobility & orientation.

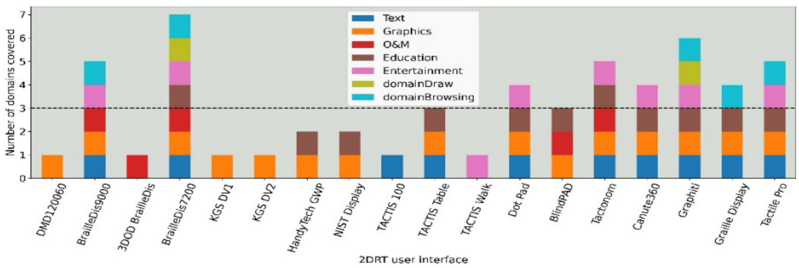

Fig. 4. Number of domains covered by 2DRT user interfaces.

5 Conclusion

Past reviews on 2DRT displays are not up-to-date and are focused only on hardware characteristics. Our overview does update the state-of-the-art of 2DRT displays user interface characteristics, comparing both hardware and software characteristics. 2DRT user interfaces were classified accordingly to their hardware characteristics, software features and domain coverage. We find indeed that user interface design has not yet matured. There are already interesting approaches from past research, such as multi-touch gesture recognition, zooming operations and element highlighting. However, further research is needed, particularly on the software side in internet browsing, drawing applications and orientation & mobility. For future work, we will develop 2D refreshable tactile user interfaces with audio feedback (which is not commonly used in this technology yet) to improve the general user interaction. As a result of this overview, these user interfaces will be grounded in the context domain of orientation & mobility since it is considered a very important topic by blind persons and was not addressed by the majority of the state-of-the-art devices.

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Impact of the Layout on Web Comprehension

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Abstract. In this day and age everybody makes use of the Internet and all the content it provides, but there are groups of people that may face some problems to consume this information because of their disabilities, age or even education. Some entities have tried to help solve this problem by providing guidelines and laws to improve the readability and accessibility of web pages and its content. In this paper we have studied these recommendations in search of some web elements that may help improve content comprehensibility. Moreover, we have collected a corpus made up of a great variety of different web pages and extracted those web elements. Thanks to machine learning algorithms we have obtained a classification model, using all the elements extracted from the corpus, that helps classify a web page according to its comprehension difficulty.

Keywords: Web Comprehension, Readability, Accessibility, Machine Learning.

1 Introduction

Nowadays, many daily activities require the Internet, from simple administrative procedures to the need to satisfy information queries. However, unfortunately, today's web sites are not as readable as they should be, and many people have problems understanding their content. Among others, people with cognitive disabilities, the elderly, poorly educated people, etc. It is crucial to make the web accessible to everyone, so that the content of the web can be understood by anyone. The difficulty in understanding does not only depend on the language used, but also on other elements such as the layout or that the content is properly structured within the page.

The objective of this paper is to examine the impact of web page design and structure, and their relationship with the webpage content comprehensibility (readability). To this end, the presence of elements related to the webpage structure (such as links, bold or italic letters, number of words per paragraph, etc.) will be analyzed and how they influence the web readability

This paper is organized as follows. In the introduction the motivation for this work is presented, as well as a brief description of the objectives of this study. In the next section, we discuss the state of the art, where we will describe existing readability guidelines, as well as other analogous research that analyzes the impact of design on text comprehension. In the methodology we will explain the approach followed in the work to analyze the impact of layout on web comprehension. Finally, we will find the conclusions obtained and comment on possible future work.

2 Literature Review

In this section, the main laws and guidelines dealing with text comprehension and research work on readability are going to be described. Next, some relevant works on the topic are discussed.

2.1 Laws and Guidelines

Currently there are different European and international entities that have proposed guidelines and recommendations to facilitate the development of easy-to-read documents. These guides are aimed at different population groups, from people with cognitive or physical disabilities to general recommendations addressed to any user, regardless of their physical, cognitive, or cultural situation.

Examples of these guidelines are:

1. Recommendations intended for the public in general, regardless of their personal circumstances: Public Law 111 of the United States Government [2] proposes a series of "Plain Language Guidelines" [3]. The law aims to improve access to government and administrative information for all types of documents, including digital publications and web pages. The standard insists on how to make texts more accessible, clear and concise, but does not mention how the layout should be for the web.
2. Aimed at people with physical disabilities: There are other guidelines that establish a series of recommendations aimed at facilitating accessibility, such as those proposed by the W3C [4] which includes the WCAG guidelines [5]. WCAG (Web Content Accessibility Guidelines) aim to promote a common standard for the accessibility of information on web pages and web applications, especially for the visually impaired population. In other words, they emphasize aspects more associated with legibility (e.g. text size or contrast) than readability. After reviewing the WCAG guidelines we can confirm that, although there is a wide variety of guidelines defined to help design more accessible pages for people with any disability, no rules are defined that deal with the structuring of a page at the HTML level.
3. Regarding population with cognitive disabilities: the Easy-to-read guideline of Inclusion Europe [1]. It should be noted that although the focus is on cognitive disability, the recommendations are applicable to other population groups. For example, to segments of the population that are not native speakers of the language or have a low cultural level. Similar to the W3C WCAG standards, work is being done on a compilation aimed at the cognitively impaired population, COGA [6]. In this case, although there are some standards related to HTML structuring, this is not its focus.

2.2 Research Works on Readability

In addition to the guides on accessibility recommendations and easy reading, there are also other works that have studied the comprehension of web pages. One of the works carried out is a tool for analyzing web pages called Comp4Text Checker [7]. The main function of this tool is to calculate the readability level and to show the problems of readability and comprehension of the information on a web page, but it is only focused on the Spanish language. The tool does not analyze the complete design of the web page, for example it does not take into account the number of links. Although there are already applications that perform the same function, none of them is specific to Spanish and this is something to consider since readability metrics are very language dependent.

Another work, carried out by Peter Williams [8], studies the preferences that people with disabilities have in web pages. From a study involving a group of 25 people, they concluded that some aspects such as large font size, horizontal structuring of the home menu and the use of images are favorable elements for pages. Although this work has taken into account the opinions of a group of people with cognitive disabilities, it is true that the study remains a superficial and visual analysis of the design of the pages, and many of the problems encountered by the participants were related to navigation and the large amount of information presented on the pages.

Unlike previous work on readability and comprehension of Web sites, in our work we focused on the structuring and layout of the information rather than on the information itself. Furthermore, instead of focusing on a superficial view of the web, as in the work of Williams [8], we have gone into the body of the pages, i.e., their HTML and CSS files. With this we want to find elements that facilitate the design of pages to make them more understandable for people with cognitive disabilities.

3 Research Methodology

In order to carry out this research, the following steps were followed:

1. First, characteristics related to the structure of the web document that could have an impact on the comprehension of the document were identified. These features also incorporate characteristics of the style files. Special care has been taken to analyze the aspects included in the accessibility and readability guides, although additional elements have been incorporated.
2. Then we collected a total of 640 web pages from public administrations in order to create a corpus with a great variety of templates. Special care has been taken to diversify the provenance of these pages, as the analysis of the underlying template is critical.
3. Using Python libraries, the features identified in the first step have been extracted.
4. Next, a set of 68 web pages has been selected from the corpus for the learning phase of the machine learning process. These pages have been classified by readability experts into two classes: easy and difficult to understand. This classification has been made considering the guidelines for easy reading and web accessibility.

5. Using Machine Learning algorithms and the data from the learning collection of the previous point, a classification model was obtained, which was subsequently validated with documents from templates not used in the learning process.

4 Evaluation

4.1 Design

Goals. The aim of this work is to identify design features of web pages that can help determine the level of comprehension of the information contained in the page. For this purpose, the structure of the different templates of the pages that form the corpus has been analyzed in depth to find possible design elements in their HMTL and CSS files. In addition, these elements have been searched to see if they have any relation with the comprehension of the information. For example, the structuring of text using headers is known to clearly influence the comprehension of information, as can be seen in the COGA [6] and Plain Language [3] recommendations. But there are other page elements that could influence text comprehension and whose identification is not clearly outlined in the readability guidelines. This motivates this research work since it seeks to find the relationship of style and content elements (HTML and CSS) that may influence comprehension and that are not currently included in these standards and guidelines.

The decision to include style elements, CSS, has been taken considering that these also influence the layout of the pages. Some of the elements analyzed are included in the recommendations on accessibility and easy reading in the guides mentioned above, but other elements have been chosen because we believe that they may be relevant for comprehension, despite not being clearly outlined in the regulations on readability.

In short, we have tried to take as many relevant web page design elements as possible to see which of them have the most impact when evaluating the difficulty of a web site.

Corpus. In order to carry out this work, it was necessary to obtain a robust corpus with a sufficient variety of templates to avoid the results being conditioned by a few designs. A total of 640 web pages have been collected to build the analyzed corpus. Many of the web addresses (URLs) that make up the corpus are from the same domain and therefore share the same design template. However, this does not invalidate its usefulness since within the same web domain the construction of some of its pages may vary and it is also necessary to take this into account. For example, there are cases where in a page of a domain we find longer paragraphs than in other pages, or that include more links, or that use different hierarchies of headings, etc. In Table 1 we can see the number of root domains that formed the corpus divided in terms of comprehension difficulty.

Table 1. Web domains distribution.

Difficulty of comprehension	Web domains
Easy	46
Difficult	58
Total	104

In addition, as in this work we do not focus on the content of the information displayed on the pages, page domains in different languages have also been included to enrich the corpus, since language does not affect the layout. It should also be noted that all the web addresses are from public administrations.

Of a total of 640 pages that make up the corpus, 310 have been classified as easy to understand and the rest as difficult. This first classification has been done manually considering the recommendations proposed by the previously mentioned guides on readability and accessibility. The reason why it has been decided to classify the corpus following these guidelines is because a page that does not follow any of the proposed indications to facilitate the reading of a page will make it more difficult for a person with cognitive problems to understand it without problems. Other considerations that we have taken into account for the classification are the appearance on the pages of the easy-to-read logos or W3C, since they indicate which ones comply with the readability and accessibility guidelines, and the purpose of the web site, that is, to see if its purpose is to simplify administrative procedures of other official pages.

Future Analysis. The template elements analyzed were based on the extraction of 30 HTML and CSS features. These features were considered relevant to our study, either based on heuristics based on page compression or already proposed in the literature (guides and research papers). Table 2 shows some of these features.

Table 2. Features extracted from guides.

Inclusion Europe [1]	Plain Language [3]	WCAG [5]	COGA [6]
Mean size of font in paragraphs	Percentage of words in paragraphs	Alt attribute in images. Alternative text in tooltips	Mean size of line spacing in paragraphs
Percentage of words in paragraphs	Presence of text with bullet points	Mean size of line spacing in paragraphs	Heading labels with a short sentence
Percentage of words in lists' elements	Presence of tables		Presence of text with bullet points
Percentage of underlined words			Number divs
Average font size in the paragraphs			
Heading labels with a short sentence			
Percentage of words in bold			
Presence of images			

Classification Model. The machine learning process consists of two parts: a first learning phase, where the classification algorithm is trained with some input data, and another classification phase, where the algorithm performs a classification of some new data from the previous learning [9].

For this study, the use of a classical supervised classification algorithm using decision trees has been chosen, since the aim is to analyze the priority in decision making in the tree, when one element influences readability more than another. The algorithm used in the evaluation was the J48 algorithm provided by the Weka tool. The J48 algorithm is an implementation of the ID3 or C4.5 algorithm [10] and is commonly used in data mining applications.

For the learning part we took a first set of 68 pages from the corpus, of which 37 were classified as easy and the rest as difficult manually, as explained in the Corpus section. With this first set, different training tests were performed varying the input attributes (or items). A first training test was done with all 30 input attributes obtained in the analysis of the web structure and following recommendations. Then a second test was performed with the same set of pages, but two attributes were excluded for this test, the number of videos and tables that appeared on each page, because they didn't provide any relevant information for the classification. For the last test, in addition to those two attributes, we also excluded the number of paragraphs and the total words from each page because we considered that these absolute values wouldn't be as significant as other attributes such as the percentage of the words that were in paragraphs or the average number of words per paragraph.

For the classification phase, different datasets were tested, and the classification model was tested with these additional documents. The new datasets included pages from domains that had not been included in the learning set as well as others that were from the same domain but did not share the same template.

5 Results

As a means to obtain the classification model, several different datasets were tested for the training phase, but from all the tests made with each one we concluded that the dataset formed by 68 pages was the one that gave the best results. The difference between this dataset and the others tested was the variety of templates included.

The results of the three training tests mentioned in the previous section are shown in Table 3, and as we can see the first two had the same result, which prove that the two excluded attributes were indeed irrelevant. However, in the third test there is a slightly improvement in the results thanks to having excluded the other two attributes mentioned before from the input set. The accuracy measures the frequency on which the classifier does a correct prediction, and it is more valid the more balanced the training set is. In the case of this tests, we have 37 easy pages and 31 difficult ones so we can state that the accuracy results are very reliable. Nevertheless, we also must consider on the precision and recall indexes that, as we can see in the table, are slightly better on the third test as well.

Table 3. Training tests' results.

Test	Input attributes	Accuracy (%)	Precision	Recall
#1	31	80,8824	0.800 (easy) 0.821 (difficult)	0.800 (easy) 0.821 (difficult)
#2	29	80.8824	0.800 (easy) 0.821 (difficult)	0.800 (easy) 0.821 (difficult)
#3	27	82.3529	0.857 (easy) 0.788 (difficult)	0.839 (easy) 0.839 (difficult)

Therefore, the classification model we picked was the third one and as we can see it in Figure 1 and its classification tree in Figure 2. As we can see the more important attributes for this model are the ones in Table 4.

Table 4. Description of attributes from final classification model.

Name of attribute	Description
p_mean_size	Average font size in paragraphs
cells/table	Average number of cells per table
per_h1	Percentage of total words found within the h1 tag
alt_img	Percentage of images that have alt text
per_li	Percentage of words found within the li tag, compared to the total of words.

```
Test mode:    10-fold cross-validation

=== Classifier model (full training set) ===

J48 pruned tree
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p_mean_size <= 13.451613: difficult (18.55/1.0)
p_mean_size > 13.451613
|   cells/table <= 6.5
|   |   p_mean_size <= 16.896552
|   |   |   per_h1 <= 0.15528
|   |   |   |   alt_img <= 40: easy (6.0/1.0)
|   |   |   |   alt_img > 40
|   |   |   |   |   per_li <= 0.479435: easy (2.0)
|   |   |   |   |   per_li > 0.479435: difficult (11.91)
|   |   |   per_h1 > 0.15528: easy (8.0)
|   |   p_mean_size > 16.896552: easy (16.54/0.54)
|   cells/table > 6.5: easy (5.0)
```

Fig. 1. Classification model.

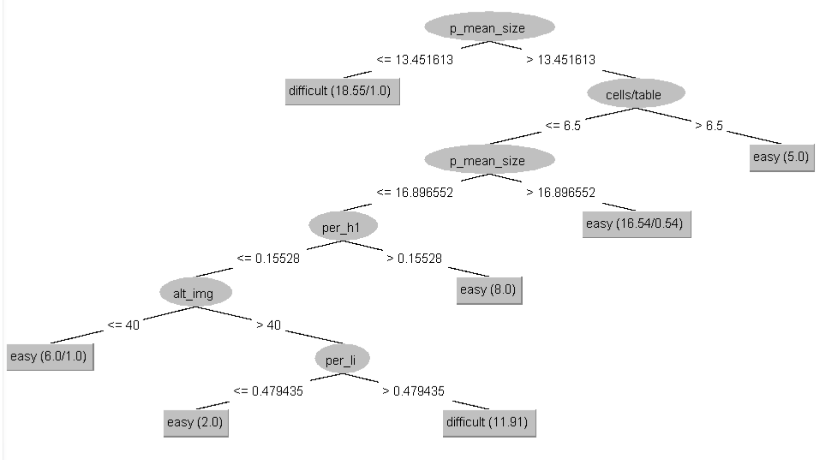

Fig. 2. Classification model's decision-making tree.

6 Conclusions and Further Research

This study has shown an analysis of a set of public administration websites to see which HTML and CSS elements have an impact on their comprehension. The starting point was a study of some guidelines of recommendations on easy reading and accessibility to try to extract some common characteristics to classify web pages according to their difficulty of comprehension.

With a series of tests made from machine learning on data obtained from a set of web pages we have obtained results that seem to be promising. The readability aspects have been widely studied, but always under non-web formats, the main contribution of this study is to consider the web dimension. This study shows that there are HTML elements that really can help to design web pages who are easier to comprehend for people with cognitive disabilities.

In this work we have avoided introducing the elements of classical readability, such as the richness of the vocabulary. However, it is worth considering that the present variables and models interact in some way with these variables.

One aspect of interest at the beginning of the study was to know to what extent the recommendations adequately reflected what was observed for the web, and the conclusion is that these recommendations do reflect the main guidelines for online publication.

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Robotic and Virtual Reality Technologies for Children with Disabilities and Older Adults

Use of an Immersive Robotic Telepresence System to Foster Inclusive Education

Preliminary Results from a Qualitative Study

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Abstract. Immersive robotic telepresence combines virtual reality (VR) with robotics to provide a teleoperator with a means to act in a distant environment. The objective of this contribution is to focus on the views of teachers and parents to explore their opinions about using an immersive robotic telepresence system to implement inclusive robot-based group activities in primary school settings. Eleven adult participants attended three focus groups. Through thematic analysis, participants' views were grouped into five main themes. Overall, our results point to considering the use of an immersive telepresence system as a promising complement to pre-programmed robot-based activities. It still remains unclear, however, whether the telepresence strategy can be considered usable in a school setting with limited technical support available.

Keywords: Social Robotics, Immersive, Telepresence, Disability, Education.

1 Introduction

In recent decades, inclusive education of autistic students in mainstream schools has become a global trend. Current evidence reveals, however, that the social participation of autistic students in inclusive educational settings is far from being optimal and therefore interventions are clearly needed to increase their opportunities for social engagement [1]. The most basic approach to support social relationships of autistic students within inclusive school settings may be to develop games or activities in which all students are equally motivated to participate [2-5]. An example is the intervention designed by Koegel et al. [4], in which three primary school autistic students were involved in small groups activities (i.e. 'social clubs'). Each social club involved one autistic student and 6 to 10 neurotypical peers and was developed based on the interests of both autistic students and their peers (e.g. board and table games, videogames or craft activities). An adult facilitator with no specific training was also present to introduce the daily activity and gradually faded his/her presence once the activity started. Results from controlled studies show that group activities based on shared interests may

be a promising and affordable approach to promote social engagement of autistic students in inclusive settings [4,5].
To ensure that group activities based on shared interests are effective in promoting social responsiveness of autistic students, educators should propose activities that are (a) attractive for both the autistic students and their neurotypical peers, (b) expected to have an effect on social interactions, and (c) capable of engaging autistic students with a range of cognitive and communication difficulties [4].

Evidence has long highlighted that autistic children, along with their neurotypical peers, have a special interest in computerized activities [6]. Specifically, there is a growing body of literature suggesting that autistic and neurotypical children are both interested in robots that resemble the human aspect [7]. Humanoid robots, in particular, are robots that look like and behave like humans and are increasingly used in general education to engage students in mainstream curricular activities [8].

Because current commercially available humanoid robots are not yet ready to autonomously participate in group-based activities, teachers would require controlling the robot by themselves in a flexible (and natural) manner. Here we argue that immersive robotic telepresence may be a promising solution to enable teachers controlling a humanoid robot in group-based activities (e.g., social clubs) and cope with the challenges of complex interaction scenarios (Botev & Rodríguez Lera, 2021).

Immersive robotic telepresence combines virtual reality (VR) with robotics to provide a teleoperator with a means to act in a distant environment. The key feature of such immersive systems is to allow the teleoperator to perceive the remote environment as if it were there, with the consequence that these systems are thought to be more effective compared to the traditional ones (e.g., tablet-based).

1.1 Aim of the Study

The current study is part of a larger, ongoing project conducted by AIAS Bologna in the municipality of Bologna, Italy, aimed at exploring the perspectives of various stakeholders on the use of social robots in school settings to foster inclusion of students with neurodevelopmental disorders. The objective of this contribution is to focus on the views of teachers and parents to explore their opinions about using an immersive robotic telepresence system to implement inclusive robot-based group activities in primary school settings.

2 Method

2.1 Participants

Eleven participants were grouped according to three sub-groups of stakeholders. The first group included four teachers (all females) who used the NAO robot in their daily teaching activities over the two academic years preceding the present investigation. The second group involved four teachers (three females, one male) who were interested in using the NAO robot in their daily teaching activities but haven’t never used it. The third group involved three parents (two mothers, one father) of students 7-10 years old with a diagnosis of neurodevelopmental disorder, namely, one with a diagnosis of specific language disorder and two with a diagnosis of autism spectrum disorder. Participants were recruited with the support of the local school district.

2.2 Protocol

Due to the COVID-19, participants completed individual semi-structured interviews on ZOOM, a real-time video conferencing tool. The interview protocol has been developed in close collaboration with three teachers and pilot tested with one teacher. The interviews lasted about 50 minutes. The part of the interview dedicated to the immersive telepresence system lasted approximately 20 minutes. It first included the presentation of a video explaining the functioning of an immersive telepresence system, then a series of questions were asked to participants to explore (a) their overall impression about the system, (b) its potential usefulness and areas of application, and (c) barriers to its implementation.

All participants provided their verbal consent to be audio and video recorded before starting the interview.

2.3 Data Analysis

The whole qualitative data set comprised of interviews' transcripts. The two interviewers served as analysts of the qualitative data set. As a first step, the analysts read in full the whole data set in order to comprehend the meaning of the data in their entirety. Analysis began by using a line-by-line open coding technique. Codes identify a feature of the data that appears interesting to the analyst, and is defined as 'the most basic segment, or element, of the row data or information that can be assessed in a meaningful way regarding the phenomenon' ([10]; p. 88). During this phase, the analyst followed an inductive approach, which consists of reading the text and assigning the codes that reflect the emerging concepts without using a preconceived framework. This approach allowed the code structure to evolve 'inductively', thus reflecting the participants' experience. Once the qualitative data set was coded line by line and the codes were saturated, the two analysts met to discuss the emerged codes. Each code was reviewed, and any alternative interpretation was discussed until consensus was achieved.

3 Results

Through thematic analysis, participants' views were grouped into five main themes. A summary of each theme follows.

3.1 Theme 1: Children Seem to be Attracted by a Humanoid Robot, Regardless how it's Controlled

All interviewed teachers agreed that a robot could represent a source of interest for students, especially a humanoid one that appears to be autonomous and can communicate through verbal and nonverbal modalities. Such interest from students, in turn, may enable teachers to design educational activities that are capable of engaging children with diverse interests and skills, thus providing a tool to promote more inclusive teaching practices. Teachers with some experience in using the robot confirmed that, when used in classroom, most students immediately formed a kind of emotional bond with it:

"I remember that the children caressed him, told him so many sweet words; therefore, it was a way of saying "we love you, you reciprocate our affection in the same way"

In a similar vein, parents showed a positive attitude towards the use of a humanoid robot in education. One stressed in particular the difference between the robot and the tablet used at school and reasoned that the former might help students "quit from the isolation" produced by the former.

3.2 Theme 2: Telepresence May be a Solution to Endow a Machine with Human Skills

Teachers and parents had mixed views on the use of telepresence. According to participants' comments, this strategy can have certainly an added value in that it might help overcoming the limitations of the robot. According to a comment made by the mother of an autistic child, using the telepresence system is a way to benefit from both the human and the robot:

"[a human] would only provide an added value to a robot. I would feel more secure knowing that a robot [controlled by a person] is in charge of managing the social interactions among students in classroom".

The mother further goes on by saying that, on the other side, the robot could be useful in that it may reduce the emotional impact of the human teacher, thus creating the conditions for a less stressful educational setting for a child with social and communication difficulties.

With regards to the comments made by the teachers, participants with no experience in the use of the robots hypothesized that the telepresence strategy could be useful to implement group-based activities without the presence of the adult teacher. The exclusion of the adult, in their opinion, would allow for a more natural observation of the child with social difficulties when engaged in interactions with his/her peers. More experienced teachers, in addition, considered the telepresence approach as an opportunity to enable the robot to display a less rigid (i.e., predictable) behavior repertoire. The rigid behavior of the robot, initially thought as an added value to promote engagement of children with social and communication difficulties when robots were used in individual sessions, was considered less useful when the aim is to promote social inclusion and participation.

3.3 Theme 3: Applications of Telepresence in Educational Settings

The most commonly mentioned application for the telepresence approach was providing students with neurodevelopmental disorders confined at home (e.g., due to COVID-

19 restrictions) with a means to interact with others through an engaging digital device (i.e., the robot). Parents highlighted their frustration to convince their children to stay focused on a laptop or a tablet during distant learning. In the opinions of teachers, such a system can be also useful to allow peer-to-peer interactions when social contact is not allowed or possible. In this view, children might control the robot to interact and stay in contact with their peers. A further area of application mentioned by one teacher regards the support to promote autonomy. Specifically, the robot can be used by an educator to monitor how a group of children is performing during an academic task and intervene when needed. According to the teacher, such remote control would allow the children in the group to feel more autonomous in the completion of the task, while allowing the teacher to continuously monitoring the learning and social processes at play.

3.4 Theme 4: Risks for the Children

The use of remotely operated robots to substitute the teacher in certain occasions as proposed by some parents and teachers during the interviews raised some concerns. Not surprisingly, safety of children was the most commonly mentioned reason why children should not be left alone with a robot even if controlled by a human. Teachers further mentioned the possibility that children in small groups may damage the robot because of the absence of the teacher and then engage in maladaptive behaviors. The use of a headset to control the robot has been also mentioned a critical aspect of this system. Teachers may get used to this solution, but children – especially those on the autism spectrum - may find wearing the headset rather uncomfortable.

3.5 Theme 5: Barriers to Implementation

According to the teachers, the main barriers to the application of an immersive telepresence system in a school setting include teachers' resistance to change and lack of curiosity. One teacher commented that:

"[to apply the telepresence system in school] you have to find teachers willing to take a challenge".

4 Discussion and Conclusions

The present study reported on the preliminary results from an investigation conducted to explore - for the first time in the Italian context - the use of an immersive telepresence control system to remotely operate a humanoid robot in a school setting. The aim was to get first insights on the potential of this solution to support teachers in the creation of inclusive teaching practices. Along with the views of teachers, parents of children with neurodevelopmental disorders were involved to enrich the information gathered form school professionals.

Overall, our results point to considering the use of an immersive telepresence system as a promising complement to pre-programmed robot-based activities. Specifically, teachers as well as parents agreed that the robot controlled by a human operator in real time could promote inclusion of children with neurodevelopmental disabilities by enabling teachers creating group-based activities and thus managing them by means of timely verbal and nonverbal behaviors delivered by the robot.

Interestingly, the repetitive and predictable behavior of the robot was seen as a limit of this tool rather than an advantage to promote cognitive and social development of children with neurodevelopmental disorders. This finding seems in contrast with available literature that emphasizes the predictability of robot behavior as an added value of robot-based interventions for certain populations (e.g., autistic children; Alcorn et al., 2019). The need to introduce the robot in a socially rich environments as proposed by participants in the current study to promote inclusive learning practices, however, might require that robots are capable of flexibly adapt their behavior to unpredictable circumstances. In this view, it can be argued that an immersive telepresence system may provide teachers with the possibility to switch from rigid to flexible robot behavior depending on the circumstances.

It still remains unclear, however, whether the telepresence strategy can be considered usable in a school setting with limited technical support available. Future research may build on present results to get more informed feedback from teachers after having implemented an immersive telepresence system in a real school setting. Research is specifically needed to define in which educational settings the use of the robot guided through telepresence may bring benefits, to whom, and what conditions must be fulfilled for making this happen. Comparisons between the effectiveness of immersive telepresence and other means of remote control (e.g., tablets) are also warranted.

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Using Robotics to Support Social Learning for Adolescents with Autism Spectrum Disorder

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Abstract. This paper will present a pilot program run in Australia and the USA to evaluate the effectiveness of coding robotics and tools within inclusive STEM lessons as they are used to support social-emotional learning and the acquisition of soft-skills in middle-level classrooms. Students with Autism Spectrum Disorder worked collaboratively to use small coding robots (Ozobots) to solve a variety of problems and tasks. A final task required that they teach students without disabilities to use the Ozobot, taking on the role of an expert. Data were collected using a modified rating scale, modified by the researchers and validated by a panel of experts in the field. The scale included verbal, non-verbal, communication roadblocks, self-control, and relationship measures. The rating scale was completed by the classroom teacher for each participant, before the program and at the conclusion of the program. Combined country results from the pilot programs indicated statistically significant changes in non-verbal communication, self-control, and relationships evident on completion of the program. The teachers were interviewed and indicated that many STEM and soft skills were developed throughout the program including curiosity; problem-solving; flexibility; accuracy; social awareness; collaboration; creativity/innovation; responsibility; and persistence. Areas for discussion include the role of the teacher as facilitator of learning, best ways to integrate the coding robots into the curriculum and areas of social skill development that are supported by the use of coding robots.

Keywords: Robot, Coding, STEM, Autism, social skills, soft skills.

1 Background

Much attention has been placed on developing procedural skills in technical content areas--such as science, technology, engineering and mathematics (STEM) for students with disabilities, as they often underperform in traditional content specific measures of learning [1]. However, the remedial teaching of skills often fails to help these students learn the habits of mind necessary to be successful in STEM. These habits of mind include learning to listen and critique academic arguments, defending and reasoning about specific facts and evidence, creative problem-solving, and equally participating in discursive interactions with peers [2]. Furthermore, many adolescents with disabilities also feel that failure is likely, and often unavoidable and feel that no matter how hard they try, success is not obtainable in STEM [3]. As such, for middle-level students with disabilities in STEM classrooms, learning what it means to think and behave like a mathematician or scientist means little despite the importance of these actions [4, 5]. Thus it becomes important to teach technical habits of mind as they are also beneficial in co-developing students' social and emotional skills, as many individuals with disabilities, particularly those with Autism (ASD) are known to struggle in these areas [6]. Despite many interventions that have been used such as video and peer-modeling; innovative technology, such as robotics and coding-software, hold the potential to advance soft-skills in STEM classrooms for individuals with disabilities better than some traditional interventions.

1.1 Technology and Students with ASD

Robotics in classrooms have been widely used to expose students to STEM content and potential careers as they provide a platform in which students can apply critical thinking, analytical problem solving, and collaborative work [7]. Moreover, the use of robotics in the classroom can support the development of soft-skills necessary to be successful in STEM careers such as communication, collaboration, and social exchanges [8]. However, the key is effective integration of the technology through on-going, classroom-embedded coaching [9]. Additionally, the use of robotics can support positive interactions in STEM that include soft-skill development, persistence, and greater achievement of which are essential for success in these content areas and careers [10].

Today, there is a chronic underrepresentation of individuals with Autism and other disabilities in STEM as well as historically marginalized racial and ethnic groups in STEM disciplines [11] that needs to be addressed. Robotics such as the Ozobot hold the potential to reach all students, especially when it is viewed as a collaborative activity. Since robotics have been shown to engage and motivate students [12,13], and Ozobots are a functional medium that can be used to enhance and develop social interactions, this article focuses on the implementation of Ozobot lessons that contain skill development that naturally supports the development of soft-skills.

1.2 Purpose of the Research

The purpose of this research was to evaluate the effectiveness of coding robotics and tools within inclusive STEM classrooms as they are used to support social-emotional learning and the acquisition of soft-skills for students with ASD. The research was conducted as a multi-national project in Australia (Western Australia) and the USA (Idaho). A social skills measurement tool was developed to determine changes in social skills observed over the length of the research. Soft skill demonstration was determined through observation and teacher interview. The research questions addressed in this research included:

1. To what extent is social-emotional skill growth achieved through interactive coding experiences for middle-level students with Autism Spectrum Disorders?

2. What soft skills are demonstrated through interactive coding experiences for middle-level students with Autism Spectrum Disorder?

