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CWUAAT

11th CAMBRIDGE WORKSHOP ON UNIVERSAL ACCESS AND ASSISTIVE TECHNOLOGY

Proceedings of the

11th Cambridge Workshop on Universal Access and Assistive Technology

St Catharine's College, University of Cambridge
Cambridge, United Kingdom

27th - 29th March, 2023

Joy Goodman-Deane, Hua Dong, Ann Heylighen,
Jonathan Lazar and John Clarkson (Eds.)

CWUAAT

Preface

The Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT) series has hosted the multifaceted dialogue on design for inclusion since 2002, involving disciplines such as computer science, engineering, design, architecture, ergonomics and human factors, policy and gerontology. The workshops were held every two years at Fitzwilliam College in Cambridge University until they were disrupted by the COVID-19 pandemic in 2020. This report arises from the first CWUAAT workshop after this disruption, which was held in St Catharine's College, Cambridge, in March 2023. The report contains the papers selected by an international panel of currently active researchers for poster presentation at the conference.

The conference theme is *Design for Sustainable Inclusion*, which was inspired and informed by the United Nations Sustainable Development Goals (available at: https://sdgs.un.org/goals). These include, among others, 'good health and well-being', 'reduced inequalities' and 'sustainable cities and communities'. Addressing this challenge requires a cross-disciplinary approach and CWUAAT 2023 invited participants from a wide variety of disciplines to discuss the implications of design for sustainable inclusion openly, critically, rigorously and imaginatively.

We would like to thank all the authors and researchers who have contributed to CWUAAT 2023.

Joy Goodman-Deane, Hua Dong, Ann Heylighen,
Jonathan Lazar and P. John Clarkson
The CWUAAT Editorial Committee
University of Cambridge
March 2023

Content

Designing a Digital Aid to Help Adapt to a Type 2 Diabetes Diagnosis

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Abstract: This paper details the development of a Digital App to assist patients who are newly diagnosed with Type 2 Diabetes in making the lifestyle adjustments required to maintain their health. It was developed over the course of a semester long project in a graduate level Industrial Design studio class. The instructional goals were to introduce and refine skills related to collaboration with industry professionals, research and analysis from multiple sources, engagement with end users, and creation of functional prototypes to facilitate user testing and refinement. The nature of the project and the specific project requirements were defined to provide proper education of future generations of industrial designers for a more inclusive world.

1 Introduction

In the United States, more than 37 million people have diabetes, with 90-95% of them having type 2. With Type 2 diabetes, the body does not respond to insulin normally, resulting in abnormally high levels of blood sugar. Type 2 diabetes often develops in people over 45, but it is increasingly prevalent in children and teens (CDC 2022). Successfully managing Type 2 diabetes requires a number of significant lifestyle changes. These changes can be difficult and lead to social or psychological problems that get in the way of a person's ability to self-manage their diabetes (Garrett and Doherty 2014). The need to perform glucose monitoring for example, has been described by adolescents as the least favorite task, leading some to avoid testing in social environments due the associated stigma (McCarthy et al. 2017).

Behavioral factors are an important component of successful diabetes self-management. There is a high prevalence of depression with diabetes and an opportunity to integrate mental health treatment with diabetes care in order to improve patient and public health outcomes (Ducat et al. 2014). Generalized anxiety disorder and eating disorders have been found to be more prevalent in people with diabetes (Robinson et al. 2013).

This paper presents a case study of a student solution for improved diabetes management. It was developed over a semester long project in a Master level studio course focused on healthcare design. It was sponsored by Cognizant, who supported the project teams with funding and expertise.

Students in the course were provided a brief that outlined prompts for several different project directions. This was followed by virtual panels of industry experts who were made available for questions in order to help students identify a project direction to undertake. The team featured in this paper focused on a topic of 'treatment of chronic diseases.' Once identified, over the course of the project students were expected to engage in collaboration

with industry experts, perform research and analysis from academic literature as well as from forums and end user information available online (referred to as netnography), develop and test evidence-based design solutions, and finally to generate a functional prototype to allow for usability testing, validation and refinement.

Industrial Designers routinely engage users to better understand design problems as it is not possible to truly solve a problem without this understanding. The goal of this paper is to present an overview of the design process used by students in the design of a Digital App intended to assist Type 2 Diabetic patients; specifically to highlight how user research and usability testing were used successfully in the development of a proposed design solution and its impact on student learning and design outcomes.

2 Method and Development

Several project sponsors pitched possible projects to the students at the outset of the semester, after which students formed teams of 2-3 individuals to address their choice of project over a full semester.

After reviewing project choices, two teams of 3 students chose to tackle problems relating to the "Treatment of Chronic Diseases". Initially, both teams of students performed background research in order to better understand the problem, the needs of users, the nature of competitive and compensatory solutions and to identify appropriate design objectives and criteria for subsequent design efforts. As a part of this initial research, students identified stakeholders and the needs of users so that they could develop personas to help better empathize with the needs and concerns of potential users.

After this initial research into the problem, both teams decided to focus on the needs of Type 2 Diabetic patients but taking different avenues to assisting users. The team whose efforts are the subject of this paper chose to address the difficulties faced by newly diagnosed patients in making required lifestyle adjustments (i.e. diet, exercise etc..) to maintain their health.

A virtual interview was initially conducted with an expert from Cognizant in which students learned that Type 2 Diabetes is difficult to self-diagnose and that 25% of the money spent on healthcare in the US is spent on treatment of Diabetes. They also learned that patients diagnosed with Type 2 Diabetes have more difficulties than those with Type 1 Diabetes in making required adjustments in day-to-day diet and exercise habits because Type 1 patients are typically diagnosed at a younger age. The reality is that making changes to an established lifestyle is difficult.

Netnography and a literature review were conducted to research the emotional and mental effects of Type 2 Diabetes. Takeaways from this effort included the understanding that psychological and social problems affect roughly a third of diabetic patients, more prevalent than what would be found in the general population.

Working with family and friends, the team interviewed an elderly Diabetic patient with whom they were able to discuss challenges that she faced in treating her Diabetes. Insights from this interview that made an impression on the design team included (1) the understanding that the first three months immediately following a diabetes diagnosis is different from following phases; and (2) that adjusting to a healthier life-style "can be rewarding".

As the team was interested in developing an App to address the problem, 30 "competitive products" (Apps marketed to Diabetic patients) were evaluated to ascertain their particular strengths and weaknesses so as to identify design opportunities for the design of a new App. It was determined that the general approach of each app could be

assigned to 1 of 4 categories: All-in-One Solution, Diet and Recipes, Community, or Blood Sugar Tracker.

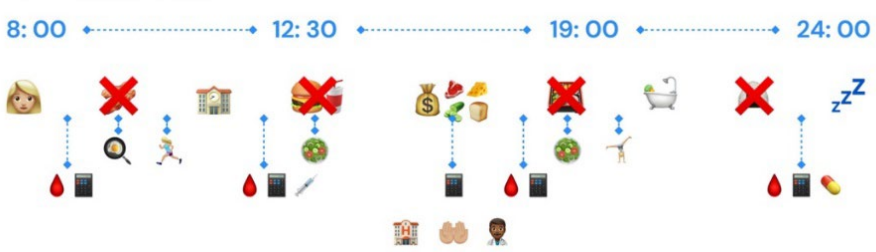

Fig. 1. Journey Map of Lifestyle Changes Required by Type 2 Diabetes Diagnosis

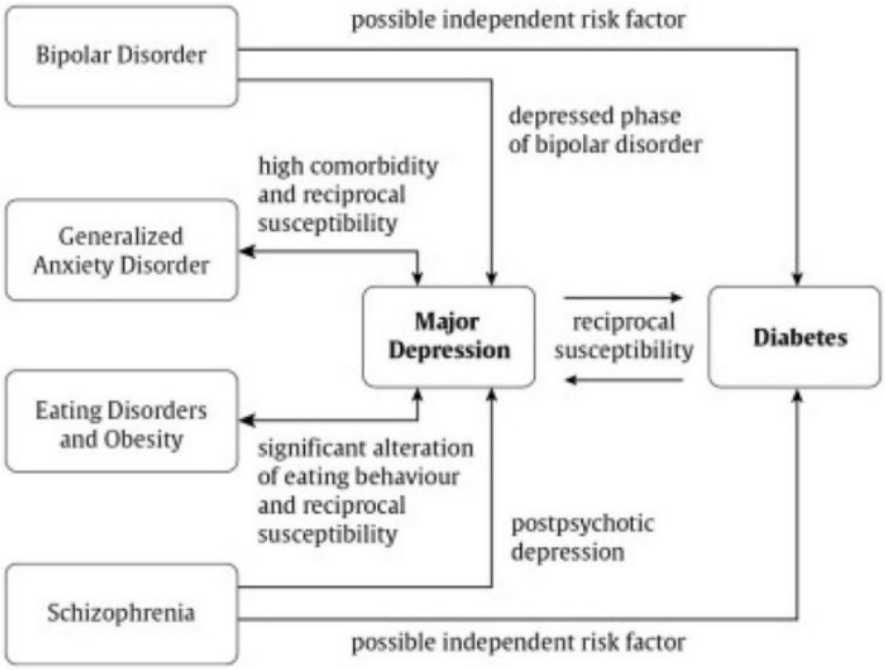

Fig. 2. Correlation between Serious Mental Illness and Diabetes

After this evaluation of competitive Apps, the team noted that many products address issues of blood sugar measurement and lifestyle recording but that none address issues related to the psychological problems experienced by diabetic patients. This was recognized as a key design opportunity.

