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Enhancing Internet Search Abilities for People with Intellectual Disabilities in Sri Lanka

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ABSTRACT

This article presents how young adults with intellectual disability (ID) from Sri Lanka, who had not previously used the Internet, interacted with Google search while enhancing their web search abilities throughout three web search workshops. Considering the little attention paid on the learning needs of people with ID in the current offering web search learning tools, we iteratively developed a suite of learning tools to support our participants when they need help in the web search workshops. We employed an iterative participatory approach, with observations and semi-structured interviews, to reflect on how to design eLearning tools that enhance the participants' interactions with web-search. The qualitative thematic analysis resulted in five distinct themes on strategies to support, build on and develop the abilities of a young adults with intellectual disabilities as they engage with Google search in their native language: application of existing abilities, basic skills to match with learning needs, conceptual understanding, animations to facilitate visual memory, and promoting active engagement. These themes will be a starting point for understanding participants' learning needs and behavior on web search, which would be important for future research on learning support as well as on software design.

CCS CONCEPTS:

• Human-centered computing~Human computer interaction (HCI) • Information systems~Information retrieval~Users and interactive retrieval~Search interfaces • Social and professional topics~User characteristics~People with disabilities

KEYWORDS

Web search, People with intellectual disabilities, Human-computers interface interaction, Accessible design

1 INTRODUCTION

Online information access and digital literacy remain a barrier for many people with intellectual disabilities, despite the increasing availability of accessible content on the web [8, 19, 86, 108]. In this context, while there are numerous opportunities for learning the web search process, little attention has been paid to the specific learning needs of people with intellectual disabilities (ID) [1]. Supporting people with ID to enhance their capacity to search the web can empower them to be independent in many daily tasks [19, 57, 76, 83], including in searching for information about health [72]. This has been recognized by scholars as they have focused on supportive web interfaces [33, 88, 113, 112] and ability-specific basic ICT training [115].

This research was motivated by the lack of research into exploring the specific requirements of people with ID worldwide [75, 114], including those in the Sri Lankan context, in terms of both interface design and learning needs perspectives, that might restrict them in using this important information source. Recent research by Sitbon et al. [99] shows that young adults with ID in western countries have developed strategies to use search engines and access online information. This suggests an opportunity to provide appropriate basic web search training for young and older adults with intellectual disabilities, including those living in developing countries. This study aimed to identify how young adults with intellectual disabilities, who did not have previous experience with the Internet, interact with, and learn web search.

We conducted the study across a sequence of three web search workshops, in which a web search eLearning tool was iteratively developed to support a learning journey based on their developing abilities. Generally speaking, learning new skills leads to two types of knowledge: declarative knowledge (knowledge of what) and procedural knowledge (knowledge of how) [5]. We established that young adults with ID may need the knowledge about ‘what’ web searching is, and ‘how’ the search engine works, and we focused the study to advance our knowledge of the type of support they need to increase their abilities to search the web.

An interest-based approach to training is more likely to motivate people to develop new skills that can feed such interests [98]. Their interest in interacting with technology would, in turn, make eLearning appealing for them. The UN [106] highlights the need of empowering health decisions and good health with access to health information, considering it as a right [105], yet people with ID experience problems in getting needed health information [20]. Latteck and Bruland [53] identified health topics relevant to daily life to be more appropriate in introducing health information to people with ID. Therefore, the workshop used health topics relevant to daily life as examples. This provided greater motivation for the participants in web search workshops, who were keen on finding more on what ‘they’ need. The workshops in this study thus introduced the web as a health information source and the Google search engine as a tool for locating the information.

We conducted the study in collaboration with young adults with ID from two special schools in Sri Lanka. We selected the participants on the assumption that participants who can read and spell to some extent, and can work with a computer, would have the cognitive abilities involved in using search engines; abstraction, task sequencing, task switching, prioritization, and reading [98]. The three web-search training workshops were held in the computer labs located in the partnering special schools. The eLearning tool aims to develop the participants’ abilities to interact with the Google search interface, including formulating a query, entering it using the search engine interface, executing the search, getting a list of results, identifying links from the search results list produced by the system as relevant to the query, and navigating to the resulted web pages. We observed how the participants, who did not have previous experience with the Internet, increased their abilities interacting with web search and navigation, as well as with the learning tool. We also focused on how the participants integrate their previous experiences and learn skills to search the web. We took notes of observations and participants’ comments and questions during each training workshop. Without a wealth of prior research on web search training in special education in developing countries, we found that a mixed-methods approach with observations and semi-structured interviews had the greatest potential to help us understand our participants’ interactions with web-search and how they enhanced their web-search abilities. Besides, it provided deep insights for future web search eLearning tool design considerations towards narrowing down the digital divide.

This article contributes a broader perspective on how young adults with ID in Sri Lanka interact with the human-computer interface in web-search as novices and how they can be supported to increase related abilities. Our insights emerge from observations and reflections on how we iteratively developed an eLearning tool, integrating new insights after each training workshop. This paper provides methodological insights for researchers who aim to identify the learning needs of novices with ID with regards to web search, how to integrate them within accessible eLearning, and how to ensure cultural alignment (language, interests, and metaphors). The originality of this paper is its combined focus on developing skills to interact with the web search interface, and on the aspects of a specific approach to include people with intellectual disabilities. Hence, it provides important insights for search engine developers and education tool designers in practice for increasing accessibility to web search, while attending to the aspects to be considered for increasing web search abilities of people with ID.