2 Research Design

2.1 Participant Sample

Selection criteria for the participants included a diagnosis of ASD and involvement in STEM lessons in a middle school setting. In the USA and Australia, two classes of students were part of the research. In all cases, school, teacher, parent and student written permission was sought to undertake the research, which only proceeded on receipt of the permission, in accordance with university ethical guidelines.

2.2 Methodology

A mixed methods approach was taken to the research [14], as the researchers aimed to determine a change in behavior using a scale (quantitative) and to explore the thoughts and experiences of teachers and students when using the Ozobots during STEM lessons (qualitative).

2.3 Data Collection

Data were collected using a modified scale to meet the needs of the present study using robotics and robotics instruction as a tool to teach the soft-skills. The scale was validated by a panel of experts in the field. Domains to measure were; 1) verbal communication, 2) non-verbal communication, 3) communication roadblocks, 4) self-control, and 5) relationships. When modifying the scale intrinsic behaviors (i.e. depression, anxiety) were removed as it may be difficult for the teacher to discern these feelings and they may not be trained in the area of psychological well being. Teacher behavior (e.g. prompting, instruction, student redirection) was also removed from the pilot as the authors wanted to solely focus on student outcomes as a result of their interactions with peers and the robots individually and as a group. The scale originally was developed on a 5-point Likert scale. The authors included percentages to help guide the teacher's ratings of the students. Students were rated as 1) never engaging in the behavior or 0%, 2) rarely engaging in the behavior or 10%, 3) sometimes engaging in the behavior or 33%, 4) often engaging in the behavior or 66% or 5) always engaging in the behavior 90+%.

Data were also collected using interviews and observations in the classroom. Interviews with teachers lasted approximately 60 minutes and observations lasted the duration of the intervention. Observations were collected anecdotally, reviewed and used to make meaning of the scale ratings. Interviews were conducted to include questions about the process of implementing the robots in the classroom, difficulty with the lessons, perceived successes with the lessons, and student outcomes that may have been beyond the scope of what had been typically observed for the students.

2.4 Procedure

Teachers were provided with a set of Ozobots and initial training (approximately 1 hour) delivered by the researchers. Lessons using the Ozobots were held during STEM lesson times and were delivered over eight weeks, once a week, in Australia (35- 45 minute sessions, one per week) and four days for each class in the USA (27-55-minute sessions). The lesson sequence involved:

- Introduction to the Ozobot (including student exploration of the tool)
  - including discussion of Technical (STEM) Habits of Mind and why they are important
- Coding investigations
  - What matters (e.g. size, width)
  - Ozobot Cross the River
  - Ozobot personal map and race
  - Ozobot scavenger hunt
- Instructing of same age neurotypical peers on the use of the Ozobot

2.5 Data Analysis

Data from the scale were analyzed for each country using a Wilcoxon signed rank test for the quantitative element (rating scale). A Wilcoxon signed rank test was used as the data were not normally distributed however met the assumptions for the non-parametric test. Data were then aggregated for both Australia and the USA to determine overall change in behavior before and after the use of the Ozobots.

No specific analysis was undertaken for the qualitative sample (teacher interviews and observations) as there were only two teacher responses and limited observations due to researcher constraints. Quotations illustrating the teachers' perspectives on the use of Ozobots in STEM lessons to promote social and soft skill development were identified and included to support analysis of the quantitative data.

3 Results

3.1 Participants

In the USA, the first class was a Grade 6/7 class with 22 students, seven of whom were diagnosed with ASD. The second class was also Grade 6/7 and comprised 15 students all with a diagnosis of ASD. In Australia, there were also two classes involved. The first was a Grade 7 class with five (5) students diagnosed with ASD, who were joined by five neurotypical peers of the same age. The second class consisted of four students at Grade 9 level, three of whom were diagnosed with ASD.

3.2 Social Skills Scale

A Wilcoxon signed-rank test was applied to data to determine the extent of social-emotional growth achieved through interactive coding experiences for middle-level students with Autism Spectrum Disorders. Each country was analyzed individually and then data were aggregated. Data from Australia showed that a social skills coding robot intervention in middle years STEM lessons for students with ASD elicited statistically significant change in social skills in the areas of Communication Roadblocks ($Z = -2.207$, $p = 0.027$), Non-Verbal Communication ($Z = -2.539$, $p = 0.011$) and Relationships ($Z = -2.384$, $p = 0.017$). There was no significant finding for Verbal Communication ($Z = -.949$, $p = 0.343$) or Self-Control ($Z = -1.933$, $p = 0.053$). See Table 1.

Table 1. Wilcoxon Signed Rank Results (Australia)

Skill Area	Mean – Pre	Mean – Post	Z	Sig (2 tailed)
Verbal Communication	17.5	18.75	-.949	.343
Communication Roadblocks	21.125	15.625	-2.207	.027*
Non-Verbal Communication	17.25	19.875	-2.539	.011*
Self-Control	7.0	7.875	-1.933	.053
Relationships	28.0	36.375	-2.384	.017*

*$p < .05$

Data from the USA differed as there were no significant changes in social skill areas. See Table 2 for the results of the Wilcoxon signed-rank test. Differences may be accounted for by the variation in time given to students in Australia as compared to the USA.

Table 2. Wilcoxon Signed Rank Results (USA)

Skill Area	Mean – Pre	Mean – Post	Z	Sig (2 tailed)
Verbal Communication	13.22	16.22	-1.679	.132
Communication Roadblocks	16.22	18.22	-1.033	.332
Non-Verbal Communication	19.22	19.55	-.129	.900
Self-Control	5.88	6.77	-1.577	.154
Relationships	19.44	21.22	-.601	.564

*$p < .05$

A Wilcoxon signed-rank test on aggregated data from Australia and the USA showed that a coding robot intervention in middle years STEM lessons for students with ASD elicited statistically significant change in social skills in the areas of Communication Roadblocks (Z = -2.201, p = 0.043), Self-Control (Z = -2.667, p = 0.017) and Relationships (Z = -2.652, p = 0.017). There was no significant finding for Verbal Communication or Non-Verbal Communication. See Table 3.

Table 3. Wilcoxon Signed Rank Results (Aggregated Australia and USA)

Skill Area	Mean – Pre	Mean – Post	Z	Sig (2 tailed)
Verbal Communication	15.23	17.41	-1.982	.072
Communication Roadblocks	16.71	19.00	-2.201	.043*
Non-Verbal Communication	21.47	17.94	1.830	.0.86
Self-Control	6.41	7.29	-2.667	.017*
Relationships	23.47	28.35	-2.652	.017*

$^*p < .05$

3.3 Teacher Interview

Interviews of approximately 60 minutes were conducted with the teachers, during which they were asked about the use of Ozobots with their students, focusing on social skills and habits of mind that were exhibited. They were also asked about the practical aspects of using the Ozobots in the STEM lessons. Prior to the use of the Ozobots, the teachers suggested that the students with ASD did not persist with tasks, did not choose to work and communicate with other students and wanted to sit in the same seat for each lesson.

The Australian teacher suggested that using the Ozobots helped to teach soft skills almost incidentally and without great effort from her. She suggested the Ozobot lessons contained many soft skills that naturally supported the development of these skills. “Listening to the banter between them, it's never been like it was towards the end of the term. They’ve never been quite so spontaneous and it's the taking of turns that I found amazing”. She was also able to identify and provide examples of soft skill development including: curiosity, problem solving, flexibility, accuracy, social awareness, collaboration, creativity/ innovation, responsibility and persistence. One example of responsibility is when the students placed cushions on the floor below the desk so that the Ozobot would be protected if it went over the edge during use.

The American teacher suggested that using Ozobots helped teach soft-skills such as communication with peers, describing their thought process, and problem solving collaboratively. Further, she suggested that students who typically did not participate in discussions, collaborative work with peers, or social interactions seemed to naturally engage with peers. “I had several students who never will work with peers actively get up and talk with students and share their thinking, I almost couldn’t tell they had Autism”. Additionally, she suggested that in the future she would like to use Ozobots in multiple content area lessons as a result of the changes she observed in her student’s communication.

4 Discussion and Conclusion

There has been a shift in the way that children learn; moving from the teacher as the distributor of all knowledge to the student independently using their own media, robots, computer, and Internet to extend their learning. Education has evolved to a relationship between the learner and the educational tool rather than the student and the teacher [15]. Recognizing the use of technology as a conduit to support skill development necessary for success in employment and many post-secondary transitions, it becomes necessary to identify ways to effectively integrate robotics for students with disabilities; hence this initial pilot explored how to introduce the robots, guide instruction, and support student interaction while collecting data with the modified scale in the classroom.

Results from this study demonstrated initial positive steps in the development of social-emotional skills and soft skills with students with ASD. Some significant changes were particularly noted in the area of relationships and communication - two areas that are known to be difficult for students with ASD [8]. The teachers involved in the study were able to identify soft skills used by students throughout the lessons, and expressed their surprise at the ease with which these skills were enacted by the students, using the Ozobots as a conduit.

We recommend replication of this study with a larger sample size over a period of eight weeks. Moreover, we recommend the inclusion of thematic lessons that have a focus on communication skill development specifically for students with ASD. Ozobot pre-developed lessons could be paired with content lessons such as mathematics (e.g. measurement, angles, scalar, vectors), literacy (e.g. coding the end of a story or creating an alternative end), geography (e.g. coding the Lewis and Clark trail), and science, (e.g. application of the scientific methods, coding the migratory patterns of mammals vs aviation animals).

5 Limitations

There were two limitations of this study. First, the amount of time allocated to the Ozobot intervention differed between the two countries. The US was given eight days over the course of two weeks while Australia was given eight weeks, once a week. Second, more sophisticated analyses were precluded given the small number of participants.

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Playing Robots for Persons with Disability

Motivations and Examples

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Abstract. Play is a right and a tool for development for everybody. Physical, interactive objects, i.e. robots, can effectively engage the player in a pleasurable activity, adding to the play experience the dimension of the interaction with an autonomous object able to react and to propose activities. We present a framework and a set of experiences done in the development of robots for playing with persons with disabilities, showing that it is possible to exploit the robotic technology to implement simple, low-cost tools that can be used to reach developmental targets by means of a playful activity that is not perceived as a therapy.

Keywords: Autonomous robots, Play, Game.

1 Introduction

Play is a right and a tool for development for everybody [1], too often negated to persons with disabilities because of lack of time, mostly occupied by therapies, lack of proper toys, lack of companions. Physical, interactive objects, i.e. robots, can effectively engage the player in a pleasurable play activity that may support the development of skills while the subject enjoys the interaction with the robotic toy, and through it, possibly, with other players in inclusive play activities. Robots can react and even propose activities where they play the role of stimuli and even companions, with some abilities and a nature different from persons, and in many cases may offer chances for a good interaction. Pleasure and engagement come from a mix of challenge and reward that depends on the attitudes, skills, and mood of the player [7], matched by the abilities of the robot and the design of the play activity.

Complex and expensive devices are not needed for this: well-designed devices that consider appropriate sets of signals and cause-effect relationships, integrated in play activities designed for the specific players, are enough to provide effective and interesting play experiences. A key modality to obtain this is to co-design the play activity (and the robot, if not available), involving perspective players and their caregivers, which can provide needs and desiderata, together with designers and technicians that can provide technological solutions.

Since more than ten years, we have developed several low-cost robots to be used by people affected by disabilities[18]. We are providing here some motivations for this kind of development, a list of elements to consider when designing such experiences, and some examples of the recent play experiences done with the robots we have developed.

2 Motivations

We consider "play" as an alternative to "therapy" to both develop skills, and provide pleasure. Among the many definitions of play [2], we take the one proposed by Garvey: "Play is a range of voluntary, intrinsically motivated activities associated with recreational pleasure and enjoyment." [8] We consider that play activities can be proposed to, but also requested by a person with disability because this would like to play, and not necessarily has to reach a therapeutic goal: this may come as effect of the play activity, and it often happens that even unexpected outcomes emerge.

There are many motivations to include robots in play activities proposed to per- sons with disabilities. Different categories of robots have been defined by IEEE [9], among which are autonomous and remote-controlled robots, on which we focus here, each offering different play possibilities. In the following, we will refer to robots to be designed, and to the process of designing them, but if robots with the proper characteristics are available on the market, the same criteria may be applied to the selection process.

Autonomous robots add to the play experience that could be done with inactive toys the dimension of bi-directional interaction: the device that the player interacts with is physically acting in the world and may react to the player's actions or even stimulate activities. This changes the typical way to play with a toy since the control of what happens is no longer fully delegated to the player, but may depend on the robot's design, perception, and action. This may be beneficial and engaging for persons that have limitations in taking initiatives or in abstraction, such as persons with neuro-developmental disorders (NDD). The robot may support their playing and stimulate them, if its actions are compatible with their specific attitudes and preferences; this calls for careful design and the necessity to tune the robot's behavior on the player either online or by modifying parameters in preparation of the play session.

The design of the robot should consider aspects such as the type of signals that can be exchanged with the player, and how they can be modulated. We may have different input and output communication channels.

As input to the player the robot can stimulate the visual channel both with movement, lights, and the body itself, with its shape and colors, The hearing channel can be stimulated by sounds like beeps, music, which has often the effect of involving the player either because is recognized or because it stimulates dancing, or speech, which may be implemented either by selecting pre-recorded sentences or by generating utterances on-the-fly with the support of online services, these last unfortunately not yet mature for a

[18] Some examples are available at `http://playbot4all.polimi.it` and on [2], a book that describes in details the play topic and the possible use of robots to play with persons with disabilities.

safe (also w.r.t. privacy) and fluent interaction. Touch can be stimulated by the material of the body; for instance, fabric or fur may be better accepted than plastic, soft bodies more pleasant to touch than hard ones.

As input to the robot we may have the hearing channel, which, depending on the cost of the robot, may detect just sounds trespassing a given threshold (like a clap, or a scream), specific frequencies (like a whistle), or natural language speech, with the support of online services (or large computational capabilities on board), and with a relatively low word recognition rate in the typical environments, and quite low understanding possibilities for a natural language dialogue that may also be unstructured.

Given all these possibilities, the robot design should consider the needs for the specific play activity, to be achieved with a quality compatible with its playability. If the firstly designed activity cannot be implemented as a natural flowing activity with the robot that it is possible to employ, it should be re-defined in order to make it playable, i.e., not only accessible, but also enjoyable as a play activity, satisfying the Garvey's definition given above.

The specific characteristics of both the environment and the player should also be considered; in particular, the player may have limitations, specific needs, taboos, and preferences. For instance, loud or high-pitch sound signals may not be accepted by all, or a human-like aspect of the robot body may limit the interaction, so that a cartoon-like shape may be preferred.

The affordance presented by the robot is suggestive of what it is possible to do with it. A soft, small robot can be handled and may react to manipulation (e.g., Paro [11]), while a bigger, wheeled robot (e.g., Teo [6]) can move on the floor and may be used for games involving spatial relationships and wide movements. Some small humanoids, like Nao [10], could in principle walk, but they are so slow that most of the play activities done with them are based on gestural interactions involving upper limbs while they sit or stand on place.

Depending on the type of robot, different activities may be designed. Play activities may belong to the four main categories: "practice play", "symbolic play", "constructive play", and "rule-based play" (or game). The player may be left free to explore the playing tools ("play for the sake of play" or "free play"), or be introduced to a play activity of one of the mentioned types. Robots can be adopted in any of these situations [2].

An autonomous robot may be only reactive, so answering with a suite of pre-defined behaviors to given stimuli, which may come from a simple button pressing, up to the detection of presence or distance or speed of the player, or even the identification of posture, gesture, activity and direction of sight, made possible by artificial vision tools that may be embedded on board. The same sensor capabilities may also support proper engagement of the robot in games, where rules should be followed. An autonomous robot can also propose activities and act as an agent when the player needs to be stimulated or supported to be engaged in the play activity.

Remote-controlled robots give the possibility to drive a kind of avatar in a play situation. Through the design of proper interfaces it is possible to enable players with impairments to participate actively in games that they would not be able to play, because they would need unavailable abilities, often related to motion control. Moreover, if the identification with the robot-avatar is strong enough, and this heavily depends on the quality of the interface and on the play experience design, it is possible to use the robot itself to interact with others, either directly on a playground, or with avatars that others may drive. The possibility to drive the avatar may also enable other people to play with a subject without appearing in person. This may be the case when person-to-person relationship may introduce limitations, while, at the same time, leaves the care-giver a full control of the play activity.

All robots may hold sensors that could also be used to collect objective measures about the play experience, so supporting care-givers in the objective evaluation of the evolution of both interaction and skill acquisition.

3 Examples

In this section, we provide an example for each of the two considered categories (autonomous and remote-driven robots) introducing three of the robots that we have developed and some experiences we have made with them.

Fig. 1. DragonFlu: a remotely driven, mobile, table tennis ball launcher. Balls are thrown from the mouth upon command from a remote app. The robot can move, driven by moving the phone/tablet where the app runs.

DragonFlu (see Figure 3) is a simple, remote-driven, 70 cm high robot that can move on the floor with a differential drive kinematics. Under the cask is a repository of table tennis balls that can be thrown through the mouth. It is driven by an app that can run on Android phones or tablets. The movement of the device is mapped to the movement of the robot: turning the phone forward makes the robot go forward, left will move left, and so on. A big virtual button on the screen makes the robot throw the ball through the mouth. The robot moves quite slowly (up to about 80 cm/sec). Its body is obtained by a trash bin covered by polyurethane foam for safety, and pile as finishing material that may improve its acceptance. The cost in material for this robot does not exceed 50 Euros at the shop.

The design of the play activity was intended to induce the driver to exploit manual movement control, but also strategy and planning skills, and the other players to explore movement in space and strategy. The robot was designed for children with cerebral palsy under the assumption that the control of the remote was for them more accessible than throwing directly the balls. We devised two games: one where the driver should hit the others with the balls thrown by DragonFlu, so that the other players should escape, and the other one where the others should catch the balls that the robot would "pass".

The robot was tested at a summer camp held in Milan by the FightTheStroke Foundation, with 10 children affected by cerebral palsy showing different levels of impairment. Possibly because of the shape and of novelty of the experience, the robot attracted attention. The playing activity turned soon in something much less structured than what was planned: no one counted any point, but children enjoyed the activity of collecting the balls. They very soon understood that the ball reservoir was below the cask, so the cask was removed to have the possibility to refill it immediately. Trying to catch the robot to put the ball in was another play activity that emerged spontaneously. It often happens with toys that players find ways to use them alternative to the designed ones, and this is intrinsic in the nature of toys, so also of robots used to play. The players may identify in the possibilities offered by the robot new opportunities of play as soon as they can discover its capabilities. This discovering activity may be supported by the care-giver, but, being a component of play, it should emerge directly from the players.

Some issues where raised because of the difficulty of someone to control the robot with the phone that was used in this trial, and this is being managed by tuning the parameters that characterize the mapping of the phone/tablet accelerometer/gyro signal to the robot movement, as well as using a different mechanical holder for the phone/tablet. Children where so involved by the activity that expected more animacy in the robot, and asked for giving it the possibility to speak (or at least emit sounds), and move some parts. We are working to integrate these capabilities in further play activities.

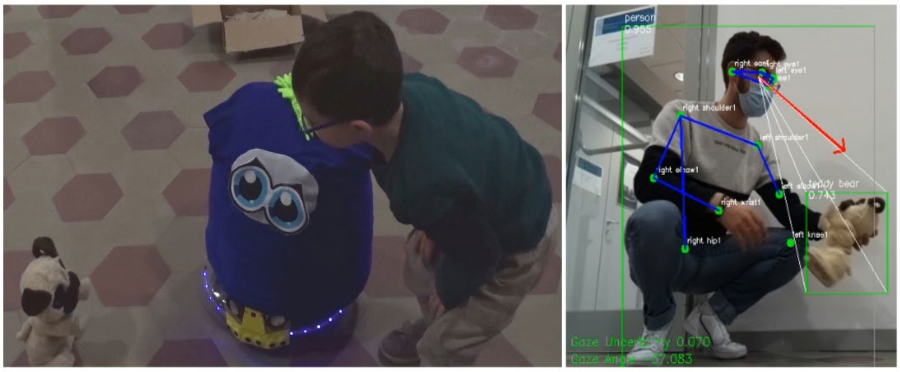

Fig. 2. (a) The mobile robot OIMI in action attracting the attention of the player to the puppet on the left. (b) The skeleton and sight direction detection from OIMI's camera images.

The second robot we would like to introduce is OIMI (see Figure 2(a)). It is a mobile robot, the fifth generation of Teo [3, 6], intended to act autonomously, used both for free play and structured games. It runs at up to 1.4 m/sec on omnidirectional wheels. It has distance sensors, accelerometers, a camera, hugging sensors on the soft body, capacitive sensors and a speaker. it is managed by a Raspberry PI4 assisted by Arduino for sensors and motor control, and connected to two hardware AI modules: a Google Coral and an Intel Movidius2. The AI modules can interpret images to detect and recognize objects, and to identify persons' skeletons and sight direction (see Figure 2(b)).

This robot is equipped to perform rich free play. From the skeleton it is possible to identify gestures (for instance, tantrum precursors), and to act with a rich information about the player and the environment. We have developed an architecture to enable the robot to build a world model and to play scripted, goal-directed interactions, ready to autonomously modify the script to adapt to the situation.

We have performed trials to induce joint attention on an object. The design of movements and sounds made it effective to attract the attention of kids. The absence of moving parts in the body (a design choice to obtain a safe soft body without any possibility to harm or to be damaged), makes it difficult to point at an object, but, with the robot movement only, it was possible to obtain some successful joint attention episodes. The system is quite complex, and still requires adjustments to be used in real settings, possibly supported by new, more powerful hardware.

Fig. 3. The mobile robot Teo, presented in the playing environment. The coloured patches can be substituted by others functional to question-answers games. The eye expression and mouth can also be selected by the player to customize the emotional aspect of the robot.

The previous versions of this robot (Teo - see Figure 3) didn't have any computer on board, nor a camera, but only an Arduino Mega controller board, distance and hug sensors, and four virtual buttons, implemented as sensible elements on the soft body on which patches could be attached by VelcroTM strips, functional to implement different structured games. It was able to manage both free play and simple question-answering games, with a cost in materials below 400 Euros, at the shop. One such robot has been operational for more than 4 years at the care center "Il Sogno" in Castelnuovo Garfagnana (LU) [6]. It was used with the guest children (about 50 children with different dis- abilities, mostly neuro-developmental disorders) both as a reactive autonomous robot, with players exploring its reactions to the fact that they were getting close, or hugging, or hitting it, or stimulating its sensor capabilities in any way, and also as proposer of question-answering games where the robot asked questions that could be answered by touching one of its patches.

The typical session started with the robot still in the environment, together with other toys, so that the kid could familiarize with its presence. Then the robot was turned on and waited for interaction, sometimes making small movements to stimulate curiosity and to make the player aware that it was active. At this point, the player usually starts an interaction driven by curiosity. After the experience accumulated in the years, we have designed these first movements to be as gentle as possible, just to show the possibility of interaction, without moving too much so that the player may gradually start to consider the robot. Sometimes the player gets anyway scared, and the caregiver may intervene either directly or through the app that controls the robot. Sometimes an aggressive behavior has been observed, which may turn in a jump on the robot that may tear it down. This is detected, as many other manipulations, by the on-board sensors: the robot stops its motors and starts crying, sadly dimming the lights in the lower body. In one of these situations, a kid, aged 5 with autistic spectrum disorder, went back to the robot, raised it (so obtaining a grateful feedback based on movement, sound, and light) and tried to comfort the robot giving it a piece of fabric of a color similar to its body.

When a relationship is activated, the player can interact with the robot. This may last from 5 to about 15 minutes. Then, the robot can be used for structured games, as desired by the therapists. With this version of the robot, these were games based on questions to be answered by touching one of the patches on the robot body, where a symbolic representation of the answer was represented. The robot proposes the question and waits for the answer. When a correct answer is provided the robot shows to be happy, starts to play a song and dances it, so involving all the children in a common dance. The therapists requested to have songs known by the children so that they could even sing together with the robot. Upon a wrong answer, it encouraged the player, through a recorded voice, to try again with another answer. At the end of the game a dance is proposed to leave a positive feedback for the whole experience. These games were also played in small groups (3 to 5 people) to stimulate turn-taking, so that the final dance was also a chance for group activity.

No statistical evaluation was done on the experience in this site, given the wide spectrum of players and their relatively small number, but therapists provided qualitative evaluations of the outcomes of the use of the robot. They could assess a stable improvement of both verbal and non-verbal communication abilities, turn-taking, visual following, focusing, and attention on all the subjects. Moreover, they reported that children with touch limitations wanted to hug and caress Teo, as we planned, since it is not a person and has reactions that can be expected because they are qualitatively similar each time. Motivation could make noise-sensitive children to accept the sounds produced by Teo, which, anyway, were designed to be produced at not too high volume and with medium pitch, far from the beeps that may be associated to robots as shown in movies like Star Wars. In general, children liked to interact with Teo, and they requested a session with it with gestures, when they couldn't speak. Some of them were over-excited on the first session, possibly a way to cope with novelty, but then emotion got regulated in autonomy as they became acquainted with it. The verbal feedback provided by Teo in the question-answer games was taken as positive reinforcement, triggering expectation and motivating to keep attention, and to retain what was proposed in the structured game.

4 Conclusion

In this paper, we have given some motivations to adopt robots to implement play activities, and we considered in particular autonomous and remote-controlled robots. We have introduced two examples, one for each category, showing what was possible to obtain, with low-cost robots. Some robots are available on the market and may be used as they are or programmed to participate to play activities that may be designed to match their abilities and those of the players. Other robots may be implemented, with a relatively small effort and skill need, involving therapists, families and perspective players, possibly following guidelines provided in books [2] and papers [4, 5].

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Development, Evaluation and Assessment of Assisitive Technologies

Knowledge Mobilization Strategy within a Municipality to Improve Accessibility of the Built Environment:
A Research Protocol

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Abstract. Introduction: The increased number of people living with a disability and in urban areas makes it essential to create accessible and inclusive cities for all. Universal accessibility (UA) was recognized in 2006 by the United Nations Convention on the Rights of Persons with Disabilities. Municipalities play a key role in the implementation of accessible environments but are facing challenges. Adapted and effective knowledge mobilization (KM) strategies are necessary to foster implementation practices of accessible environments. However, we don't know much about the strategies used by municipalities, as well as their effectiveness, to mobilize knowledge in the implementation of UA measures. Objective: This project aims to support the municipality of Quebec, Canada, in best practices of KM to improve the implementation of UA measures. Methods and analysis: A case study based on a realist evaluation and a participatory approach will be used. (1)A scoping review was conducted to document strategies used by other municipalities (2)Determinants of implementation will be documented by a questionnaire created from the CFIR. (3)Focus groups will be conducted to co-create KM interventions. The interventions will be implemented and monitored for 12 months. (4)The questionnaire will be retaken to assess the effects of the interventions. Results and discussion: findings of the scoping review outline importance of the involvement of all stakeholders, information sessions and interactive knowledge mobilization strategies to facilitate the implementation. Conclusion: KM strategies adapted to municipal context will actively facilitate the introduction of new evidence to change practices and behaviors regarding UA.

Keywords: universal accessibility; design for all; municipality; knowledge mobilization.

1 Introduction

Worldwide, 14.3% of the population live with a disability[1]. In Canada, this proportion rises to 20%[2, 3]. It is also estimated that by 2050, two-thirds of the world's population will live in urban areas[4]. It is therefore essential to make cities accessible and inclusive for all people, including those with disabilities[1]. Actions improving the accessibility of environments are recognized to benefits from the entire population, not only people living with disabilities[4-8]. Indeed, an accessible environment is an added value for all: the elderly with a loss of mobility, families with strollers, or tourists with their suitcases. The concept of universal accessibility refers to the character of an environment that provides equitable access to the infrastructure, the services, the transportation, the information, or the employment[9]. Universal accessibility allows all individuals to carry out their daily activities independently, in an equitable and inclusive approach[5, 9]. In 2006, the United Nations Convention on the Rights of Persons with Disabilities recognized the legislative obligation to implement actions that increase universal accessibility of environments[1]. This convention marked a turning point in the approach to disability and played a pioneering role in the promotion and protection of the rights of persons with disabilities, by emphasizing the basic human right to mobility and access to services and infrastructure for all[10, 11]. In Canada, the Canadian Accessibility Act aims to ensure the economic, social and civic participation of all persons in Canada, regardless of disability, and to enable them to fully exercise their rights and responsibilities as citizens in a barrier-free country[12], promoting the development of universal accessibility measures.

Municipalities play a key role in the implementation of accessible environments[13, 14]. However, those organizations are facing different challenges when implementing better universal accessibility practices to reduce the risks of social exclusion and improve the participation of individuals living with disabilities[14, 15]. The implementation of practices improving the universal accessibility of built environments by municipalities is complex and presents several challenges[16] due to the singularity of the municipal structure (e.g. unstable relationships, uncertainty, unpredictable changes) [17, 18]. The identification of adapted and effective knowledge mobilization strategies is necessary to foster implementation practices of accessible environments. Implementation specialists suggest that implementation strategies be adapted to the specific context and designed to allow an effective actualization of the innovation[19-21]. Knowledge mobilization strategies enable for the development and implementation of a new process[22, 23] and bridge the gap between research innovation and practice. We currently know very little about the strategies used by municipalities, as well as their effectiveness, to mobilize knowledge to improve the implementation of universal accessibility measures. It is therefore important to explore the different determinants of implementation to better tailor strategies and facilitate knowledge mobilization and implementation of accessible environments[24].

2 Objectives

This project aims to support the municipality of Quebec, Canada in the implementation of best practices in knowledge mobilization to improve the implementation of universal accessibility principles. The specific objectives are to: (1) Synthesize evidence about the knowledge mobilization strategies used by municipal organizations to improve universal accessibility and their effectiveness, (2) To document the determinants of universal accessibility among municipal employees in Quebec City, (3) To co-create and implement a universal accessibility intervention, optimized specifically for each municipality, (4) To evaluate the mechanisms and effects of the intervention on municipal employees with respect to the implementation of the universal accessibility measures developed.

3 Methods and Analysis

A case study based on the foundations of a realist evaluation and a participatory approach will be used to address all objectives. The project is presented in three distinct phases; 1) documentation (objectives 1 and 2); 2) implementation (objective 3); and 3) evaluation (objective 4).

3.1 Phase 1. Documentation

Objective 1. A scoping review was conducted following the steps of Arskey and O'Malley and the PRISMA guidelines. The search strategy included two concepts: (1) Universal accessibility (e.g., Universal* design, Universal* access*, design for all, accessible design, facility design) and (2) Local governments (e.g., Local govern*, City, Cities, municipal*, county, towns). Searches were completed in August 2021 and limited to 2006-2021 (begin of the application of the UN-CRPD) and to French or English articles. The data was extracted independently by two authors and was classified in an excel table by implementation, dissemination, integration, or capacity-building strategies. Barriers and facilitators identified in studies were also extracted. Raw data of the studies were reported as author, year, area of study and objective (what was implemented). Analysis was conducted according to the combined used of the Consolidated Framework for Implementation Research (CFIR) and the Theoretical Domain Framework (TDF) [1-4], allowed to identify determinants, facilitators, and barriers to the implementation of universal accessibility measures by municipalities.

Objective 2. Initial determinants facilitating and hindering universal accessibility implementation will be documented by a questionnaire created from the Consolidated Framework for Implementation Research (CFIR)[4]. The questionnaire is created in collaboration with the City's steering committee (two researchers, a PhD Candidate, a city representant of universal accessibility committee and two city managers). It is also validated by a committee of experts made up of 4 researchers specialized in accessibility and implementation fields as well as one research professional specialized in universal accessibility. To build the questionnaire, the various CFIR constructs were mapped to existing tools in a five-step process: (1) Looking at references used by Damschroder and al., (2) Overview of existing systematic review on tools based on CFIR, (3) Documenting constructs in PubMed, (4) Checking out JBI implementation science table of contents, and (5) Transforming questions from the CFIR qualitative tool into quantitative questions. Based on these 5 steps, questions were proposed for each construct and was validated by the expert committee as well as City's steering committee. The questionnaire will be distributed to municipal employees. Descriptive analysis will classify the determinants identified as barriers or facilitators to implementation. Further analysis could be conducted to provide more details on the determinants of implementation as perceived by municipal employees representing all job types (seasonal, manual, professionals, public agent and managerial).