Initial research findings were analyzed, and design objectives and criteria were developed to guide subsequent design efforts. Teams presented a summary of their preliminary research and the resulting problem statements and design goals to the project sponsors to provide the opportunity for confirmation/correction.

The team that is the focus of this paper developed the following problem statement: “Diabetes patients are faced with huge lifestyle changes and are under stress, which are more likely to lead to emotional and mental issues. This will affect their treatment, attitudes and behaviors, making it a vicious cycle”. The stated goal was “to create a product that mitigates mental issues of diabetes patients in order to let them better focus on healthy lifestyle and diet, and better control their disease”. Specifically, the product should address

issues of emotional support, adjustment to lifestyle habits, and provide an online community and treatment guidance.

At this point, student teams proceeded to generate ideas using a 2D ideation process. Several different brainstorming techniques were discussed in class and a variety of suggestions were made to help students generate as many ideas as possible throughout this process. Students were encouraged to approach the problem incrementally (i.e., break overall problem down into manageable pieces), from different POV's (including generation of ideas that would make the problem worse…), to changing up their environment and activities to maximize productivity. (These strategies are based on the understanding that the range of ideas one can generate is necessarily limited by one's experience and surroundings).

Ideas were initially sorted according to common topics or themes and subsequently were then organized into concept proposals using morphological matrices.

The initial App concept proposed by the team was envisioned as a "one-stop experience" that would permit patients to manage their daily life in key areas including diet, social life, exercise and medication - all previously identified as pain points for the newly diagnosed Type 2 Diabetic patient.

In the case of digital solutions, wireframes were prepared to represent possible configurations for each App concept.

At this point, the team recognized that additional research was needed to better understand user needs. 6 interviews were remotely conducted with Diabetic patients. Most of these interviewees had prior experience with Diabetes support groups and the larger community. By organizing and evaluating the observations made during these interviews, it was observed that those patients with a generally positive outlook tended to offer more insights and exhibited more control of their outcome as opposed to those with negative outlooks, who tended to lack motivation, complained about the need to adjust their lifestyles and also exhibited poorer physical conditions. Respondents reported that the need for lifestyle changes and the inability to control their behavior had the most influence on negative outcomes. It was recognized that differences between individuals may make it necessary to provide both general and individual treatment strategies. It was also determined that patients typically need immediate results when testing for blood glucose levels after eating or exercising. Finally, it was also determined that there seems to be a causal relationship between a lack of medical knowledge and negligence in self-care.

After conducting these user interviews, the student team developed additional refined concepts that specifically addressed the pain points identified by interviewees. Some of these concepts included physical components in addition to the digital App functionality. The three refined concepts were evaluated in terms of their inherent "Pros" and "Cons" in order to identify the most promising direction. After careful consideration a single concept was selected for subsequent development based on its' "patient-centered" platform "that can provide all the information and support patients need to go through the tough transition period [immediately after a Diabetes diagnosis]".

Refinements were made to all aspects of the chosen concept. Personas were developed to represent three different user groups, including mentor/guides, optimistic learners and negative patients. The intent of these personas was to help the team better empathize with users and to understand the interaction between and relationships among the different user groups.

There are multiple relationships in which users can interact with one another as they transition between the "Negative Patient", "Optimistic Learner" and "Mentor" roles - as shown in Figure 4. This led to the concept of users connecting with "Data Twins" and "Mentors" to ease the transition period after a Type 2 Diabetes diagnosis, a result that is innovative and central to the team's approach to the problem.

The team then created a low-fi digital prototype of the refined App design. This prototype was tested with a group of four UX designers, who were asked to complete a list

of tasks. The completion time and rates were documented and analyzed to validate the usability of this App concept.

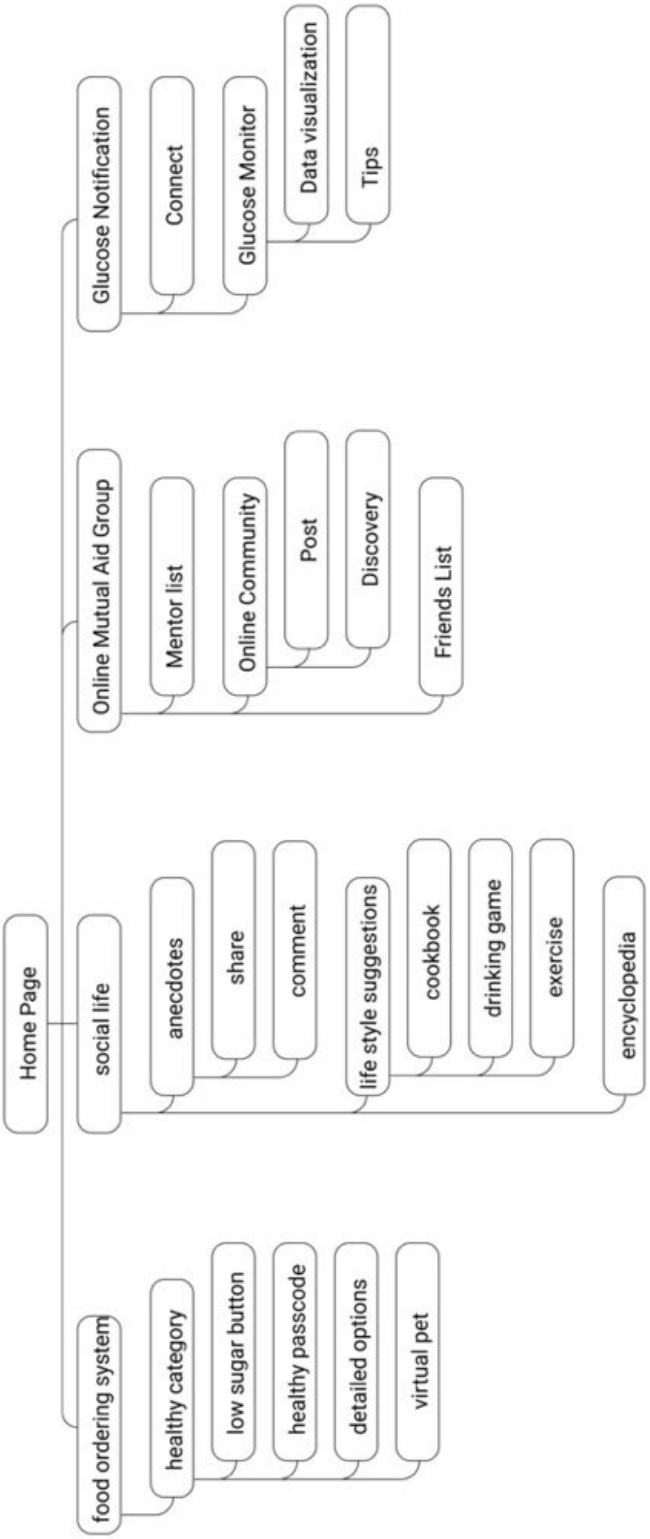

Fig. 3. Key Features Needed in App Solution

The team then refined the final App design based on the results of this preliminary usability testing. As a part of this final refinement, the team developed a graphic theme that addressed the colors, icons and typography used in the final App design to provide a unified aesthetic. Given sufficient time & resources, the next step would be to test the refined App design with actual end users – newly diagnosed Type 2 diabetes patients to learn whether the proposed app could be an effective tool in making the required lifestyle transitions.

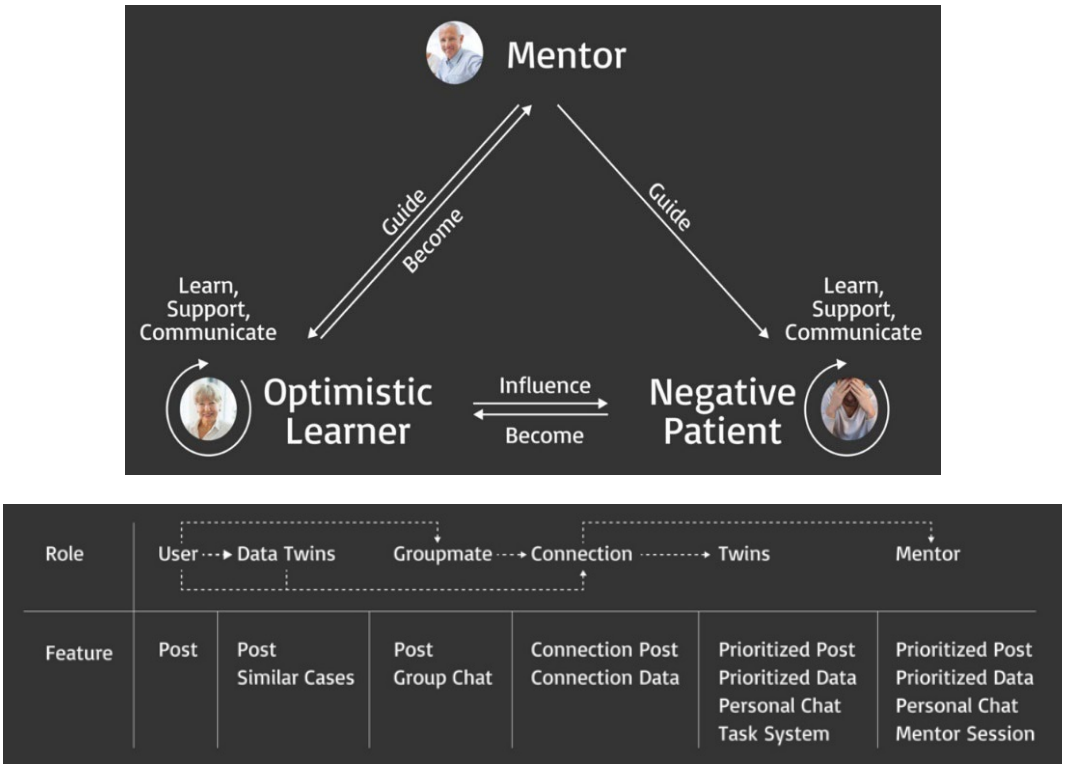

Fig. 4. User Flow and Relationships Key to Final Concept Based on Analysis of User Interviews

3 Results and Discussion

Using a design process that involved engagement of users during research and preliminary concept refinement based on limited testing of initial designs with users permitted the team to develop a more relevant solution to the identified problem. Students benefited from working directly with industry experts and interviewing potential users. The final solution developed by the team was refined in response to testing of a low-fi prototype by UX designers with expertise in the development of digital Apps. Clearly this process resulted in a more successful proposed solution to the problem(s) identified by the team. While user testing of proposed solutions was an educational requirement for this studio, the degree and effectiveness of testing varied substantially between the teams. Testing with actual users would ultimately be more meaningful.