The rest of the paper is organized as follows. First, we review literature on the interests and capacity of people with ID to interact with web search, also highlighting the need for opportunities to learn and increase abilities to search the web at their pace. Next, section 3 describes the study design. Then, section 4 presents results, under four themes, about how the participants increased their abilities while interacting with Google search and the eLearning tool. Next we present a contextualization of the findings and implications. Finally, section 6 concludes the article.

2 BACKGROUND

2.1 Challenges and Opportunities in Searching and Navigating the Web for Health Information

Search engines have become popular among health information seekers. In this context, attention has been drawn to the search interface [50, 93] as well as the quality of information retrieved through general search engines [29, 91, 97]. The Web Content Accessibility Guidelines (WCAG) 2.1 present guidelines to ensure navigability (e.g. by providing appropriate information to identify links, users’ location, input functionality, supported with text/image labels on icons) and understandability (e.g. by presenting interface content and interface operations, including input assistance, in predictable and consistent ways) of web pages [50]. These guidelines are also applicable to search web pages. The

W3C guidelines specify the need to avoid too much content on the web for “making content usable for people with cognitive and learning disabilities”, which Seeman et al. [93] suggest is best exemplified by the Google search web page, as an example of the simplest and easiest web search user interfaces.

Considering retrieval effectiveness for health information searches, Lopes and Ribeiro [59] report that general web search engines offer more precision than health-specific engines. As Google reported the best performance, mainly in the first ten results, they identified Google’s first results page as a good place to start searching for health information. Further to these qualities, Google has become popular among people with intellectual disabilities, for its simpler search interface [67]. Referring to the language-specific searches on the web, Lewandowski [54] points out that the use of the interface in the target country is better when Google is used for searching for information in the languages spoken in that particular country.

People with ID prefer general web search tools. They are interested in the web as an information source and seek opportunities to increase their abilities to search and use the web [3, 39, 57, 62, 87]. This motivating involvement in digital participation would assist them to experience independence and autonomy in their life. Hence, as noted by Harrysson et al. [39], the opportunity for them to use the Internet creates a ‘smart and awesome’ experience. However, many still have trouble when interacting with the Internet and accessing information. Rocha et al. [87] report that young adults with mild to moderate ID are typically able to perform basic functions in the browser, including starting and closing the browser, navigating forward and backward, and scrolling. They have noted that participants need support to process the search results list, and propose that this may be due to the cognitive difficulty of processing a large volume of text. They have identified entering keywords and copying a URL to the address bar as other challenges. More importantly, they have observed the participants’ ability to learn the specificity of texts and images that provide a link to another web page. Hence, web-search training opportunities that address their cognitive needs would be helpful, while focusing on supportive functions (such as keyword and URL suggestions) and the simple interface in Google search and search results web pages.

Digital training programs in special education reported in the literature have given attention to computer skills including using a browser and browsing websites. However, they have not broadly dealt with training on web search [56]. Yet, the need to provide support through ability-centric basic training programs has been flagged in prior literature [76, 94, 115]. As observed in a training program, Li-Tsang et al. [57], report that a “step by step” approach allowed their participants with mild and moderate ID to learn and retain mouse, keyboard, and web browser skills. They highlight that people with ID would learn Information and Communication Technology (ICT) skills with regular practice; this could be supported with basic training programs fitting the level of their intellectual ability, projecting from basic to advanced skills, as also noted by Rocha et al. [87].

Access to information is a universal right; people with any form of disability may need information [105]. According to Tuffrey-Wijne et al. [104], people with ID showed an interest in information on cancer and they could comprehend the information in accessible formats. Hence, the ability to search the web would support them to independently access information, increase their awareness on a range of health topics [21, 104] and develop life skills [2]. Similarly, Kotwal et al. [52] explored the acceptability of a ‘Getting ready for your visit to the genetics clinic’ information and report that such informative approaches would assist people with ID in clarifying health issues and prepare them for taking decisions. Collins et al. [21] noted that awareness about health information among people with ID is important to help them diagnose early. In disseminating information to people with ID, it is important to consider their requirements for information in easy-to-read, accessible formats [70], i.e. easier to find and use [71].

The health information needs can be for themselves, someone else, or for both [80]. People with ID can have previous experiences, sometimes that are related to their life, due to a person close to them (a family member or a friend) being ill, that may significantly influence their motivation to know about health topics and help each other [36, 61, 65]. Access to health information would support them in discussing and making decisions about their health care, and experiencing healthier lives; education, as well as technology applications for increasing accessible health information, can address the limitations [3]. Besides, web search training programs focused on health information access would support the promotion of online health information retrieval among people with ID [64], taking on their interest in health information [104] and the motivating effect of using electronically disseminated health information on the web [32]. Health topics related to daily life have been found to work well in introducing health information access [53] and were used in this study for people with ID to decide related keywords of interest and practice Google search.

While focusing all those support approaches on a wider lens of strengths and abilities of people with ID in searching for information, the allocation of additional help in new designs constitutes a positive response on the issues related to the cognitive deficits and would be an encouragement for inclusion. This focus on accessibility rather than discounting due to difficulties experienced by people with ID is comparable to focusing the ‘quality on the road’ for a “good drive” rather than objecting to the vehicle. Supportive approaches can be defined across several dimensions and can include for example “defining search queries for information needs, suggesting correct spelling, making the search

results web page accessible and assessing web pages for authority” [98]. Web search training programs for people with ID can introduce these supportive technologies and offer the opportunity to practice the search procedure (with several steps to reach the information), recalling sequences such as pressing the ‘Enter’ key or clicking on the search button to run the search as well as clicking a link of a web page to open [19]. We focused on incorporating these in an eLearning tool iteratively developed throughout a series of web search workshops, also reflecting on how people with ID interact and enhance their web search abilities.