3.2 Phase 2. Implementation

Objective 3. Two focus groups with managers of Quebec City will be conducted. The first one will be to identify an initial theory of change, based on the determinants identified as barriers and the literature documented in the scoping review. This theory will take the form of a context-mechanism-effects (C-M-E) association. The second focus group will be to co-create the knowledge mobilization interventions by identifying its final format with the city managers (e.g., Workshops, videos, awareness campaign, sensitivity training, etc.). The constructed interventions will then be implemented in the cities and monitored for 12 months.

3.3 Phase 3. Evaluation

Objective 4. The initial questionnaire will be retaken by municipal employees representing all job types to assess the effects of the interventions on the implementation determinants of universal accessibility measures. Same analysis as objective 2 will be conducted to compare the results. In addition, ten interviews will be led with municipal employees, to understand the efficiency of the intervention and what worked, for whom, and under what circumstances.

4 Results

4.1 Objective 1

1328 articles were identified through the search process and 236 duplicates were removed. The remaining 1132 articles were screened based in titles and abstracts according to the inclusion criteria. 1059 articles were excluded, and 73 articles were subjected to a full-text review of their eligibility according to the inclusion criteria. Of these articles, 66 were excluded because they did not meet the inclusion criteria. The references of the remain 6 articles were included in the final review [14, 25-29]. Findings from the scoping review outline the importance of involvement of all stakeholders as an implementation process strategy [25, 27-29]. It also put forward the importance of publications and reports to foster knowledge as dissemination strategy [14, 25, 29]. Integration strategies listed by studies are implication of expert in landscape and accessibility to increase skills [14, 26, 28], interactive and diversify knowledge mobilization strategies (video, photovoice, journal)[14, 28] and representation of people with disabilities into the process[25, 28]. Few studies talked about capacity-building strategy, but the two most recent studies talked about the importance of new knowledge assessment[14, 28]. Involvement of all stakeholders was identified as a facilitator by 5 studies over 6 [14, 25, 26, 28, 29] as the lack of awareness by municipal actors was identified as a barrier by half of the studies [25, 27, 29].

4.2 Objectives 2-3-4

The second objective will allow to identify facilitators and barriers perceived by municipal employees of Quebec City. These results, joined with the results of the scoping review, will act as a basic premise to guide the co-creation of knowledge mobilization interventions and tools with the city (objective 3). These interventions will answer an existing need and will be adapted to the reality of municipal organizations. The fourth and last objective will allow to evaluate the impact of these new knowledge mobilization interventions on the determinants of implementation among municipal employees.

5 Discussion

The implementation of knowledge mobilization interventions adapted to the specific needs of the municipalities of Quebec City is an innovation. Indeed, literature about knowledge mobilization strategies is increasing in the health field. However, it seems that in urban planning and universal accessibility, we have little information on the strategies used to promote change in practices, nor how effective these strategies are. Thus, this project will allow us to propose innovative solutions in a context that is still poorly documented, to improve knowledge and skills related to the implementation of universal accessibility practices and inspire other municipalities. The intervention will facilitate the operationalization of the practices by municipal employees, which could contribute to the creation of accessible environments and promote the social participation of people with disabilities.

6 Conclusion

The implementation of universal accessibility measures requires effective strategies that are adapted to the municipal organizational context. Knowledge mobilization will actively facilitate the introduction of new evidence to change practices and behaviors, and to determine which methods work best in which context. This research project will also identify what mechanisms for change are effective in a given context to achieve the desired results in terms of application of universal accessibility measures by municipalities.

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Promoting the Design of a Sensory Toy for Children with Disabilities through Interdisciplinary Teamwork:

A Classroom Experience

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Abstract. Background: Environmental adaptations that enable participation in play for children with disabilities is essential in the development of neurological, cognitive, and socio-emotional abilities. Toys designed as assistive technologies (ATs) can enhance parental behaviours that benefit play activities and increase family enjoyment. Interprofessional pedagogical strategies can improve the design and implementation of ATs. Aim: This study aims to develop a teaching-learning strategy with the aid of a web-based simulation tool in an AT course that promotes interprofessional skills development through the process of designing a sensory toy for children with disabilities. Method: We used the Significant Learning Framework to guide the implementation of a teaching learning strategy that includes functional knowledge, application, integration, a human dimension, caring, and learning how to learn. We designed an activity with the use of web-based tools and an ad-hoc rubric for quantitative and qualitative hetero- and co-evaluation. Results: Teamwork, interdisciplinary work, and design processes were positively evaluated. Students acknowledged the importance of interdisciplinary cooperation as well as improving the clarity of the disciplinary roles. Co-evaluation showed the need to improve clarity regarding the characteristics of the toy and the pertinence in relation to the user needs. Conclusion: AT design and implementation benefits from interdisciplinary approaches, and experiential learning brings students closer to real needs. The use of technology provides opportunities to materialise dreams and ideas that contribute to the enhancement of accessible and universal design for persons with disabilities.

Keywords: Assistive technology, Interprofessional learning, Children with disabilities

1 Introduction

The Convention on the Rights of Persons with Disabilities (CRPD) adopted by the UN in 2006 establishes the rights and fundamental freedoms of persons with disabilities. To guarantee the rights of persons with disabilities (PwDs), environmental adaptations and actions to promote and enable participation in meaningful activities through occupations are critical. Adaptations include changing social attitudes, providing support, and implementing the use of assistive technologies (AT) in different contexts. These technologies include equipment, products, or systems aimed at increasing, maintaining, or improving the functional capabilities of individuals with disabilities.

ATs are especially relevant during early childhood when neurological development takes place and children achieve milestones in terms of gross and fine motor skills and cognitive, language, and socio-emotional abilities [1]. During this developmental process, play is important for cognitive and social development. However, children with disabilities often experience difficulties with engaging with objects or toys for play, which may reduce the frequency of play with peers in educational and home environments [2]. Designing toys that are suited to the needs of children with disabilities is critical. Toys have the potential to enhance parental behaviours that benefit play activities and increase family enjoyment [3]. Child-toy interactions usually involve low-tech devices initially, which are easy to implemented due to their availability, low costs, and accessibility. If the child and the family interact successfully with the toys, these low-tech devices can be considered as appropriate enablers.

The design of sensory toys aimed at promoting play in children with disabilities can be promoted in basic and higher education institutions. This also constitutes an opportunity to introduce interprofessional cooperation between health sciences and engineering students. There are strategies to create occasions where members of two or more professions can learn from and about each other [4]. In addition, the classroom is a conducive setting for experiments that encourage flexible and collaborative thinking [5].

The increased use of programming and digital tools in educational contexts can boost the creativity and resourcefulness of students. Activities such as prototyping and 3D printing of adjustable objects can create transformative learning experiences [6]. For example, hackathons (a collaborative event where people work in groups on a hardware/software project) are increasingly being used as a model for cross-disciplinary collaboration and learning [7]. Hackathons have extended far beyond the tech world and have expanded into educational, creative, corporate, and governmental contexts [8]. It is a suitable strategy for teaching assistive technology that can be adapted to virtual or remote access environments to ensure engagement and active participation in challenging activities [9, 10]. Moreover, it fosters collaborative work between members of different disciplines [11]. Hence, we propose a teaching methodology for an assistive technology course that uses digital web-based tools for modelling and prototyping to promote interprofessional skills development during the process of designing a sensory toy for children with disabilities.

The aim of this work was to develop a teaching-learning strategy with the aid of a web-based simulation tool in a AT course that promotes interprofessional skills development through the process of designing a sensory toy for children with disabilities.

2 Methods

The theoretical part of this work is based on the Significant Learning Framework. On the other hand, specific intended learning outcomes (ILOs) and the user-centred design approach were also used to design the practical activity. Finally, an ad-hoc rubric was designed to evaluate the activity.

2.1 Significant Learning Framework

The proposed strategy is based on the implementation of significant learning experiences. Significant learning means that the experience encourages a lasting change in the learner's life. Categories in which learning experiences can be significant include functional knowledge, application, integration, human dimension, caring, and learning how to learn. Functional knowledge refers to students' ability to understand and remember key ideas or specific information that serves as a special value and provides the basic understanding required for other kinds of learning. Application allows students to learn how to engage in various kinds of thinking (critical, creative, practical), which enables other types of learning to become useful. Integration occurs when students acknowledge and understand the connections between different elements related to their work and the global context. The human dimension is the pursuit of the process of discovery from the perspective of personal and social implications from what the students have learned; they acquire a better understanding of how and why others act in the way they do, or how the learner can interact more effectively with professionals from other disciplines. In caring, a learning experience may change the degree to which students care about something and can influence the configuration of new feelings or values; when students care about something, they have the motivation that they require to learn more about it. Finally, how to learn provides students with the tools to continue learning successfully into the future [12].

These learning experiences are characterised by non-hierarchical relational and interactive interactions. The key components of the Significant Learning Framework are situational factors (which includes the relevant information that needs to be gathered for any project or case study) and the integration of the intended learning outcomes, teaching and learning activities, and feedback or assessment of the activities [12].

2.2 Activity Design

Essentially, we designed the activity with consideration of the various educational transformations brought about by the COVID-19 pandemic. This means that it should be possible to implement the activity in virtual or remote access modes. Consequently, the activity had to enable the students to meet via videoconference, use web-based tools to design their proposed project, and build a final product using 3D printing web services. The strategy was implemented for one year (2021) in an elective course (named *Assistive Technology*) in the School of Medicine and Health Sciences (EMCS, by its acronym in Spanish). Students from any of the seven disciplines that the EMCS offers (i.e., occupational therapy, physical therapy, speech therapy, biomedical engineer, psychology, nursing, and medicine) could register for the course. Throughout the course, students improved their knowledge on the meaning of ATs and the specific foundations of a user-centred design approach (situational factors). To guarantee an interprofessional approach, two professors (one from the engineering field, a biomedical engineer, and the other from the rehabilitation field, an occupational therapist) coordinated the course. A third professor, also from occupational therapy, supported the students during their meetings. The professors organised the groups and balanced the number of students and disciplines involved (5–6 students per group and at least three disciplines).

We designed a three-week learning activity, based on the hackathon model, to conduct after the introductory sessions. The ILOs that were aligned with the Significant Learning Framework components human dimension, integration, and application guided the teaching-learning situation. Interprofessional skills, such as the contribution of knowledge from others and contributions from the joint planning and implementations, were also considered [4]. In regard to the situational factors, the students had to provide a feasible solution for a hypothetical child with a cognitive disability who requires sensory stimulation. Students had to develop a creative low-cost design for a sensory stimulation toy or device that incorporates at least two sensory functions (hearing, vision, tactile, olfactory, proprioceptive, or vestibular). The students from different disciplinary backgrounds had to contribute and combine their knowledge and perspectives for the design. During the first week, they worked on the *plan of action stage*: a first proposal of the device and the selection of a web-based tool for its construction (suggested tool: Tinkercad[19]). In the second week, they worked directly with the web-based tool on the *design stage*; the device had to combine their disciplinary approaches (clinical and engineering). Once they had created a suitable design, the third week involved the *construction stage*; the device was sent as a prototype for manufacture with a cutting laser or 3D-printer. Finally, a 5-minutes video that explains the process was created and shared with the entire class in a virtual portfolio.

2.3 Activity Feedback

Feedback is a critical component of the Significant Learning Framework [12]. The framework proposes realistic learning tasks through cycles of performance-feedback-revision-new performance [12]. The three-week-hackathon experience was intended to provide enough time for the creation of a qualitative feedback-adjustments-enhanced performance. The final products (the proposed device and the video) were quantitatively (graded from 0.0 to 5.0) and qualitatively assessed with an ad-hoc rubric that was created following the method proposed by Stevens et al. in [13].

The rubric had six criteria for the evaluation of the hackathon activity, using a quantitative measure. Each criterion had a different percentage weight for the total score. The criteria included phases of planning, design, and construction; sensory functions stimulated by the toy; explanation of the functionality and physical structure of the toy according to the needs of the hypothetical child; teamwork demonstrated in the video

[19] Creating 3D digital designs with online CAD interface, https://www.tinkercad.com

in terms of the participation and contribution of each team member; interdisciplinary work regarding the performance of each professional role demonstrated in the video; and the length of each video. The qualitative evaluation was based on written constructive feedback for each group. The rubric was completed by the professors (traditional evaluation) and by the students (co-evaluation), who evaluated the other groups. The final score was calculated with the mean of all the grades. The rubric was presented to the students at the start of the activity so that they would be aware of the assessment criteria. Subsequently, they received a summary of the quantitative and qualitative results.

Table 1. Rubric for hackathon evaluation

HACKATHON ACTIVITY				
Aim: To develop a creative low-cost design for a sensory stimulation toy or device that incorporates at least two sensory functions (vision, smell, hearing, touch, taste, proprioceptive, vestibular)				
Quantitative evaluation: Grade from 0.0 to 5.0 according to each criterion				
CRITERIA	EXEMPLARITY	COMPETENT	DEVELOPING	Grade
Phases: *Planning, Design, Construction* (20%)	All the project phases (three) are portrayed in the video	Two phases of the project are portrayed in the video	One phase of project is portrayed in the video	
Sensory functions (10%)	The toy clearly stimulates at least two sensory functions	The toy clearly stimulates one sensory function	The applicability of the toy for any sensory function is not clear	
Explanation in the video (20%)	Students explain the functionality and physical structure of the toy according to the needs of the case	Students explain only the functionality or the physical structure of the toy according to the needs of the case	Students explain only the functionality or the physical structure of the toy	
Teamwork (20%)	The participation of all team members is demonstrated, and they appear in and contribute to the video	The participation is incomplete; only some team members appear in the video	The participation of team members is not demonstrated, the video is audio-descriptive only	
Interdisciplinary work (20%)	The video displays the roles of all the participating disciplines	The video displays only some roles of the participating disciplines	The video does not display the roles of the participating disciplines, or the roles are not clear	
Time (10%)	The video is between 5 and 6 minutes long	The video is between 3 and 4 minutes long	The video is shorter than 3 minutes or longer than 6 minutes	
			Total	
Qualitative evaluation – Please provide constructive feedback to the group:				

3 Results

The results correspond to one academic period (one semester) of applying the strategy. In that period, 30 students from physical therapy, occupational therapy and biomedical engineering enrolled in the elective assistive technology course. They worked in six groups via virtual meetings during the pandemic.

After the strategy had been implemented, the quantitative and qualitative results were obtained. The final mean score for the six groups that participated in the activity was 4.79 (SD = 0.05, MIN = 4.72, MAX = 4.86). This shows an overall exemplary performance from all the groups. The criterion with the highest overall mean score was teamwork (mean = 4.98, SD = 0.04), followed by interdisciplinary work (mean = 4.87, SD=0,21), and phases — planning, design, and construction — (mean = 4.83, SD = 0,20). The lowest overall scores were for the criteria for sensory functions (mean = 4.75, SD = 0.15), explanation (mean = 4.63, SD = 0.23), and time (4.49, SD = 0.34). The qualitative results highlighted the importance of group activity and collaborative work. Some groups acknowledged the importance of interdisciplinary cooperation, while others stated a lack of clarity on the roles of the different health professions. Several groups mentioned that they valued their newly acquired skills related to creativity and innovation. With reference to the videos, co-evaluation led to classmates recommending strategies to reduce the length and provide more clarity on the characteristics and stimulation possibilities of the toy. Regarding the process, some groups noted a lack of coherence between the initial design process and the final product as well as the need for a more comprehensive description of the product.

Regarding the sensory toys, the students perceived a positive relationship between the child's need for stimulation and the possibilities of the use of the toy in play. Moreover, they provided recommendations for improvements related to structure, materials, size, and functionality. Figure 1 shows some of the sensory toys that resulted from this activity. Image A shows a sensory stimulation toy made with different fabrics, such as velvet, wool, and suede; each tentacle has a tactile or sound stimulus. Image B shows a 3D-printed toy designed for tactile-texture and auditive interaction, as well as an intended body-schema for laterality recognition. Image C is a sensory pillow; it is a cloud-shaped toy that was created to promote the emotional intelligence and social skills of children through sensory stimulation. It was made with soft cotton and a light that is activated through motion. It also included an instruction manual for parents.

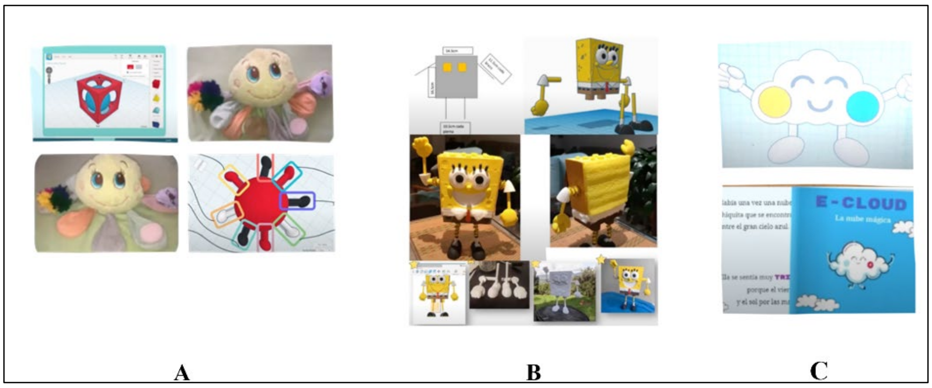

Fig. 1. Samples of sensory toys. **A:** Octopus: the little sensory octopus; **B:** Bob Sensations; **C:** E-cloud: the sensory pillow.

4 Discussion

This study aimed to develop a teaching-learning strategy that promotes interprofessional skills through the process of designing a sensory toy for children with disabilities in an assistive technology course. The design of assistive technologies requires the identification of the needs of individuals and communities and the testing of possible solutions in natural contexts. During the COVID-19 pandemic, the applied restrictions created a challenge for courses that were traditionally taught face-to-face. Therefore, new approaches had to be implemented to continue the acquisition of knowledge and competencies for planning, designing, and constructing technological aids for persons with disabilities.

Trust et al. [6] stated that, during the pandemic, educators needed different strategies to respond to pedagogical challenges, which required adaptations with the use of technology. Our study addressed this issue by implementing a pedagogical strategy with the use of a web-based tool and a shared online rubric for the design, construction, and assessment of a sensory toy. The students' qualitative feedback showed that the strategy constituted an opportunity for creativity in the process of building the toy and engaging collaboratively in the production of the video and the co-evaluation rubric. This finding is also supported by previous studies that used web-based tools in pedagogical settings. Abburi et al. [5] found that, with the use of the tool Tinkercad, students were able to participate online and analyse other students' projects. It comprises a laboratory platform that allowed professors and classmates to monitor the design process without the need for a license. Dalton et al. [14] also encourage the use of Tinkercad and 3D printing for the design of tactile books based on inclusive design and accessibility to different types of pedagogical materials related to children with disabilities.

Regarding the interprofessional and teamwork aspects of the strategy, we found that these positively evaluated by both classmates and professors. It is an increasingly important competency for health sciences and biomedical engineer students when working with persons with disabilities. Güldenpfennig et al. [15] have shown successful results with the implementation of co-designing approaches for therapeutic toys, with the participation of different professions such as psychology, pedagogy, and design. Similarly, Rahmawati et al. [16] confirm that project-based multidisciplinary learning is an essential skill that promotes collaboration, empathy, creativity, and critical thinking. Moreover, it enables the construction of learning through experience, which contributes to abilities such as problem solving and the integration of information.

Our study had some limitations. We were unable to provide a physical setting to test the usefulness of the toy to the final user, and we had no opportunity to assess the user-specific needs objectively and systematically. The design was based on the analysis of a hypothetical case study. Implementing the strategy in a real setting may produce additional challenges that will have to be considered. In addition, we found that the qualitative techniques can be improved in the future by conducting focus groups or interviews. While written feedback was a suitable approach for co-evaluations, we believe that an analysis of the perspectives of students on how they experienced the learning strategy can enhance future pedagogical innovations.

Teaching AT interdisciplinary courses constitutes an opportunity to create significant learning opportunities to raise awareness of real needs among students. Moreover, digital prototyping and 3D-printing tools provide students with the opportunity to materialise dreams and ideas, test them in real settings, and make affordable improvements based on the needs of individuals. This teaching-learning experience acknowledges the importance of AT to enhance play in children with disabilities.

5 Conclusion

Interdisciplinary approaches are essential for the design of ATs because they provide synergies that improve the quality of the products in terms of usability, appreciation of needs, and context-based suitability. These approaches should ideally be implemented early in the experience of any health professional during the process of training at the University. The promotion of scenarios that allow students to interact, share, teach, and learn with other students from different disciplines is a pertinent and relevant challenge that must be considered in higher education.

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Development of an Assistive Dynamic Arm Support for a User with Spinal Muscular Atrophy

A Retrospective Analysis after Two Years of Daily Use

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Abstract. People affected by Spinal Muscular Atrophy typically suffer from decreased muscle strength in upper and lower limbs and face many challenges in accomplishing daily activities. This work presents the usercentered design, development, and long-term evaluation after two years of daily use of an assistive dynamic arm support for a specific user suffering from Spinal Muscular Atrophy. The personalized device provides active assistance to switch the user's elbow between two functional positions and active or passive support of elbow flexion and extension sufficient to conduct activities of daily living such as eating, drinking, controlling the wheelchair or using computers or smartphones. The device was assessed at multiple time steps, whereas the device has shown to be robust with only minimal maintenance required. The user's satisfaction, measured by the Quebec User Evaluation of Satisfaction with Assistive Technology 2.0 score, was perceived as high (average score between 3.6 and 4.3, possible range 0 to 5) and the Psychosocial Impact of Assistive Devices Scale indicated that the dynamic arm support positively affected the independence, well-being, and quality of life of the user (average score between 0.85 and 1.5, possible range -3 to +3). This work underlines the benefits of a user-centered design approach and long-term evaluations in terms of usability and, consequently, device adoption of assistive devices, as well as the need for adaptability to the individual needs of different users with muscular weakness.

Keywords: dynamic arm support · user-centred design · user involvement · neuromuscular disorder

1 Background

Neuromuscular disorders such as Spinal Muscular Atrophy (SMA) lead to progressive muscle weakness for the people affected. As a result, many activities of daily living become troublesome or impossible to be completed independently. Various dynamic arm supports have been developed to assist users with reduced upper-limb strength in activities such as eating, drinking, controlling their wheelchairs, or using computers and smartphones [8]. For example, passive arm supports such as the *Armon Pura* (Armon Products B.V., Netherlands), the *WREX* (Jaeco Orthopedic, USA), the *SaeboMAS mini* (Saebo, Inc., USA), or the *Mobility Arm* (Nitzbon, Germany) use mechanical springs or counterweights to reduce the effort required to move the arm against gravity. Hybrid solutions such as the *Armon Ayura* (Armon Products B.V., Netherlands), the *Gowing* (Focal Meditech B.V., Netherlands), or the *iFloat Powered Assist* (Assistive Innovations B.V., Netherlands) rely on similar gravity compensation mechanisms as passive solutions, but allow additional active control options such as the adjustment of the degree of weight compensation or fixation of the arm in a certain position. Purely active solutions, such as the *MyoPro* (Myomo, USA) move the arm with motors controlled by various input signals.

Despite the broad availability on the market, a recent survey found that arm supports were used by only 30.6% of respondents with SMA, although their level of impairment would indicate that they could potentially benefit from such an assistive device [1]. The low acceptance may result from size constraints exceeded by the available arm supports, insufficient support of the desired movement, or a lack of mobility, e.g., when the device is fixed to a table or a chair [7]. This raises the concern that the specific needs of many potential users might not be sufficiently fulfilled by the arm supports available on the market, emphasizing the need for stronger user involvement in the design process and more personalized solutions for individual users. Thus, following a user-centered design approach, we developed a wheelchair-mounted dynamic arm support in close collaboration with an individual target user with SMA. The usability of the device was evaluated in multiple sessions spanned over two years of daily use. This long-term evaluation allow to unveil insights and limitations only appearing when integrating such a device into the user's daily life and along a potential progression of the disease and not apparent during a single-session evaluation [3, 7]. Accordingly, these findings allow for an in-depth analysis of the long-term usability of the device and its impact on quality of life.

2 Methods

In a first user-centered design iteration cycle [4, 6], the dynamic arm support was built to support elbow flexion and extension, as these were identified as being the functions that limited the user the most in daily tasks. Device functionality and usability were extensively evaluated using functional task success rates and the Quebec User Evaluation of Satisfaction with Assistive Technology 2.0 (QUEST 2.0) questionnaire [2]. After 1.5 years of daily use, the Psychosocial Impact of Assistive Devices Scale (PIADS) was used to determine the effect of the device on the user's independence, well-being, and quality of life [5]. Based on these findings and due to the progressive nature of the target user's muscle weakness, a second iteration cycle was conducted. The new, extended device, "Mike's Arm Mover" (MiAMove), additionally supports upper arm movement to a certain degree to allow additional functional tasks. The extended device was again assessed using the QUEST 2.0 and the PIADS, and its frequency of use was measured over a period of three weeks using an internal counter.

3 Key Results

The final design of the MiAMove is composed of two subsystems, as shown in Figure 1. The "forearm entity" consists of a passive a pulley-based counterweight system mounted at the back of the wheelchair for passive or active support of elbow flexion and extension while holding the elbow in a fixed position on the armrest of the wheelchair. The "upper-arm entity" consists of a motorized rail system that allows to actively move the elbow fixation between two functional positions: the "back" position in which the user controls the wheelchair and the "front" position to eat, drink, or use a smartphone or computer. The active support of both subsystems is triggered by push buttons selected and placed based on the user's residual capabilities.

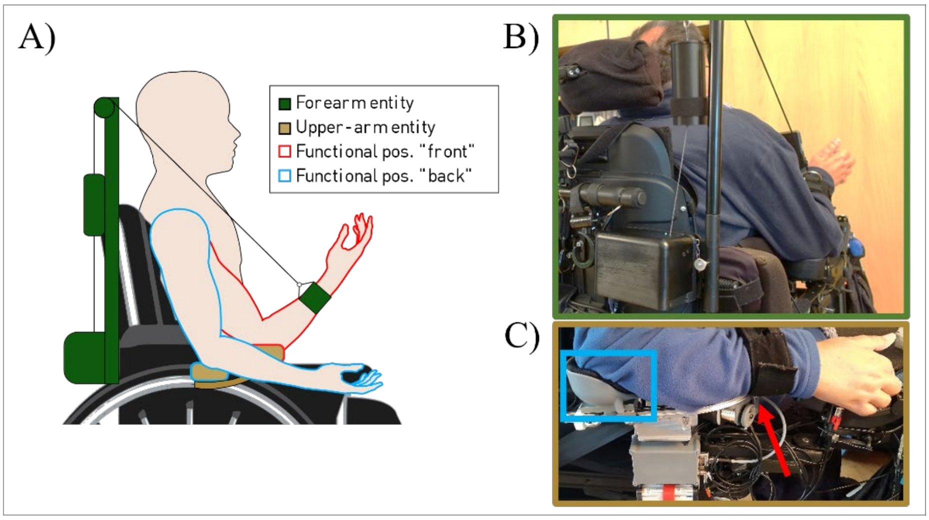

Fig. 1. Concept of the MiAMove. A) Schematic representation of the device including both subsystems, forearm entity (green) and upper-arm entity (brown) as well as two functional elbow positions, "front" (red) and "back" (blue). B) Photo of the forearm entity, C) Photo of the upper-arm entity with both functional elbow positions indicated.

The user was able to conduct all the previously mentioned daily life tasks in both functional positions independently, which was not possible without the device. The initial average rating of the "assistive device" part of the QUEST 2.0 after two days of use of the "forearm entity" was 4.2 (standard deviation (SD) = 0.75, min. 0, max. 5) but decreased to 3.6 (*SD=0.8*) after 1.5 years of daily use. The PIADS resulted in an average rating of 1.5 (*SD=1.28*, min. −3, max. +3) across all 26 items, with 17 items perceived as positively and no items negatively influenced by the device. The addition of the "upper arm entity" increased the average QUEST 2.0 score to 4.3 (*SD=0.78*) but decreased the PIADS to 0.85 (*SD=0.91*) after two months of daily use of the combined system. Measured over a period of three weeks, the user activated the MiAMove to switch between functional elbow positions on average 60 times per day, representing an estimated fourfold increase of the frequency of the same movement supported by an assisting person before having the MiAMove.

4 Discussion and Conclusion

We presented the MiAMove, a personalized dynamic arm support developed for the individual needs of a specific user with SMA. As opposed to commercial arm supports tested previously by the user, it enabled conducting various activities of daily living without restricting mobility. The device has been in everyday use for over two years. During this time, it has shown to be robust with only minimal maintenance required, and the user's satisfaction with the device was perceived as high. However, the observed decrease in satisfaction after multiple months of usage highlights the importance of assessing the user satisfaction not only at the time of the hand-over but also after the users had sufficient time to fully explore the functionalities and limitations of the system and integrate it into their daily life. The device has been shown to positively affect the independence, well-being, and quality of life of the user. Re-evaluating the device after the addition of a second subsystem did not show an equally positive effect, despite providing more functionality to the user. According to the user, a reason for that could be the progression of his disease, which brought forward additional limitations which were not tackled by the designed device. This work underlines the benefits of a user-centered design approach and long-term evaluations in terms of usability and, consequently, device adoption of assistive technologies such as dynamic arm supports, as well as the need for adaptability to the individual needs of different users with muscular weakness.

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AccessDesign

An Inclusive Co-Design Toolkit for the Creation of Accessible Digital Tools

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Abstract. Existing toolkits and resources to support co-design are not always accessible to designers and co-designers with disabilities. In this paper we present a study based on an innovative co-design programme, in collaboration with St John of God Community Services, where 3rd year computer science students work with service users with intellectual disabilities to create digital applications together. We conducted a series of co-design focus group sessions involving the service users who were previously involved in the co-design collaboration with SJOG Services and TU Dublin. The data collected during these design sessions has been integrated to form an accessible design toolkit through a series of iterative workshops. This toolkit is intended to generate a sustainable resource to be reused in the programme at TU Dublin but also in the wider community of inclusive design.

Keywords: Co-design, Inclusive Design, People with intellectual disabilities.

1 Introduction

Co-design is a methodology where the user participates in the process as an active co-designer [1]. The collaboration between the researcher and the co-designer goes further than the practice where the user is invited to participate in the processes of gathering and evaluating requirements, it is through this collaboration that they give value to the product or service by creating more meaningful experiences for the users [2]. The wide recognition of the role of co-design in improving the design of products has resulted in several studies investigating collaboration between researchers, stakeholders, and co-designers, primarily in medical and technology use.

Co-design is an important participatory approach to the field of Human Computer Interaction. However, to achieve genuine participation among all stakeholders may require time and resources that are not always available in industry and academic projects. Additionally, projects that claim user-centred and participatory approaches to technology design can become technology led rather than user driven [3]. Participatory design approaches are particularly important for the creation of inclusive technologies as a way for developers to understand the lived experiences of those that they are designing for.

TU Dublin and St John Of God Community Services run an innovative co-design programme where computer science students work with service users to create digital applications together [4,5]. This programme 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. Preparation, communication, empathy, respect, vision and realism have been identified as key components to successful co-design projects [4]. The collaboration has also highlighted a need for accessible design resources and training materials for both students and co-design participants.

2 Co-design Tools

2.1 Extracting Tools from State-of-the-Art Literature

A literature review was conducted to find tools to assist in the digital co-design workshop for people with intellectual disabilities. The literature review was carried out using the Elsevier database and Google Scholar. The keywords used in the search equation were classified into two categories: 1) Co-design and 2) Co-designers; the Co-design category was broken down into words such as co-design process, co-creation, co-creation process, participatory design and participatory research; while the Co-designers category was broken down into keywords such as co-creators, co-creators with intellectual disabilities, and co-designers with intellectual disabilities. The selection of articles began with the inspection of titles that could be related to the review topics, followed by the analysis of the abstract. Then, the articles that contributed to the knowledge of the research topic were chosen. The final review was completed with 16 scientific articles.