The final solution developed by this team was particularly innovative in the aspects of the idea of "Data Twins" (users with similar characteristics) and creating mentors for the newly diagnosed (by "Becoming a Giver"). This concept was illustrated in the final presentation by the team through the analogy of a novice rock climber typically seeking

guidance from a more experienced climber and the reliance of climbers upon one another during climbs (i.e. connected with climbing ropes). These aspects of their solution most certainly would not have been identified or pursued further had the team not engaged users during their research efforts or had the benefit of interacting with industry professionals.

4 Conclusions and Recommendations

The improvements in final project deliverables demonstrate the effectiveness of user testing and subsequent refinement and resulted in designs that were demonstratively more effective solutions to the problem. It is the admittedly subjective opinion of this author that only 3 of the 6 teams that participated in this project developed unexpected or particularly innovative solutions. 2 of those 3 teams employed significant user research and usability testing in developing their solutions.

The design team featured in this paper identified several action items to further improve upon their proposed solution in future efforts – including the need for usability tests with target users (i.e. evaluation by users who would be in the position of incorporating the Digital App into their lives while adjusting to a Type 2 Diabetes diagnosis vs. UX designers), developing a web-based version of the platform, developing a version for elderly users, as well as the identification of potential sponsors and technical support resources and ultimately developing a business model.

Acknowledgements

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Inclusive Tourism: Co-developing a Methodology to Uncover Business Opportunities through Universal Design

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Abstract: Despite the increasing attention for inclusive tourism, from both a social and economic perspective, the actual implementation remains a challenge for many tourist accommodation providers. Here, we describe a 2-year project in which the possibilities of Universal Design as a strategy were explored for the purpose of structurally uncovering and addressing potential business opportunities. Based on three 'building blocks' (i.e., an inclusive customer journey, a multi-level approach linking mindset, management and infrastructure, and a focus on diverse user needs and personas) and in close collaboration with a group of stakeholders, including 17 accommodation providers, we co-developed and executed a seven-step process to integrate and implement Universal Design in their business model. Results of the project are discussed as to how the applied methodology can act as a catalyst to increase knowledge and understanding of how diverse guests experience their travel journey and how this knowledge can be used to address inclusive business opportunities in practice, rendering tourist accommodations more economically and socially sustainable and more welcome to all.

1 Inclusive Tourism as a Social Right, a Business Opportunity and a Challenge

Inclusive tourism as a concept has been receiving increasing attention in many countries (e.g., see the European Network for Accessible Tourism), both from a social justice lens as well as from an economical perspective (e.g., Biddulph and Scheyvens 2018; Singh et al. 2021). Also in the region of Flanders, the northern part of Belgium, there is a growing awareness of the importance of making society in general but also the tourist sector in particular, more inclusive for all. Indeed, there is a growing and diverse group of people that want to enjoy the benefits of staying in a tourist accommodation, but were de facto excluded because the physical, social or virtual environment was not compatible with their needs. Research further shows that for their holidays, Flemish people with specific care

needs also prefer an inclusive approach instead of going to separate specialized care facilities (Pinpoint 2015). At the same time, although overall occupancy rates in Flemish accommodation providers had been rising (before Covid), there was still a considerable improvement to be made in the overall occupancy rate (64% in 2018, Toerisme Vlaanderen 2018). Combining these two observations, it would seem that adopting a Universal Design (UD) approach, where environments, products and services are designed with a broad diversity of people in mind, would provide considerable opportunities for both (cf. Michopoulou et al. 2015).

However, in practice, it remains a challenge for accommodation providers to really embrace and implement inclusion in their business model. Research with entrepreneurs in the Flemish province of Limburg, indicates that the very strong feeling of responsibility in this context, the necessary investments as well as a too limited knowledge about the needs of different target groups are the most important bottlenecks in effectively implementing inclusion in their business (Cops and Hermans 2018). Research with Flemish architects confirms that budget constraints but also skepticism from other stakeholders are perceived as barriers to implement a UD approach (Ielegems et al. 2019). So, despite an increasing awareness of the societal value of inclusion, the growing demand of people with specific needs for accessible tourist accommodations and the existing economic potential, the actual implementation for individual business owners remains a challenge.

2 A Methodology to Uncover Business Opportunities through Universal Design: Three Building Blocks

Within the context sketched above, we set up and executed a 2-year (Oct 2019 - Sep 2021) applied research project, funded by a Flemish governmental agency (Vlaio, the Flanders Innovation and Entrepreneurship agency, nr. HBC.2019.2052), with the aim of developing ways to stimulate and implement the potential of Universal Design as a 'business transformator' in the tourist accommodation sector in Flanders. Earlier research in the region (Sys 2015) had shown that a holistic approach, taking the financial aspect, communication, and customer friendliness into account would be essential for a transformation towards more inclusion in this sector. So, to ensure a holistic approach, covering the whole value chain, the project included a steering group of representatives of i) the accommodation providers, ii) suppliers (e.g., furniture companies, architects, website developers), iii) governmental and policy organizations (e.g., city council, tourist organizations), iv) the end-users, and v) networking and knowledge organizations (e.g., relevant academic or professional research groups).

The specific goal of the project was to develop and test a method to realize and facilitate the integration of Universal Design into the sector's business models. And while some general underlying principles were clear from the start, the project was explicitly intended as a co-design project, where detailed development of the method occurred in close collaboration with different stakeholders. At the heart was a core group of 17 entrepreneurs who exploit a tourist accommodation in Flanders (five B&B's, five hotels, two youth hostels, four camping grounds with vacation homes and one business with vacation homes) with whom we co-developed and ran through a seven-step process centered around three 'Building Blocks'.

The first central Building Block was to approach the business from a multi-level perspective, as the goal of the project was not about offering a fixed 'solution' but rather to stimulate companies to adopt and integrate UD principles in their business thinking. Therefore, we looked at three levels within the company. The 'accommodation level' refers to the more tangible, infrastructural elements, while the 'management level' refers to how

the company DNA is translated into the daily workings, including marketing and communication. Lastly, we also included the 'mindset level', relating to attitudes regarding business transformation, i.e., integrating UD and effectively implementing changes into all layers of the organization.

The second central Building Block was the 'inclusive customer journey'. Given the importance of every step in the process of a tourist stay, we made this customer journey explicit and included four phases ("touchpoints"): i) planning and booking, ii) traveling to and arriving at the accommodation, iii) the time spent staying on site, and iv) going back home and remembering. For each phase, we looked for minimal criteria that would be essential for a person with certain needs to stay there independently, as well as other criteria that create a welcoming experience for everyone.

Finally, the third Building Block consisted of a set of 26 user needs to operationalize the diversity of guests when examining the customer journey. This does not cover the needs of the whole population, but it does considerably broaden the perspective to a much more diverse group of potential guests. To effectively communicate and discuss these issues with the participants, we developed a set of 12 personas, embodying this set of user needs. Although the use of fictitious but concrete people can also have disadvantages (e.g., Turner and Turner 2011), talking about personas is considered to create more understanding and awareness than talking about mere user needs and it makes assumptions explicit (e.g., Schulz and Skeide Fuglerud 2012; Van der Linden et al. 2019). However, it was also clarified to participants that each persona represented user needs present in many other profiles (so by addressing the needs of one persona, a much larger group would benefit).

3 Co-developing a Seven-step Process to Implement UD

With this basic methodology, we co-developed and executed a seven-step process with the 17 cases to integrate and implement Universal Design in their business model. In *Step 1* we created a literature-based UD screening, with 244 questions, linked to (combinations of) the three Building Blocks. Some questions were linked to a single Building Block (e.g., general questions on mindset, such as on the attitude dealing with criticism), but the majority focused on assessing specific criteria related to mindset, management or infrastructure for a given touchpoint, taking the set of 26 user needs into account. For example, items on *management* in the *planning and booking phase* included questions on graphic design elements of the website, on available information (e.g., is there a floorplan of the room on the website?) or on the possibility for guests to express certain needs during the booking process.

Step 2 involved testing, updating and executing the screening in each of the 17 accommodations providers, while in *Step 3* the resulting data were analyzed to provide each entrepreneur a case report detailing what is good and what could be better overall, per touchpoint and in terms of the target groups for which the accommodation is already suitable or not. Overall, results show for example that all cases meet the minimum criteria to let the persona 'foreign tourist (not speaking the language)' stay there independently, but on average more than 35% of relevant items were not in order, so there are still opportunities for improvement, especially at the management level (where most opportunities to improve could, on average, be found). Surprisingly, many cases did not meet the minimal requirements for 'older people' and 'people in a wheelchair'. Usually this involved just one (relatively minor) element that lacked, but this result did function as an eye-opener for the case in question and emphasized the importance of a holistic approach.