2.2 Supporting to Learn Web-Search Process

As noted by Williams [110], “neither a physical nor a cognitive disability stops someone from learning and achieving, if they get the right support”. Hence, education is a better option than attempts on specific designs for engaging people with different cognitive skills [17, 44, 85].

Previous research reports that people with ID are best supported in increasing their abilities to perform multi-step tasks, with regular practice, close personal support, and instructional designs that present contents in small chunks in accessible formats [17, 81]. Buehler et al. [17] mention that the accessible format of eLearning tools for people with ID, which incorporate how-to-videos, along with consistently arranged large visual icons with text description displayed during mouse-over (easy to follow visual cues), is important to support inclusion. Furthermore, instruction for people with ID is best when centered on the learners’ current understandings (personal understandings) and with access to technology [16]. Brandt [89], who focused on constructivism, mentions that integrating learners’ previous experiences were best suited to best teach how to search the web. As a support for the creative approach of learning, the goal must be “to influence the construction of knowledge by demonstrating the connections between basic skills that relate to smaller mental models to build a more complete mental model of information retrieval as a process” [89].

User interface designs use examples from the real world to match the new design with the real-world [73] so that these examples would be recognized by the users, aligning with their existing knowledge. These examples related to the real world, called metaphors, could be used to understand users’ existing mental models, and also to support them to understand and interact with the new designs, by modifying the existing mental model [45]. According to Nielsen [74], “what users believe they know about a UI (User Interface) strongly impacts how they use it”. This internal belief of the user about a system at hand has been termed as the users’ ‘mental model’ [74]. Hence, novices to the Internet can be supported to learn web search by integrating their existing mental models from the real world, to create new mental models based on a conceptual understanding of how the search engine works [90].

“Humans naturally tend to relate new systems to existing knowledge, often by associating them with other physical objects” [45]. Referring to the interactions with the search interface, Zhou et al. [117] mention that metaphors familiar to the learners can be used to help them create mental models representing different elements in the search interface [117]. Nielsen [74] emphasizes the importance of instruction designs that support novices to improve their mental models about the system, while also attending to the mental model mismatch. This emphasizes the need of drawing instruction designers’ attention to learners’ existing mental models.

For most people, visual memory is stronger than verbal memory [5, 43]. Therefore, an eLearning tool that presents a visual demonstration on the web-search process while attending to mental model mismatch, can be expected to be beneficial and engaging [15, 79]. A meta-analysis of 26 studies by Höffler and Leutner [40] compared the use of static and dynamic visuals in instruction, and revealed that animations can be used to support learning and that they should be: a) “representational rather than decorative”, and b) “highly realistic” for gaining better outcomes. They found that dynamic visuals (i.e. animations) are more beneficial when “acquiring procedural-motor knowledge”. We used animations in the eLearning design that describe the web search process; each page describes the basic functions of the interfaces throughout the Google search process. Lowe [60] defined three forms of animations, considering the types of changes visualized in the animated graphic: *transformations* by form changes (alters the size, shape, color, and texture), *translations* by position changes (moves from one place to another), and *transitions* by inclusion changes (appearance or disappearance); these forms of animations take the attention of the learner and supports them build mental models. de Koning and Jarodzka [27] present three ways to guide attention, found in the literature that applied dynamic visuals for supporting learners: (1) cueing (signaling e.g., with arrows, progressive color ribbons or colored circles), (2) eye movement modeling examples (using an expert’s eye movements to direct attention), and (3) gesturing (pointing gestures e.g., facial expressions, pointing hands). We applied this attention guidance to support learners’ focus and increase their understanding.

Insights on how people with ID interact with web search, integrating existing abilities/mental models, and creating mental models, are important for focusing web search instruction designs on their specific abilities and needs. Zhang [116] identified users’ mental models of an information system to be in four dimensions: the whole system, content, information organization, and interface. For example, Zhang [116] noted that the construction of mental models of an interface represents two aspects: navigational elements (they may include a search box, menus, sidebar, hyperlinks, tabs, logo), and interface functionalities (search, advanced search and browse). People with ID who have previous

experiences working with word processing and computer-assisted learning, although they have not interacted with the Internet, can have already created mental models of interface elements such as menus and icons, and functions such as selecting from links and browsing through pages, which they can also apply in web search. Zhang [116] mentioned that an approach more focused than interviewing, concept listing, or drawing would be helpful to identify the mental models relating to the procedural knowledge of the system. We propose that an iterative participatory design process, in which the eLearning tool about web search is employed in web-search training workshops and which builds on observations, may respond to this.

2.3 The Sri Lankan Context

2.3.1 Education Background and Access to Technology. The education system in Sri Lanka attends to the learning needs of students with disabilities. Students with disabilities, including students with intellectual disabilities, are encouraged to attend schools and are provided with facilities to engage in educational activities, as it can support them with basic skills to succeed both academically and socially. Various learning environments are offered, such as placing them in classrooms based on their skills and abilities in special schools, or in special units in regular education schools (self-contained classrooms) regardless of their age or abilities. In special schools or units, they develop communication abilities, literacy skills (reading and other subjects referring to their cognitive needs), and skills for social inclusion, with the support of their teachers [68].