This phase identified tools such as semi structured interviews [6–10], surveys [6,10], cultural probes [9,11] personal diaries [11], participant observation [9], service mapping [12], ethnographic cases [7], workshops [7], focus groups [13,14], meetings [8,15], and emotional mapping [8].

While the above literature highlights useful research methodologies that have been applied to participatory design with people with intellectual disabilities, Colin Gibson et al., [16] acknowledges there is a lack of guidelines to support researchers in the co-design process. There are numerous guidelines and practical resources and toolkits in the fields of design thinking and user experience (UX) design that support co-design activities (IDEO https://www.ideou.com, D School; https://dschool.stanford.edu/resources, Service Design Tools https://servicedesigntools.org/). 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 co-design participants without training in the field of UX or interaction design.

2.2 Extracting Tools from Design and Tacit Knowledge

Based on the literature outlined above and our previous co-design work, a set of tools were created or adapted for the focus groups sessions keeping in mind the characteristics of our co-designers to be able to extract all their expertise and needs. For this adaptation, two overarching principles were implemented:

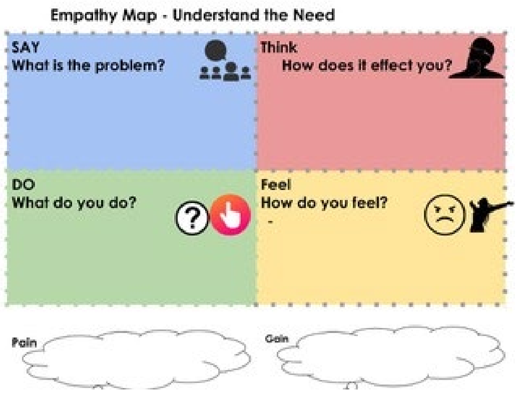

Fig. 112. Empathy Map

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).

"The Empathy Map" (Figure 1), adapted from the D-School toolkit, includes realistic pictures, simple text and a quadrant layout to make it more accessible for co-designers. "Managing expectations" (Figure 2), 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.

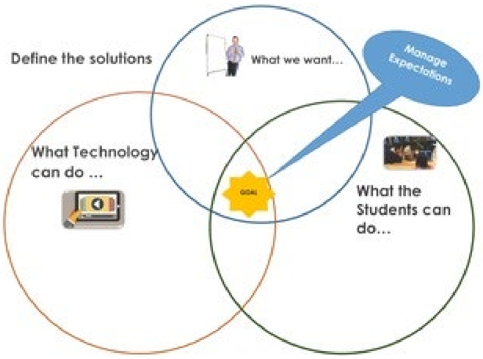

Fig. 2. Managing Expectations

Unrealistic expectations by the co-designers was highlighted as a specific issue by designers and lecturers during individual interviews in a previous study [17]. 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.

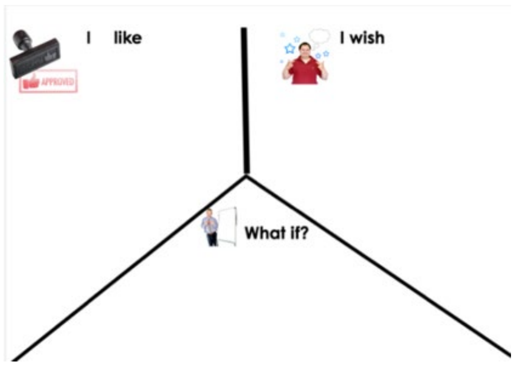

Fig. 3. I like, I wish, What if

"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.

3 Co-creating the Toolkit with Co-designers

Co-designers, are the experts of their own lived experience in co-design, and it is essential that their opinions are heavily weighed, as the connotations of co-design research directly impacts on them.

In order to ensure the active inclusion of the SJOG service users in the cocreation of the toolkit, five one-hour focus groups were organised in order to co-create the toolkit; one for every phase of design thinking (Empathise, Design, Ideate, Prototype, Test) as proposed in Hasso Plattner Institute of Design [18]. All focus group sessions had the same format, with some slight variations taking place between the sessions in terms of design process content. We focused design sessions on an online personal planning tool that all participants were familiar with and that required a redesign. Participants for the focus groups (n= 20) were recruited from St. John of God Liffey Services, and (n=5) students and lecturers who previously participated in co- design activities.

In the following sections we present the tools and methods that drove our design sessions, which were honed and iterated on based on feedback from co-design participants.

3.1 Accessible Ethical Procedures

One barrier to involving individuals with intellectual disabilities in co-design is the complexity of the consent process. Therefore, we highlight the importance of an accessible protocol to engage individuals with intellectual disabilities to focus groups, and the proposed protocol focuses on co-designing accessible technologies. In this study, participants with intellectual disabilities taking part in focus groups, self-recruited through a gatekeeper, after reading a modified (highly visual), easy to read (included images, colour formatted) information leaflet and consent form that the gatekeeper sent to them. There was a timeframe of a week allowed for an opportunity to reflect and ask questions before deciding if the individual wishes to participate. The consent letter also advised the participant to discuss their decision with their family members and support staff.

3.2 Engaging and Accessible Design Session Plans

During each focus group participants worked together on a design challenge using co-design tools to create a user interface design or give feedback on an existing design. Where SJOG participants were asked questions, they were minimally intrusive and straightforward, balanced questions around the co-design process, implementing question tools provided during the sessions to assist in answering. For each session, we created a set of slides and screens to share designs and structure each session. While we did not create a script for co-design facilitators to follow, we did open each sessions with introductions and a recap from any previous sessions. We also reiterated the meaning of co-design and highlighted some ground rules for the sessions. For example:

- “Everyone is equal”
- “There are no bad ideas!”
- “Feel free to speak and give your ideas.”
- “We value everyone’s contribution”

3.3 “Empathy Map”

Empathy maps were primarily used during the inception of the co-design process, to precisely target the problem faced by co-designers, for the designers to improve or build on. There is a tendency for co-designers to be unwilling to state flaws or issues, in part, to not dismay the interface designers. The empathy map assisted in addressing this core issue, by almost providing an allowance by the co-designers to directly state the problem they feel. At times, this tool was found to be slightly abstract by both computer science students and SJOG co-designers and special attention in explanation may be attributed to the “what do you do?” quadrant. Empathy maps were found to be useful for reflection on co-design sessions and as method to sum up feedback at the start of a new design session.

3.4 “I Like What If” and “Define the Solution”

During the co-design workshops, where initiating a response to a co-design question was challenging for some co-designers or putting forward their opinion was difficult, despite comprehension of the question. It was evident that the tools, such as the I Like What If (Fig X) and Define the Solution (Figure X), provided a framework to guide the answers of the co-designers with intellectual disabilities, whilst including their own thoughts and opinions. Furthermore, it provided a tool for the interface designers to accessibly engage with the co-designers, when they may have felt stuck or at an impasse during a design stage.

3.5 “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” (see Figure 4), 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.

Fig. 4. Guessing Game

3.6 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 [19], is an easy to use table of neutral- nonbiased questioning methods, see Table 1 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?"

Table 1. Neutral- nonbiased questioning methods

When this happens:	Try this:
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.
If you ask a question to the group and do not get any response	Rather than ignoring this or moving on, initially, try adjusting the question to make it more comprehensible (no response may mean little understanding or an unwillingness to provide a wrong answer). If there is still no response, then perhaps,try going around the table or virtual meeting by calling out names and asking people to contribute

4 Conclusion and Future Work

Despite the numerous successes of co-design, the tacit knowledge gained from real-life co-design experiences has not been formally recorded nor tested. The tools presented in this paper form a collection of methods that have been successfully applied and validated by co-designers with intellectual disabilities. This work will help future co-designers identify which tools are the most feasible to work within projects that seek to develop products or services for end-users with intellectual disabilities or other user groups with diverse capabilities and requirements. For example, we plan to apply these tools in the design of an assistive application for persons with mild dementia to enable them to manage activities of daily living in order to live independently at home. An accessible toolkit will allow persons with dementia to articulate their needs with respect to activities of daily living and to co-design and co-create assistive technology with software developers to help monitor and maintain these activities while living at home. As this toolkit evolves we would like to invite a wider cohort of participants to include people with sensory and physical disabilities, UX practitioners and accessibility experts to further develop and evaluate the materials.

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Escape Games

An Approach to Start Participative Technology Development

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Abstract. A core principle behind the participatory design is sharing of decision-making power between all participating parties. A prerequisite to claiming this decision-making power is a fundamental understanding of the resulting consequences. In the ladder of participation, the first step of participation is an informed decision. In participative technology development, making an informed decision requires a basic understanding of technology's opportunities and challenges. Escape games offer the possibility to convey this understanding interactively and playfully. In doing so, they create an opportunity to start a participatory process. This paper describes this possibility, and an escape game for the Smart Home domain is presented, developed for juveniles in institutional welfare settings.

Keywords: Participatory design · Juveniles · Escape game.

1 Introduction

The participatory design recognizes the importance of user input to create relevant solutions. This becomes visible when looking at the three guiding principles described by Bratteteig and colleagues [3]: having a say or sharing the decisionmaking power, mutual learning from each other, and co-realization of solutions.

While the point in which such participation starts is not clearly defined, e.g., Schuler and Namioka [12] are writing about a "critical role in designing", at least a minimum requirement can be formulated when looking at the ladder of participation first presented by Arnstein [1]. The ladder of participation attempts to categorize participation and, in particular, to make false participation visible [7]. Many authors have built their versions upon the ladder of participation like Hart [8] or Unger et al. [14]. These versions have in common that the lowest level of participation starts with the informed decision. Hart [8] describes the requirements to fulfill an informed decision as follows:

1. The children understand the intentions of the project;
2. They know who made the decisions concerning their involvement and why;
3. They have a meaningful role;
4. They volunteer for the project after the project was made clear to them.

For these requirements, the target audience must understand the problem space in which a participatory project is taking place to understand the intentions and assume a meaningful role. This can be pretty hard, depending on the domain and the target audience. Technology, for example, is part of most people's lives but is nevertheless a mystery box for many. This is aptly formulated by Clarke [4] in his quote: "Any sufficiently advanced technology is indistinguishable from magic". This magic-looking technology creates a barrier to participation.

This effect is even more pronounced when the target group is disadvantaged in using technology, as described by Bosse et al. [2] for juveniles in institutional welfare settings. This setting creates the need for primary technology education for all participants to create the basis for a participatory process. The question arises of how this introduction can be conducted.

Research Question: How can non-tech-savvy people experience technology to make informed decisions in a participative process?

A suitable solution for this technology education could be escape rooms or, in a less specific version, escape games, as they have worldwide inspired teachers to adapt them for entertaining education [11]. escape games are tasks (mostly riddles) designed playfully with the simple goal to solve or escape the room/game.

These tasks can be used to introduce people to technology piece by piece. An Example of such an escape game within an educational context is The Leblanc Process from Dietrich [5]. Figure 1 shows an example from this escape game that teaches chemistry. This paper views the current usage of escape games in technology education.

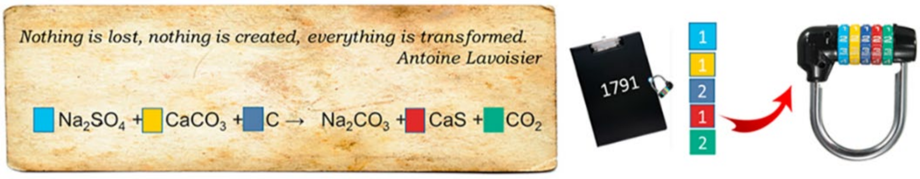

Fig. 1. Riddle Sheet from The Leblanc Process - An Educational escape game [5]

An escape game as an introduction to a participative technology development process for everyday life solutions is presented. This escape game focused on the Smart Home domain and targets juveniles in institutional welfare settings.

2 State of the Art

"Escape rooms are live-action team-based games where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal (usually escaping from the room) in a limited amount of time." [9]

It is vital to differentiate the terms to understand escape rooms or escape games. Nicholson [10], one of the most prominent authors about escape rooms, mentions escape rooms, which mean a whole room set as the riddling space. Other authors like Guigon et al. [6] use the broader term escape games, not limited to a specific room. Escape games can, for example, also be boxes that contain riddles, which would be a more versatile solution when a fixed room is not available. The term escape room will be used primarily as most literature uses it in this chapter.

However, in the following chapters, the term escape game will be used as it describes the implementation, which is not a room, more accurately.

The most common content in escape rooms, based on Nicholson [9], are:

1. Searching for physical objects
2. Team communication
3. Light
4. Counting
5. Substitution of Symbols, Ciphers, or something similar

Veldkamp et al. [13] have created a systematic review on escape rooms in the educational domain. The final data set consists of 39 studies that describe educational escape rooms in their review. These games are used for various tasks, including recruiting students, awareness for services, education in a specific domain, or improving soft skills.

Most of these escape rooms are a) escape rooms that teach a specific domain like the chemistry escape game shown in figure 1, or b) escape rooms that teach soft skills like leadership or teamwork. There is one key difference between these two types of escape rooms. games of the first type are mostly specially created for the given domain and can only be used there, while games of the second type a generic and can be easily reused. Therefore, understanding an escape room's fundamental goal is essential when designing it. For the case described in this paper, an escape game of the first kind is needed as it teaches a specific domain:

Smart Home. escape games of this kind with a non-tech-savvy audience in mind do not exist in the scientific literature.

Besides the escape room type, Veldkamp et al. [13] show that escape rooms have already been used for STEAM education and seem suitable for them. While most studies were very evaluated by observation and uncomplicated surveys, the vast majority of participants enjoyed the activity and were highly engaged.

Mainly this point lets the author assume that escape games could be a great solution to start participation.

3 Setting

As participation is greatly affected by the participating stakeholders, it is essential to describe the escape game's domain shortly.

In a participatory design research project, everyday-life task solutions are developed with juveniles with special needs. The focus lies in technology-based solutions. The first target for possible everyday-life solutions is within the borders of the institutional welfare settings. This means that the juveniles are living within the institution. To work flexibly with these institutions, it is required to use a mobile escape game instead of a whole room to educate technology. That is also why the term escape game is used as building a whole static room is not always feasible in participative projects.

The project stakeholders are primarily the juveniles and the social worker who support the juveniles.

4 Escape Games

To start a participative technology development process, first of all, a basic understanding is created through an escape game. The escape game shows users first-hand what the private Smart Home market currently offers, thereby creating a shared understanding of what is realistically possible. The goal is to get handson experience with the technology in simple games. The focus is not to get a deep understanding of the underlying hardware. It is more to get a broad understanding of the possibilities and how these possibilities feel.

The Smart Home escape game is presented in Figure 2 packed in a Case. This allows easy transportation to the designated institutions. The whole game is designed to be set up by social work professionals in the institutions and then used by juveniles in one session. During this session, the researchers are on-site or remotely connected for questions and troubleshooting. Besides that, the juveniles experience the technology by themselves at their speed. The escape game consists of various elements that can be found in Smart homes, like smart light bulbs, buttons, keypads, and various sensors. Most elements are off-the-shelf parts and can be directly used by the juveniles to think about possible everydaylife solutions. Besides the shelf parts, alternatives like 3D-printed parts and laser cutter elements are presented as an option for personalized things. In addition os, the core logic of the escape game is provided in a visual programming language. While the juveniles do not need to use or see this code, it allows them to show and explain it in the case of possible questions. This allows, therefore, to open the black box and see inside.

Besides the technology contained in the case, there are also detailed introductions for the social worker and tips for the juveniles in case a riddle is too hard.

An example riddle out of the escape game consists of a smart light bulb, a wirelessly connected switch, and a cryptic letter. The letter has a pattern, making reading the underlying message impossible. A participant can plug in the light bulb and use the switch to change its colors. With the right color, the text on the letter is readable. Afterward, the participant can, if wanted, play further with the light bulb in a digital interface. This lets a participant experience a) what current lightning and buttons off-the-shelf solutions can do and b) how things can interact with each other wirelessly. By introducing other elements like sensors or actuators and presenting the interchangeability of elements, the participants start to catch the endless combinations that are possible.

Fig. 2. Packed Smart Home escape game

5 Conclusion

Escape games are an already established solution to convey knowledge. They offer the extreme benefit of being very engaging, which creates an excellent start in a participative process. A great start is essential in an environment heavily influenced by the balance of power that exists within institutions of social work.

Escape games are also closely related to technology as many commercial solutions are already technology-based. This let escape games seem like an ideal way to give non-tech-savvy people a basic understanding of technology (in this case, Smart Home technology). They interactively introduce technology and create an environment that enables experimenting.

Nevertheless, it is also essential to understand the drawbacks of escape games, which are, first and foremost, a good deal of work in advance. It is also hard to estimate the correct level of difficulty beforehand.

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Co-design to Support Engagement in Activities of Daily Living and Meaningful Activities for People Living with Dementia

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Abstract. Dementia is a chronic and progressive neurodegenerative illness, which can lead to significant difficulties in a person's capacity to perform activities of daily living and engage in meaningful activities. The Smart Dementia Care project aims to establish an understanding of how best to design digital tools that persons with dementia and their carers will find useful and usable for care planning and goal setting. This paper discusses the first phase of this project and describes how co-design is being used to support engagement in activities of daily living and meaningful activities for people living with the early stages of dementia, with such engagement intended to extend the period of independent living for the person with dementia. It is anticipated that adopting a co-design approach and involving people living with dementia throughout the design cycle will allow for an application that is viewed as usable and intuitive while also acting as a tool of empowerment rather than a burden. At the same time, the intention is that integrating personalized goal-setting functionality focussing on individualized activities and everyday tasks will result in a system that is useful and effective.

Keywords: Dementia, Self-care, Activities of Daily Living, Meaningful Activities, Co-design, Goal-setting.

1 Introduction

Dementia is a chronic and progressive neurodegenerative illness. Dementia affects memory, behaviour, personality and functional and cognitive abilities, results in problems with communicating and reasoning and can lead to significant difficulties in terms of a person's capacity to perform activities of daily living (ADLs) [1, 2]. The estimated number of people globally living with dementia was 50 million in 2018, with this number set to grow to 82 million by 2030 and 152 million by 2050 [3]. Dependency levels can be considered an indication of both disease severity as well as quality of life (QoL) in persons living with dementia (PLWDs) [4]. Cognitive deterioration can impact instrumental activities of daily living (IADL) performance significantly, add to pre-existing functional limitations and contribute to depression due to restricted activity and social participation [5]. With this in mind, it is imperative that strategies are developed to address cognitive decline in order to anticipate and delay the onset of disability and maintain ADL ability among older adults [6]. Specifically, there is a need for an easy-to-use interactive visual care-planning system which reflects the needs and preferences of persons with dementia and allows for active self-management of the condition and shared decision-making with carers.

The Smart Dementia Care project[20] aims to develop a digital toolkit to support someone living with mild-to-moderate dementia, together with their informal carer(s), to self-manage their care, engage in shared decision-making, and to live independently for longer in their own homes. We intend to design a computational goal model of care qualities based on a review of the literature and existing frameworks (see [7]). This will be supplemented with co-design activities to confirm the model and better understand the needs and preferences of PLWDs in relation to their own care goals. The toolkit will allow for the planning and monitoring of personalised care goals, with targets derived from care plans, existing models of daily activities, as well as activities described as meaningful by the individual PLWDs and their carers. It will include a digital visual application for tasks such as setting up personal care plans and goals for daily living activities. The application will be developed using a co-design approach involving PLWDs, their informal carers and healthcare professionals, throughout the design cycle. This paper discusses the importance of participatory co-design when supporting PLWDs' engagement in individualized meaningful activities and ADLs.

2 Background

2.1 Health and Wellbeing

Living well with dementia and providing support around this have become key objectives of public health and research plans internationally [8] with the focus progressing from prolonging life to also enhancing QoL through delaying or preventing further disability [6]. The level of support and help PLWDs require from both family members and carers in general increases over time owing to the progressive nature of the disease, which in turn can result in increased levels of burden and stress among those with the primary responsibility of providing care. For this reason, there is a need for increasing support and assistance to be provided to both the care recipient and the person providing care to ensure adequate care is provided and QoL is maintained [9].

Quality of Life. Lawton's model of QoL (1991) has been highly influential in QoL and dementia research and has driven the approach to and development of QoL instruments [10]. This model suggests assessment should involve both subjective and objective factors and it identifies four main dimensions that contribute to QoL: psychological well-being, behavioural competence, objective environment and perceived QoL [11].

[20] https://www.smartdementiacare.ie

Psychological wellbeing is the subjective evaluation regarding the quality of inner experiences and, according to Lawton, should be viewed as the ultimate outcome of a QoL model [11, 12]. [13] point out that overlap exists with regard to essential features of good QoL as rated by both PLWDs and family carers: positive mood and engagement in pleasant activities.

Activities of Daily Living. Independent living tasks can be categorised into ADLs, which concern basic activities relating to personal care and hygiene, as well as IADLs, which are more complex and concern activities needed to function and reside independently in the community [14, 15]. Deficits in basic ADLs are seen to occur primarily once cognitive decline has progressed to the moderate stage, with declines in bathing, dressing, and grooming ability being particularly prevalent beyond this stage [16]. IADLs can be categorised as follows: transportation shopping, managing finances, meal preparation, housekeeping and home maintenance, managing communication, managing medications. In Europe, increased longevity has brought with it an increased prevalence of IADL limitations, which has negative implications in terms of burden placed on healthcare systems [17].

Meaningful Activities. Both PLWDs and their carers have reported that daytime activities, social contact, as well as issues relating to psychological distress comprise the areas of life which are most negatively affected by dementia. The diverse range of interests and abilities among PLWDs frequently results in a mismatch regarding services offering daytime and social activities, with PLWDs coming to view such activities as lacking in meaning and value [18]. To design programs which both satisfy psychosocial needs and improve QoL for PLWDs, it is therefore crucial to establish what their views and experiences are regarding meaningful activities [19]. The sense of meaning attached to these activities comes from feeling that things matter alongside a sense of pleasure, connection, participation or autonomy. These feelings are apparent and relevant regardless of cognition and dependency levels [20].

2.2 Technology Design for PLWDs

The Co-Design Approach. Co-design as an approach aims to move beyond participation by focussing more on co-production, equal collaboration, and joint decision-making. Co-design techniques in digital health which involve developing a granular understanding of how target end-users spend their day are associated with better adoption of end products across a variety of clinical domains [21]. An important element of co-design in this context is the development of a broad understanding of living with dementia through initial exploratory meetings and discussion with both PLWDs and carers. Holding such meetings in a focus group format with a semi-structured protocol allows for co-questioning and discussion to emerge, revealing insights which may go uncovered within a one-to-one, fixed protocol scenario [22, 9]. Following this, thematic analysis of the meetings can allow for designers to generate ideas around possible technological interventions, solutions or supports which could address issues that arose during the meetings. These ideas can then be brought back to the participants for analysis and feedback during workshops, with ideas viewed as most promising then being refined and further iterated upon [23].

While early stages are likely to feature paper prototypes, issues surrounding cognitive impairment and the need for creative input from the participants may call for functional prototypes to be introduced earlier than design cycles involving participants who are not cognitively impaired. Such an approach was taken by [22] whereby rapid development of functional prototypes was used to mitigate both the potential for memory loss between sessions and the limitations to using paper prototypes with PLWDs. In this case, the prototypes were then personally tailored to individual participants to further limit the need for abstract thinking. Following the development of prototypes, usability tests can be conducted to ensure the design is robust and usable and meets the initial user requirements as laid out in the exploratory meetings, with further iterative design cycles being held should issues continue to arise [24]. In order to address issues that may arise due to cognitive impairment when adopting a participatory approach, [22] suggest a number of strategies: incorporating review into meetings to ensure what was previously recorded is accurate, maintaining a consistent point of contact across meetings so as to reduce confusion, and using existing support groups where possible to allow for familiar environments and participants during meetings while creating opportunities for discussion.

3 Methods

Enabling PLWDs to remain at home for as long as possible while also maintaining a good quality of life is of paramount importance. At the same time, there is an urgent need to deliver more efficient, effective, person-centred care in the community. To achieve this, it is necessary to appreciate and address the needs and preferences of PLWDs in relation to their own care goals. As such, this phase of the Smart Dementia Care project involves requirements gathering and iterative design and testing with relevant end-users of the digital toolkit's visual application and those who care for them.

3.1 Requirements Gathering

Semi-structured interviews and focus groups are currently being conducted involving three groups (PLWDs, carers, and health professionals working in this area) to allow for in-depth exploration of needs and requirements. Interviews / focus groups will be specific to individual stakeholder groups, i.e. carers will not be present in healthcare professional focus groups and vice versa. However, persons with dementia can have their informal carers present during any activity if this is more comfortable for them. Topics explored will include what constitutes quality of life for the person with dementia, how to maintain quality of life over time, engagement with (I)ADLs, how engaging in these can contribute to and maintain quality of life and finally what represents meaningful activities. Related to this is the importance of identifying those activities that were valued and enjoyed before the dementia since these are likely to be considered intrinsically meaningful in terms of everyday life and past experience [25]. Interviews will also explore the goals of participants in relation to future health and wellbeing. Participants will be invited to discuss their experiences to date with technology in general, as well as possible technological solutions and supports for activities of daily living and meaningful activities. As recommended by [22], a consistent point of contact will be maintained from the outset so as to create a sense of familiarity and reduce confusion where possible. Following thematic analysis of the interview data, we aim to design and conduct a series of co-design workshops to interactively explore the themes arising from the interviews (and the literature). During the initial co-design sessions, each PLWD will be invited to expand further on activities they find enjoyable, pleasant, or meaningful. They will also be asked to think about activities they would like to continue engaging with in some form going forward. Insights gained from analysis of the initial interviews will also inform a prepared list of activities, which will be used to complement those activities previously elicited by the participants.

3.2 Co-design

Following each workshop, data from the session will be analysed and mock-ups generated based on feedback during the previous session, for presenting and further feedback at the next session. This iterative, user-centred co-design process will ensure the design of a digital application that is useful, meaningful, and usable to participants. Throughout the co-design sessions, methodologies such as personas, scenarios and storyboards will be used to explain technology and design concepts in lay terms to participants, while interactively exploring the themes arising from the interviews and the literature. The aim of incorporating such methodologies is also to clearly contextualise the discussion and illustrate the ways in which the designs could potentially fit into routines and relate to individual activities [9].

The same participants will be involved in the co-design workshops as took part in the interviews phase. Reviews will be incorporated into each meeting to confirm with participants what was previously discussed is accurate and reliable [22]. Each co-design workshop will have a maximum of 5 participants so as to enable each participant to have opportunities for discussion, i.e., 5 persons with dementia (and their carers as needed) or 5 carers. Efforts will be made to ensure both PLWDs and carers feel comfortable to express themselves openly and with adequate time, providing opportunities for separate sessions also should the need arise [22, 9, 24]. Healthcare professionals will also be engaged in some sessions, for example to validate features or content of the application from a clinical perspective. Once initial prototypes of the application have been developed, usability testing will be carried out with PLWDs and informal carers to ensure robustness and ease of use.

4 Discussion and Conclusion

For PLWDs, self-management involves coping with and adapting to the gradual changes to everyday life that are associated with dementia such to the extent that quality of life is maintained or even improved. Technologies designed for self-management in turn need to consider not only compensation for deficits, but also ways in which positive and meaningful experiences can be highlighted and encouraged [26]. With regard to technology development within dementia care, leisure and activity are now considered among the main areas of interest; this is based on the view that technology may be used beyond the narrow confines of medical care solely, with opportunities also existing to empower and support PLWDs to live a more meaningful life [27, 28]. Designs which focus on and encourage activation of existing capacities can allow for PLWDs to engage in both (I)ADLs and meaningful activities, which in turn should positively affect quality of life [20, 24].

In order for a design to be personally tailored to the individual, it is necessary that the needs and requirements are elicited from the end-user. However, this can become challenging when considering people living with dementia, who at times can struggle to articulate themselves clearly and concisely. As such, multiple stakeholders may be needed to participate in a co-design process to gain comprehensive insight into user needs [28]. For these reasons, the Smart Dementia Care project is adopting a collaborative approach, with end-users co-designing the application from the outset, as well as expert input being provided in the form of interviews and focus groups held with both carers and health professionals.

Following a diagnosis of dementia, it is likely that a person's interests and hobbies will remain as they were prior to diagnosis, highlighting the importance of identifying what these areas are and finding ways to enable the person to continue engaging in activities that align with these interests. It is also important to note that these interests do not necessarily need to be purely related to pleasure or entertainment, and value and meaning for an individual can be found in other areas such as self-management or household tasks and other areas related to IADLs [29]. Seen in this light, encouraging engagement in such activities considered meaningful to the PLWD serves the dual purpose of providing meaning, pleasure and a sense of normality while also supporting the individual's ability to maintain independence in those activities considered necessary for independent living. It has also been suggested that early behavioural interventions aimed at assisting individuals with mild levels of cognitive impairment and their carers to remain engaged in meaningful activities could potentially decelerate the rate of cognitive decline while also addressing changes in relationships and mood [30]. This phase of the Smart Dementia Care project aims to conduct user-centred research and design activities to support the development of a digital application for planning and monitoring personalised care goals for people with dementia, focussing on both activities of daily living and activities considered meaningful to the individual. It is anticipated that the proposed system, once designed to fully meet the user requirements determined during the co-design phase, will allow for quality of life to be maintained or improved, while also supporting the PLWD to live independently for longer in their home.

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ICT to Support Inclusive Education - Universal Learning Design (ULD)

Polygraf Online – Video-Conferencing System for Accessible Remote and Hybrid Teaching

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Abstract. In 2016, we presented the first version of a video-conferencing system for remote interpreting of sign language in higher education (CoUnSiL 1.0) [1] at the ICCHP conference in Linz. The system was capable of transmitting video and audio in very high quality (low latency, sustainable framerate etc.) among all participants, it enabled to transmit more than one video stream of a participant and provided discussion-moderating features. Compared to capabilities of mainstream video-conferencing systems of that time, CoUnSiL 1.0 allowed remote sign language interpreting in the conditions that were very close to interpreting *in situ*. However, there was a crucial shortcoming of the system – its setting up was extremely complicated and it had excessive requirements for network bandwidth and network configuration. That is why we started to rebuild the system completely and developed a new one. As it is a web application, no initial setup is needed. It does not require any extraordinary network configuration nor bandwidth and at the same time, all the features and the quality of video and audio retain on the level of the first version. Moreover, further enhancements and new features have been also implemented – mainly, the new system is able to transmit a real-time text transcription of speech (speech-to-text reporting service – captioning) in parallel to sign language interpreting. The feature has been implemented by combining it with our other system – Polygraf [2]. This has given the video-conferencing system a new name: Polygraf Online [3].

Keywords: video-conferencing, remote sign language interpreting, remote real-time speech-to-text, remote captioning.

1 State-of-the-art of Mainstream Video-Conferencing Systems

Facing the extremely increasing demands for remote services in the last two years, all the mainstream video-conferencing systems (Google Meet, MS Teams, Zoom etc.) have made great strides in their development and enhancement in many aspects. That also includes accessibility, i.e. accessibility of their user interface as well as features allowing more accessible communication among participants. However, the mainstream systems are still lacking several features that:

- would meet complex requirements of remote and hybrid forms of teaching, and
- would make the communication among teachers and students adequately accessible via sign language and speech-to-text service.