In *Step 4* the results were further processed together with the participant. To determine the UD business opportunity priorities that best fit the concept and potential of the specific accommodation, other variables including timing and cost indications needed to fulfill missing criteria were also integrated. Based on this, the participant then determined a priority by focusing on either making a specific touchpoint more inclusive for all, or on making the whole customer journey more welcoming for a particular target group. Next, for this selected priority, a more detailed action plan, specifically tailored to the specific business, was then developed (*Step 5*). This consisted of a concise checklist and a more elaborate guide with background information, relevant links, measurements… Tools in this action plan would support participants to undertake targeted actions to a business transformation on the short term as well as the long term (*Step 6*). Lastly, in *Step 7*, a re-evaluation of the business is to be executed (cf. Step 1) to assess the actual improvement following the interventions. Of course, as Universal Design and inclusion is not an end-state but a continuous process, participants are also invited and stimulated to continue to work along this track.

Unfortunately, the Covid pandemic, which started early 2020, has had a very negative impact on the tourist sector and the project, preventing a more systematic quantitative evaluation of the results of the seven-step process. Still, the qualitative feedback from the participants has largely been positive and the co-design process has yielded a number of successful trajectories of accommodation providers implementing UD. These success stories are now also actively shared with the sector as showcases for the added value of making your accommodation more inclusive for all, to further stimulate the uptake of UD and inclusive tourism.

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Design-led Audio Technology Deployment at Knepp Rewilding Estate: Technological Pitfalls and Opportunities

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Abstract: This article documents a design-led technological deployment of *machine learning audio technologies.* The scoping and positioning work presents opportunities for preferable sustainable futures. Technological proposals were deployed in renowned rewilding locale, *The Knepp Estate*, in collaboration with *Oppo* (n.d.). The work used 'research in the wild' with technological deployment methodologies, and it was supported by stakeholder interviews with wildlife rangers, ecologists, and landowners.

We concluded impacts, pitfalls, and benefits of design-led machine learning audio in environments for conservation and public edification, through serendipitous, and planned audio interactions / recordings. The research objective was to *comprehend the potential: impacts, pitfalls, benefits, and opportunities of remote audio interactions. The aim investigated and unpicked scaling of this approach*.

Keywords: Sustainability, Digital Economy, Sensing, Design-led, Machine Learning.

1 Introduction

We have become distanced from natural world, causing shifts in our impacts and behaviour (Papworth et al. 2009). These trends are replicating across industries impacting our (public) view on sustainable practices. However, personal experiences (of nature, wellbeing, and environment) can transition our behaviour (Lekies et al. 2015). Our state of climate requires urgent action (The Economist 2022).

Sensors and accessible technologies include remote monitoring (NHS 2020), citizen data informing science (PLOS 2022), tool replication (Public Lab contributors, n.d.) and more. Sensing enables learning from parallel situations, e.g., growing food and redesigning cities to reduce heat or positive action for rewilding (Jung et al. 2021). We frame 'audio sensing', in this article, specifically for birdsong and wildlife species recognition (Arce-Lopera et al. 2021).

The works 'design space' crosses technological, ecological, ethical and user divides (holding potential) requiring scoping via ethical design-led means. It also embodies "the more we engage, the more we care about our environment, the more chance it has a priority in our personal/national decision making" (Foster and Clark 2018). This work emulates Nature Positive values: 1. "Invest in innovative technologies enabling efficient, effective conservation and sustainable use of natural resources" and 2. "Invest in human capital, to develop skills" (Nature Positive 2021).

Public Interest Technologies (PIT's), empower communities and municipalities creating 'optimum' conditions enabling data sharing for good leading to 'evidence based' societal change. PIT's inform digital economies and "how data is forming a currency people want stake(s) in", benefiting human/non-human species rights and leveraging amenities for wider audiences (McGuinness et al. 2021).

In summary, authors believe enriched data experiences and digital interactions have long-term benefits. They stimulate our experiences, impact our behaviour and wellbeing for sustainable benefit(s). We are not intent on replacing physical experience(s) but provide distanced interactions to enriching lives. Without disturbing natural world(s) but nurturing it and in turn increasing our wonder of it.

1.1 Technological Deployment Site

Since 2001, Knepp (pioneering rewilding project) uses grazing animals as the drivers of habitat creation. They are seeing extraordinary increases in wildlife. Extremely "rare species i.e., turtle doves, nightingales, peregrine falcons, and purple emperor butterflies are now breeding" on the 3,500-acre estate in West Sussex (Schulte To Bühne et al. 2022). Knepp is radically different to conventional nature conservations as goals and target species are not the motivating force. Its "driving principle is establishing a functioning ecosystem where nature is given freedom" (Tree 2017). Knepp hosts The White Stork Project intent on restoring 50 breeding stork pairs by 2030. The Knepp storks are free flying/living in the local area.

1.2 Method

Work included three (static) technological deployments over one month in August 2022. Deployed technologies used Bird.net audio machine learning software and opensource Raspberry Pi hardware, depicted in Figure 1. Deployed technologies had machine learning software to recognize and record birdcalls, stork bill clacking and wildlife audio. Deployments are essential mov[ing] design out of the lab, making it into an unremarkable feature of everyday life (Tolmie et al. 2009).

The "most profound technologies disappear, weaving themselves into everyday life until they are indistinguishable from it" (Weiser 1999). Deploying technologies and proposals enable better understanding of 'real world' capabilities (Tolmie et al. 2009). Gaver et al. (2007) comment "designs are not complete until it's used" akin to 'research in the wild', testing artefacts and documenting responses. Our ethical study conditions ensured recording technologies were deployed in non-publicly accessible locations, under password protection protocols.

Ten participants of Knepp staff, including landowners, rangers, ecological experts and volunteers, were interviewed under informed consent (Shafieisabet and Haratifard 2020), identifying potential impacts, pitfalls, and benefits of remote audio recording, using 'research through design' methods. Knepp staff reflected on:

1. *Potential scope for public purposes and communication for human species?*
2. *Potential for scientific rationale(s), for sustainability of non-human species?*

Fig. 1. Technological deployment with the stork enclosure at Knepp. *Images courtesy of James McCauley Photography.*

1.3 Results and Stakeholder Reflections

Due to the article length (a short paper), we framed the Knepp staff responses into impacts, pitfalls, and benefits of contextual audio monitoring. The authors shared the audio data with the interviewed participants, informing discussions. But it was not possible to include the gathered audio data within this article.

Impacts:

- *Emotive responses:* "sound alone can be overwhelming. We do Nightingale safaris, in the dark. It's just auditory. We've had people, so overwhelmed by emotion of what they're experiencing, in the dark". (*Ranger 01*).
- *Remote connections:* connecting "people with nature has huge scope, also the scientific monitoring side, being able to survey an area better than perhaps you could if you were just a person on foot". (*Ranger 04*).
- *Wider Communities:* there are many developments levering the sound of our immediate natural environments and domiciles i.e., for hospital wards, wellbeing, schools, and community groups.

Pitfalls:

- *Openly Public:* bird song apps are misused by amateurs, encouraging birds to "sing more frequently", changing natural behaviours (BBC News 2013).
- *Skills Divide:* we are reliant on tech and "no longer building our unique nature aware skill set, i.e., identifying birdsong" (Moss 2021).
- *Mis-use:* through our deployment, technologies were never 'openly broadcasting', data was captured onsite, accessible via password protected devices. Public contexts set a different ethical challenge worthy of further exploration.

Benefits and Opportunities:

- *Autonomy:* linking inaccessible spaces to people, e.g., remote piers, remote cliff habitats could increase interest and behaviour whilst reducing potential damage of physical footfall.
- *Sustainable practice(s):* audio interactions that can not only benefit stakeholders but also improve our decision making and subsequent behaviours, e.g., audio of surrounding nature reserves influencing our behaviour and actions.

- *Health Environments:* hospital spaces with outdoor spaces can be linked to nature havens for health and wellbeing impacts. Akin to BBC 'Slow TV' movement. Encouraging sustainable architecture and conservation actions in the area.
- *Digital Economies:* collecting data for employment, by approved or 'pre-trained' parties, e.g., supplying annual data on waterways, air quality, etc.

2 Conclusion

Insight(s) from interviews included benefitting science practice and engaging local populations. Knepp staff stated their communities respond totally differently when they have evidence and recorded activities. They also highlighted the opportunity for public edification, using recorded material for 'slow radio channels' or seasonal audio interactions.

There is potential for a larger research area (and project) that can link sensing and wellbeing, for local communities to positively influence or transition behaviors. Authors see this as a means for more heightened digital interactions transitioning humans' local behaviour, at a safe uncompromising distance. There is clear potential to benefit science practices based on repeat trials and deployment lengths.

Future work will include sharing data sets or deploying live feeds to corollate potential impacts on (local) residents. Finally, there is strong potential to share audio data with health institutions for wellbeing or meditation purposes.