However, the facilities in these special schools in Sri Lanka are very limited. They can only serve a limited number of children and pay more attention to people with visual and hearing impairments. This has caused difficulties for people with ID to attend a special school close to their home [34]. Only a limited number of students from remote areas are attracted to the special schools with special units for people with ID because they have to be away from parents and stay in school hostels. This directs them to access special units in regular education schools, which would not properly focus on their needs. Accordingly, non-formal educational facilities run by non-governmental organizations in Sri Lanka provide alternative educational approaches for those who leave or do not have access to formal school education with special attention to people with ID. These encourage adolescents, young adults, and older adults with disabilities to further their learning beyond school-age years and to develop skills required to transition from school to community [34].

The Department of Census and Statistics (DCS) in Sri Lanka reports that one out of every five houses in Sri Lanka has access to computer facilities. However, the statistics also show inequalities in the distribution of computer facilities between rural areas (with 19.7 % computer-equipped households) and urban areas (with 38.0 % computer-equipped households). This digital divide in Sri Lanka is confining computer facilities to a limited number of urbanized main cities [26, 107], while all the provinces in the country are almost equally populated (hence majority living in rural areas) [18]. Besides, the statistics report mention that smartphones (72.2%) are more popular in Sri Lanka than desktops/laptops (24.1%) or tablet computers (2.0%) to access the Internet. Besides, more than 50% of those who use a smartphone to access the internet are living in rural areas, which may contribute to transforming the effect of limited computer facilities in those areas [26]. In addition to this limited access to computer technology, a low level of computer literacy among the adult community aged above 35 years (including their parents or carers) [26] means that people with ID would benefit from more attention in the school environment or other support services, with access to appropriate learning tools, technology infrastructure, and training support.

2.3.2 Information Technology Support and Capabilities. Alongside a recent dramatic increase in global Internet use [38], Internet use in Sri Lanka has also significantly increased [7]. According to the Department of Census and Statistics (DCS) in Sri Lanka, the overall computer literacy level in Sri Lanka has increased at an overall rate of 30.8 % in 2019. Furthermore, it states that school/university education has served as the major source of computer knowledge contributing 54.3% of computer literates [26]. However, the contribution of different types of schools including special schools providing infrastructure with trained support, and the status of capabilities including educational attainment and/or computer knowledge of people with different levels of abilities in the Sri Lankan context has not been fully described [34, 68].

Special education settings should aim to fully develop the capabilities of students with disabilities. The focus on integrating information and communication technology (ICT) in curricula [58, 75, 115] and educational support [78, 96] can support effective learning of ICT skills. In turn, these ICT skills may support independence and integration in society [76].

Special education teacher training programs, available in the form of in-service training and pre-service training [34], can support positive outcomes by including ICT-based teaching strategies and usage of ICT tools in education. The literature points out the need to explore how to support special education teachers' professional development, enabling them to integrate technology in teaching technology [48]. Such an approach should encompass digital

inclusion, implementation of appropriate e-facilities / e-tools, and suitable infrastructure in the school environment, to benefit both the special education teachers and their students [57].

2.3.3 Sinhala Language Use in ICT. According to computer literacy statistics in Sri Lanka, in 2019, just below 40% of Sinhala language literates reported being computer literates. In contrast, above 70% of English language literates were prominent among computer literates [26]. However, when people with different levels of abilities and communities using different languages are considered, language can act as a major factor contributing to the digital divide. Kommalage and Thabrew [51] report that 93% of Sri Lankan health websites are published in the English language creating a limitation on accessibility to health knowledge on the web to those who cannot understand English. However, the literature does not include any studies of this aspect concerning people with ID in Sri Lanka. Thus, a culturally sensitive approach is needed to provide access to ICT and information on the web in Sinhala Language [69]. Our research explores the experiences of people with ID with computer technology together with their perspectives on web search interfaces, and the contexts in which they interact with and learn to use them. This study more specifically explores how young adults with ID from Sri Lanka, who had not previously used the Internet, enhanced their abilities to interact with the human-computer interface for Google search, throughout iterative design of an eLearning tool for supporting them to learn Google search. The next section will detail the methodology through which the eLearning tool was developed, gaining insights on the specific learning needs of people with ID and the strategies applied in developing their abilities.

3 METHODOLOGY

3.1 Design

Qualitative methods are widely used in exploring experiences and abilities of people with ID with technology use [28, 39, 56] considering the flexibility allowing the researcher to gain good insights [10]. For this study, we followed an iterative participatory approach, where we engaged with a group of participants in a sequence of three workshops, each offering support with a new iteration of the eLearning tool. Hence, the workshop materials (in print format) used in workshop 2 were developed integrating the insights from workshop 1. The workshop materials (the eLearning tool in PPT format) for workshop 3 were improvements of the print materials integrating the insights from workshop 2. Towards developing the eLearning tool (as described in section 3.4), this approach helped us identify the learning needs of people with ID, which would not otherwise be expressed; it helped us concentrate on how the workshop materials can best recognize our participants' cognitive capacity.

Qualitative data were collected through observations and semi-structured interviews at each workshop, to both explore participants' perspectives on web search and inform improvements on the design of the eLearning tool. Observations in the context of the use of the technology are essential in this setting, as demonstrating use (or non-use) allows participants with ID to express their views in a manner that does not necessitate abstraction. Semi-structured interviews allow us to build on these concrete experiences to further our understanding. In-person support was provided in all of the workshops if participants required it. This also generated a form of a semi-structured interview. Noting when and what support was required constitutes useful observations, and providing the support is part of our focus on designing supportive technology rather than merely identifying barriers to access.