Examples of the most important capabilities that are usually missing in the common systems:

- **video**:
  - one participant cannot share more than one screen/document at the same time;
  - one participant cannot transmit more than one video of his/her video devices
- access to speech via **speech-to-text reporting (captioning)**:
  - most of the systems (Google Meet, MS Teams) do not support input of captions from a human transcriber (they are utilizing automatic speech-to-text engines only);
  - most of the systems allow to display the transcription as subtitles only (not as unbroken and fluent text)
- **user interface** of a running meeting:
  - arranging other participants' windows on a user's desktop is limited

2 Polygraf Online – Overview

While designing the new version of our video-conferencing system, we considered all the common shortcomings mentioned above, with special focus on the features that improve accessibility of communication among participants via sign language and speech-to-text service. Development of Polygraf Online resulted in a system with features and capabilities as follows:

2.1 Video

1. Sign language interpreter's video is transmitted with higher framerate (min. 30 fps) by default to increase readability of sign language on users' side.
2. One participant can share up to three videos (screens, documents, 2nd camera etc.) at the same time. It is suitable mainly for teachers who need to broadcast e.g. two cameras, presentation slides, interactive whiteboard - especially in a hybrid form of teaching.
3. More than one participant can share their screens simultaneously (e.g. a teacher is sharing his/her presentation slides and a student is sharing his/her work document).
4. Video window of the participant who has been given the floor, is automatically enlarged (beneficial especially for signing participants).

2.2 Speech-to-text Reporting (Captioning)

1. Input of the speech-to-text transcription comes from the Polygraf Writer application [2], i.e. it is made manually by a transcriber.

2. Within the UI, speech-to-text transcription is displayed in a window of adjustable size which can display multiple lines of the text, i.e. not just as subtitles.
3. More than one speech-to-text reporting can run in parallel within a single video-conference.

2.3 User Interface

1. It is an easy-to-start web application with responsive user interface.
2. A user may arrange all the windows within a video-conference as he/she prefers, with the option to save the layout or use it as a default one.
3. Each window (including chat and speech-to-text transcription) may be popped out from the main UI to a separate window (to display sign language interpreter or speech-to-text transcription centrally on a projection screen, for instance).

3 Future Outlook

Although the implementation of the new user interface has increased user experience, several parts of the system are still to be improved, mainly:

- management of users and meeting rooms has to be enhanced in order to allow better structuring of users and rooms and improve security; it will also enable to prepare the meeting rooms by users themselves, independently on system administrators;
- the Polygraf Writer application is used by transcribers to feed the Polygraf Online system with real-time speech-to-text transcription – user interface of the application has to be improved in regards of establishing connection to the Polygraf Online meeting rooms.

As said above, in the last development we have combined our two systems that were independent before. However, we are going to interconnect them even more, for instance the current Polygraf mobile apps will be upgraded to provide the service on mobile devices and remotely (mainly remote provision of speech-to-text reporting service).

4 URL of the System

The online system is available for public at: **https://online.polygraf.app**.

5 Appendix – Screenshots of the User Interface

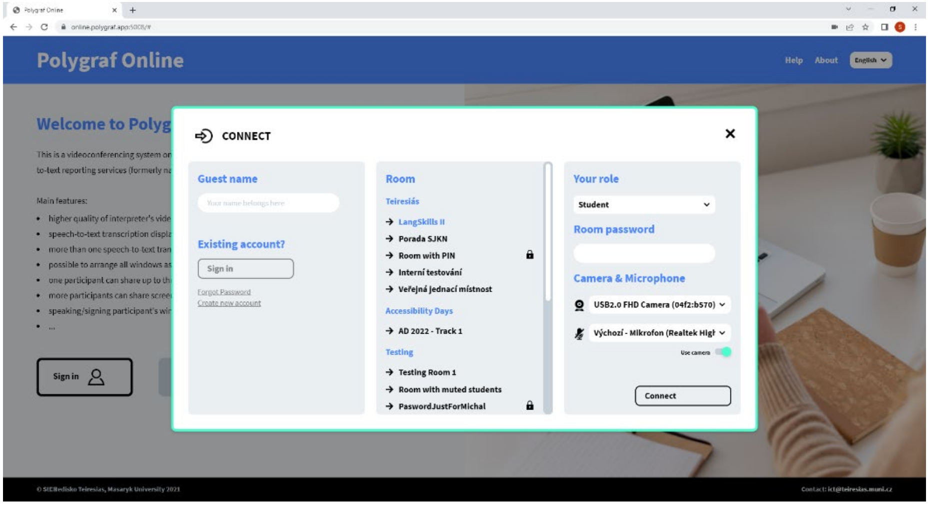

Fig. 1. Homepage of the Polygraf Online – a dialog box for joining a room

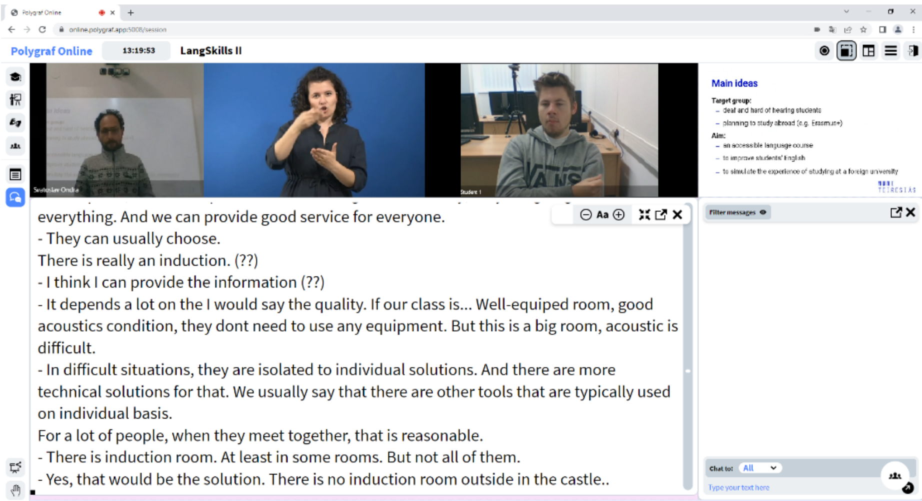

Fig. 2. User interface of the active meeting (presenter, sign language interpreter, a participant, speech-to-text transcript, chat).

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Comprehensive Training to Implement Inclusive Distance Education for Students with Visual, Hearing, and Motor Disabilities in North African Universities

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Abstract. In the framework of the EU funded Erasmus+ project InSIDE, whose goal is to build capacity to deliver inclusive Distance Education (DE) in universities of the Maghreb region, a comprehensive training for teachers and university staff have been carried out. The aim of these training is to prepare the participating universities to enable the social inclusion in the delivered DE and to setup an accessibility unit for providing support services to students with visual, hearing, and motor disabilities at their institutions.

Keywords: Digital Accessibility, Distance education, eLearning, Tertiary education.

1 Intro

InSIDE (Including Students with Impairments in Distance Education) [1] is a Capacity Building in Higher Education (Erasmus+) project that aims at developing accessible, inclusive, and educationally effective Distance Education (DE) programs for individuals with Visual, Hearing and Mobility (ViHeMo) impairments through a user-centered design. DE programs will be structured on three axes: a) educational material, b) DE delivery system, and c) educational effectiveness / pedagogical approaches. Eleven universities from Maghreb – four from Morocco, four from Algeria, and three from Tunisia – are trained by the University of Macedonia (UOM), Greece, National and Kapodistrian University of Athens (UOA), Greece, and Johannes Kepler University (JKU), Austria, so that they are able to implement the DE programs at hand [2]. These programs will deliver critical competencies for vocational rehabilitation. They will provide opportunities for lifelong learning, skills enhancement, and personal fulfillment with the ultimate aim of suggesting an intelligent solution against the problems of limited access or the high percentage of dropouts in Higher Education in individuals with impairments.

Therefore, the aim of this training is to prepare the participating universities to enable social inclusion in the delivered DE and to set up an accessibility unit for providing support services to students with (ViHeMo) disabilities at their institutions.

2 Project Activity Plan

The original plan for this training comprised:

- Each of the eleven universities from the Maghreb appoints two accessibility advisors and six representatives to be trained.
- The training is provided by accessibility experts and staff from support services for students with disabilities from the participating European universities.
- The main goal is to teach not only guidelines, procedures, and usage of tools and Assistive Technology (AT) but also to perform proposed practical tasks and activities in order to build expertise among trainees so that they will be able to adapt known and tested systems to their local context by effectively implementing the lessons learned.
- The training is structured in three training sessions of four days each. Each sessions are led respectively by UOM, UOA, and JKU. The contents covered in each session are:

1. Development and use of adapted educational material:
   - 1.1. Creation of tactile pictures, braille emposement, and verbal descriptions.
   - 1.2. Accessible video and creation of audio-tactile pictures.
   - 1.3. Accessible e-books and PDFs and their creation.
   - 1.4. Accessible mathematical and chemical representations and accessible presentations.
2. Teaching using the Learning Management System (LMS) adapted to the project:
   - 2.1. Introduction to Moodle, installation, languages, user roles, and course creation.
   - 2.2. Moodle maintenance, accessibility, and test, assignment, and quiz creation.
   - 2.3. Production of accessible educational video.
   - 2.4. Production of accessible educational textbooks, Word, PDF, and PowerPoints, and accessible math and music notation.
3. Delivery of Distance Education (DE) programs for students with impairments:
   - 3.1. Assessment of students, local context, and cooperation with third parties.
   - 3.2. Preparation of the student support infrastructure, university, and students.
   - 3.3. Issues with the learning material when supporting students and exam adaptation.
   - 3.4. Sustainability of the student support service, problem-solving and development of training about inclusion and accessibility for teachers and students.

3 Needed Adaptations and Alternative Solutions: from Drawback to New Chances

Although it was tried to stick as much as possible to the original plan, the final development of the training differed notably. By January 2022, when the training was expected to happen on site in Austria, COVID-19 protection rules that constrained the freedom of people traveling from abroad and limitations to social gatherings were set. Postponing the activity was not a reliable option. These circumstances made it impossible to give an in-person training at JKU Linz. Therefore, the consortium was forced to switch to a distance training mode.

This change might be assessed as a negative impact issue, as it is a risk for the project and involves additional work. However, it offered a good opportunity for both trainers and trainees to have a first-hand experience in what they intended to implement: distance higher education. The complexity of the topics required to frame the training sessions in a highly interactive way, allowing trainers to adapt their teaching pace to the remote trainees.

First, the scheduled activities were changed in three key points:

- Shorter inputs. This allowed additional time for questions and answers and provided frequent contextual information to minimize trainees' disorientation and loss of teaching pace.
- Activities, such as homework, after each training day were planned.
- Fully interactive recapitulation training sessions, in which trainees showed their results of the activities from the previous day and received feedback from peers and trainers, were implemented.

Second, in order to minimize the downsides of the distance training mode and to increase trainees' involvement, the following measures were set to make the communication as much effective as possible:

- Use of email addresses with low response time for technical and organizational support.
- Before each training day, the training program and instructions on how to access the virtual room were sent out in time.
- Communication means like chat and email, with trainers were always available.
- After the training day, a summary with recommended activities, a list of links to discussed resources, and training material used during the day was provided.
- Live transcription in all the interactive training sessions was implemented.

Third, while teaching the highly complex key topic of the delivery of DE programs for students with disabilities, training sessions were introduced called "Excursion" that allowed social and professional exchange while encouraging reflection and idea generation for implementing those programs in the trainees' universities. Those excursions gave an insider's view on how the accessibility industry, public projects and institutions devoted to social inclusion work. Some of them were:

- Insight into works and procedures of association BookAccess that adapts school-books to visually disabled students in Austria.
- Presentation with a demonstration of work done by the GESTU project for supporting deaf and hard-of-hearing students at all universities in Vienna and surrounding, besed at Vienna University of Technology (TU Wien).
- Presentation of the Buddy project and how it works to match cognitive disabled people with the right assistive technology.
- Presentation of the SIDPT project and how trainees can benefit from the training materials for the publication industry it offers for born-accessible digital document production.

4 Evaluation and First Results

When the training was concluded, participants were invited to fill in a quality assurance questionnaire set by the project's quality assurance plan annonymously. The questionnaire is divided into seven sections assessing different training aspects. The first six sections contain 5-point Likert scale questions and one open question to enable the discovery of new findings while participants express their own opinion. 50 members from the eleven universities in the Maghreb region participated actively in training, and 48 answered the questionnaire. Following is a summary of the main results:

1. Training goals:
   - Did you achieve all the learning goals?
     positive or very positive: 91%
   - To what degree were your training expectations met?
     high or highest: 72%
   - As a whole, how do you rate the learning experience?
     high or highest: 80%
   - To what extent have your skills improved?
     high or highest: 48%, neutral: 43%.
2. Before the training
   - To what extent did you know the objectives of the training?
     high or highest: 65%, neutral: 24%
   - How well were you informed about the training before taking it?
     good or very good: 43%, neutral: 57%.
3. Training content
   - What was the overall quality of the content?
     high or highest: 89%
   - Does the structure of the training logical and easy to follow?
     positive or very positive: 46%, neutral: 54%
   - The content was in-depth enough.
     agree or completely agree: 80%
   - The difficulty was appropriate?
     agree or completely agree: 48%, neutral: 52%
   - To what extent was understandable the material?

high or highest: 65%, neutral: 26%

- To what extent the content was concise and not repeated?
  high or highest: 59%, neutral: 24%, low or lowest: 17%
- The provided material was accessible to you?
  agree or completely agree: 52%, neutral:28%, disagree or completely disagree: 20%
- Does the amount of assignments was appropriate?
  agree or completely agree: 48%, neutral: 41%.
- The duration of the training was enough to achieve the training goals.
  agree or completely agree: 57%, neutral: 33%
- The provided material helped you to achieve the training goals.
  agree or completely agree: 59%, neutral: 28%
- The provided material helped you to improve your skills.
  agree or completely agree: 59%, neutral: 24%, disagree or completely disagree:17%.

4. Trainers
   - What is the overall rate that you give to the trainers?
     high or highest: 91%
   - What was the expertise of the trainers?
     good or very good: 91%
   - How was the communication with the trainers?
     good or very good: 91%
   - Did you feel comfortable when asked or expressed your opinion?
     positive or very positive: 89%
   - Were your questions solved effectively?
     positive or very positive: 57%.
5. Venue
   - The infrastructure to provide the training was generally a good environment(s) for learning.
     agree or completely agree: 67%, neutral: 20%
   - All needed teaching material was always available.
     agree or completely agree: 59%, neutral: 24%, disagree or completely disagree: 17%
   - The accessibility was taken into account.
     70% agree or completely agree: 70%, neutral: 22%
   - The access to the training was easy.
     85% agree or completely agree: 85%.
6. After the training
   - Have you received enough further guidance information?
     positive or very positive: 91%
   - Do you have enough knowledge to perform the tasks you were taught?
     positive or very positive: 54%, neutral: 37%
   - Do you feel qualified to perform the tasks you were taught?
     positive or very positive: 48%, neutral: 41%.

The answers point to a general reasonable satisfaction being the median and the mode of the answers is always on the positive side.

On the plus side, trainers received the highest scores among other assessed topics. Other aspects that receive an over-average grade are the access to the training, the guidance information provided for the after-the-training activities, and the quality of the material provided during the training.

On the side of things to be reviewed, it has been identified a number of different issues. Participants felt that:

- they were not well informed about the training beforehand,
- the structure of the training was not as logical and easy to follow as they expected,
- the material provided was not accessible to them as expected,
- they were not very confident in performing themselves what they were taught.

In the 7th section of open questions: On the plus side, the most exciting topics for the audience were the practices on accessible educational material creation, AT tools, and the organizational aspects of the disabled student support office. On the minus side, they expressed the need for more practice and face-to-face training. Some of them suggest reordering the lessons placing some of part 2 at the beginning of the training. Additionally, some expressed that lessons that tackle the accessible educational material creation could be reduced because they saw there some content overlapping and this time could be filled with practices.

The main lessons to be applied in the future training are:

- The information about the training has to be available with more time in advance to participants.
- Better coordination and agreement among trainers on the schedule and topics treated.
- Make available training material before the training sessions to allow trainees to be ready.
- Increase the focus on practical activities.

5 Next Steps

After having performed a later training of two days focused on revisiting, practicing, and solving questions on the topics covered, the next step planned in the project is providing additional training in the settings of each of the eleven universities. This focuses on practical activities to reinforce the lessons taught and to increase the self-assurance of trainees while using the ATs and the learning management system provided by the project. Once this training is completed, it will be time for each participating university to design and deliver training to their fellow teachers, technical staff members, and students with disabilities on their premises.

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Accessibility Standards and Laws

Implementation for Successful Digital Education within the Eurozone

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Abstract. The United Nations Convention on the Rights of Persons with Disabilities defines the right to equal opportunities for all citizens. Article 21 of the convention details how the accessibility of information and communications should be ensured in practice. As a result of the convention, international, European and national policies, standards and law have been established, creating a legal and binding framework for compliance. This paper considers the current standardisation for digital accessibility and laws of the European Union member states, in particular Ireland, France and Spain in relation to compliance for digital educational practices. In view of the IMPACT (Inclusive Method based on the Perception of Accessibility and Compliance Testing) project, the paper will assess the level of compliance with digital accessibility standards at regional level within the aforementioned Eurozone Member States. The authors will address the current accessibility requirements and outline support and training strategies to support professional digital content creators and educators in conformance with existing guidelines and requirements.

Keywords: Accessibility, Legislation, Standards, eLearning, HCI.

1 Accessibility in the Eurozone for Digital Education

In March 2021 the European Commission (EC) presented a ten-year strategy for the rights of people with disabilities. Commission President Von der Leyen (European Commission, 2020) stated that “Persons with disabilities have the right to have good conditions in the workplace, to live independently to equal opportunities, to participate fully in the life of their community. All have a right to a life without barriers. And it is our obligation, as a community, to ensure their full participation in society, on an equal basis with others."

Approximately 80 million people or 1-in-6 people living and working in the European Union have some form of disability. In 2019 the EU Commission estimated that approximately 120 million persons in the EU would have multiple or minor disabilities by 2020. While there has been no further statistical information regarding disabled citizens from EU sources, in recent times (2021) the World Health Organization estimated that 135 million people in the region live with a disability.

The EU aims to make products and services more accessible while respecting the principle of equal treatment. The strategy sets out three key initiatives around three main themes: EU rights, independent living with autonomy and non-discrimination and equal opportunities, moving toward a solid legal framework comprising the European Accessibility Act and the Web Accessibility Directive. The aim is to ensure that EU citizens can participate in society on an equal basis in both physical and virtual environments. This need has become even more highlighted during the recent Covid-19 pandemic and has become particularly apparent in the digital education space as students and educators were forced into online learning environments. While this was in some respects beneficial to some in terms of accessibility, it also highlighted areas of weakness within web-based educational accessibility [1].

1.1 Accessibility for Digital Education

While the EU's aim for improved the rights for disabled citizens is a positive move, compliance disparity between regions in relation to enforcement and monitoring of EU standards must be removed.

The key to the successful implementation of the strategy lies an acceptance of the strategy framework across the European zone. Training and dissemination of information to stakeholders, in particular system developers, educators and service providers, is essential for a coherent strategy, especially in terms of learning content and universal design implementation in digital educational settings. Standards set out at European level act as an umbrella over all European regions, however, different regions, for example Ireland, France and Spain have different national legislative processes, regulations and laws in place to address accessibility issues. On this basis, the authors consider the regional implementation strategies of eurozone members and highlight the goals of the IMPACT (Inclusive Method based on the Perception of Accessibility and Compliance Testing) project which aims to define the skills and competencies that ICT accessibility educators and mediators should hold for compliance.

2 The European Standard for Digital Accessibility and Regional Strategies

Article 9 of the United Nations Convention on the Rights of Persons with Disabilities defines the right to equal opportunities for all citizens. Furthermore, Article 21 of that same convention details how the accessibility of information and communications should be ensured in practice. In consideration of compliance the European Union member states ratified this convention in 2010, building a solid legislative framework for improving accessibility for people with disabilities and creating a barrier-free Europe. Different initiatives were brought together to guarantee the full participation and improvement of the rights of people with disabilities. The Digital Agenda for Europe (2010-2014)[21]and the European Disability Strategy (2010-2020)[22] formed the basis for introducing general political strategies, incorporating specific actions to guarantee access to ICT for people with disabilities and implementing policies for disabled access.

The Web Accessibility Directive (2016)[23], the updated Audio-visual Communication Services Directive (2018) and the European Accessibility Act (2019) are the main directives that were developed at legislative level to regulate accessibility in the European Union.

The enforcement of global and European standard implementation can be lacking by regional Governments can be inadequate through the issue of unmonitored compliance guidelines [3]. Member State must adapt their laws and standards to meet this legislative framework to ensure barrier-free access to media and digital content for all European citizens.

2.1 Accessibility Legislation in The Republic of Ireland

In 1996, a milestone Irish report entitled “A Strategy for Equality”[24] was issued by the Commission on the Status of People with Disabilities[25]. The landmark document outlined three key principles that were to be adopted by the Commission including; Equality, Maximising Participation and Enabling Independence and Choice. The report led to the establishment of legislation in the guise of the 2005 Disability Act[26] which aimed to obligate government departments to facilitate the inclusion of people with disabilities. The Act was given legal effect through in 2000 by the Government of Ireland policy on disabilities. Further legislation enacted to protect equal rights focuses on employment through the Employment Equality Acts [27]1998–2015 and the provision of

[21] European Commission (EC): *Digital Single Market*: updated audiovisual rules. (2018). Retrieved from: http://europa.eu/rapid/press-release_MEMO-18-4093_en.htm)

[22] European Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe. Retrieved from: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM%3A2010%3A0636%3AFIN%3Aen%3APDF

[23] Web Accessibility Directive, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32016L2102

[24] Strategy for Equality, National Disability Authority of Ireland, https://nda.ie/nda-files/a-strategy-for-equality.pdf

[25] Strategy for Equality, Commission report, Ireland https://nda.ie/nda-files/strategy-for-equality-overview-and-commissions-recommendations11.pdf

[26] Disability Act 2005, Ireland, https://www.irishstatutebook.ie/eli/2005/act/14/enacted/en/html

[27] Employment Equality Act, Ireland, https://www.irishstatutebook.ie/eli/1998/act/21/enacted/en/html?q=Employment+Equality+Act

goods and services through the Equal Status Acts of 2000 – 2018 consolidated[28] as supported by the Irish Human Rights and Equality Commission which provides guidance on compliance. The National Disability Strategy[29] (2004) aims to secure the inclusion of all people in society through the support of current policy and legislation. The aim is to enforce the promotion of equality and inclusion of people with disabilities. The focus of the strategy surrounds the areas of disability legislation, Statutory Sectoral Plans on disability for a number of Government departments, and a multi-annual investment programme to focus on disability services in the areas of employment, environment and disability services, social welfare, transport and communications.

Giving effect to the Web Accessibility Directive (EU "Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016), the European Union (Accessibility of Websites and Mobile Applications of Public Sector Bodies) Regulations 2020 came into force in Ireland in September 2020. The Statutory Instrument obligates all Irish public bodies to ensure that their websites and mobile applications are equally accessible to all people, including persons with disabilities. The 2020 Regulations build on existing obligations to make websites and services offered to the public under the Disability Act 2005 and the Code of Practice on Accessibility of Public Services and Information provided by Public Bodies[30].

Consequently, and as part of the National Disability Strategy, the Centre for Excellence in Universal Design (CEUD)[31] was established by the National Disability Authority (NDA)[32] in January 2007 under the Disability Act 2005. CEUD is dedicated to enabling the design of environments that can be accessed, understood and used regardless of a person's age, size, ability or disability. The contribution to the development and promotion of standards in Universal Design, the Centre Participate in and contribute to relevant standardisation work, with national, European and international standards bodies and Encourage compliance with national and international standards in Universal Design being the main agenda. CEUD has a responsibility within the educational spectrum to support and promote the introduction and integration of the principles of Universal Design in educational courses and examinations.

2.2 Accessibility Legislation in France

In France the Disability Act, "law for equal rights and opportunities, participation and citizenship of disabled people" is in place since 2005. Article 47[33] of the Act targeted the public sector and imposed a reference-based system in line with the international WCAG 2 standards. Article 47 of the 2005 Disability Act has been updated to uphold

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[28] Equal Status Act, Ireland, https://www.irishstatutebook.ie/eli/2000/act/8/enacted/en/html

[29] National Disability Strategy of Ireland, https://www.justice.ie/en/JELR/NDA%20-%20POLICY%20-%202.Pdf/Files/NDA%20-%20POLICY%20-%202.Pdf

[30] https://nda.ie/Good-practice/Codes-of-Practice/Code-of-Practice-on-Accessibility-of-Public-Services-and-Information-Provided-by-Public-Bodies-/

[31] The Centre for Excellence in Universal Design, Ireland, https://universaldesign.ie/About-Us/

[32] The National Disability Authority Ireland, https://www.nda.ie

[33] Article 47 2005 Disability Act, France, https://www.legifrance.gouv.fr/loda/article_lc/LEGIARTI000037388867/2020-09-15

the enforcement of the European Web Accessibility Directive and, to consider European requirements.

The French legislator went beyond the European obligation to extend the scope of application to private companies with a turnover of more than 250 million euros.

The French RGAA (Référentiel général d'amélioration de l'accessibilité) has also evolved from version 3 to version 4. However, this change was made in the direction of a minimal transposition of European requirements, which meant a regression in the level of requirements, with the removal of criteria that were legally exempted based on Article 3 of Decree 2019-768 of July 24, 2019[34]. It should be noted that this implementing decree does not allow for the full entry into force of the provisions of the law, which in theory provides for administrative sanctions to be set by decree. Article 6 III of the decree provides "The declaration is communicated to the administration through a teleservice in accordance with the terms and conditions determined jointly by the minister responsible for persons with disabilities and the minister responsible for digital." However, the decree setting the terms of the teleservice has never been issued.

Furthermore, the European Commission indicates on one of its websites the list of Member States' bodies in charge of monitoring the Web Accessibility Directive[35]. For France, the 2 bodies mentioned are: 1. The Directorate General for Social Cohesion (DGCS) for monitoring and reporting, 2. The Defender of Rights for the enforcement.

However, each Member State had to submit a report to the European Commission on the implementation of the Web Accessibility Directive by December 23, 2021[36]. All Member States have done so, except for 3 countries, including France, which had not yet published its report by April 20, 2022. The reason for this is the lack of resources in the administrations in charge of monitoring the subject, as reported by the press (Yanous, 01/10/2021- Article in French [37]).

Finally, in addition to the law and the decree, let us note a French particularity in the transposition of the European Directive, with the decree of September 20, 2019 on the general referential of accessibility improvement (RGAA) and which constitutes an adaptation of the European standard EN301549 on the Web part. This RGAA was published in its version 4.1 on February 18, 2021 and benefits from a long tradition of transposition of international WCAG rules since 2003 in France, with at the time an associative reference framework carried by the BrailleNet association and which was called AccessiWeb, with a community of auditors trained in this reference framework, and which became since 2015 the RGAA from its version 3.

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[34] Article 3 of Decree 2019-768 https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000038811937/

[35] Web Accessibility Directive Monitoring https://digital-strategy.ec.europa.eu/en/policies/web-accessibility-monitoring

[36] Web Accessibility Directive Monitoring Reports https://digital-strategy.ec.europa.eu/en/library/web-accessibility-directive-monitoring-reports

[37] À la recherche de l'accessibilité perdue
https://www.yanous.com/pratique/informatique/pointsdevue211001.html

2.3 Accessibility Legislation in Spain

In Spain, the first national legislation related to ICT accessibility were Law 34/2002[38] on Information Society Services and Electronic Commerce, and Law 51/2003[39] on Equality of Opportunities, Non-Discrimination and Universal Accessibility for Persons with Disabilities. Both laws transposed several European directives and made the accessibility of public administration websites mandatory at the three levels: state, regional, and local. None of the laws, contained any specific details about web-accessibility requirements. To this aim the Spanish standards organization, AENOR, developed the Spanish web accessibility standard UNE 139803:2004[40], which defined the level of accessibility that public sector organizations must conform. This standard was substituted for UNE 139803:2012[41], which updated the requirements of the previous standard from WCAG1.0 to WCAG2.0. UNE 139803 was also referenced in the new Royal Decree 1494/2007[42], which established the basic accessibility requirements for ICT accessibility.

A major milestone in accessibility-related legislation in Spain was the adoption of the United Nations Convention on the Rights of Persons with Disabilities in 2008. This fact conformed an extensive set of responsibilities that the Spanish public administration had to implement in the coming years. The current accessibility-related legislation in Spain is the Royal Decree 1112/2018[43], which encompassed the previous legislation, and is the transposition of the Directive (EU) 2016/2102 at a national level. It covers the accessibility of all websites and applications for mobile devices. In terms of compliance, it is recommended to follow the latest version of standard UNE-EN 301549: 2022[44], which establishes the functional requirements to ensure that ICT products and services are accessible to all people. This standard includes the latest version of the harmonized European standard EN301 549, which incorporates WCAG 2.1.

The goal is to provide a single shared standard for the accessibility of web content that ensures access to content for all citizens. Still, the real implementation of these policies has been quite limited. As highlighted by the Spanish Accessibility observatory report (2021)[45], awareness has grown substantially, and all stakeholders are now familiar with accessibility. Even so, more training for the proper implementation of accessible ICT products and services is still much needed.

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[38] Law 34/2002 (https://www.boe.es/buscar/act.php?id=BOE-A-2002-13758)

[39] Law 51/2003 (https://www.boe.es/buscar/act.php?id=BOE-A-2003-22066)

[40] UNE 139803:2004 (https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma?c=N0032576)

[41] UNE 139803:2012 (https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma/?c=norma-une-139803-2012-n0049614)

[42] Royal Decree 1494/2007 (https://www.boe.es/buscar/doc.php?id=BOE-A-2007-19968)

[43] Royal Decree 1112/2018 (https://www.boe.es/diario_boe/txt.php?id=BOE-A-2018-12699)

[44] UNE-EN 301549: 2022 (https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma/?c=N0068037)

[45] Observatorio de Accesibilidad (2021) Informe sobre el resultado del seguimiento (https://www.tuwebaccesible.es/wp-content/uploads/2021/12/informe-resultado-seguimiento.pdf)

3 Educating for Compliance and Sustainability

As highlighted in the previous section, most countries have already transposed the accessibility-related European legislation. Yet, even if legislation makes accessibility mandatory, it is not enough. Accessibility policies should make sure all professionals are trained in why accessibility is important, and how to provide solutions. This is the only way of ensuring that accessibility caters for the needs of all people not just because it is mandatory but because it is a human right. In this regard, on many occasions, a web developer enables a web page to make it compatible with screen readers, without having received training on how users who use this service navigate the Internet. On the other hand, the growing convergence towards the web of the audiovisual content of the media, results in a growing demand for professionals with training in digital accessibility. In this sense, the IMPACT project aims to train the figure of the educator/mediator in digital accessibility to be able to advise and guide the different agents involved in the development, design, content creation, and procurement of online digital systems, services and products.

4 The IMPACT Project

The European IMPACT project aims to define the skills and competencies that an educator or mediator in ICT accessibility should acquire and master for the correct implementation of the harmonised European accessibility standard digital EN 301 549. The recent adoption and entry into force of the Directive on Web Accessibility have highlighted the scarce training in digital accessibility outside of the technological field [5], resulting in the development of this initiative for the training of new professionals. As the requirement of digital accessibility increases, the importance of quality and the need for training professionals in this field should be highlighted.

In the field of accessibility there is currently a lack of professional training from a universal design and user-centric perspective. On many occasions, the emphasis in digital and media digital accessibility training is placed on technical aspects essential to reach the end-user [4,6] without considering fundamental competencies, such as: understanding accessibility, needs and preferences of the different users, service competence to be able to mediate and deliver accessibility properly, or promoting promotion to be able to raise awareness and involve stakeholders. As highlighted by Oncins et al. [5] most digital accessibility training is included in academic IT studies related to the development of technological systems, services and products. Aiming to comply with standards without providing a deep understanding of the users' needs [5]. In this sense, the IMPACT project (2019 - 2022) aims to train the educator/mediator in digital accessibility to facilitate the provision of advice and guidance to the different agents involved in the design of digital systems, services and products.