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Methods of Studying Inclusion in Public Toilets: A Contextual Review for Urban India

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Abstract: Public sanitation systems are an essential component of sustainable and inclusive cities. In the context of urban India, there exists a spectrum of human diversity across age, ability, gender, and socio-economic status. Despite the variability in demographics, the need for accessibility in public toilet systems remains constant. There exists numerous barriers and challenges to inclusion in urban public toilets of India. While there are numerous efforts also being undertaken by various stakeholders to address the issues, it is necessary to have a holistic understanding of the current state of inclusion in the public toilets of Indian cities. Thus, to enable the above-mentioned intent, this paper identifies and interprets the existing means of studying inclusion in the context of public toilets from a global lens, while bringing forth a critique of appropriation in the Indian urban scenario. This paper concludes that there is a need for more context-specific studies of Indian cities to better understand the adaptability of the methods used globally in the Indian scenario.

1 Background

With increasing urbanisation, making cities sustainable, accessible, and inclusive, is increasingly becoming a topic for numerous discourses across the world. It has been established that public sanitation systems play a critical role for the same (Kitchin and Law 2001). Despite sanitation being a fundamental need for citizens, there are vulnerable groups in every city, who face numerous challenges to get equitable access to the urban public sanitation systems. The lack of inclusion in public sanitation systems leads to reduced participation in daily urban living for the vulnerable groups which includes persons with disabilities, elderly, women, transgender and others.

As of 2020, nearly half of the world (54%) did not have access to safely managed sanitation. (WHO and UNICEF 2020) In the Indian cities, the need for more public sanitation amenities is increasing as the urban population rises. There are considerable efforts being undertaken by the Indian government to address this, which includes the Swachh Bharat (Clean India) Mission. Under this initiative, more than 7 million toilets have been constructed in the Indian cities (Kant 2021). However, inclusion in public sanitation facilities remains a challenge, in a society with rapidly changing demographics.

At the centre of the concept of inclusion, coinciding with the concept of public sanitation, is the citizen. The citizen represents human diversity which may vary across an intersectional spectrum of age, ability, gender, socio-economic status, and other such

aspects. The diversity of the citizen also implies the diversity of challenges and barriers faced by the citizen in public sanitation. More than 2.1% of the population of India lives with some form of disability, and 31% of them reside in urban areas (Government of India 2021). This proportion is expected to increase in the coming decades. Similarly, the elderly population of India is 138 million as of 2021 and projected to increase by 41% touching 194 million in 2031 (Zompa 2021). The above data highlights the increasing need for inclusive public sanitation systems in Indian cities. However, despite ongoing efforts, there is a long way to go to address all the barriers and challenges faced by various vulnerable groups to have equitable access to public sanitation systems in Indian cities.

To progress further, an assessment of the present situation in terms of barriers and challenges to inclusion is required. Thus, the intent of this paper is to identify and review existing global models of studying inclusion in the context of urban public sanitation systems. The review shall inform further on the suitability of the methods in the Indian context.

2 Methodology

The papers to be reviewed were identified using a bibliographic search method of the well-recognised Scopus database. The keywords to search were identified as 'urban, public toilets'. The fundamental theoretical understanding for further screening was that inclusion in public toilets is primarily an intersection of 'design', 'policy' and 'management'. This streamlined the process of identifying the documents. The screening process involved filtering documents based on limiting search to relevant subject areas (viz. social sciences, engineering, arts and humanities, business, management and accounting, economics, econometrics and finance and multidisciplinary), limited access, relevance to the topic, and consideration of overlaps. (See Figure 1).

3 Results

It may be noted that five (05) out of twelve (12) reviewed papers were overlapping between the search results of design, policy, and management respectively, thus reinforcing that the three aspects go hand in hand for inclusion in public toilets. Nine (09) out of twelve (12) reviewed papers are from the global south thus indicating possible adaptation of methods in the Indian context owing to certain similarities in socio-economic dimensions. It was understood that there is a possibility of refining the three dimensions of inclusion from 'design', 'management', and 'policy' to 'human-centric or people-oriented', 'infrastructure and management-oriented' and 'urban planning-oriented' dimensions. These derived dimensions are more specifically relevant to the methodological understanding derived from each of the papers as discussed in this section.

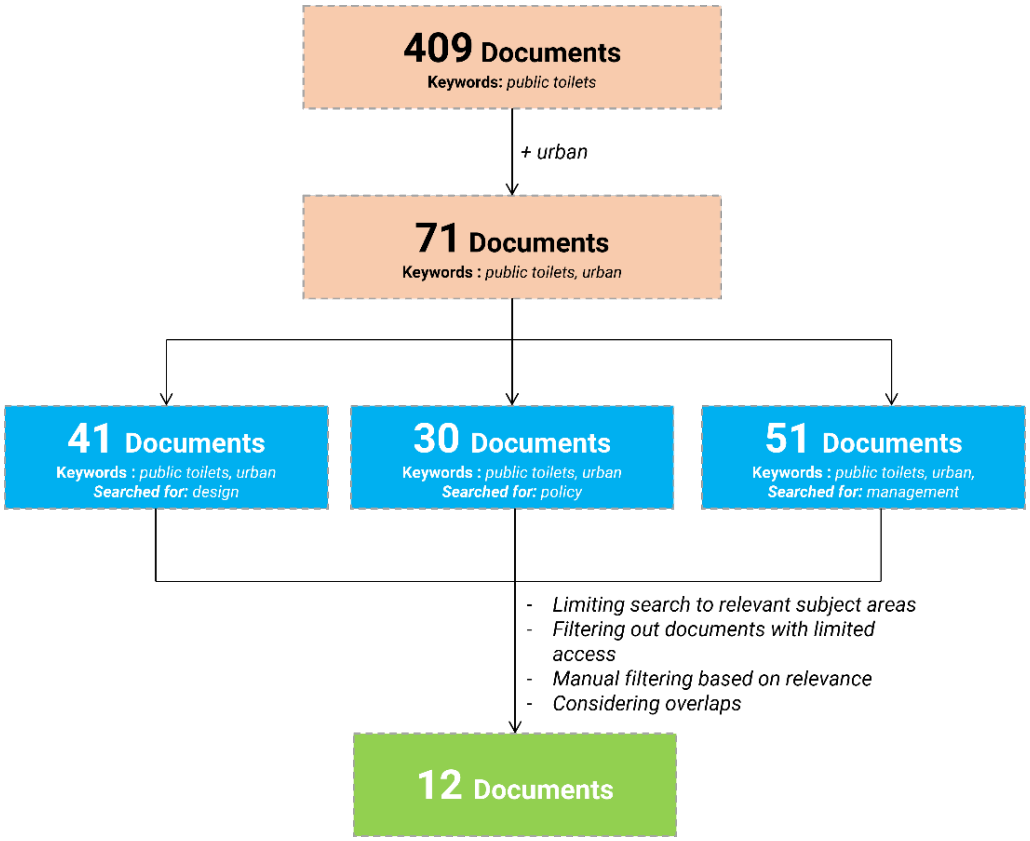

Fig. 1. Diagram of Keyword Search and Screening Documents from the Scopus Database

3.1 Human-centric Dimensions

Human centric or people-oriented dimensions of public toilets are crucial in the understanding for inclusion as the person is at the centre of the public sanitation experience. In a context-specific study of the United States of America (USA) by Anthony and Dufresne (2007) the historical discrimination in public toilets by gender, ability, sexual orientation, class, race, etc. has been extensively described, whilst also shedding light on other problems posed by public toilets for persons with disabilities and other diverse conditions including women, children, elderly, and caregivers. The authors have reviewed legal sources as well as media coverage, apart from scholarly publications. The paper signaled a growing revolution in the domain of public toilets, and it was able to describe novel technological inventions being developed to tackle the barriers to an inclusive public toilet experience. Even though the paper mentions the problems posed to various user groups, it focuses primarily on gender and family toilet issues and presents twelve possible solutions spanning across legal, planning, design, and other aspects, in the context of the twenty-first century. Methodologically, it highlights the possibility of deriving insights from reviewing policies and media coverage for an improved understanding of human-centric dimensions of inclusion in public toilets.

A broader review on human-centric dimensions in inclusion was carried out by Moreira et al. (2021) wherein a detailed systematic literature review was carried out on sanitation access in urban public spaces. The study was carried out considering relevant keywords as derived from the human right to drinking water and sanitation (HRWS) report published by the UN in 2019. The search was carried out using keywords derived from relating

elements described in the UN report to the areas of public health, sanitation, and urban planning. These included terms like accessibility, gender, provision and urban planning, human rights, etc. The paper was able to bring out recent trends of publications in the domain of public toilets, whilst highlighting that the area of human rights to public sanitation is still not sufficiently explored. The study was beyond any fixed geographical context. It demonstrates the use of a systematic review as a method to identify the various general themes of access and inclusion in urban public sanitation from across the globe which (in this case) were provision of the toilets, sex and gender, accessibility, and health.

To capture human-centric dimensions in terms of the ground reality perspectives, survey-based methods have been used. An exploratory field study to understand the human needs in addition to problems posed by toilets was conducted by Afacan and Gurel (2015) in the context of the city of Ankara in Turkey. The study used a mixed-methods approach, having both qualitative and quantitative components. The qualitative component involved field observations and studying photographs of public toilets of the city to understand the problems in what exists on the ground along with informal discussions with citizens. The quantitative component involved statistical analyses and factor-based analysis methods to assess the results of structured interviews and formulate six key 'inclusive public toilet factors'. The paper also reinforces what studies by Anthony and Dufresne (2007) and Moreira et al. (2015) have mentioned about the importance of studying the evolution of policies and the political domain for inclusion and thus the consequent impact on the human-centric dimensions.