With this support standpoint, a series of web search sessions were defined for participants to perform a web search, starting from locating the browser icon through directing to a web page about the searched topic. The same health topics were introduced, allowing them to use their preferred keywords on those topics for variability in the search experience. The focus was on skills related to interacting with the human-computer interface and sequencing through Google search (recalling the search procedure) rather than on supporting query formulation and refinement, or to choose a search result discerning its credibility.

To minimize the short-term effect of learning between the workshops, we organized them at two months intervals. Previous research investigating how people with ID enhance their technical abilities in short term training that employed observational assessments before training, immediately after training, and after one month, mentions the possibility of decreasing the acquired skills related to comparatively difficult functions after a one-month duration [56, 57]. Gehring et al. [35], in a study with people without ID, observed memory performance to be superior for pictures than words at all intervals throughout three months. We focused on introducing learning support integrating text in a simple form with visual metaphors, animations, and audio descriptions.

3.2 Participant Recruitment and Ethical Considerations

This research has received ethical clearance from the Queensland University of Technology Human Research Ethics Committee. The selection of the research methods for this study encompasses ethical considerations, chiefly with a focus on giving a voice to participants with ID through participation. Additionally, our research approach, employing genuine, relevant, and appropriate training materials, supports reciprocity.

Informed consent was obtained using an easy-to-read informed consent form, translated into the local language (Sinhala). The consent form described the objectives of the study, benefits to the participants and others, alternatives for the participants if they no longer want to participate, and the confidentiality of data throughout the study, in terms of both notes and pictures collected during the study. Participants were informed and continuously reminded that participation in the research is voluntary and that they are free to discontinue participation at any time without penalty or judgment from either the research team or their teachers. Pictures to illustrate the specific concepts were placed close to the associated text in the consent form. To make the pictures appropriate for the participants with ID, we selected related pictures with people with ID in a similar age group. The IT literacy diagnostic session and the workshops were conducted in an environment familiar to participants to provide a comfortable experience during the study period [22].

The objectives and the benefits of the study were described and consent from the principals of the two special schools was additionally obtained for conducting the three workshops at the school premises and for collecting data. Before contacting the people with ID, their parents were informed using a letter that describes the purpose of the study and the ethical concerns. After the parents' consent was obtained, the people with ID were contacted. The consent form was read and described by the class teacher to the potential participants, and they were also allowed to read it before signing it. Each participant wrote his / her first name on the consent form, confirming the receipt of the information and the agreement to participate in the study.

We followed the American Association on Intellectual and Developmental Disabilities (AAIDD) definition for intellectual disability that focuses on significant limitations in both intellectual functioning and in adaptive behavior which originates before the age of 18 [4]. Since IQ tests only cover part of this definition, they are no longer generalized. Instead, the teachers who are familiar with the practical abilities and support requirements of people with ID helped us select young adults with ID. Our selection criteria included 1) aged between 18 - 30 years, 2) able to verbally communicate, read and spell to some extent in their mother tongue 'Sinhala' and 3) able to use a computer. We observed that their writing and reading proficiency coincides with that of neurotypical people learning in grade 2 or 3 (Table 1). Across the two schools, ten young adults with ID consented to participate in the research. The participants included 5 males and 5 females (with mean age 19.20 (SD 1.22)). Two of the participants have received a medical diagnosis of Down syndrome and 8 have received a diagnosis of learning difficulty.

Table 1: Participants' Profile: Demographics and Abilities to Interact with Computer Software

Participant	1	2	3	4	5	6	7	8	9	10
Gender	M	F	F	F	M	M	M	F	F	M
Reading text (as at Grade at school)	G3	G3	G2	G2	G2	G3	G3	G2	G3	G2
Using the keyboard	1	1	2	1	2	1	2	2	3	3
Using the mouse	1	2	2	2	2	1	1	3	3	2
MS Word										
Typing own name	1	2	2	2	3	2	2	2	3	3
Changing font size	1	1	1	2	2	2	2	3	3	2
Saving a file	1	2	2	3	2	3	2	3	3	2
Paint										
Drawing a picture	2	2	2	2	2	2	2	2	3	2
Coloring the picture	1	1	2	3	3	2	2	3	3	2
Using general interface elements in the Learning software										
Finding the Icon to start the program	2	2	2	2	2	2	2	2	2	2
Using navigation buttons	1	2	2	2	2	2	2	2	2	2
Using menus	2	3	2	3	3	3	2	3	3	2
Using links	2	2	2	2	2	2	2	2	2	2
Closing the window using Button X	1	2	2	2	2	1	2	3	2	2

M – Male, **F** – Female, **G2** – Reads as neurotypical people in grade 2, **G3** – reads as neurotypical people in grade 3

1 - Performed independently (We assigned score 1),

2 - Performed with guidance (verbal prompting or encouragement) (We assigned score 2),

3 - Performed with individual support (physical help) (We assigned score 3)

3.3 Procedure

The two special schools had computer facilities with Internet access in dedicated rooms (computer labs). Yet, none of the participants had previous experiences in using the Internet. The training workshops and associated data collection sessions were conducted in those computer labs. The study included an initial IT literacy diagnostic session and three web search workshops conducted for young adults with ID who consented to participate in the study.

3.3.1 IT Literacy Diagnostic Session. At the IT literacy diagnostic session, we held 10-minute semi-structured interviews for each participant to identify their current experiences with computers, which were then confirmed with observations. Observations continued while each participant was interacting with computers (MS word, paint, games, and learning programs installed on computers) for 20 minutes. We noted that some participants interacted with computer applications without support (independently) (1), while others needed support in the form of guidance (verbal prompting or encouragement) (2), or with individual support (physical help) (3).