4.1 ECQA Certification

European Certification and Qualification Association (ECQA), an IMPACT project partner, provides a solution to the need for new and emerging professions and job roles, where no or only very heterogeneous training is available. Accessibility professionals, for example, usually do not have a diploma or any official recognition, however, through the ECQA, these professionals can obtain international, European certificates confirming their expertise in universal design. The ECQA currently facilitate accessibility certifications within international and EU funded projects. Certificates for professionals, jointly developed by industry, academia and the ECQA, are issued by ECQA GmbH. Currently, the ECQA Certificates, certified training programs highlight three main topics including accessibility, innovation and sustainability.

5 Conclusions

The right to equal opportunities for all citizens in terms of Article 21 of United Nations Convention of Human Rights details how the accessibility of information and communications should be ensured in practice. The concept of accessibility has seen a shift towards a universal concept instead of the exclusive one, which is user-centred and proactive [2]. This shift is supported through International, European and national policies, standards and law established to create a legal and binding framework for compliance. This paper has considered the current standardisation for digital accessibility and laws of different European Union member states, in particular Ireland, France and Spain in relation to EU standard compliance for digital educational practices. In view of the IMPACT (Inclusive Method based on the Perception of Accessibility and Compliance Testing) project, the paper outlines compliance strategies with digital accessibility standards at both regional level within the Eurozone. The authors outline support and training strategies to support digital content creators and educators in conformance with existing guidelines and requirements.

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Universal Design of Inquiry-Based Mathematics Education in Universities

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Abstract. This article context is the teaching and learning of mathematics at university level. The article's author was a member of the team working on the international PLATINUM that aimed to improve learning and teaching of mathematics at universities. The project partners are aware of the fact that the learning of mathematics at universities is very often procedural and students only learn to reproduce mathematical procedures in line with tests and examinations. The project partners aimed to change this trend by designing and implementing inquiry-based activities in order to create the conditions for a deeper conceptual understanding of mathematics for their students so they should have stronger analytical and problem-solving skills. They payed attention to difficulties students with identified needs may encounter in the different phases of an inquiry process. In this article, we offer two examples of teaching units to introduce readers with Universal Design recommendations we designed with respect to students with identified needs so they can actively participate in mathematics courses full of inquiry-based activities.

Keywords: universal design, inquiry-based education, mathematics, university

1 Introduction

The international project PLATINUM[46] was funded by the EU Erasmus+ programme (September 2018 to December 2021). Partners of the project, mathematics lecturers, educators and researchers coming from eight European universities, sought to innovate in their practice as they are aware of the following fact: "Considerable evidence shows that the learning of mathematics widely is highly procedural and not well adapted to using and applying mathematics in science and engineering and the wider world; also, that students learn to reproduce mathematical procedures in line with tests and examinations, rather than developing a relational, applicable, creative view of mathematics that they can use more widely." [1, p. 8] The aim of the project partners was to verify whether an **inquiry-based** approach to teaching and learning will help to change this trend for university students of mathematics.

[46] PLATINUM—Partnership for Learning and Teaching in University Mathematics

The developmental outcomes of the project are presented in the book *Inquiry in University Mathematics Teaching and Learning. The Platinum Project* [1]. As students with identified (or special) needs were one of the three core topics of the project (besides pedagogy and didactics and ICT: new technologies and digital competences), the project partners paid attention to difficulties these students may encounter in the different phases of an inquiry process. “During the first year of the project, they were asked to describe the communication between teachers, students with identified needs and offices for their support in the partners’ universities” [1, p. 50]. They confirmed the information on such students is usually offered at the beginning of the semester, but they develop their courses much earlier. They concluded they should take the needs of their students into account when designing the very processes of learning, assessment and organisation, and not make adjustments on demand with the intention to fit into existing approaches to learning and teaching because the course’s design has already been finalised.

The previous ideas require a tool to design courses well in advance with respect to all the different needs of future students. **Universal Design** is an option suitable for this purpose and the project partners were introduced to this methodological framework. Later on, they tried to develop their courses and inquiry-based teaching units with regard to Universal Design recommendations proposed by the author of this article. This approach is based on the **Social model of disability**, in which school authorities take responsibility and remove barriers to education in order to ensure an inclusive learning environment for as many students as possible.

2 The State of the Art in this Area

Much work has been done recently in the field of inquiry-based mathematics and science education, but mostly at primary and secondary school levels. Let’s name few of European research projects addressing this topic:

- The Fibonacci Project (http://www.fibonacci-project.eu, 2010–2013) contributed to the dissemination of inquiry-based science and mathematics education throughout the European Union. 25 partners from 21 European countries under the supervision of a scientific committee collaborate to transfer inquiry-based methodology to primary and secondary schools in Europe;
- the PRIMAS Project (https://primas-project.eu, 2010–2013) was realised by a consortium of 14 universities from 12 European countries that aimed to promote activities and materials supporting teachers to implement and use inquiry-based learning approaches in their classrooms;
- the PROFILES project (http://www.profiles-project.eu/}, 2010–2014) was focused on inquiry-based approach in science education through raising the self-efficacy of teachers from 20 European countries who worked together in order to implement existing, exemplary context-led teaching materials enhanced by teacher relevant, training and intervention programmes.
- the MaSciL Project (https://mascil-project.ph-freiburg.de, 2012–2016) aimed to make science and mathematics more meaningful to students or primary and

secondary schools. 18 partners from 13 European countries researched how to innovate a teaching culture to include real-life contents from the world of work.

The PLATINUM project is unique as it deals with inquiry-based mathematics education at universities, i.e. in a very different learning environment compared to primary and secondary schools. Lectures with hundreds of students with diverse backgrounds, loaded curricula to be covered in a short period of time, and lack of pedagogical experience—these are the main obstacles for university mathematics teachers to start with inquiry-based approach.

Regarding the universal design of inquiry-oriented mathematics instruction (IBME), we (the project partners) drew on the work of Ronald L. Mace (North Carolina State University). His research group introduced the Universal Design principles in 1985 as a "design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [2]. Later on, **Universal Design for Learning** (UDL) was developed at the Center for Applied Special Technology led by Anne Meyer and David Rose. This framework is closely related to education and aims to improve and optimize teaching and learning for all people.[47] **Accessibility of digital content** is under the care of the World Wide Web Consortium (W3C), international community leading the development of standards on this field. We took all these sources of information into account when designing mathematics courses and its inquiry-based teaching units with respect to students with identified needs.

3 The Methodology Used

When developing Universal Design recommendations for IBME we first needed to understand what pedagogical processes are present during inquiry-based instruction. "Inquiry is about asking questions and seeking answers, recognising problems and seeking solutions, exploring and investigating to find out more about what we do that can help us do it better" [3, p. 396]. During inquiry-based activities, students interact in small groups or together with teachers, examine textbooks and other sources of information to see what is already known, use tools to gather, analyse, and interpret data, make observations, propose explanations and predictions and communicate results of their work [4]. We identified these processes chronologically by breaking down an inquiry activity into some typical sub-activities (see the Figure 1).

Inquiry in university mathematics can be organised at a large hall, a small classroom, a computer or another lab. Students can use computers or manipulate physical instruments. Very often it starts with a *teacher's presentation* of the problem. He/she can also prepare written instructions or *information resources* students are supposed to work with during inquiry. Students usually *collaborate in teams*, they may prepare long-term projects. Very often they are supposed to *use specialized applications* to gather, analyse and interpret data. They *discuss* their findings, observations, they share their thoughts or questions with other students or teachers. Finally they may be asked to *present their results* with others.

[47] https://udlguidelines.cast.org/

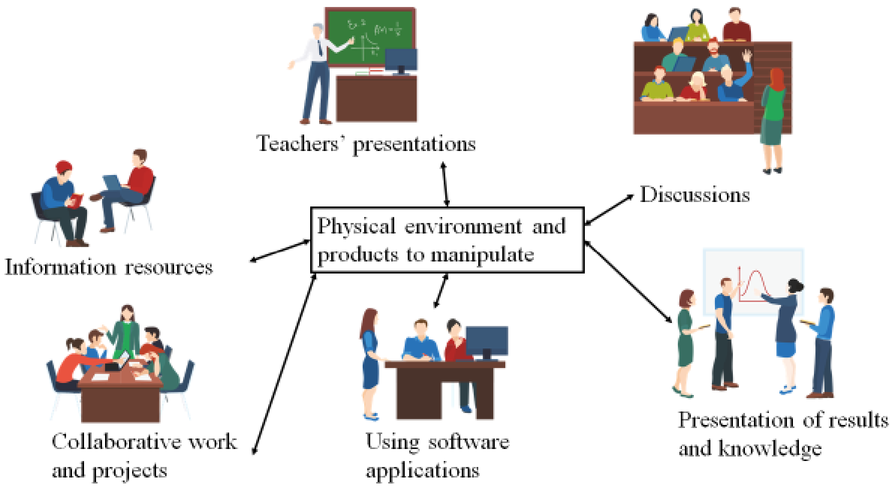

Fig. 1. Pedagogical processes that are present during inquiry-based instruction (Abstract vector created by macrovector_official, http://www.freepik.com)

4 The R&D Work and Results

After dividing IBME into the sub-activities, we

- tried to capture differences of students with identified needs when they undertake any of the previous processes and
- prepared a set of recommendations suitable for teachers who plan to establish an inclusive learning environment during IBME.

We tried to project general principles of Universal Design, Universal Design for Learning and W3C Accessibility Standards[48] onto the inquiry-based education of mathematics at universities. We selected/interpreted the most important ideas of these frameworks and offer them in the form of recommendations relevant to each pedagogical process mentioned above.

In this article, we do not offer a detailed list of the recommendations as it can be found in the book *Inquiry in University Mathematics Teaching and Learning. The Platinum Project* [1] and its Chapter 4. Instead, we demonstrate benefits of the recommendations' implementation on two examples of inquiry-based tasks designed by PLATINUM project partners.

48 https://www.w3.org/WAI/standards-guidelines/

4.1 Example 1: Universal Design of the task on Complex Numbers

We start with an example given by a colleague from Loughborough University, one of the Platinum project partners. She teaches students of Foundation programme which should prepare them to enter the degree on engineering or science. Many of them are with identified needs. On Figures 2 and 3 there is a task involving inquiry on addition of complex numbers. Students work in pairs in a computer lab with the software called Autograph[49] for helping them to explore complex number arithmetic in a geometric perspective and connect geometric insights with algebraic manipulation. There are two screen shots of the Autograph file (see the Figure 2) and then structured instructions the colleague prepared for her students (see the Figure 3).

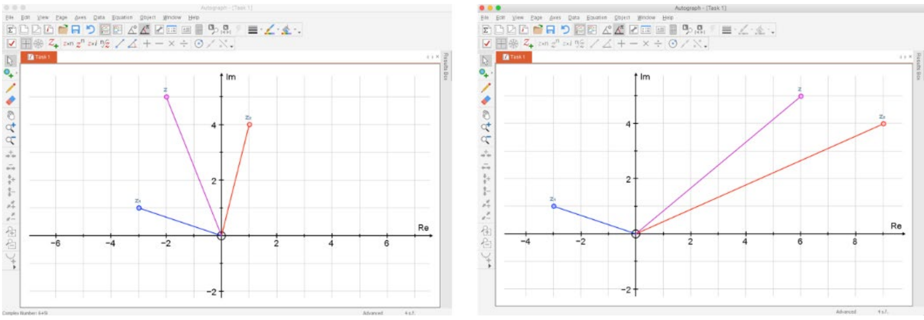

Fig. 2. Two screen shots of the Autograph file with graphical representation of the three complex numbers z_1, z_2 and z given in the Task 1 (the image on the left) and the change of their position if z_2 is moved (the image on the right).

Task 1: There are three complex numbers labelled z_1, z_2 and z ; z_1 is to be kept fixed while z_2 and z can be moved. Select z_2 and move it until z reaches the position $6+5j$.

1. What complex number is z_2 ? Right click and “Unhide All” to check your answer. The correct answer appears in green.
2. What is the relationship between z_1, z_2 and z ?
3. Now calculate by hand: With $z_1 = -3 + j$ and $z = 6 + 5j$, find z_2 such that $z_1 + z_2 = z$.
4. Re-load Task 1. Move z_2 around the screen and notice how z changes as a consequence. What is the geometric connection between z_2, z and the complex number z_1 (which has stayed the same during your movements)?

[49] https://completemaths.com.autograph

5. Now you are allowed to move both z_1 and z_2. Move these to different locations but make sure that z still ends up being $6+5j$. Make note of the positions of z_1, z_2. Does your geometric connect from 4. still hold?
6. Repeat another four times so that you have five different pairs of values for z_1 and z_2 with each of them making z to be at $6+5j$. For all of these, what is the relationship between z_1, z_2 and z and does your geometric relationship still hold for each of them?

Figure 3. Instructions for the original Task 1 in the complex number arithmetic teaching unit, used in the Loughborough Foundation programme [1, p. 110].

The feedback from her students was that the instructions are very detailed and too wordy. Students with dyslexia noticed they lost the track during reading instructions.

4. She reduced the instructions. But still the tasks remain the same, only their presentation is different.
5. She added approximate times for the whole task and for particular subtasks. This was helpful for students with autism spectrum disorder who need to know some boundaries to the time they spend on tasks.
6. She added colors which was useful for students with dyslexia. All the three complex numbers are coloured differently (z_1 in blue, z_2 in red, and z in pink) and this may help to distinguish them more easily (see the Figure 4).

<u>Task 1:</u> (Total time 15–20 mins.)
Open the Autograph file *Task 1*.

There are three complex numbers labelled z_1, z_2 and z; z_1 is to be kept fixed while z_2 and z can be moved. Select z_2 and move it until z reaches the position $6+5j$.

7. What complex number is z_2?
   Right click and "Unhide All" to check your answer. (2–3 mins.)
8. What is the geometrical relationship between z_1, z_2 and z? (2–3 mins.)
9. Now calculate by hand: With $z_1 = -3 + j$ and $z = 6 + 5j$, find z_2 such that $z_1 + z_2 = z$. (2–3 mins.)
10. Re-load *Task 1*. Move z_2 around the screen and notice how z changes. Describe the position of z in relation to z_1 and z_2. (5 mins.)
11. Explore this relationship. Move z_1 and z_2 to different locations but make sure that z still ends up being $6+5j$. Does what you thought in 4. still hold? (5 mins.)

Fig. 4. Modified instructions in the Task 1 about addition of complex numbers, after application of some Universal Design recommendations [1, p. 121].

She helped students to organise their inquiry more easily as she structured the whole task into small subtasks. She enhanced the visual readibility of the instructions (modifications 1, 3), and indicated a time schedule of inquiry (modification 2). These improvements are in line with the Universal design recommendations for Information resources and their preparation [1, p. 63], and useful for all the students not only those who display differences in reading skills, time management, concentration, planning activities, etc.

Using the specialised software Autograph during the inquiry on complex numbers addition is a fundamental part of the students' work. It is therefore helpful to optimise access to this application. We recommend letting the students know in advance about any specialised software they are supposed to work actively during instruction. Sharing suitable support materials to students can save their time during the inquiry as they can familiarise themselves with the interface of the software in advance. If students with visual impairment or physical disabilities are supposed to work actively with such a tool as Autograph, they may need an advice on how to use the software effectively. As some subtasks require students to move graphical objects and change their position in the Autograph workspace, those users who access applications only with keyboard and use key strokes for any mouse action may encounter barriers when trying to use the tool without previous preparation. In such a case a teacher should consult accessibility of applications with experts in assistive technology in order to find the best option for these students [1, p. 64–65].

All these recommendations are based on Universal Design principles but are not sufficient enough for blind students. As the goal of the inquiry is to explore complex number arithmetic in a geometric perspective, students who cannot use their sight are not able to follow visual display of complex numbers in Autograph, manipulate their position and compare arithmetic and graphical representation of these mathematical objects. An individual adjustment is needed in such a case. Teachers should therefore know how to get in touch with institutions responsible for these adjustments and collaborate with experts to deliver them in time and properly [1, p. 67].

4.2 Example 2: Universal Design of the task on Function properties

The second example is related to the course *Mathematical Analysis 1* offered to students at the Faculty of Education, Masaryk University (Brno), who prepare themselves for the career of mathematics teachers in secondary schools. Usually few of them are with identified needs. Students are introduced with the course topics during lectures on a more theoretical level (2 hours per week). Seminars are more practical as their tutors discuss the course key terms with the students and guide them during practical solution of examples (2 hours per week).[50]

The seminar tutors designed a short inquiry-based activity (see below *The task instructions*) intended to encourage the students to

- "recall the concept of limit and continuity of a real function, and
- get back to their own resources and read through the notes they made about the topic during the previous lecture" [1, p. 243].

[50] See details in the case study published at [1, p. 242–247].

The task instructions: Make groups of 2–4 people. One specifies limit conditions or requirements on continuity of an unknown function. The others try to find an example of the function which meets the requirements. You can change the roles then.

Examples of requirements:

1. Find the function $f(x)$ such that $\lim_{x\to 3} f(x) = 5$.
2. Find the function $f(x)$ such that $\lim_{x\to 3} f(x) = 5$, but $f(x)$ is not continuous for $x = 3$.
3. Find the function $f(x)$ such that $\lim_{x\to\infty} f(x) = 0$ (see the graph of the function $f(x) = \arctan x - \frac{\pi}{2}$ corresponding to this condition on the Figure 5).

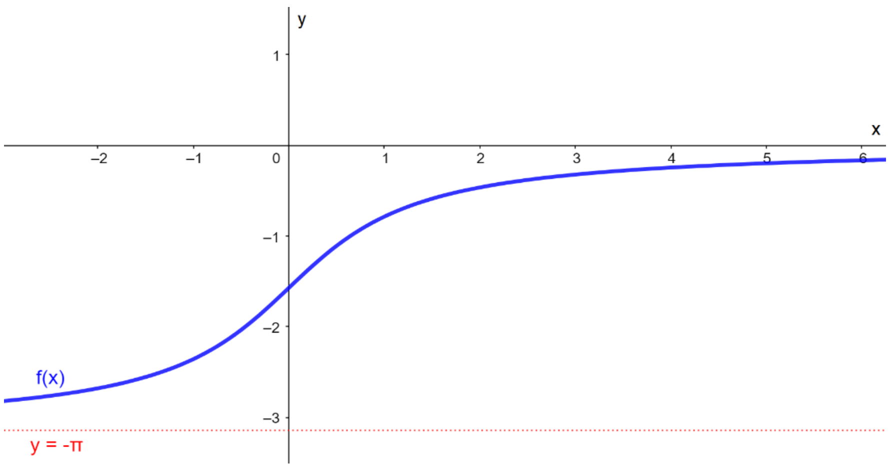

Fig. 5. Graph of the function $f(x) = \arctan x - \frac{\pi}{2}$ such that $\lim_{x\to\infty} f(x) = 0$.

After the first implementation of the activity during the seminar, tutors came with few remarks and proposals of improvement.

- "All students made groups and started actively working on the task" [1, p. 243] as tutors enabled flexible groupings with no fixed requirement on the number of persons per teams and designed the activity as a game in which one "plays" against others trying to come with conditions not easy to satisfy.
- The goal of the activity was not clearly defined. Some students took the examples of requirements listed in the instructions and used them during the activity. That was not the intention of the activity's designers, they gave these examples only for inspiration, not for use.
- The time reserved for team working was not specified, the topic of the following discussion was communicated only verbally and not very precisely, only in a way: "let us know your impression of the activity". As a result, students were not well

prepared to contribute to the discussion and came with general comments, in most cases not very valuable.

- Some groups worked slower, therefore not all their members made it to “play” against others. The tutors realised that they should have encouraged their students more strongly to use applications for plotting graphs of functions, which would have saved time in verifying whether their proposal was correct or not.

The designer of the activity reflected on the feedback and re-designed the instructions:

1. He added approximate time for the whole activity.
2. He defined expectations for the group work more clearly. He added the statement asking students to create their own limit or continuity conditions and not use these ones listed in the examples of requirements. He added a note to the instructions in which he recommended to use applications for plotting graphs of functions.
3. In order to prepare the students for the following discussion, he closed the instructions adding one more task: to select, present and comment the most interesting example the group dealt with. It was up to all the teams whether they describe the selected example verbally in front of others or write it on the sheet of paper and share it with the tutor.

All these improvements are based on Universal Design principles. In this case, respecting recommendations for collaborative work in teams (see [1, p. 63–64]) and discussions (see [1, p. 66]) helps the students, but also the tutors who can better realise their ideas about the students’ work corresponding to the objectives with which they designed learning activities.

The seminar is held in a classroom not equipped with computers. As some planned learning activities require use of computer-based devices, tutors ask students to bring their laptops, tablets or at least mobile phones to seminar sessions on a regular basis. As for the previous Example 1 on visual manipulation with complex numbers in Autograph, the students should familiarise themselves in advance with the interface of the software for plotting graphs of functions (Wolfram Alpha, Geogebra, etc.). Again, according to Universal design principles, tutors should let the students know about suitable support materials and consult with experts in assistive technology to determine which of these tools is appropriate for users with visual impairment or physical disability [1, p. 64–65].

5 The Scientific and Practical Impact or Contributions to the Field

The main objective of the PLATINUM project is to innovate university mathematics education. We established an international group and local communities of mathematics teachers, educators, and researchers who use an inquiry-based approach to create the conditions for a deeper conceptual understanding of mathematics for their students so they should have stronger analytical and problem-solving skills. Designing inquiry-based teaching units, implementing them during instruction, and evaluating their effectivity needs a closer collaboration of all the members of such communities. It is not only the students who do inquiry, but also their teachers and educators who analyse the IBME data, make observations and reflections and help improve the design of inquiry-based activities. This developmental research approach and three-layer model (students, teachers, educators/researchers) was adopted by the PLATINUM partners within their local communities and helps to facilitate the design and implementation of IBME.

By applying Universal Design principles we hope for creating an inclusive inquiry-based learning environment that reaches the needs of as many students as possible.

6 Conclusion

In this article, we try to describe results of the European project called PLATINUM. We introduce readers with Universal Design recommendations we designed with respect to students with identified needs so they can actively participate in mathematics courses full of inquiry-based activities. Collaboration on the design and implementation of these recommendations can be based on principles of developmental research and three-layer model described in [1], [3] or [4]. "While students undertake inquiry-based instruction, teachers inquire how to implement some of the Universal Design ideas into their lectures and seminars. Such development is continuous and clearly needs the feedback not only from students but also from experts on inclusive education in order to evaluate the effectiveness of implemented recommendations and plan other modifications of the course" [1].

As the project is unique and no one before us dealt with inquiry-based mathematics education at university level and within such a broad international group, a change in improving teaching mathematics in tertiary level can be a long and slow 'journey'. We hope that the PLATINUM project and its results will contribute to the above mentioned goals.

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Co-designing an Accessible Digital Skills Education Solution with and for People with Intellectual Disabilities

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Abstract. Digital literacy is required to harness the increased opportunities online for supporting health, accessing health professionals, and connecting with services and maintaining connections with family and friends. People with Intellectual Disabilities (ID) experience much poorer education, health and wellbeing outcomes, exacerbated through their digital exclusion especially during Covid. Digi-ID PLUS is a multidisciplinary pan-European collaborative partnership with people with accessibility needs, disability service user organizations and advocacy groups, education, engineering, health academics and practitioners that addresses the challenge of digital inclusion and digital literacy among people with ID. DigiAcademy is an accessible digital skills e-learning platform co-innovated and co-designed, within the Digi-ID PLUS study, with and for people with accessibility needs to address this digital literacy and access challenge to ensure better health, well-being and inclusion outcomes. We have developed and applied a user-centered de-sign process which is inclusive and iterative and involves the users in all the different phases of the project. In this paper we present our inclusive co-creation process with adults with ID and original findings from our focus group and user testing sessions.

Keywords: accessibility, digital inclusion, eLearning, user centered design, intellectual disability, health, social inclusion.

1 Aim

Digital literacy is required to harness the increased opportunities online for supporting health, accessing health professionals, and connecting with services and maintaining connections with family and friends [1]. People with Intellectual Disabilities (ID) experience much poorer education, health and wellbeing outcomes, exacerbated through their digital exclusion especially during Covid. They also have high levels of communication difficulties, with one in three reporting difficulty talking to healthcare professionals. A recent international review of people with ID's digital access experience during Covid demonstrates a lack of prior support and training for both people with ID, support and health care staff, was both a barrier and a challenge to pivot to support online meetings and loss of autonomy and an increased reliance on support for many blocked digital opportunities. [2, 3]. Digi-ID PLUS is a multidisciplinary pan-European collaborative partnership that addresses the challenge of digital inclusion and digital literacy among adults with ID.

A recent international review [2] confirms vital need for accessible digital skills training with a worrying trend noted in the review in [4] was how few had accessed COVID-19 information from the internet and social media (only 4% living in service homes and 12% living in family care).

The project developed a co-innovated accessible digital skills education platform: DigiAcademy, designed with and for people with accessibility needs, starting with those with ID, to address this digital literacy and access challenge to ensure better health, well-being and inclusion outcomes. At the heart of our project is a user centered and led design process. Embedded within the team is our Citizen Advisory Panel (CAP), seven individuals with ID, hired as paid experts supporting the project based in lead Partner country Ireland and intentionally established to bring together diverse voices with diverse age, gender and digital competency. Their voices, insights and experiences are heard and included in every critical decision of our project.

In this paper we present our inclusive co-creation process with approx. 300 adults with ID. We also present original findings from our user testing sessions to demonstrate the iterative design process we adopted and how user feedback was implemented to create new design and assistive features.

2 Method

We have adopted a user-centered design methodology and iterative co-creation and co-design process to inform, to shape and to determine the solution: DigiAcademy.

User-centered design may be defined as "an iterative process whose goal is the development of usable systems, […] achieved through involvement of potential users of a system in system design." [5]. As demonstrated in the research [6,7] and validated with our research, the User-centered design is an iterative co-design process that focuses on the whole user experience and user needs to enable an optimal result. The User-Centered design permits to the full team to focus on the specific needs of the requirements in a coordinated manner, always thinking about the satisfaction of the end users. User involvement is essential, and users are involved when they are informed, actively engaged, their views are considered, and exchange of knowledge and experience takes place between users and providers. [8,9]

The first co-creation phase was the content development and app design. This phase involved focus group and consultations for app development and the co-creation of our education content and technology development. Focus groups with people with ID have been used to gather data for content co-creation of the educational programme. Groups of approximately 6-8 individuals have been facilitated online and in person and the discussion was focused on health and social needs, how technology is currently used to support this, and what helps/hinders use of technology.

The second phase was the Citizen review and testing. This phase has engaged a group of people with ID, who were not engaged in requirement gathering focus groups, to be programme testers. This group has engaged in prototype testing and evaluation to refine and quality assure programme content. User testing was focused on asking about the user's experience accessing and using the accessible digital skills education programme. A one-to-one user testing interview will follow best practice guidelines on solution design accessibility [10, 11] and in accordance with Web Content Accessibility Guidelines (WCAG) 2.1. We ran 15 rounds of user testing, both online and in person, to include the user testing feedback to shape various iterations of the protype making modifications and adjustments to ensure the final protype incorporates all user testing feedback. User testing sessions have entailed observation of the tester using the programme by the researchers (i.e. exploring the site, experience of user interface, going through the education programme) and eliciting feedback from the user using a semi-structured format guided by the interview schedule.

The Digi-ID PLUS study has received full ethical approval from Trinity College Dublin's Faculty of Health Sciences Ethics Committee and from all the collaborators services Ethics committee. All study information intended for prospective participants with an ID are written in an accessible Easy to Read format, containing visual images to enhance comprehension. To support their informed consent, prospective study participants have been provided with accessible Easy to Read recruitment packs, containing: (1) An accessible letter from the study PI addressed (anonymously) to the person with ID, to introduce the study; (2) An accessible Participant Information Leaflet providing details about the study and contact information for any questions; (3) An expression of interest form; (4) An accessible consent form.

To guide the smooth running of focus groups and interviews and ensure our core digital literacy skills were addressed, the team from Trinity College Dublin (TCD) developed a scheme and framework for data collection and guided all the co-creation activities. The purpose of developing these tools was to promote a consistent approach to running focus groups and recording data from different groups in each partner country. It also aimed to ensure a consistent and systematic approach was adopted across each of the EU partners. These tools were critical to the overall success of the project, as they laid the foundation for a consistent and systematic approach to collecting data in the co-creation and co-design focus groups and user testing. And this data is establishing the direction and focus of the content that would be included in the DigiAcademy educational programme and is shaping the design of the app.

The focus group guide and data framework were structured according to the key themes that were to be explored in the co-creation focus groups and user testing, namely: (1) Your health and well-being; (2) Your social inclusion and social connection; and (3) Co-creating our digital skills education. All the key topics were discussed and validated with CAP members.

In this paper we will focus on the Theme 3: "Co-creating our digital skills education" of our data analysis and we will present the findings of our study from April 2021 to April 2022. In our iterative co-creation and co-design process (see Fig. 1) we have met approx. 260 people with ID and accessibility needs within focus groups in our EU partner countries, and many user testing sessions with more than 20 users.

We design accessible monthly CAP meetings to engage with all members in meaningful ways to review and validate our research data and provide expert by experience review of prototype work. Digi-ID PLUS project advocates strongly for the recognition of the role of CAP as paid experts by experience team members.

We pushed our user centered co-creation process to an optimum level, through supports and coaching to enable CAP members to become our 'digital educators', demonstrating the power and potential of people with ID to be the 'face' and 'voice' of our accessible education programme. The DigiAcademy programme is comprised of short video tutorials on priority topics identified with users during the focus groups and validated with our CAP, delivered by our digital educators.

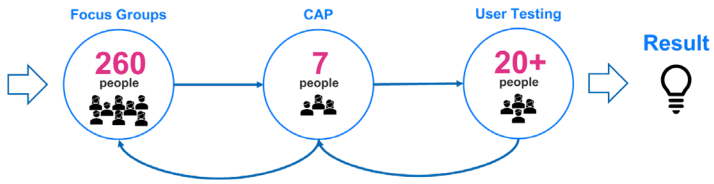

Fig. 1. Digi-ID PLUS citizen co-creation and co-design methodology

Online learning is not a new concept with several excellent offerings available such as Udemy, Coursera, amongst others. However, these platforms currently do not have the ability to meet the goals of DigiAcademy. In the section below we will present some of the key differentiators of our solution.

The platform and its content have been specifically co-created and co-designed to meet the learning outcomes. No video-based e-learning platform on the market currently offers an accessible, personalised learning experience for people with low levels of digital skills. The platform will allow the user to tailor their learning path to their needs, with the help of a supporter (social worker, caregiver) and by utilising AI to identify the best learning strategies to each user based on their profile and learning behaviour. The courses content is presented by people with ID themselves, who both act as ideal tutors as well as motivational role models. The digital educators expanded their own knowledge and confidence during their work with the team enabling them to showcase their own digital experiences to support their peers' digital engagement. They said: *"I loved the experience and really felt empowered and respected as the teacher"*, *"I had great fun. […] before I couldn't use email, now I can't believe I am the teacher for others to learn."*, *"I really enjoyed working together to produce the tutorials. I love knowing my videos can help others get started and be more independent."*.

3 Findings

Our co-creation focus groups informed our understanding of people with ID digital inclusion needs and preliminary analysis identified priority digital skills topics (Fig. 2). Repeatedly people with ID and their supporters discussed the need for introductory digital skills training (e.g. getting people started and building up skills from an introductory basis). Reviewing our findings with our CAP we validated this need for introductory digital skills and we identified main digital skills education topics and we selected the most commonly known software: getting started with email – Gmail, getting started with social media – Facebook, getting started with videocalls – Zoom and getting started with phone messages – WhatsApp. In our CAP members' competency in independently using these software was identified. Following a series of CAP meetings, where the skills of three members were demonstrated, they were recruited and supported to assume role of digital educators. Together we co-created Easy Read education materials and video tutorial scripts, coordinated practice and coaching sessions. These one to one sessions enabled us to test and validate the education materials and video tutorial scripts together and significantly invest time and energy build the individual's confidence in communication and presentation skills to prepare for professional video tutorial production.