Sahoo et al. (2015) have demonstrated methods of deriving insights on deeper levels of human-centric dimensions in the sanitation experience, in the context of the women of urban slums in the state of Odisha, India. This paper focuses on assessing psychosocial stress of women in their daily routine of sanitation related activities. The methodology involved a grounded theory approach involving an iterative process of sample selection, data collection and analysis. In-depth interviews in local language (i.e., Odia) were conducted for data collection followed by analysis using coding-based approaches. The process was able to bring out three broad categories of psychosocial stressors which were environmental, social, and sexual violence stressors. The study goes one-step forward to also understand to the behavioural regulation practiced by women to avoid these stressors and the variations in the stress based on geographical differences within the state.

It is observed from the literature that environmental and infrastructural factors play a key role in affecting the human experience of inclusion in public toilets, and this impact is discussed by Peprah et al. (2015) for the case of low-income neighbourhoods of Accra, Ghana. A mixed-methods approach was applied over a period of six months in four neighbourhoods with the intent of gathering information on the physical state of public toilets, the population's usage rates, and the socio-demographics and opinions of public toilet users. The data collection involved household surveys, weekly observations of the public toilets, exit interviews conducted at the public toilets and focus group discussions. These methods brought out results highlighting the level of access to the sanitation, the physical conditions of the public toilets, the demographic breakup of the user groups and their opinions in terms of satisfaction level and demands. The paper brought out factors that deterred use of public toilets and hence contributed to the practice of open defecation in the neighbourhoods.

3.2 Infrastructure and Management-oriented Dimensions

The public toilet itself is an infrastructural element and its management plays a critical role in creating an inclusive experience for all citizens. It is interesting to realise the economic

aspect of management and infrastructure which makes sense as to being a critical factor in the scalability and efficiency of public toilets in the urban realm. Gaisie et al. (2018) have studied this aspect in the context of Kumasi in Ghana in terms of the cost and quality of outdoor sanitation facilities in informal urban settlements. The study involved collection and analysis of both primary as well as secondary data. The secondary data covered both global and local contexts, with the global component covering local component covering reviews of development plans of the city and the larger urban development dynamics in Ghana. The primary data collected involved semi-structured interviews of heads of public institutes and agencies handling the water and sanitation facilities, in addition to that of traditional leaders and local representatives. The household surveys were conducted using structured questionnaires in informal settlements. This study was able to bring out the economic implications of the project on the people.

There is a shortage of sanitation quality metrics that are theoretically supported in a way that enables empirical comparisons of quality across various types of sanitation, even though there are constant discussions about what constitutes adequate sanitation. To capture universal features of sanitation quality from a public health perspective, Tidwell et al. (2018) in their study mention the Healthy Sanitation Framework (HSF) which proposed five dimensions—hygiene, use, sustainability, desirability, and accessibility—for measuring sanitation quality. The authors conducted their study in the peri-urban areas of Lusaka, Zambia, and developed a Peri-Urban Healthy Toilet Index (PUHTI) to gauge the level of on-site peri-urban sanitation. In a peri-urban area of Lusaka, Zambia. Despite obstacles to systematically measuring validity, a composite measure created from these categories demonstrated high reliability and reasonable validity. Methodologically, a general framework was derived first which was followed by developing it into an index by using field-based qualitative formative research methods in addition to consulting local experts. This demonstrated contextualizing frameworks to measure infrastructural and management-oriented elements of public toilets of a particular area.

Another demonstration of contextualising efforts, in the Indian context, is described by Pathak (1991) wherein he discusses about the initiative of ‘Sulabh Shauchalaya’ i.e., affordable toilets and how it was developed as a scalable model throughout India. This paper provides a theoretical explanation of features and impact of affordable innovations by a specific Indian non-governmental organisation. Even though the study itself does not describe any particular methodology, the importance of adopting appropriate methods of thoroughly reviewing policies and establishing a connect with on-ground implementation is highlighted.

3.3 Urban Planning-oriented Dimensions

Public toilets are an essential component of the overall urban fabric and hence, the aspect of provision of toilets for spatial equity in the larger urban realm is crucial for the intent of inclusion. Various methods have been adopted to assess the urban demand and subsequent provision of public toilets. It has been observed in the reviewed literature that Geographic Information System (GIS) based (and related) techniques have been used extensively for the above-mentioned purposes. Fu et al. (2019) undertook a study in Shenyang, China, to develop strategies to address service capacity and spatial equity of public toilets. The intent was to evaluate levels of urban public sanitation in various aspects relevant to inclusion. The authors adopted a methodology which used geographic analysis of big data gathered of POI (points of interest) across the city in conjunction with data gathered from field research.

Chen et al. (2019) also employed similar methods in a similar context of Chongqing, China, to propose a data-driven approach of identifying appropriate sites for building new public toilets. The authors also used various urban data sources like taxi trajectory, points of interest (POI), etc. to aid in the identification process of sites for locating public toilets. Zhang et al. (2018) also used quantitative methods and location analysis tools like the Facility Location Problem (FLP) to identify shortage of public toilets in the Shanghai metro system, China, and propose a network-based location system for the same.

The applicability of this model in a different context has been demonstrated by Nega et al. (2022) wherein survey research methods alongside GIS-based tools were utilised to identify the people's demands and optimize sites for locating urban toilets in Debre Markos Town, Ethiopia. The use of survey research methods incorporates the perspectives of the citizens to provide results that cater to people's needs and expectations.

The relevance to Indian context of all the above methodologies of studying the three identified dimensions of inclusion in distinct contexts is discussed in the next section.

4 Discussion

Based on the review, there is a clear need for more context-specific Indian studies on inclusion in urban public toilet context as the number of studies found in the Indian context were limited. There is limited literature highlighting urban toilet needs for persons with disabilities, elderly, women, children, and other diverse user groups.

The review highlights the use of urban data and GIS as methods of identifying locational, spatial equity and other attributes of public toilets for improved monitoring practices, evaluations, and assessments, which are essential to promote inclusive public sanitation from an urban planning point of view. However, there is limited literature on the applicability of these methods in the urban Indian context. For example, the methods discussed by Chen et al. (2019) and Fu et al. (2022) rely more on big data gathered from urban sources as compared to user surveys and the availability of this data can be challenge for the current state of Indian cities. However, given the rapid urban development in the country under initiatives like the Smart Cities Mission, soon these methods may prove to be efficient in the Indian context. For the Indian context it may be wiser to adopt methods that give due weightage to people's perception owing to the lack of technology penetration in cities, especially in urban informal settlements. Thus, methods adopted by Nega et al. (2022) in the context of Ethiopia which focuses on analysing people's demands as key starting points may fit appropriate in the urban Indian context.

Methods of developing assessment frameworks for inclusion through infrastructure and management-oriented dimensions in public toilets has been discussed Tidwell et al. (2018), in terms of key factors for inclusive public sanitation. It remains to be understood the contextual relevance of these factors in the Indian scenario, and hence the methods to develop these frameworks for India would need to be sensitive to certain dimensions that are unique to the Indian cities. There could be additions of possible factors that might prove relevant in the Indian scenario, like affordability of use and innovations for easy maintenance, which were highlighted by Pathak (1991). Since the study conducted by Gaisie et al. (2018) focused on the low-income and informal settlements in urban areas, the methods may be adaptable to assess the ground reality of inclusion in public toilets of the informal neighbourhoods of Indian cities.

Use of mixed methods approach involving structured and semi-structured interviews, focus group discussions, etc. along with methods of analysing quantitative data have been used to assess human-centric dimensions. In-depth interviews (IDIs) have also been demonstrated as tools for studying qualitative aspects of human experiences. Studies have

highlighted and identified the factors for inclusion in public toilets of urban areas. In the Indian context, it has been observed that in some cases people are quite hesitant to openly discuss and talk about issues and challenges in sanitation (Purkayastha and Raheja 2022). Thus, the applicability of the methods of typical questionnaires and interviews as discussed by Afacan and Gurel (2015) needs to be studied further and remains to be validated for the Indian context. However, the study conducted by Peprah et al. (2015) thus highlights a possibility of getting a broad understanding of public challenges using mixed-method approaches, especially toilet exit interview methods and focus group discussions for low-income groups. Study conducted by Sahoo et al. (2015) for the women in Odisha also highlights a grounded theory approach of developing narratives from in-depth interviews for specific user groups that are vulnerable to challenges in their complex public sanitation experiences and methods to assess the subsequent behavioural changes that are taken by the people to avoid those challenges.

5 Conclusion

The context of urban India is quite complex which when layered with human diversity and the fundamental need of public sanitation makes it even more relevant to have appropriate methods. As per the literature available, there are limited studies of assessment and methodologies of studying inclusion in Indian cities. As per review, the validity of the methods of studies used in other countries needs to be assessed contextually keeping in mind the key distinguishing factors of Indian cities across the domains of policy, governance, management, and infrastructure. In the centre is the human, and the human diversity in Indian cities is layered across age, gender, ability, socio-economic status, regional and cultural backgrounds, etc. To bring together the aspects of cities, people, and access to public sanitation, it is critical to define inclusion and the methods of studying inclusion. Since the search methodology for this paper involved only ‘urban public toilet’ as a starting keyword combination, different keyword combinations also need to be studied for providing a more holistic view in this context. The way forward would involve testing the applicability of the key methods identified in this paper in the Indian urban context, across the human-centric, infrastructure and management-oriented and urban planning-oriented dimensions. This would inform this domain with unique challenges and insights specific to the Indian context and possible modifications to assess the level of inclusivity in public sanitation of Indian cities.