Table 1 presents the participants' profiles with their background including the range of their reading abilities.

Our participants could read as neurotypical people in grade 2 (G2) or grade 3 (G3) at school. Our assessment of support needed to use the mouse and the keyboard echoes the most common support needed throughout a range of mouse and keyboard functions, such as illustrated in Table 2.

Table 1 also presents how our participants interacted with a specific function of the computer software, as we observed them interacting with MS Word, Paint, and the Learning software during the diagnostic session. In Table 2, we detail how the various abilities specifically involved in the context of the diagnostic session relate more generally to computer abilities, at least partially. In turn, we anticipate participants will leverage during the Google search process.

Table 2: General Computer Abilities Underpinning Specific Interactions with Computer Software

General Computer Abilities		Interactions with Computer Software
Using mouse functions	Hovering the mouse pointer on the screen	Pointing to program icons, Drawing and coloring with paint, and playing games
	Double click	Starting Paint, MS word, learning programs, and games from the taskbar and/or desktop
	Single-click	Navigating forward and backward; Playing games; Drawing and coloring with pen, eraser, and colors in Paint; Clicking on words/links in the learning program, Closing window using X-button.
	Using the scroll wheel/ scroll bar with the mouse	Moving down the page to view more in MS word and paint
Using keyboard functions	Keyboard character set	Inserting words in MS word and Paint
	Arrow keys	moving the cursor using arrow keys, playing games
	Delete key	Erasing mistakes in MS Word, and Paint
Using general user interface elements	Using Icons	Using icons to start working with Paint feature, MS word, learning programs, games
	Using Navigation buttons	Navigating between pages in the learning program using a home, forward, and backward navigation
	Using Links	Using links in the form of lists of subject topics directing to other pages in the learning program
	Using Menus	Identifying and clicking on both text and image navigation menus in the learning program
	Using Close Button X	Closing the windows of MS word, Paint, games to terminate the program

3.3.2 Web Search Training Workshops. We planned web search workshops for the participants to learn how to search the web using Google search in Sinhala with Google Chrome browser. Participants could familiarize themselves with the interface of each page and its related functions (what to do on each page).

Search sessions included starting web browser, typing the URL "Google.lk", and proceed through identifying links in the web search results page to go to web pages with searched topics. Web search sessions did not focus on their ability to find a specific piece of information, or to assert the credibility of information; instead, the researcher observed their

behavior as they interacted with the resulting web pages, and returned to the search results page. Furthermore, the researcher provided guidance /individual support as needed (see below), while observing and taking notes.

Participants were invited one by one, for the web search sessions held in the computer labs in their school. Each participant was accompanied by their teacher for the web search sessions. The participants were not visibly inconvenienced by the presence of the researcher and interacted with her in the same way they would with a new teacher. After the diagnostic session, they were enthusiastic and said “now we can go to the computer” when the researcher arrived. Each participant started web search sessions by starting the computer, used a physical qwerty keyboard (to type URL, and press ‘Enter’/ Delete keys, etc.), a mouse (to click/move around the cursor), and the Google Sinhala virtual keyboard at “Google.lk” (to type keywords in Sinhala) (see the section 3.4 for a description of the Google Sinhala virtual keyboard).

The researcher introduced the same set of health topics across the three workshops, however allowing each participant to select related health topics and use his/her own choice of keywords. As a reference, this study employed the health topics (specific disease or medical problem, diet, nutrition, healthy foods, exercise, a particular doctor or hospital, and dental health information in Sinhala terms) adapted from the 2006 Pew Internet & American Life Project report about Online Health Search [31], also attending to general health care information needs [61]. Participants’ keywords related to the health topics that we provided for web search included: teeth, names of foods, food pyramid, sleep and rest, exercise, and diseases, all in Sinhala terms.

In line with levels of supports defined from the IT literacy diagnostic session, at first, each participant was asked to perform a web search independently and was guided by the researcher/observer if the participant took more than 4 minutes to identify any element in the search interface or perform one of the actions for web search independently. In Workshop 1, the guidance was to tell the participant to move the cursor into the search box and click inside the search box before typing or to move the cursor onto the Search button and click on it (verbal prompting or encouragement). The suite of learning tools, which includes insights from previous workshops, was introduced, guiding each participant in workshops W2 and W3. In the workshops W2 and W3 the verbal guidance was to direct each participant to the page relevant to their current issue. In W2 that the tool was in print format, and the observer provided a live audio description. The PPT tool used in W3 included an audio recording. If the participant still required support after 4 minutes for acting on that guidance, and if the participant requested, then individual support was provided. For example, the researcher/observer helped them move the mouse aiming to bring the cursor on to the Google Chrome icon (physical help) [111]. This support approach also focused on identifying the specific learning needs of individual participants. During the workshops, we used the same ternary categorization as in the IT literacy diagnostic session to quantify our observations.

- a) Without support (score 1) - Participants were given 4 minutes [84] to initiate an independent performance, for example moving the cursor on to Save icon in word and clicking on it.
- b) With guidance (score 2) - Approached with guidance when requested or offered when participants were apparently no longer progressing through tasks after 4 minutes.
W1 - Workshop 1: Verbal descriptions by the researcher
W2 - Workshop 2: Pointing to print aids with verbal descriptions by the researcher
W3 - Workshop 3: Pointing to page of the eLearning tool, with animated illustrations and audio recordings in Microsoft PowerPoint format (PPT)
- c) With individual support (score 3) - Individual support was provided if the participant did not respond within 4 minutes to the guidance.