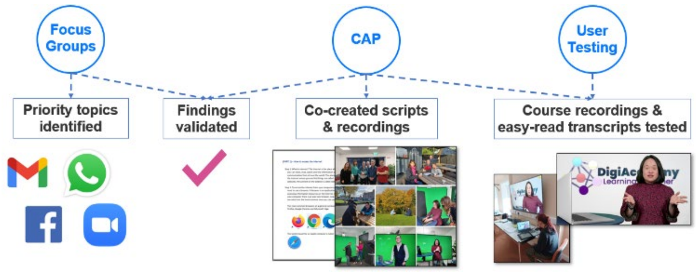

Fig. 2. DigiAcademy education citizen co-creation methodology

The tutorials had positive feedback from all the users and inspired other people to be the next digital educators. The users loved the content, the design of the step-by-step guide and the excellent work done by our digital educators. Peer to peer learning has been recognized as an enabling factor in the acquisition of new skills:

"I find so empowering to see that people are learning, growing, realizing their potential. I love to see that the people with disabilities are our teachers."

Digi-ID PLUS co-creation and co-design activities' findings shaped the development and improvement of the DigiAcademy solution. Based on prior analysis and findings we created the first sketch of the app as a mock-up of the solution showed in Fig. 3 and we reviewed it in the first CAP meetings and focus groups. Main changes were adopted to adapt the solution to the needs of the users.

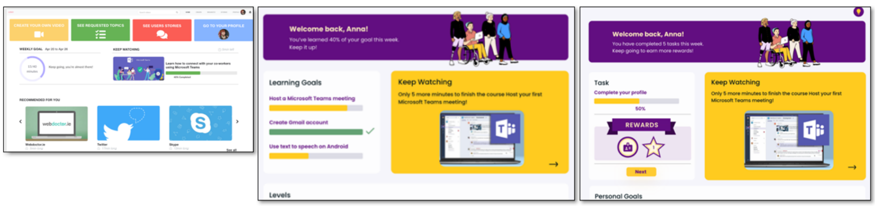

Fig. 3. DigiAcademy first mock-up design (left) and other 2 following versions.

The first mock-up of the app that we developed based on initial feedback was subsequently considered too complex. To address this, we implemented a new structure of the app moving the menu on the left and reducing the content on the homepage.

Feedback on our “Learning Goals” bars while initially positive ultimately after a user testing session was found to be less clear (Fig. 3 in the center). Therefore, we introduced tasks and we created the section “Personal goals” without completion bars. Focus group findings helped to identify the importance of gamification features for autonomy, immersion and satisfaction needs. To address this, we added a rewards system within the app with some funny animations, and the feedback was very positive (example of rewards in Fig. 3 on the right).

From our initial mock-up we co designed and tested our first working prototype. In line with our user centered iterative design process we adopt a cycle of continuous co creation with regular design updates based on our user feedback. Results from testing our working prototypes during our co creation focus groups and validating with our CAP identified issue with our homepage, which led to new design choice again validated with our CAP and next round of focus groups.

It is standard practice in mainstream educational platforms to provide a home page. However, our users found this layout confusing, with too many functions on this one page as the following feedback from one user whose experience was echoed by all our user testers:

“I can’t understand what I’m supposed to do here, there are too many buttons and I don’t know what I should click. I would like to watch new tutorials.”

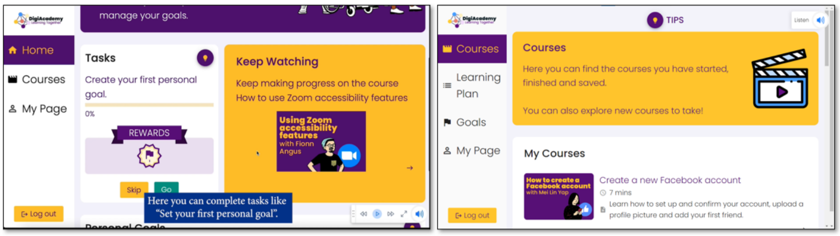

Fig. 4. One version of the prototype (left) and current version of DigiAcademy (right)

We also learnt from our user testing sessions and validation with CAP that it was vital for our users with accessibility needs to create separate areas for functionality, even the minor ones, creating more pages and sections. For example, the design with the goal section (see Fig. 5 on the left) placed in the home page below the tasks and the videos sections (see Fig. 4 on the left), was reported as too confusing for the users. Therefore, based on our user testing sessions feedback and re-testing process, to address these difficulties, we co-designed the new app without a Home page and different pages were required for each function: (1) “Learning Plan” page where the user can manage their tasks and (2) “Goals” page (Fig. 5 on the right) where the users can manage their goals.

In addition, during the user testing, once logged-in, many users automatically navigated to the ‘Courses’ tab, instead of exploring the home page. We tested the courses tab as the main tab (where the users navigate to as soon as they log in). This navigation route received positive feedback from all our users. Therefore, in the current version of DigiAcademy (Fig. 4 on the right) the Courses page is our main page.

From user testing sessions, we identified that it is essential to provide our users with an accessible step by step guide and examples on how to add their own information to our supplied data fields. Creating a list of options instead of a free-text field or providing examples with context is most effective approach to significantly reduce risk of confusion and to ensure the user does not get stuck and become demotivated. For example, during our user testing sessions, and also our co creation focus groups supported this insight, verified with our CAP, we found that users often struggled to understand what to include as a personal goal, as often this an activity that they receive support with from a trusted person. At the time they had to invent something as they could not think of a 'real' goal on the spot, and they reported that they often need assistance to create a new goal. To incorporate this feedback, we implemented a redesign of our Tips section. Here now the users can access some examples of digital skills that will support enhancing health, well-being and social inclusion and how to create goals based on these life experiences.

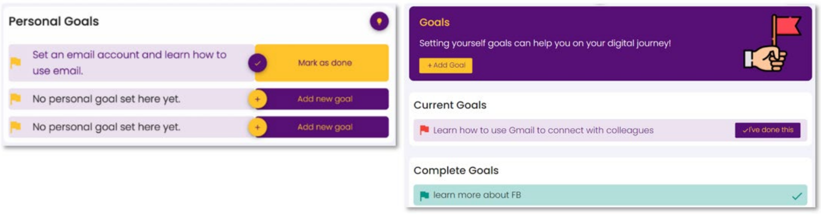

Fig. 5. Previous version of the Goals section (left) and current version of the Goals page (right)

In the Personal Goal section, the "Add new goal" and the "Mark as done" buttons (Fig. 5 on the left) were not clear and accessible for many of the users. Therefore, we changed the design creating a new page "Goals" (Fig. 5 on the right) with two different buttons with clearer text: "Add Goal" and "I've done this". This new language and design were suggested and tested with our CAP.

We also tested different versions of completion bars (see two examples in Fig. 6) were reported as highly inaccessible with users expressing frustration and difficulties in understanding their meaning.

Fig. 6. Two versions of completion bars tested.

To avoid confusion, it was essential to create customized buttons for all the actions in line with the style format of our app design. For example, the default "upload a picture" button was identified as inaccessible for many users. To address this, we created a customised "Browse" button instead, in line with style of our app design and with a user friendly icon to guide the users with greater ease. (Fig. 7)

Fig. 7. My Page Picture pop up: before (left) and after (right)

During our user testing sessions, we observed that the most common functions of a web app are generally known by the users and when they view something outside this familiarity, they feel confused or get stuck. This feedback informed our choice to remove the customized versions of the common functions and insert the known ones and some known icons. For example, the "Join DigiAcademy" (to register) and "Already joined?" (to log-in) buttons, designed based on initial feedback, was subsequently considered too complex and not clear. To address this challenge, we tested different design options and the current version of the app has the "Create account" and "Login" buttons with new icons, which have received positive feedback. (Fig. 8)

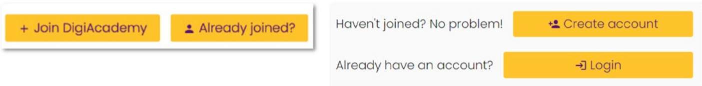

Fig. 8. Landing page login/register buttons: before (left) and after (right)

Another lesson learnt is the importance to avoid the "skip" options. It was reported that it creates confusion and often the users click on it only to check what is next, losing the focus on the content and causing frustration. For example, the first working prototype had the "tasks" function in the homepage where the tasks appeared sequentially: the user had the choice to skip the current task or start it (Fig. 9 on the left). Consequently, this was confusing for users and counterproductive. The users enjoyed trying out the tasks and earning badges but did not understand that "go" meant "start this task". In some cases the user associated the button "Go" with the Rewards section above and they clicked it to go on the Rewards. (Fig. 9 on the left).

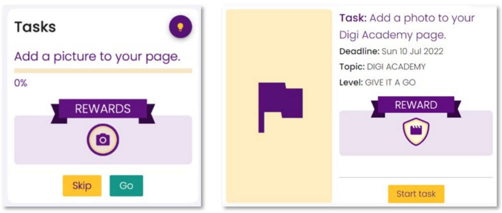

Fig. 9. Tasks: before (left) and after (right)

Therefore, a new page "Learning Plan" was created and validated with our CAP. In this new page the user can manage and create their own tasks, choosing from all the tasks available divided by categories to help the user fully understand the context, and setting a deadline for each of them. We changed the "Go" button in "Start task" button and we added a line before the button to separate it from the "Reward" section above (Fig. 9).

During our focus group sessions and CAP meetings we also co designed our app's Tips sections, which are a vital support sections for the users to understand how to navigate the app, especially for those loggin on for the first time. Each tip section contains both text and video co created with our CAP and it is designed to aid the user via instructions and some suggestions should they get lost or stuck.

4 Conclusion

Significant feedback from 260 end user interactions with co-creation focus groups and user testing sessions of initial prototype with Irish, Dutch French and Swedish users for current EIT Health funded Digi-ID initiative validates the urgency of an accessible education programme to address health, well-being and inclusion equity issues that have been exacerbated during the pandemic. Key issue identified was the need for introductory accessible digital skills education to support empowering end users to independently access and use technology and so alleviate pressures on staff, families and carers.

Authentic engagement and inclusion of people with ID and accessibility needs throughout the entire process of developing our programme is at the heart of Digi-ID PLUS. In line with the 'nothing about us' disability advocacy ethos, Digi-ID PLUS study participants think that anything designed for them should be made with them because only people like them can understand their needs and preferences.

There has been an urgent need for ensuring all citizens have digital access and support during the COVID-19 pandemic given reported negative impact of digital exclusion especially for those with accessibility needs [12]. Inaccessibility of mainstream technology and lack of appropriate support has resulted in a heightened reliance on support from family and staff, especially for people with ID and accessibility needs.

People would like to be listened and to become more independent in the digital life of their choice. It is essential that the development of the solution enables their inclusion in all the decisions of the creation, design and innovation. It is important that they feel directly involved and that the solution is following their suggestions and their point of view, this leads them to feel comfortable with the solution itself and to be inspired to participate more "in the decisions of the society" and to improve their digital skills both independently and via the solution created. Ultimately the user centered design process leads to an implementation of a solution that is listening and accommodating all aspects of its delivery to the accessibility needs and wishes of the community of users it is being co created for.

To date Digi-ID PLUS has developed the following innovative features: (1) Accessible website and mobile app: unlike competing solutions, will ensure users with accessibility needs navigate independently/with limited support; (2) Accessible content:

video tutorials on digital skills topics co-developed with individuals with accessibility needs; (3) Gamification: personalised badges and point systems motivates learners to keep upskilling; (4) Learning Plan: platform enables the learner (and a connected supporter) to build a personalised learning plan and follow tasks to achieve goals. The team is working in continuous iterative co creation process with wide network to hone these features and to develop new innovative features. New areas identified include investigating adaptive learning, refining assessment strategies with the intention of providing a personalised learning experience to enhance user learning experience and engagement.

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Assistive Technologies and Inclusion for Older People

Smart Community-Based Services for Older Persons with Disability

A Desk Review and Analysis of Design Projects

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Abstract. Persons aging with disability (AWD) experienced the onset of disability in the early-mid life and their experience is quite different from those who acquire age-related disabilities in late life (disability with aging, DWA). Appropriate intervention models and services are required for these populations to enhance independent living and inclusion in a life-span and ecosystemic perspective. Smart Community-Based Services (SCBS) exploit technologies and systems to empower the persons into more integrated and coordinated networks. This study analyses the state of art in SCBS through a desk review. The 11 selected projects range from small to large-scale projects, adopt different approaches from techno-centric to user-centric, and exploit diverse key-enabling technologies to form smart ecosystems. Even if the research on this topic is still limited and often experimental, SCBS has the potential to address cross-population AWD/DWA needs, and connect diverse environments by orchestrating technologies, services and key-persons in the communities and favouring a more sustainable service planning.

Keywords: Aging with disability, Assistive Technology, Smart Community, Smart Community-Based Service, Service design, Desk research

1 Background

As a result of the social and medical progress, an increase in the life expectancy of persons with disabilities (PwD) has been registered [27]. *Persons ageing with disability* (AWD) are those who experience the onset of (motor, behavioural, sensory or intellectual) disability in the early or mid life and they grow old with disability [20]. Their experience is quite different from those who acquire age-related disabilities in late life due to the ageing decline (*disability with ageing*, DWA) [10]. AWD is subject to the interactive effects of age-related declines which tend to occur earlier and progress more rapidly compared to DWA. So, new needs for support with ageing-related challenges are added to life-long needs for assistance [5]. This phenomenon calls for defining appropriate theoretical and intervention models for this specific population [4], redefining social-health services overcoming the assistive logic [21] while enhancing independent living and inclusion, addressing cross-population needs as well as working across service networks in line with a life-span and ecosystemic perspective [20]. In light of this, Smart Community-Based Services (SCBS) are designed to exploit technologies and systems (assistive and mainstream) connecting people, places and resources to empower ageing PwD, support the caregivers and promote new local opportunities. SCBS go beyond the design of stand-alone Assistive Technologies and aim at reorganising services into more integrated and coordinated networks using innovative technologies to pursue participation and inclusion for all as a common goal irrespective of age and abilities.

2 Objectives and Research Questions

This study maps the state of art in SCBS for adults and elderly with diverse forms of disability, analysing their design and technological implementation in real life contexts. The study is guided by the following Research Questions (RQs).

RQ1: What are the existing initiatives of SCBS for the ageing population?
RQ2: What are the approaches and the roles of the users in the design?
RQ3: What are the technological solutions, systems and services designed to respond to the needs of persons ageing with disabilities?
RQ4: What are the development trajectories for the future of SCBS?

3 Method

3.1 Data Selection

According to the RQs and their exploratory nature, a desk review was employed to investigate the state of the art and gain a broad understanding of the topic [9]. From October 2021 to February 2022, some databases were used to search for relevant case studies: IEEE Xplore, ACM Digital Library, Scopus, EU database of funded projects. The keywords used for the searching were: smart community*; service; disabil* older people OR disab* elderly; design, technol*; period: 2014 to 2022. The collected documentation includes scientific papers, book chapters and, when necessary, the websites of the projects were visited to collect further detailed information.

3.2 Inclusion/Exclusion Criteria

While most of the ATs are developed as single stand-alone solutions applied to specific life domains or activities (e.g, screen readers), we search for projects that integrate different tools, services, people and environments to create ecosystems tailored to the needs of persons AWD/DWA. The following inclusion criteria were used to select the case studies: a) the document is in English language; b) the design project addresses people ageing with disability or disable elderly as target users; c) the design project proposes a SCBS as an ecosystem of technologies, users and contexts. This study does not consider theoretical contributions nor literature reviews, since it aims at investigating SCBS as they are designed and implemented in real contexts.

3.3 Data Analysis

Once collected, the desk review follows three steps [9]: 1) scanning the literature to keep focused on the research scope for the preliminary overview; 2) analysing secondary data, such as projects websites, to contribute to improving detailed information; 3) the team coordinator creates an annotated, linked list of all selected resources, organised by RQs.

4 Results and Discussion

The desk review contributes to identify n. 11 projects, whose main references, projects' name, year, countries and authors' background are listed in Table 1.

Table 1. List of selected projects

P01	Project title: **City4Age** [17]; *Countries*: Greece, United Kingdom, Spain, France, Italy, Singapore; *Authors' background:* Computer science, Engineering, Biomedical engineering; *Years*: 2015 - 2018
P02	Project title: **ACTIVAGE** [1] [17]; *Countries*: Spain, France, Italy, Germany, Greece, Finland, United Kingdom; *Authors' background:* Computer science, Engineering, Biomedical engineering; *Years*: 2017 - 2020
P03	Project title: **ProACT** [8] [15] [19]; *Countries*: Ireland, Belgium, Italy; *Authors' background:* Engineering, User Experience Design, Computer science, Economy, Psychology, Health Science; *Years*: 2016 - 2019
P04	Project title: **vINCI** [7] [28]; *Countries:* Cyprus, Romania; *Authors' background:* Computer science; *Years*: 2018 - 2021
P05	Project title: **Make and Connect** [23]; *Country*: Australia; *Authors' background*: Computer Science, Interaction design, HCI; *Years*: 2017 - 2019
P06	Project title: **My portfolio suite of apps** [23]; *Country*: Australia; *Authors' background*: Computer Science, Interaction design, Human-Computer Interaction; *Years*: 2016 - 2020
P07	Project title: **AYUDO** [26]; *Country*: Austria; *Authors' background*: Medical

	computer science, Software engineering, Graphic design, Applied psychology, Computer security; *Years*: 2019 - 2022
P08	Project title: **Contempo** [18]; *Country*: Indonesia; *Authors' background*: Computer science, Public Health; *Year*: 2014
P09	Project title: **Smart Home for the New Elder** [14]; *Country*: China; *Authors' background*: Industrial design, Service design; *Year*: 2020
P10	Project title: **Wearable Sensor Based Elderly Home Care System** [2]; *Country:* Bangladesh; *Authors' background*: Computer science, Engineering; *Year*: 2015
P11	Project title: **TCitySmartF** [11]; *Country*: United Kingdom; *Authors' background*: Computer science, Engineering; *Year*: 2019

The selected cases range from small projects (P04, P05, P06, P07, P08, P09, P10, P11) to large-scale projects (P01, P02, P03), with diverse objectives and methods, pointing out several design challenges. As emerged from the authors' backgrounds, the interdisciplinary nature of the projects is highlighted.

4.1 RQ1: Existing Initiatives of Smart Communities for Ageing Population

In most cases (P03, P04, P05, P06, P07, P08, P09, P10), the smart systems are designed for the home environment to monitor the person's health status (e.g., vital parameters, motility) and they are inspired by a biomedical model of well-being. Other projects highlight new trends (P05, P06) to support diverse life domains (e.g., socialisation, leisure activities) as a way to address hedonic needs and meaningful recreational activities which can positively impact cognitive functioning and mood [12].

These initiatives support the creation of a "community" as long as they involve the elderly and their caregivers, health-care and social services, all connected through smart objects, cloud infrastructures and mobile devices. Instead of merely supporting surveillance purposes, such ecosystems have the potential to meet the needs of the older persons for agency, empowerment and self-care [26], to continue living at home and prevent the hospitalisation, while supporting the work of the caregivers and limiting the pressure on the healthcare system [3]. Moreover, there is the need to expand the focus beyond the home setting towards the wider living environment, taking advantage of what the cities and the local communities already offer (P01, P02).

Finally, as highlighted by the literature [3], these experiences unfortunately share the limit of assuming experimental characteristics which would require stabilisation, generalisation, and a wider diffusion.

4.2 RQ2: Design Approaches and Roles of the Users

The selected case studies adopt different approaches along a continuum from a techno-centric approach focusing on the functional performance of the system (e.g., P8, P10), to a user-centric approach focusing on the user-technology interaction in real contexts (e.g., P3). The shifts between the opposite points along this continuum are needed in diverse design phases (e.g., definition of requirements, development phase) and a proper balance is pivotal to ensure that the designer's mental model fits with the users' mental models. Consequently, diverse levels of user involvement are required [6]: informative role when the users act as providers of information and as objects of investigation, consultative role when they comment and evaluate predefined design solutions (P01, P02, P08, P10), or participative role when they actively take part in the decision making process about the project solutions (P03). The remaining n.6 projects do not mention particular details about users' involvement.

It is acknowledged that the co-design with the target users drives to high quality solutions that really meet users' needs [22] and promote their abilities and desires [3]. But involving people with disabilities in the design process requires specific methods especially in the case of people with severe intellectual disability [16] [24]. Moreover, to design a SCBS, the involvement of diverse actors (e.g., informal caregivers, healthcare professionals) is useful to map the different needs [8] [15] [17], adopt a systemic perspective on the social and organisational factors which play a role in the promotion of well-being [3]. The design techniques used during the selected projects range from traditional social science methods like interview, questionnaire or focus group (e.g., P08), to mockup and prototypes (e.g., P01, P02, P10) that enable the users to experiment with the proposed solutions and discuss their experience of use.

4.3 RQ3: Technological Solutions, Systems and Services

The selected projects exploit the potentialities of diverse key-enabling technologies with different functionalities to form a connected ecosystem of wearable devices, sensors embedded in indoor/outdoor environments, smart everyday objects, in addition to personal devices like smartphones, cloud platforms and analytics systems. The following are two example scenarios showing how different tools are combined.

The scenario of the ProAct project (P03) aims to empower the person by promoting a sense of ownership over their health and lifestyle: the smart watch monitors heart rate, sleeping and daily physical activities, while the sensors monitors temperature and air quality in the home; these data are sent to the analytics system in order to inform the caregivers who can plan personalised interventions, as well as to provide useful tips to the older person through a mobile app with a chatbot.

The scenario of the ACTIVAGE project (P02) aims to enable older people to freely and safely move in outdoor contexts: using WiFi network and bus services of the city, the mobile app tracks users' movement and help them get to their destination, while the wristband monitors the physical activity and heart rate; the cloud system collecting the information about the users, through some rule-based processing, detects potential risks and sends direct messages to the user or through other assistance services.

The introduction of home automation and intelligent systems able to collect sensitive data, take actions and provide recommendations, often face the users' scepticism, reluctance and distrust. A way to deal with this is to design non-invasive systems or gamification and persuasive strategies (P03), or to transform everyday objects like a kettle into smart objects (P05).

4.4 RQ4: Trajectories for the Future Design of SCBS

Based on the analysis of the selected projects, we can derive some recommendations for the future design at different levels.

Considering the conceptual framework, the selected projects merge the concepts of Ambient Assisted Living, Smart Home, Smart City with the framework of Active Ageing, to enhance the quality of life of people as they get old. In light of this, the project ProACT (P03) calls for a coordinated and integrated approach, given that most models of care across the EU are focused on a single disease approach, and they are not adaptive to the needs of people with multiple chronic conditions and changing needs. Thus, the future design of SCBS should support person-centred healthcare models rather than single-disease specific approaches, and support the abilities of the person instead of focusing on the impairments [3].

Regarding the methodology, the design of the future SCBS should consider the long-term adoption of the system by the actors involved in the community. As pointed out by Malavasi et al. [15], maintaining the user engagement over time is a crucial challenge to reach the expected impact (e.g., support independent living). But the matter is not merely related to the user's interaction with a single tool, rather for SCBS it depends on the ability of the smart community to remain relevant in the different life stages and according to changing needs of people ageing with disability. To this end, a multidisciplinary team can gather diverse expertise needed to adopt a holistic and life-long perspective (e.g., social sciences, psychology, geriatrics, computer science), as done for the ProACT project (P03).

Concerning the technological implementation, the main issue pointed out by the selected projects is related to the interoperability among different devices, sub-systems and services which are combined in the SCBS [15] [17] [18]. The interoperability issue goes to add to the security and privacy concerns especially when in the case of medical records. Moreover, the introduction of Artificial Intelligence (AI) systems offers great opportunities for diagnosis and personalisation of the care, but they also present some risks. Indeed, there are open debates about how AI should be used to inform decision making, about the accuracy of the predictions and the risks for reinforcing and stereotyping some users' behaviours.

Moreover, the implementation of the SCBS might deal with the lack of infrastructure in some contexts (e.g., remote regions, least developed countries, local informal communities), as well as with the digital divide and the need to train the people to properly use the different technologies.

5 Conclusions

This desk research allows us to propose a definition of Smart Community-Based Service: a model that exploits technologies and services, connects people and places to address the needs of ageing persons with disabilities, to empower its members as well as to promote new business opportunities. This conceptualization poses new challenges which can be summarised as follows:

- The life-long perspective enables to consider the changing needs of the people with disabilities, recognizing the specific needs related to DWA and AWD. Flexibility and personalization are key features to accommodate personal preferences, situational contingencies and contexts.
- A multi-stakeholder approach is needed when designing the connections among different people, services, and places. Besides participatory projects are still a few, co-design is pivotal to design successful solutions and it should be carefully planned to enable the participants to take part in the process according to their abilities.
- The SCBS should orchestrate not only the enabling technologies but also the key-persons in the communities who can act as mediators for some practices (e.g., recreational activities, socialisation), and the focus on functional needs should not overshadow the hedonic needs and a more holistic vision of the experience.

Another relevant issue is related to the role of the ageing person both in the design process and in the use of the SCBS, which can be influenced by stereotypes and ageism: instead of merely being a source of information, and a deficit person to control, the ageing person should be a partner in the design process and the core actor to empower with the SCBS [3] [16] [23].

The review confirms that research on AWD is growing but still limited [10] [13] and the design projects specifically addressing this population are very few [20] and often experimental [3]. In particular, little attention is given to the changing and specific needs related to DWA and AWD. However, the SCBS has potential to create synergies between the services for elderly and persons with disability, addressing cross-population needs and connecting diverse life environments.

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Narratives of Digital Technology Use

Understanding the Role of Ageism in the Digital Inclusion of Older Adults

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Abstract. A growing ageing population introduces unique challenges in providing healthcare and government support. Proposed solutions often involve digital solutions. This means that digital inclusion of older adults has be-come an important subject for research. Our study aims to provide insight in how ageism is involved in older adults' narratives of digital technology use and how it affects digital inclusion. We conducted a thematic analysis of 37 semi-structured interviews with self-proclaimed digital technology users aged between 66 and 84 and Dutch speaking from Belgium. The analysis resulted in four themes that position the digital older adult in a more privileged position. Furthermore, we found that the narratives were built upon thought patterns and behaviour consisted with their previous life experience.

Keywords: Digital inclusion, Ageism, Interviews, Thematic Analysis

1 Introduction

Understanding why older adults are resisting the use of digital technology has become more important than ever, as a growing ageing population encounters new and specific age-related problems that according to some could be solved by the use of digital devices, such as robots or health monitor devices [i.e., 1]. Successful deployment of these digital technologies within the ageing population requires a more nuanced view on technology use by older adults, as it entails more than the dichotomy of use or non-use [e.g., 2]. Kania-Lundholm and Torres [3] argue that older users position themselves against specific narratives of non-users and old age, which creates a new specific form of discrimination based on age and digital skill level. Additionally, ageism has been identified to affect self-efficacy and to lead to an underestimation of the applicability of digital technology in the lives of older adults [4]. Our study aims to provide insight in how ageism is involved in narratives of technology and how it impacts digital inclusion.

2 Digital Inclusion, Digital Technology, and Older Adults

The digital inclusion literature has often approached the differences in digital technology use in older adults as the difference between using technology and not using technology [5, 6], however recent research has shown that for older adults the use of the internet is nuanced and determined beyond access by motivation, skills, and social situation [7–9]. Van Dijk [10] acknowledges that it is necessary to go beyond the idea of digital divides and to explore the concept of digital inequality as the disparities observed in digital inclusion research cannot be explained by a simple dichotomy of having and not having, but could be understood by examining existing social inequality. This is similar to the argument of Helsper [11, 12] and could explain the differences in digital inclusion observed in older adults. Older adults themselves are not homogenous and several studies have shown that older adults acceptance and use of digital technology is layered and complex [13–17]. This study contributes to the last by further exploring the motivation of older adults to remain up to date and to provide insight in how older adults construct their ageing identity while using technology. This last is important as attitudes to ageing have been shown to impact the mental wellbeing [18] and ability to learn skills and technology adoption [i.e., 19–21]. Ageism, or discrimination based on age in the form of internalized ageism (e.g., feeling too old) has been related to non-use or abandonment of technology [19, 22]

The continuity theory of ageing (CT), as proposed by Atchley [23, 24], posits that a large portion of older adults observe continuity of obtained habits and attitudes in their lives, even though they experience changes in their health, functioning, and social circumstances due to the ageing process. Continuity theory takes a life course approach to understand the dynamic and evolutionary ageing process in which the individual's history and ideologies inform the ageing process [25]. A limitation of the approach is that although it is applicable on a large segment of the ageing population, who are observed to have a consistency in thought patterns, activities, and social relationships related to their previous life experiences, it is less applicable to those experiencing interruptions in their history, for example due to health issues or sudden changes in their social situation [24, 26]. In this article we will use continuity theory as a narrative device [27] to understand how older technology users position themselves.

3 Method

3.1 Sample

The sample consists of 37 semi-structured interviews with self-proclaimed digital technology users, aged between 66 and 84 in Flanders, the Dutch-speaking part of Belgium. Due to the COVID-19 pandemic we were restricted in only approaching those older adults capable and willing to use digital technology to conduct these interviews. The interviews took place over a period of four months, from January 2020 to April 2020 and were conducted via the communication method preferred by the participants, this ranged from MSTeams to Facetime. The research received ethical approval of the lead university's ethical review process and participants were provided with information about the goals of the study and were assured of the compliance to pseudonymisation and privacy rules.

3.2 Analysis

A thematic analysis [28] was conducted on a sample of 37 semi-structured interviews with self-proclaimed digital technology users, aged between 66 and 84 in Flanders, the Dutch-speaking part of Belgium. The interviews were audio recorded and transcribed. Furthermore, they were coded using the qualitative software MAXQDA 2020. The first author initially coded 12 interviews to provide an initial impression of the available themes, the created codebook was discussed in weekly meetings with the second author. During these meetings there were ample room for discussion and several themes were re-defined or refined. The resulting themes were further scrutinized using CT as a base-line. The resulting codebook was used to process the 25 remaining interviews if necessary additional themes were created and further discussion amongst the authors took place.

4 Findings

Using the above methodology, we developed several themes of relevance for this paper, and these will be presented below.

4.1 Tech as Identity

The theme with the strongest connection to CT as a narrative device is the tech as identity theme. This because it concerns habits that crystallised prior to the onset of old age and the associated subthemes are used by older adults both to construct what their identity is in older age as well as to explain their technical abilities to others. Many of our participants mention that they were introduced to computers as soon as the technology became available, often in a professional experience at their workplace. Chantal (75, F), says that she became aware of computers due to "gosh, because I have always taught [in high school]" and her course involved teaching "informatica [information science]" which meant that she had to remain up to date to be able to teach. Maarten (70, M) acknowledges that he "…stumbled into this via work, in fact". This is different from how others claimed the new technology as soon as it became available at their workplace, Gert (82, M) says that there is a very simple explanation for the difference between him and his fellow teachers' level of digital skills "there arrived one computer at the school and I said, 'That one is mine'. And the computer was given to me.". This eagerness was present in several participants and relates to the sub theme of historic interest, often the work experience enabled the already existing historic interest in acquiring equipment or courses that were not available for others. Jens (75, M), for example, says that he was a computer fanatic before the computer was required for his work as police officer. This historic interest enabled them to see the value of learning skills early on, meaning that they would have a proficiency in technology use prior to retirement that would enable them to build on existing knowledge while others would experience a gap. This proficiency is a source of pride for them, and it helps them to remain up to date. Rik (80, M), who used to be a technician at the University of Leuven, says that he taught himself digital skills and even though he does not want to exaggerate "you do get a bit of a certain confidence in". This is echoed by Carolien (65, F), who did not have a professional experience related to computers but used to be a typist prior to becoming a stay-at-home parent, received acknowledgement for her skills from her daughter and says:

"...she might hear of other parents who can do a lot less or who do a lot less [on the internet]. No, I do not feel [judged], but I do think that it is a bit of self-esteem that you need to cherish."