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Towards a Trajectory Analysis of the Wheelchair Artifact in an Indian Context

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Abstract: Our research investigates the trajectory of a wheelchair based on an observational fieldwork study in India. The fieldwork comprises four months of observational studies and interviews of different environments, including house visits, rehabilitation centers, surgical shops, hospital settings, and production houses. The thematic analysis describes an artifact proceeding through various stages, from production, acquisition, use, and discarding of the assistive device. To understand the challenges faced by people with a physical impairment, we examine the crucial decision points in the trajectory and put the user on the spot. Drawing on the fieldwork, we describe the elements involved that may or may not allow the users to make confident decisions, such as cost, retrofitting, etc., and how often it is too late to re-consider the choices made in the first place. We are interested in the diverse backgrounds and viewpoints of the other actors involved in the process, and the aim is to present the complexity of the whole ecosystem of the artifact.

1 Introduction and Research Approach

Research on the design and technology components of "intelligent wheelchairs" covers a broad spectrum of topics and sub-disciplines in the Human-Computer Interaction (HCI) and Human-Robot Interaction (HRI) fields. A substantial amount of research, for example, addresses ergonomic topics focused on reducing the physical and cognitive (perceptual) requirements to navigate in a wheelchair. An example of this line of research might include adapting interfaces to the specific physical and mental impairments or users' preferences by replacing the traditional joystick-based movement interface with a voice-controlled or gesture-based interface (Megalingam et al. 2011; Trivedi et al. 2013; Guedira et al. 2016). We are interested in the meaning of intelligence in the concept of an "intelligent" or "smart" wheelchair from a socio-technical perspective.

Depending on the designers' perspectives, intelligence can be placed in the assistive device or the environment. It would be helpful for designers to find a balance between

focusing on the wheelchair design or "designing" the ecosystem to foster the independence of people with mobility impairment (PMI). This aspect is primarily at stake in less-resourced settings as in the Indian context.

We position our research at the intersection of assistive technology design, CSCW, and HCI4D. We are interested in understanding the use and limits of assistive devices from a sociotechnical perspective. For CSCW, achieving successful design and innovation is considered a process where attention needs to be paid to technical possibilities and the social and work environment into which systems or innovations will be placed. Consequently, it is helpful for designers to understand how well any technical system will fit with the activities and needs of the users in a proposed setting. Ethnography (Martin and Sommerville 2004) is specifically targeted at providing rich understanding of social phenomena as it occurs in everyday settings (Randall et all. 2007).

Our research deals with how technology and assistive devices can hamper or provide support for persons to develop their independence in their daily life (Scherer 2005; Rumeau et al. 2021). This phenomenon is tied to complex interdependencies between persons, assistive devices, and the environment (Bennett et al. 2018). What factors influence the decisions of acquisition and training of an assistive device like a wheelchair? What are the challenges and the outcomes after obtaining a wheelchair as perceived by persons with disabilities? How different are the perceptions of the challenges and outcomes among other relevant stakeholders like wheelchair producers, health professionals, or family caregivers? Given our willingness and privileged access to fieldwork in India, we also have to consider the country's specific situation and adapt human- computer interaction approaches as defended by the field of HCI4D (Ho et al. 2009).

2 Fieldwork and Methods

Fieldwork provides insights into the user's everyday space, their day-to-day activities, their relationship with the device and the caregiver, the role of assistance, and most importantly, the trade-offs between being independent and interdependent, that is, relying on others. Given the distributed nature in space and time of assistive technology for mobility impairment in India, we have grounded our approach on multi-sited ethnography (Marcus 1995). Among the different strategies for conducting ethnography suggested by Marcus, we choose the one of following the object, the wheelchair, as an artifact.

Our multi-sited ethnography is organized so far into three main parts. We first conducted exploratory online interviews via zoom with multiple wheelchair users and representatives in Bangalore or Delhi (n=14). The second phase was fieldwork in Karnataka's rural and urban parts. The different locations for the ethnographic research were the user's house, rehabilitation center, hospitals, surgical shops, and NGOs. The third phase was to visit the organization Motivation UK, a global disability charity and social enterprise providing wheelchairs and services to PMI in developing countries.

We have adopted a trajectory approach for analyzing our data (Woll and Bratteteig 2019) for following the wheelchair artifact on the grounds of our fieldwork in India. This thematic analysis reflects on the ecosystem as a whole, involving the different environments, actors, and users with spinal cord injuries. To understand the challenges faced by PMI, we examine the crucial decision points and describe the elements involved that may or may not allow users to make confident decisions, such as cost, retrofitting, etc. Once the decision is made, it is often too late to re- consider the choices made in the first place.

3 A Trajectory Analysis of the Wheelchair Artifact in India

We framed our analytical contribution toward an artifact's trajectory through multi- site ethnography and highlighted the concerns within the ecosystem. This section presents how an artifact goes through the different stages, initial phase to the last stage, i.e., from production, acquisition, and use to discarding the assistive device. Through our trajectory analysis, we emphasize the critical issues that influence the decisions to acquire a wheelchair, as well as challenges and the outcomes after obtaining it. These issues stretch beyond the dialogue between designers and users through an artifact and involve stakeholders often not anticipated in assistive technology design.

3.1 Production

The Production step accounts for the challenges of wheelchair assembly and design. In our study, we encountered two organizations, Artificial Limbs Manufacturing Corporation of India (ALIMCO) and Motivation UK, with different perspectives on the end user's involvement in the design process. ALIMCO strongly focuses on making cost-efficient and mass-produced wheelchairs, and their process includes production, distribution, and training. Motivation UK is focused on the user-centered approach with a strong focus on designing the artifact and collaborating with various NGOs for distribution and training. The organization starts applying its criteria and configuration, which has a knock-on effect in the later stages. For instance, ALIMCO has an age threshold that plays a role in limiting the choices of an artifact and the compromises that users have to make in terms of parameters like portability, range, and robustness.

During our fieldwork, we observed issues with the design of an artifact. For instance, narrow seats cause discomfort and risk causing pressure sores. In conversation with a product designer at Motivation UK, he explained, "As a designer, we might have ten different ideas on how to improve the wheelchairs. However, funding plays quite an important role, and every actor involved in the process has to be on board. We have to explain why adding a slight adjustment would benefit the user because everything boils down to an artifact's cost".

3.2 Acquisition

In India, PMI obtains assistive devices through various mediums. These mediums could vary in location, level of injury, and financial aid. During our fieldwork, we had the opportunity to explore the different acquisition mediums and organizations: NGOs, hospitals, private donors, rehabilitation centers, and independent purchases from surgical shops. We encountered the challenges of acquiring the assistive device and how the lack of awareness of users' needs and resources could lead to more complications.

As mentioned by a rehabilitation center staff member, only a few organizations follow an evaluation process. "What is important is to notice that family or a caregiver has a bigger role to play. After an injury, when a person gets discharged from the hospital, he has no idea what kind of wheelchair he needs. In the end, the family decides or takes a final call". (Abhishek, Occupational therapist).

Anyone can purchase the device at surgical shops, but the shops are mostly inaccessible for people with physical impairment. The salesman asks for no evaluation or doctor's prescription for the purchase. The issue remains the same with independent donors. The hospital sometimes provides a temporary wheelchair to transfer the user from the hospital to their familiar environment (i.e., home). Only a few PMI can benefit from a well-defined

evaluation process from a rehabilitation center or NGO. They also offer training that is valuable to develop independence with a wheelchair.

Relevant evaluation and assessment of the PMI are fundamental for the use steps. Training of wheelchair skills should be part of the delivery process as this positively impacts the satisfaction of wheelchair users and increases their independent mobility.

3.3 Use

The Use step focuses on significant challenges to independence faced by the PMI in their daily mobility. These challenges also concern indoor and outdoor environments, where indoor could be at home or inside the rehabilitation center, and outside refers to the unknown or unfamiliar environment. The transition between environments is primarily of interest at this level, and we grouped the use situations we are studying into three categories: Navigation, Transfer, and Adaptation. Navigation deals with the lack of adapted space in a public setting and reclaiming shared space in the infrastructure. Transfer focuses on the different transferring techniques (i.e., from wheelchair to bed) adapted per the resources and the availability of the caregiver. Adaptation deals with the benefits and the challenges before and after rehabilitation training. It also emphasizes the importance of the caregiver in day-to-day activities and DIY transformation of wheelchairs or environments within the resources available to them for their comfort and betterment.

3.4 Discard

Discard is the last stage in the trajectory, and it deals with the reasons that lead to discarding an assistive device. An assistive device is an extension of someone's identity and the perception of society that comes along with it. While interacting with wheelchair users, multiple issues were addressed: low quality, lifespan, lack of personalization, less availability of spare parts, and the purpose of an assistive device.

The life of a wheelchair relatively varies from three to five years, but losing or damaging a part could result in discarding an assistive device altogether. In a low- income group setting, purchasing a new wheelchair seems like a big purchase, and acquiring a wheelchair through an NGO can sometimes take months and years to start the whole process from scratch. It is a lengthy process to acquire an assistive or supporting device. In rural areas, the user or their caregiver relies on the mediators to help them through the process.

4 Discussion and Future Work

We have presented our early analysis of following wheelchairs in an Indian context from production, acquisition, and use to discarding. Our analysis is still ongoing and highlights critical issues. The role of the user is missing in the trajectory. In this ecosystem, there is a scope for the user to collaborate and participate at different stages. For instance, in acquisition, there are only a few organizations that provide support for needs evaluation. The process should be streamlined for everyone to find a suitable assistive device that helps users understand how a specific kind of wheelchair will require compromises between ease of use and the boundaries of mobility. In the future, our research aims to inform the design of intelligent wheelchairs and supportive environments for PMI.