After the directed search sessions, semi-structured interviews were conducted to probe and clarify additional information about participants’ perceptions about web search and navigation sessions, and the learning support received. At the end of the workshops, participants were additionally allowed to freely interact with the eLearning tool (interactive visuals, animations, and audio in Microsoft PowerPoint) and practice Google search, in groups of 2.

Opportunities for people with ID to learn and apply skills related to self-determination in Internet use, with close personal support, might promote their potential to carefully take self-determined decisions in their life [95]. Throughout all the web search sessions, the first author was attentive about possibly misleading links and pop-ups displayed in terms of advertisements or otherwise, advising the participants about the possible threats and the need of avoiding them.

3.4 Designing and Developing the eLearning Tool (Interactive Visuals with Animations and Audio in PowerPoint)

The eLearning tool was iteratively designed throughout the study. The iterative design process followed guidelines integrating teaching strategies and usability heuristics for designing contents and interface of eLearning tools for people with ID presented by Arachchi et al. [6]. The learning content was improved, integrating strategies to support

our participants to learn and perform the functions that they found difficult throughout the Google search process. Reviews of observations and the interviews that were held at the end of each workshop, in partnership with the teachers who are familiar with the practical abilities and support requirements of the participants, helped us with insights to align the contents and the interface design with the participants' learning needs and learning styles. Before implementing it in the subsequent workshops, the design was inspected for its accessibility by two senior researchers who also co-authored this paper.

The design was first explored through interactive verbal support provided to participants in W1 in response to their support requirements, without prior scripting. The design was then prototyped with printed materials aligning with support provided in workshop 1 (W1) and accompanied with verbal support to support guidance in workshop 2 (W2). The final iteration, a functional multimedia eLearning tool, was then developed to align with the support provided and requested in W2 and proposed as guidance in workshop 3 (W3).

3.4.1 Workshop 1 – Verbal Descriptions. As the workshops were designed to identify what sort of support would be helpful for our participants to interact with Google search, verbal descriptions in W1 were established on the sort of support they needed, for example, to identify the interface elements and perform functions in Google search. We waited to see what they were struggling with and responded to those on the spot. Our observations including verbal guidance that was required in W1 served to inform the content of the print materials in workshop 2 (W2).

3.4.2 Workshop 2 – Print Material. The Printed material focused on guiding to start web search by finding the web browser icon, identify the URL, and find the address bar, and so on, to help proceed until they reach the web search results page. Figure 1 shows six selected pages from the printed material.

The first page demonstrated the Google Chrome, Mozilla Firefox, and Internet Explorer browser icons. It presented large-sized pictures of the icons to help the visual memory of the participants (Figure 1a). The next page introduces the web address (Google.lk) to go to Google search in Sinhala (Figure 1b). Figure 1c shows the page in printed material introducing where to type the web address (the address bar) using the relevant section of a screen-print, and pointing to the 'Enter key' on the keyboard. The printed material included few more pages to introduce web address suggestions displayed while typing in the address bar Figure 1d, search box, and also to show where to click to display the icon for the Sinhala keyboard (Figure 1e). The page in Figure 1f shows an image of the printed material that introduces the Google search results page, noting the link and the description text (or snippet) of a search result.

The use of specific portions of screen-prints was identified as not suitable for the learners' cognitive level. While providing the notes in short terms in Sinhala, related English terms (for example "Link") were included as suggested by the teachers at school, to make the participants familiar with those terms also. We have observed in workshop 2 (W2) that participants needed support to understand the printed materials. Most of the time they were guided to use the print aid (scored 2 in Table 3), they waited until the relevant page of the material was verbally described by the researcher. The description needed to be in the form of both vocal descriptions and pointing to the specific places on the page. For example, at the page in Figure 1c that we used in W2, the observer would say (in Sinhala), "This is the box called address bar at the top of the page. You can type the web address in it. You have to click on it to start typing. Then you can type Google.lk using the computer keyboard. After typing, you must press 'Enter key' to execute".

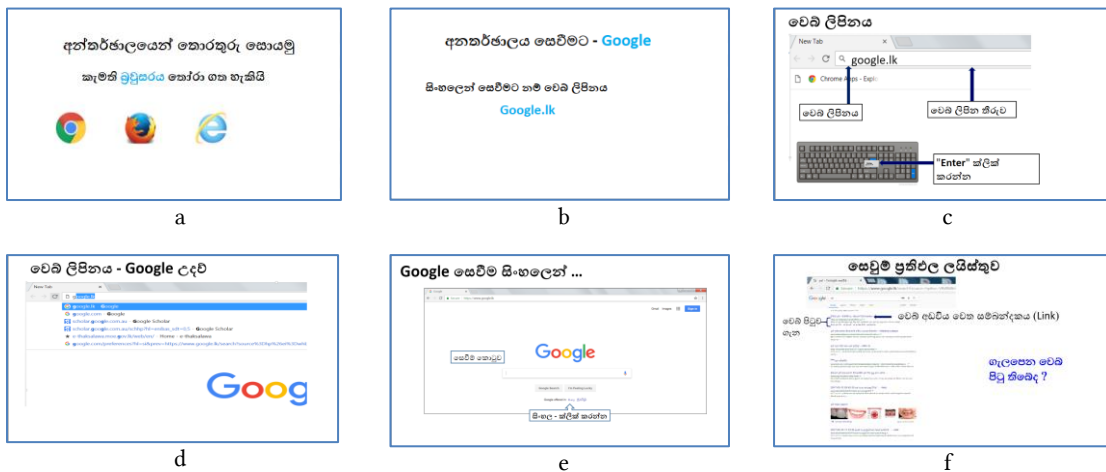


Figure 1: Pages from the learning tool in printed format (introduces a-browser icon, b-web address to search in Sinhala, c- typing web address and executing, d-search results list)