4.2 Curiosity and Resilience

Closely related to the previous theme is the *curiosity* and *resilience* that our participants express. As explained above the CT assumes that older adults try to maintain a living standard including habits, that they enjoyed prior to the onset of old age. These habits are evident in our participants' interest in *lifelong learning*, as evidenced in their attendance of webinars or expansion of their technological skills. Hans (77, M) made the connection between his habit of learning with his cognitive ability, in his words "I am just like that, as long as the mayonnaise keeps spinning, I feel young". Older adults will use these same habits obtained over a lifetime to adjust to new digital technology as a form of resilience. Kevin (73, M) states that "if there is something new that I absolutely want to know, I will ensure that I get to know it". Some of our participants credit their resilience and curiosity as the reason why they can *proactively keep up with new technology*, as expressed here by Leanne (76, F) in answer to the question how curiosity factors into her habits: "if there is something new: why shouldn't I do that? Why shouldn't I try that out?". This is opposite of the experience of José (73, M) who says that he expected that his experience early on has enabled his use and that he expects that his situation would have been entirely different without the early introduction. He supposes that his tendency to postpone, would have affected his introduction to technology use here.

4.3 Social Contribution

Our participants showed different ways in which they used digital technology to continue their social habits and interactions. This social aspect of technology is visible in two forms, first, is the way that older adults use technology to share knowledge. Especially, those participants who were teachers continued teaching and sharing knowledge in later life, such as Gert (82, M) who ensured that his wife was aware of digital solutions and able to use it. However, the sharing of knowledge also consisted of ensuring inclusion of non-digital older adults such as Hans (77, M) who invited over an older member of a council without digital skills with the express purpose of inclusion and José (73, M) explained that he made sure that his wife was able to make use of the digital devices where necessary to remain autonomous. These interactions are examples of social learning, an informal way of learning through your age-cohort.

The second aspect concerns how our participants used digital technology to connect with others. One of the most discussed was the use of communication technology to ensure contact with their children and grandchildren, especially fraught due to the lack of physical contact caused by the Covid-19 restrictions. Often these stories were accompanied by anecdotes of technical support received via their (grand) children or meaningful interactions experienced via various communication softwares. However, social media in the form of Instagram or Facebook was less seen as a valid means of contact, as said by Annelore (66, F) “but well, that is not real contact with people”. Others express an outright disdain for using these types of apps as people overshare “the GP of my wife, she posts 24/7 on Facebook what she has eaten and what they are going to eat tonight and [unintelligible] and tomorrow bike riding and dinner etcetera and all that bull” (Mark, 73, M).

4.4 Not Like Them

This final theme shows the effect of CT on the relationship between digital savvy older adults and less digitally skilled older adults and can be seen as a form of ageism. Several of our older adults positioned themselves as outside of their age cohort. This means that older adults would provide examples of others they consider old as examples of how they are opposite to their own experience of old age. For example, Brenda (75, F) compares herself with her friends and sees that her experience with technology helps her. Or Chantal (66, F) who says that “they only really want to know one thing […]. Otherwise, they don’t want nothing else […] They are not interested enough”. This last is also an example of othering of others without digital skills. This othering can sometimes be in the form of self-othering as above, but it can also be by dismissing them as unable or unwilling to learn digital skills. However, several of our participants defended this lack of digital skills in older adults and as Paul (77, M) states “and some people, I am thinking mostly of 80-year-olds, you just have to take into account that they would rather be served. And that they would rather go a service desk to be served there.” Which is both a defence of those digitally unskilled as well as placing himself outside of his age co-hort. Indeed, a small number of our participants expressed a worry for those not digital and lobbied for inclusion of people without digital skills. However, some participants also detail negative interactions such as Annelies (73,F) who encounters negative reactions from her older relatives on her continued desire to study.

5 Discussion and Conclusion

The older adults use continuity of their past technological achievements combined with their current technological activities to make sense of their place within digital society. It enables them to position themselves in this fast-changing world and they use it to position their digital skills in comparison to others. Many credit their own interest and their previous life experiences to their continued ability to grow in skills. However, this positioning also results in a new form of ageism which can lead to exclusion of those not skilled and can impact the social interactions between these groups, this needs to be explored in further research as in this study only experiences of those skilled are discussed. Furthermore, using CT to understand sense making of technology helps to understand the motivation of those already online. Understanding that the ability and interest from the older adult now can be traced to their life pre-retirement can help inform initiatives for continued learning. As we can see that CT explains these 'silver surfers' it might also inform us how to engage with the habits of those not yet online to introduce them to digital technology in a way that would engage and interest them. Further research engaging with the different habits (technological and social) would be an interesting avenue of research. Additionally, the findings of this study should be considered when setting up peer-to-peer initiatives as ageism can impact self-efficacy and continuous motivation. Ensuring that older adults are not only aware but introducing strategies to counter their (inadvertent) ageist perceptions is important and needs further investigation as to how this is best achieved. The social learning aspect and the fact that not all skills are necessary or interesting to all older adults should be seen as contributing factors in the design of a successful digital skills course. Moreover, they are a sign that it is beneficial to consider co-designing a digital skill course with and for older users of different skill levels and interests.

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Technical Support Needs of Older Users of Digital Health Technologies to Support Self-Management of Multimorbidity

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Abstract. Marketplace digital health and wellness devices have become more accessible, but there has been little examination of the specific issues that arise when such devices are deployed to large groups of novice digital technology users, such as older adults, for use over time. ProACT, a digital application and technology platform, is designed to support older people to self-manage multiple chronic health conditions. Analysis of technical support records, relating to participants of the 12-month ProACT proof-of-concept trial in Ireland, identified hardware, software and user issues with the technology. Meeting these needs required flexibility, good communication, respect, and speed from the research team. Enabling maximum engagement with new DHTs requires understanding the challenges end-users may experience, particularly those with minimal previous experience with such technologies.

Keywords: Older adults, Digital health, Multimorbidity, Technology use.

1 Introduction

Multimorbidity (the presence of two or more chronic health conditions), is both more prevalent among older adults and is considered the norm [1]. A cultural transformation in doctor-patient relationships, from a paternalistic to a shared-partnership approach to healthcare, encourages patients to take responsibility for the work of self-managing their own health and wellbeing [2]. Consumer oriented health and wellbeing devices proliferate the marketplace, often offering easy and inexpensive options for measuring wellbeing parameters. However, many 'off-the-shelf' digital health technologies (DHTs) are not specifically designed with the older user in mind, resulting in usability challenges [3].

For persons with multimorbidity (PwM), condition self-management is often burdensome, disrupting normal daily practices of living [4-5]. Successful DHT trials include a purposely-designed engagement ecosystem that considers technology usability, participant functional abilities, and the role of research team support [6-8]. This paper presents findings from technical support engagement with participants (n=60) in Ireland, during the 12-month ProACT proof-of-concept trial. ProACT is a digital application and technology platform designed to support older people to self-manage multiple chronic health conditions with or without support from members of their care network. Findings will inform practical strategies for wide scale DHT deployment among end-users unfamiliar with digital technologies, who may also be living with burdensome health or wellbeing challenges influencing adoption of digital supports for health and wellbeing self-management.

2 Method

The ProACT CareApp is a Progressive Web Application (PWA) provided on an iPad. The ProACT technology kit consisted of an iPad and a selection of 'off-the-shelf' devices from Withings (including the Activité watch, Body Analyser weight scale and Blood Pressure Monitor [BPM]) and iHealth (SPO2 pulse oximeter, iGluco blood glucometer (BGM), wrist BPM, arm BPM). The CareApp is used to self-report on health and wellbeing (e.g. breathlessness, mood), set goals in relation to physical activity, add people to a care network with whom data can be shared, view educational information, and view data over time. The full ProACT platform, including all of its backend components, has been described elsewhere [9]. Data synced from the digital device to the related third party application (3PA), was collected through the open Application Programme Interface (API), and transferred to ProACT, where the data was aggregated and displayed via the ProACT CareApp dashboard.

2.1 Study Procedures

To minimise workload for participants and avoid using personal online accounts, the relevant apps (Apple, ProACT CareApp, Health Mate for Withings devices and iHealth and iGluco for the iHealth devices) were preloaded on the iPad and anonymous accounts for each participant was set up and managed by the research team. During deployment, the research team paired and connected devices to Bluetooth or WiFi as required. Trial iPads were set up without a PIN code, to facilitate ease of access for participants. Reviewing readings, answering daily reflection questions and reviewing collated health and 'how-to [use the technology]' information required opening the ProACT CareApp on the iPad provided. An easy to remember 4-digit pin was required to open the CareApp. The full trial protocol is described elsewhere [10].

The research team undertook extensive pre-trial testing of a range of potential (Withings and iHealth) devices to determine the most appropriate based on comfort, usability and reliability (e.g. of data transfer from devices to the ProACT CareApp). At least two researchers at each trial site continued device testing throughout the trial, to maintain familiarity with the devices and CareApp. Training was provided in person during deployment, which took place over two visits, to minimise overload on participants. Training videos were available through the ProACT CareApp and a paper-based training manual provided to each participant.

A technical support help desk (staffed by a member of the research team) was available during weekdays. A 'please contact me' button was included in the ProACT

CareApp to request a support call. Where resolution was not possible by phone, a technical support visit was arranged to the participant's home. A nurse-led triage service provided clinical oversight during the trial, by monitoring readings and phoning the PwM if readings breached acceptable parameters. Over time during the trial, the role of the triage team expanded to include making monthly care support calls to participants, which at times included participants identifying technical or participation challenges.

2.2 Data Collection and Analysis

During the trial, a help desk log of calls was maintained in a shared Google Sheets document. To facilitate expedient communication between researchers in the field trying to address technical issues, and colleagues in the office, a WhatsApp group was established. Findings, presented in this paper, are based on data collected from the help desk call log summaries, researcher WhatsApp text messages, and participant interviews. An inductive thematic analysis [11] was conducted and supported using NVivo software for Windows [12].

3 Findings

Trial participants (n=60) were older adults (65 years+; median age = 73 years), mainly men (n=35, 58%), with a range of multimorbid chronic health conditions. The majority of participants (n=35, 58%) were living with others. Eight participants withdrew and three died over the course of the trial. Quotes use the format: participant trial identifier, age, sex, and health conditions e.g. (P043, 77, F, COPD+CHF). References to help desk and WhatsApp communications note the relevant participant about whom the message was being sent e.g. (WhatsApp/Help desk, P043).

From 473 help desk issues logged, 399 (84%) related to technical support required by the participant. Administrative issues such as scheduling appointments, or notification that the participant was in hospital or would be away, and requests for test strips or batteries etc. made up the remaining 74 (14%) issues. Triage nurses also provided notification to the help desk (n=54, 10%), of technical issues identified during their calls with participants. Technical support needs were due to either hardware (n=183), software (n=126) or user issues (n=90).

Technical issues logged per participant ranged from 0-27 issues (mean = 7). Half of participants (n=30, 51%) required low levels of technical support, reporting fewer than six issues over the course of the trial, with nine (15%) participants reporting over 13 issues. Variation in the types of support needed also differed by trial month (Figure 1).

3.1 Hardware Issues

The BPM was most often cited in the help desk log (n=154), '*BP [blood pressure] cuff not working properly* [participant] *tried 11 times to get a reading*' (Help desk, P053). Repeated issues were also found with BPMs, '*When using the BP cuff blue lines appear on the screen, this happened 10 days ago was resolved with a visit but it is now* *appearing again*' (Help desk, P001). Difficulties with the BGM were more likely to relate to questions about readings but occasionally participants identified malfunctions with the monitor, '*BG only working intermittently - sometimes reading will just not take even though lancing pen turned up to 5, and a lot of blood there*' (Help desk, P014). Most participants with diabetes already had a BGM and where the trial BGM was deemed unsatisfactory; participants manually entered readings from their own device.

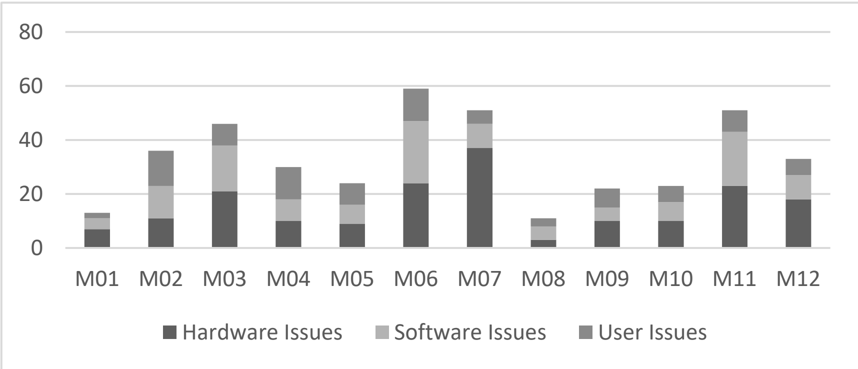

Fig. 1. Help desk technical issues by trial month

Issues with watches (n=39) included not displaying correct readings, *'[watch] is not working correctly, one min[ute] it's 2.40 and the next it could be 5.45pm'* (Help desk, P055). Attempts by both participants and researchers to correct malfunctions were not always successful, *'[Participant] has recalibrated the watch himself lots of times. Time is right, data displaying in HM [Health Mate app] right but the dial on the watch measuring steps is always at 5k'* (Help desk, P039). Furthermore, the silicone strap provided with the watch caused skin irritation for some participants, requiring replacement with leather watch straps.

The language used by participants was usually non-technical and terms such as having been 'logged out', devices having 'died', or iPads 'not working' were typical when participants made contact with the help desk team. However, iPad malfunction was rarely the cause, *'iPad working fine, however, BPM and watch weren't so these were exchanged*' (Help desk, P051). Battery life for each device type was established during pre-trial testing and a battery replacement schedule was established as part of the trial protocol. However, unscheduled battery changes were required for devices, particularly the BPM (n=23) throughout the trial. Watch batteries were expected to last nine months or more, yet despite a six-month battery replacement schedule five (8%) participants required early watch battery replacements. Reports of rechargeable devices failing to charge, was often due to use of the incorrect charging cable – all charging cables were white and with connectors of a similar size, making them difficult to tell apart. Some pulse oximeters also failed to hold a charge, requiring replacement. Internet connection quality was a challenge, requiring home visits to re-set devices, *'The participant's own iPad is working ok, yet the ProACT one keeps dropping off the WiFi.'* (WhatsApp, P038). Changes in broadband provider or interrupted internet connectivity (n=14) also affected trial devices, *'P051 had power outage and now nothing [is] working!'* (Help desk, P051).

3.2 Software Issues

Software issues (n=126) represented 32% of technical support queries, while 30% (n=37) of software issues related to updates. Of these, most (n=21, 57%) were iOS update related, such as notifications that updates were required, leaving many participants unsure about what to do. Others, who responded to on-screen instructions to initiate the update were unable to follow the steps to complete the process, such as how to respond to a prompt for iCloud backup. In some instances, iOS updates stalled in the middle of the update. Following iOS updates, some iPads required a reset and for devices to be re-paired, usually necessitating a home visit to resolve.

The nature of the ProACT trial was iterative, with learnings applied to the design of the app and platform as data was collected during the trial. As the ProACT CareApp and data aggregation platform were updated, modifications were pushed to the app, in the background. Usually this process was seamless and participants were unaware of subtle changes in the functioning or appearance of the CareApp. However, at times, display issues arose when bug fixes and updates were applied, especially early in the trial, *'COPD symptom data graphs a mess today. Getting error messages for chest tightness, phlegm amount, cough'* (WhatsApp, P043). Server errors affecting access to the ProACT CareApp were also experienced, '*there is an issue with the server - developers say it is out of their control and they have contacted IT to try and resolve it'* (WhatsApp message).

Pairing issues (n=60) arose where devices proved difficult to pair with Bluetooth or WiFi, requiring additional visits to re-attempt connecting or to replace devices, *'[the] scales will not connect. Any recommendations? We've tried taking out the batteries, disconnecting from WiFi and turning iPad off. Still not connecting'* (WhatsApp, P010). At times, the device was not recognised by the relevant 3PA to pair. On other occasions, the device was displayed as paired with the app but there was no connection when attempting to use the device, *'...had to take her BP cuff [back] it would not pair no matter what I did with it and her watch wouldn't pair either…the WiFi connection seemed quite slow but that shouldn't have an impact on the Bluetooth?'* (WhatsApp, P013). At times, however, devices could not be unpaired, to enable re-pairing and to re-establish connection, *'...both [other researcher] and I found that we can't disassociate the watch from the HM app. When trying to do so we get kicked out of the app. Only way to do it is to associate the new watch and select Yes that we want the new one to replace the existing watch on the account.'* (WhatsApp message).

Data syncing issues (n=33) occasionally arose between the devices and their related 3PA, which in turn resulted in no data transfer to the ProACT CareApp. The devices with most data syncing issues were the BPM (n=9) and the BGM (n=12). Pairing difficulties with the BPM prevented data collection because the device would only work when paired with the app. By contrast, the BGM could be used without the 3PA and would hold a number of readings for later upload. This allowed participants to continue monitoring while awaiting a technical support visit. Manually uploading blood glucose readings taken offline required opening the iGluco app to sync the data. BGM data syncing issues were, therefore, sometimes due to participants not opening the iGluco app. Nonetheless, it was not always possible to determine the cause of BGM syncing errors, *'BG readings appearing on glucometer screen and also on iPad but don't seem to be saving in iHealth [iGluco app]'* (Help desk, P027), requiring BGM devices to be replaced.

3.3 User Issues

Login difficulties (n=13) were reported by researchers addressing device 'lock out' issues, during home visits. In some cases either participants, or others, had set/re-set the iPad password, which the participant had then forgotten, *'Daughter phoned to say that there was now a passcode on iPad but there wasn't one before'* (Help desk, P025). Login issues also arose following 3PA updates, especially where participants may have responded to a prompt to update the app, which then required login details to proceed. Login details were also required to use the app following an update, *'PwM was logged out of Health Mate app, so logged her back in. When updating the apps, there were problems with validating the iHealth app'* (Help desk, P001).

Calls (n=10) were received requesting replacement of a range of hardware components from the trial-kit. Three participants reported losing watches while on holidays. Other requests were mainly for device charging cables, either because participants had lost them, or because participants believed the cables had not been provided. On occasion, it transpired upon a technical visit, that device cables were not lost but that the participant was using the incorrect charger, *'BPM wasn't charged (using wrong wire…)'* (WhatsApp, P010).

Reports of incorrect use increased during the early deployment phase but declined overall from trial month four. Incidences of incorrect use were greatest for the BPM (n=20), *'She tends to be talking and moving when using it which seems to cause the measurement to fail'* (WhatsApp, P028). Usability of the BPM was also a concern, *'[PwM} can't get BP cuff to work at all - she says when she puts it on she can't get it on tight enough and then when she goes to press the button on the iPad to take reading the cuff falls back off. Said she keeps getting a message saying measurement failed but also mentioned a red light on BP cuff*' (Help desk, P037). The BPM was identified as the most problematic device to use, *'P043 said cuff very hard to use. May try the other [iHealth] bpm with them and see if easier to use? Have had 3 people say this BP cuff is very hard to use'* (WhatsApp, P043). Furthermore, using the BPM was identified as a source of stress for some participants, *'P052 finding it very hard (to use BP cuff) and results in very high reading due to anxiety'* (WhatsApp, P051).

Concerns about the accuracy of readings (n=42) were noted in the help desk log (n=42) and WhatsApp messages, *'P055 has very irregular sleep patterns and the watch doesn't always pick it up properly.'* (Help desk, P055). For participants who had previously used self-monitoring devices, queries were raised about differences in reading values. This was particularly evident for blood glucose readings, where higher readings were noted on the BGM than on participants' own devices, *'...she's not happy with the iHealth glucometer it's showing readings that are much higher than what her own are showing and she's wondering should she be worried…'* (WhatsApp, P007).

3.4 Help Desk Support

Ongoing training was provided by telephone and during technical support visits (n=165). Help desk support was provided by project researchers, none of whom were product technical experts. As such, researchers were often trouble-shooting technical challenges in real-time, through trial and error, *'I think I connected to the 5g[GHz] with the iPad so the 2.4g*[GHz] *didn't show in the scales set up. So next week I will reconnect iPad to 2.4g*[GHz] *(if it is there!) and hopefully get it working'* (Help desk, P004). Where a home visit was unsuccessful, devices were returned to the office to be factory re-set and re-configured with the trial apps before being redeployed and paired with devices on-site, '*If I don't get it working I'll have to bring it away/replace or can I do hard reset?'* (WhatsApp, P010). Use of WhatsApp enabled real-time team collaboration for identifying cause and solution to technical challenges, '*I'm getting this message, never had this problem before. Has anyone any idea what's up?'* (WhatsApp message), or requesting passwords for 3PA accounts and facilitating two-factor authentication when re-setting up device accounts when in the field.

Participants recognised the technical support role of the researchers, *'Just the amount of effort that seems to be behind it, you know… It's sincere commitment, that's what I would call it, you know, rather than sort of just doing a job. Any of the [researchers] I spoke to so far, they all seem to be committed to the thing'* (P057, M, 83, CHF+CHD, T2). Patience was noted as an important characteristic in how technical support was provided. Likewise, speed of response ensured that self-monitoring by participants was not unduly interrupted by technical challenges, *'I was helped along every time and I offered to go in, take it in to get it sorted and I was told "no, no, no, you don't bother. We'll be out to you". And so [they] arrived straight away or as soon as possible to sort it out for me'* (P047, 69, M. COPD+CHD, T4).

4 Discussion

Participation in DHT trials requires mastery of both multiple domains (such as health interpretation and digital technology) as well as (often) multiple devices [11]. Understanding the nature and implications of providing technical support for the use of DHTs is not only pertinent to trials but also necessary for widespread adoption of new DHTs to be effective in real-world contexts [12-13]. The potential for low complexity technical challenges such as getting equipment to work, false alarms, faulty readings, battery life, power supply interruptions, and slow response time in resolving issues, to provoke sufficient irritation with unfamiliar technologies and trigger participants' withdrawal from DHT studies should not be underestimated [12-14]. Users who experience malfunctions in DHT are less likely to continue its use [15] even if users themselves cause malfunctions, such as forgetting to charge their device. Overall usability and reliability of self-monitoring devices, as well as the provision and nature of support to mediate digital self-monitoring, were found to be influential in maintaining ongoing engagement in the ProACT proof-of-concept trial [16]. While none of the ProACT research team were hardware or software technicians, they were sufficiently comfortable and familiar with the devices contained in the trial kit to provide fast, calm, and effective responses. Nonetheless, issues arose that had not previously been encountered by the research team, or for which they may not have had the technical knowledge to evaluate, requiring real-time troubleshooting rather than either simple protocol-based responses or deeper technical evaluation. Familiarity with the trial technology, including the ongoing and sometimes changing functionality of the devices, as well as awareness of contextual factors for participants (such as health status), were critical to enable researchers to react comprehensively and reassuringly to participant concerns as they arose.

Ensuring both DHT trial participation, and effective implementation planning for real-world transferability of innovations, requires comprehensive understanding of the technical support needs of users such as older adults. This paper contributes to this knowledge and encourages further research with other cohorts of novice DHT users.

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SmartGlass Implementation

Lessons Learned in Long-Term Elderly Care

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Abstract. In Long-Term Care for elderly people in the Netherlands, the demand for care is growing and the number of vacancies is increasing. One of the possible solutions to address these developments are innovative technological solutions. An innovative solution could be telemedicine, such as SmartGlass. SmartGlass provides caregivers the possibility to watch and communicate remotely. Due to the covid-19 crisis, the provision of remote care became a necessity, which unexpectedly increased the interest in and the need for use of the SmartGlass by healthcare professionals.
This one-year project researched factors that influence implementation of the SmartGlass on the work floor and the perspective of managers and project leaders on the business case. The aim of the project was to implement four use cases: remote triage (screening),wound care, training of students and observation of misunderstood behavior.
A mixed-methods approach was carried out. Questionnaires on frequency and duration of use, reason for use, and manageability and functionalities of technology were completed by healthcare professionals (N=110). Individual interviews were held with geriatrics specialists, nurses and psychologists (N=27). Two focus group interviews were held with 8 project leaders and managers.
The results of this study indicated positive experiences with the application of SmartGlass technology in long-term care facilities. However, several factors concerning the users, the organization, the technology and the supplier should be taken into account when implementing such a telemedicine intervention, as well as factors that will lead to efficiency gains for a business case.

Keywords: SmartGlass, implementation, telemedicine, long-term care.

1 Introduction

Long-Term Care for elderly people is facing tremendously challenges nowadays. In the Netherlands the number of elderly people is increasing and so is the number of people in need of care. In recent years, people have only been eligible for a nursing home if they have serious health problems that require permanent day and night care [1]. The rest of the elderly population is promoted to age in place. There is also a double aging population: the number of over-80s in the population is growing. At the beginning of 2021, 15 percent of the inhabitants were between 65 and 80 years old, and 4.8 percent were 80 years or older.

Of all employees in the Netherlands, 1.1 million work in care, over 14%. More than a third of these employees (37%) work in long term care and home care. Employment in the sector is growing and further growth is expected due to the ageing population. The demand for care is growing and the number of vacancies is increasing. At the end of 2020, there were an estimated 21,600 vacancies for care professions [2]. In addition almost all employers in the care sector are dealing with hard-to-fill vacancies; 76% of employers experience recruitment problems [3].

The developments outlined above require among other things, innovative technological solutions. One such innovative solution could be telemedicine, such as SmartGlass that offers the possibility to watch and communicate remotely ('hands free video calling'). The assumption is that this may reduce the need to travel and that the available care capacity can be used more flexibly. The use of modern technology such as SmartGlass can contribute to the more efficient deployment of scarce manpower by realizing remote expertise and creating a safe environment for staff, without compromising the quality of care. Much literature is available on the application of SmartGlass in the clinical setting and acute health care, but literature is still scarce about effects and application of SmartGlass in long-term care. For education and training of (nursing) students and health care professionals SmartGlasses were evaluated to be a viable and supporting tool, however technological issues limited its feasibility [4, 5].

In January 2020, four long-term care organizations, Zuyd University of Applied Sciences and Maastricht University, already collaborating in the Living Lab Ageing and Long-Term Care in Limburg, The Netherlands, started a one-year project. In this paper we share the lessons learned about the factors that influenced implementation of the SmartGlass on the work floor and about the perspective of managers and project leaders on the business case.

1.1 SmartGlass

SmartGlass is a wearable computing device worn as a pair of glasses with a built-in camera and two-way audio. A SmartGlass allows expertise to be called in remotely during moments of care. A caregiver can wear the glasses during care delivery, such as wound care or support of Activities of Daily Living (ADL). Another caregiver can watch remotely on a tablet, laptop or phone and provide advice or direction, if needed. There are several smart glasses and providers on the market. In this project, we worked with one provider of a specific smart glasses.

The aim of the project was to implement four use cases together:

1. remote triage (screening),
2. wound care,
3. training of students and
4. observation of misunderstood behavior.

The research plan focused not only on identifying factors influencing implementation but also on investigating the perceived added value and handling of the SmartGlass. However, the Covid-19 pandemic led to a lockdown of the various sites of the healthcare organizations in March 2020, which made managing the Covid-19 crisis a priority and put the project to the rear. The crisis also presented new opportunities: the provision of remote care became a necessity, which suddenly greatly increased the interest in and the need for use of the SmartGlass by healthcare professionals.

2 Methods

The design of the study consisted of a mixed-methods approach, including quantitative and qualitative measures. In the first months of the project, during the first covid-19 wave, the use cases of SmartGlass were selected based on the needs and capabilities of the healthcare professionals. The use of SmartGlass was encouraged by the project coordinators within the care organizations and the care professionals received training in learning how to use the technology. The corona measures, which had a major impact on elderly care, initially created a strong and rapid sense of urgency for remote working in multiple use cases. The experiences of SmartGlass users were surveyed with a questionnaire. The content of the questionnaires were based on focus groups held with staff members involved in het use-cases. Results were reflected upon with project leaders and managers through individual interviews and focus groups. In the end, insight was gained through the following data collection/input:

1. 110 completed questionnaires by healthcare professionals on frequency and duration of use, reason for use, and manageability and functionalities of the technology;
2. Individual interviews with 27 care professionals (geriatrics specialists, nurses, psychologists) focused on the perceived value, feasibility and manageability of SmartGlass;
3. 2 focus group interviews with a total of 8 project leaders and managers on implementation strategies and the business case.

3 Results

3.1 Implementation Factors

Innovation with healthcare technology is complex and this project showed that many factors influenced the implementation of SmartGlass.

These factors could be divided into four categories:

1. *The users (healthcare professionals and clients):* factors related to users included the degree of technology acceptance, fear of making mistakes, and the degree of support for change. After an initial wait-and-see attitude, professionals were open to experimenting with the SmartGlass. The direct experience of added value had a positive influence, the care support could be planned faster and more flexible, because physical presence was not necessary. Norms and values about what constitutes good

care also turned out to be important. The perceived urgency for use, was high at the beginning and weakened later on during the project.

2. *The organization:* with regard to the organization, healthcare professionals indicated the importance of a clear and communicated vision on technology and eHealth, the embedding in care processes, a strong involvement of management, good education and training, a project leader, the use of "super users", and having a help desk to solve problems.
3. *The technology*: care professionals indicated that the technology could be more plug & play (more user friendly and manageable). There were different opinions about the functionalities; some were satisfied but others experienced limitations in e.g. the quality of the image, the battery life, the fixed position of the camera, the combination with the use of other devices. In addition, wishes were expressed for new functionalities, such as a zoom, a recording function and the possibility for asynchronous communication.
4. *The supplier:* support of the implementation of the use cases by the supplier was perceived as important. This concerned in particular good accessibility and quick response to questions or problems. The availability of sufficient, clear training material was also mentioned as a requirement.

3.2 Business Case

When asked about the business case of SmartGlass, project leaders and managers made a distinction between the potential of the technology and the preconditions that this requires.

In this project, we have not been able to deduce that SmartGlass in its current form will lead to efficiency gains. There were simply still too many drawbacks to this particular SmartGlass. The technology still failed too often and was not sufficiently 'plug & play', i.e. it is still too difficult to operate at present. Some professionals expressed a preference for making a physical visit to the client. This was because with the use of the SmartGlass, part of the context or environment of the client remains invisible to the SmartGlass user. Participants indicated that they missed essential information, such as insight into the physical environment around the client, but also information based on smell and touch. Others found it more agreeable to watch from a distance, because they could then watch a client who was at a different location. On the one hand, project leaders and managers concluded that users continued to cling to the traditional way of working when not all necessary or desired requirements and preconditions are met. On the other hand, the experiences gained gave them enough confidence that by using the SmartGlass more efficiently the available capacity of healthcare professionals could be handled and time (mainly travel time) could be saved. However, the amount of glasses needed and the logistics required to properly organize their use in relation to the costs then raised concerns. Based on the price that the supplier was currently asking for the SmartGlass, it was not possible to build a business case that made scaling up interesting.

When the SmartGlass would be more plug & play, had more functionalities and the costs were more in proportion to the benefits, there might be a chance for a positive (financial) business case. A 'pay-as-use' construction in which payment is made according to use could contribute to the affordability of this product. It is also believed that, for some use cases, other available technologies (which professionals often already use), may be able to achieve some of the same goals. Technologies such as a smartphone or tablet may probably be cheaper and/or require less organization.

4 Conclusion and Recommendations

The results of this study indicated positive experiences with the application of Smart Glass technology in long-term care facilities to deliver good quality. However, despite positive experiences, several factors should be taken into account when implementing such a telemedicine intervention. Several limitations related to the users, organization, technology, supplier and questions about the business case influence the feasibility and effects of SmartGlass in this setting. The product was amongst others too expensive to realize sufficient added value. In addition, it is essential to embed the technology in the care process and to promote and facilitate its structural use. Then, it may be possible to make statements on whether the SmartGlass can contribute to more efficient care and meet professionals' needs.

The four care organizations continue the collaboration with Maastricht University and Zuyd University of Applied Sciences on the theme of remote care. Together, they address existing problems in care, if relevant with assistive technology.

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