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Towards Understanding Digital Challenges among Older Adults: A Literature Review

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Abstract: The UK and China are experiencing deep ageing. At the same time, Covid-19 has impacted the way services are delivered and, more than ever before, digital services have become mainstream. However, older people with limited digital skills or ability to access online information are affected by digital exclusion, being left marginalised in our societies. This short paper presents a summary of a literature review related to older adults' use of ICT, based on publications in high-quality journals from 2017 to 2022. The study aims to understand digital exclusion, especially in China and the UK, and the reasons for the low-level engagement of many older adults with digital devices. Rather than viewing older adults as a homogenous group, the literature review was conducted to frame the factors that must be considered in understanding the differences between subgroups. It also examined what makes people aged 60 and over the most digitally excluded group across different countries and cultures. Among the reasons, some are related to the impact of physical, sensory and cognitive deterioration on the ability to understand, learn and use digital resources. More importantly, at a psychological level, older adults show a greater lack of confidence, anxiety and ageism in the face of digital technology. The external causes are mainly the lack of stable digital devices, internet access and the lack of help from others.

1 Ageing Population in the United Kingdom and China and Digital Transition of Services

The English Housing Survey reports that nearly 30% of householders in 2018 were older adults aged over 65, comprising 6.9 million households (Office for National Statistics 2019). In China, according to the 2020 Census data, the proportion of people aged 65 and over in 149 cities is already over 14% of the total urban population (China National Bureau of Statistics 2021). According to the usual international classification criteria, a city with between 14% and 20% in this age bracket is defined as being in a phase of deep ageing (Han et al. 2020). This means that China is already in deep ageing as well as the UK, and in both countries, the ageing population is predicted to increase in coming years (Office for National Statistics 2019; China National Bureau of Statistics 2021).

In parallel with the populations' fast ageing, there has been a transition of services to digital, which highlights a topical issue of digital exclusion that affects older adult populations.

1.1 E-Government

The United Nations considered e-government as a new public service strategy that has strong potential to improve the efficiency of communication and provide convenient services to the public (United Nations 2020).

Since 2012, the UK Government prioritized the shift of public services to digital services called "Digital by Default" (Cabinet Office 2012). As of November 2022, there were 23 Ministerial departments and over 400 other agencies and public bodies offering online services on GOV.UK. Their services covered everyone's political, economic, and financial daily life.

In terms of the Chinese government, according to the 2020 UN e-Government Survey, the Chinese e-Government Development Index improved from 0.68 (2018) to 0.79 (2020), putting it in the 45th position globally. The Chinese Online Services Index ranked 9th in 2020. This shows that the Chinese government attaches great importance to the online transition of government services (United Nations 2020).

1.2 E-Health and Care Services

The Covid-19 pandemic has created many limitations for offline services, thus promoting the use of online health systems (Heponiemi et al. 2022). The Essential Digital Skills Report 2021 made by Lloyds Bank has indicated that from 2020 to 2021, the population of the entire UK population with no foundational digital skills grew from 8.7 million (17%) to 10.0 million (19%). As a result, older adults who have difficulty accessing and using digital software might be increasingly withdrawing from health and care services (Heponiemi et al. 2022).

With the rapid development of e-government, e-health, and e-economy, the global proportion of older adult users has been growing (Hargittai et al. 2018). The figures for China and the UK reflect this fact. In China, the number of Internet users over 50 years old increased by 4.8% from the end of 2017, after half a year, to reach 84 million in June 2018 (Xiong and Zuo 2018). Although more than 33% of the total older population believe they improved in digital skills from 2020 to 2021, more than 50% of UK adults aged over 65 do not have essential digital skills (Lloyds Essential Digital Skills Report 2021). Siren & Knudsen (2017) represented that these older adults have difficulty accessing digital technology and have limited information and communications technology (ICT). This means that, in 2021, around half of the older population usually have a lower level of online engagement and are facing digital exclusion.

This short paper presents a summary of the literature review related to older adults' use of ICT, based on publications in high-quality journals from 2017 to 2022. The study aims to understand digital exclusion, especially in China and the UK, and the reasons for the low-level of engagement of older adults with digital devices.

2 Digital Competence, Digital Inequality, Digital Exclusion and their Connection

Digital competence refers to a person's capability to use digital interfaces. Amongst older adults, those aged 75 and over tend to have weaker digital abilities (Goodman-Deane et al. 2021). As they are less likely to make effective use of e-services, not only they are suffering from digital inequality, but this also leads to social inequality (Goodman-Deane et al. 2021). If older adults are unable or unwilling to use internal factors - such as knowledge

and effort - and external factors – such as help from others - to improve their digital capabilities, this can exacerbate inequalities in the digital sphere (McCosker et al. 2021).

In terms of digital exclusion, some experts propose that age is the main factor (Millward 2003). Other specialists have criticised this viewpoint as they have regarded the elderly as a homogeneous group (Nordicity 2017; Wynia et al. 2019; Caidi et al. 2020). Digital literacy, as well as working experience, educational level, and age-related factors can divide the elderly into different digital generations (Barrie et al. 2021). Furthermore, as for internal factors of the elderly, negative emotional experiences with technology use such as fear, anxiety, low confidence, mistrust or being influenced by ageism, might make them refuse to adopt ICT as part of their daily life (Goodman-Deane et al. 2021). This would lead them to be gradually marginalized and even digitally excluded (Siren and Knudsen 2017).

In 2018, Hargittai et al. suggested that although some older adults have the hardware and internet connection and are willing to engage in the digital world, they are unable to take full advantage of digital technologies in a short time. This call this the "secondary digital divide". In the next section, the reasons for low online engagement will be discussed.

3 Reasons for Low Digital Engagement

To explore the influence of digital exclusion, it is necessary to make a classification of the elderly depending on several factors related to technology generations (Barrie et al. 2021). Each technology generation is divided by digital skills and experience. According to Hargittai et al. (2018), among older adults, those who are younger, with higher education and socioeconomic status are usually taking advantage of digital resources.

As for age, people over 54 are the main group facing digital exclusion (Morueta et al. 2021). Heponiemi et al. (2022) found that those aged 75 and over exhibited less variety in their digital abilities and were less likely to access online health knowledge. With similar findings, the study of Nguyen et al. (2022) highlights that as older adults age, they are no longer the center of social interaction, and without digital support, older adults appear to be less able to maintain their social relationships. This causes social isolation (Barrie et al. 2021).

As to educational level, as highlighted by Barrie et al. (2021), the former ability to gather information in the workplace slowly declines as older adults retire. According to the authors, older adults who did not learn how to use digital technology before retirement added to a lack of training in digital literacy. This may be caused by a shortage of support which can lead to digital inequalities. Therefore, help from family members, community and peer learners is necessary (Springett et al. 2021).

In terms of socioeconomic status, older adults with higher incomes often enjoy more autonomy online (Hargittai et al. 2018). On the one hand, the higher online autonomy means they have more digital competence, while on the other hand, appropriate social support promotes the psychological well-being of older adults. The bonding and bridging communication and social connections that older adults make through the Internet will increase their social frequency, strengthen their ties with family and friends, and alleviate feelings of isolation (McCosker et al. 2021).

The studies presented above highlight reasons for older adults' non-engagement online resources. They are related to several factors, like generation, educational level, socioeconomic factors, work experience, social network and support. To reduce the negative impact of digital technology, a minimum amount of instruction and giving older adults maximum space to explore is considered an effective way to help older adults to learn digital skills (Springett et al. 2021). Also are valuable are preventing age discrimination both internally

and externally among older adults, as they learn, helping them to increase their confidence, remove concerns and overcome fears through support and explanation (Barrie et al. 2021).

4 Conclusion

This initial literature review clarified how digital exclusion is formed and some of the reasons which make the older adults the most excluded age group. Age-related factors continue to be a major impediment to older adults' digital participation. From what China and the UK have in common about ageing and online services, online engagement has increasingly impacted how older adults participate in our society, whether by using online services, internet communicating or maintaining social relationships. Since older groups who are digitally excluded should not be seen as homogeneous, older user groups should be sensibly categorized, and based on the digital inequality research, stronger digital skills are possessed by people who are younger, have a higher level of education and higher social status. As digital technology develops, accomplished learners further update their knowledge and gain further benefits on the internet, which can lead to a widening of the digital divide.

The gradual withdrawal of older adults from the services of digital health and digital government leaves them with less autonomy and more dependency when it comes to their daily affairs. The future of digital technology is constantly being updated and iterated. Digital devices appear to be more accessible and with higher usability, but this fact is yet to be proven for older adults. The level of authenticity of information on the internet and the weakness of older adults to protect their information make it more difficult for them to trust new technologies. Overcoming negative feelings in the psyche of older adults seems to be the first task in engaging them with the Internet.

Appendix

All literature is sourced from the **Scopus** journal website as there are high requirements for the sources. This platform has high quality and reliable journal papers. The terms used in the selection of literature are:

- ‘Digital skills’ AND ‘older adult’
- “Digital Literacy” “Digital Divide” “Digital Skills”
- “Information Communication And Society”
- “Universal Access In The Information Society”
- “Gerontology And Geriatrics Education”
- “Information Technology And People”
- “Journal Of Aging And Social Policy”
- “Journal Of Technology In Human Services”
- “Technology In Society”

For a more recent report on the digital capabilities of older adults in the UK, mainly from Lloyds Essential Digital Skills Report 2021. This is a report with a wealth of graphical statistics, supported by accurate data.

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