3.4.3 Workshop 3 – Multimedia eLearning tool in PPT format. Microsoft PowerPoint was used for authoring the eLearning tool in the form of a multimedia PowerPoint presentation with audio recordings by the first author. Figure 2 shows twelve selected pages from the eLearning tool in PPT format, which we used to guide the participants in the third workshop (W3)

The support requested or required by our participants during Workshop 2 led us to include additional pages in the eLearning tool, introducing the very basic functions that they need to learn. For supporting them to visualize the actual locations of action, we, therefore, used screen-prints of complete web pages. Mental models related to life experience, also called metaphors, were also included to support memory by visualizing what may otherwise need several words to describe (see below in “module 2” for more details about mental models).

Our simple verbal descriptions when the print materials were in use in W2, were included as audio support for them to repeatedly listen if they need. The recording was set to be played on return to the page, and we included a speaker icon at the top right corner of each page so that the learners can click on it if they need to hear it again. Icons were placed consistently from page to page. We placed navigation arrow buttons at the bottom right corner. They were large enough to click on, and the forward button was set to blink at the end of the recording, signaling the time to forward navigation.

The vocal descriptions were connected with animations to substitute our actions, pointing to specific places and to emphasize the elements in Google search pages. We added moving mouse pointers (e.g. to show the cursor pointer movement to address bar and then click on it Figure 2c), blinking circles/squares (e.g. address bar in Figure 2b, c & d), and animating arrows. For example, the red arrow in Figure 2b was set to blink and move from the correct web address to the web address bar (Note- this picture does not represent the ‘slide show view’, but the ‘editor’s view’. It shows all the arrow images that were set to be consecutively displayed and disappeared one by one; they are viewed as moving single arrow in the ‘slide show view’). Figure 2g shows a red arrow that moves towards the first link and then moves down to the third while the recording describes the vertical organization of the results page. Hence, these features direct the learner to specific points described in the audio recording.

We organized the learning tool in PPT format into three modules including what we identified as the learning needs of our participants who were new to the Internet and web search.

Module 1 of eLearning Tool – Introduction to the Internet

Module 1 includes a simple introduction to the Internet. The concept, presented using images, is that it connects computers located in different countries around the world.

Module 2 of eLearning Tool – Presents Google search process and two sets of practice exercises

Google Search Process: Module 2 helps to learn web search in Sinhala using <https://www.google.lk/>. The eLearning tool (e.g., Figure 2a & b) used mental models related to life experience. For example, Figure 2a aims to support conceptual understanding about web addresses, by presenting what participants have experienced with phone use. A telephone number directs the call to the person that you want to talk to; likewise, the web address directs you to the web page. Figure 2b includes an image designed to introduce the selection of correct web address, following the concept of ‘multiple ways road direction sign’ with which the participants are familiar in their school environments also directing to different buildings. It consists of three web addresses including <https://www.google.lk/> and indicates the need to select the correct web address to go along the correct path. The correct web address was highlighted, and animating arrows from the web address to the address bar was used to visualize the place to type it, and it was described in the audio in parallel.

Figure 2c shows the eLearning page in which we describe typing the web address and executing. It first highlights the address bar using a color animated blue frame (i.e. ‘transformation’ [60]) while a red color arrow moves towards the address bar with a box labeled ‘Web address bar’ (‘translation’ [60]). A cursor image moves into the web address bar and blinks once there with a click sound. Then, the arrow and the label disappear to reduce the text on display (‘transition’ [60]). After that, an image of a keyboard is set to be shown, Then it shows typing of the web address by displaying Google.lk character by character, with a sound of typing (‘transition’ [60]), together with a display of the next letter to type is blinking (in the text of GOOGLE.LK, which is written in large-sized red color fonts and placed below the address bar). It was meant to help familiarize themselves with the capital letters they need to choose from the keyboard to type ‘google.lk’ displayed in simple letters while typing in the address bar. That was followed by execution, displaying a green color arrow (with a label ‘Enter’) directed to the Enter key on the keyboard, and then, blinking the “Enter” key once with a sound of clicking while the audio recording says “you need to click on the ‘Enter’ key to load the web page.

We introduced the Google Sinhala virtual keyboard to search Google in Sinhala, which is available on any computer (without changing computer settings), anywhere in the world. To support typing in Sinhala, we showed learners how to invoke the on-screen keyboard, with “keys” labeled with Sinhala characters. Learners could type by clicking on these “keys” with the mouse. Pictures in Figure 2e & f show how the eLearning tool presented the process of locating the Google Sinhala virtual keyboard for typing keywords in the Sinhala language. Figure 2e helps the learners find the

search box by pointing to it with a label. A red circle around the word "සිංහල" ("Sinhala in Sinhala") blinks to highlight and the mouse pointer moves towards the place where the word "සිංහල" is on the screen, while the audio description advices to click on the word "සිංහල" to visualize the keyboard icon in the search box. When clicked on the keyboard icon in the search box, a label pointing to the Google Sinhala virtual keyboard displays then displays the virtual keyboard (Figure 2f). The next animation presents the typing of a Sinhala keyword using that keyboard.

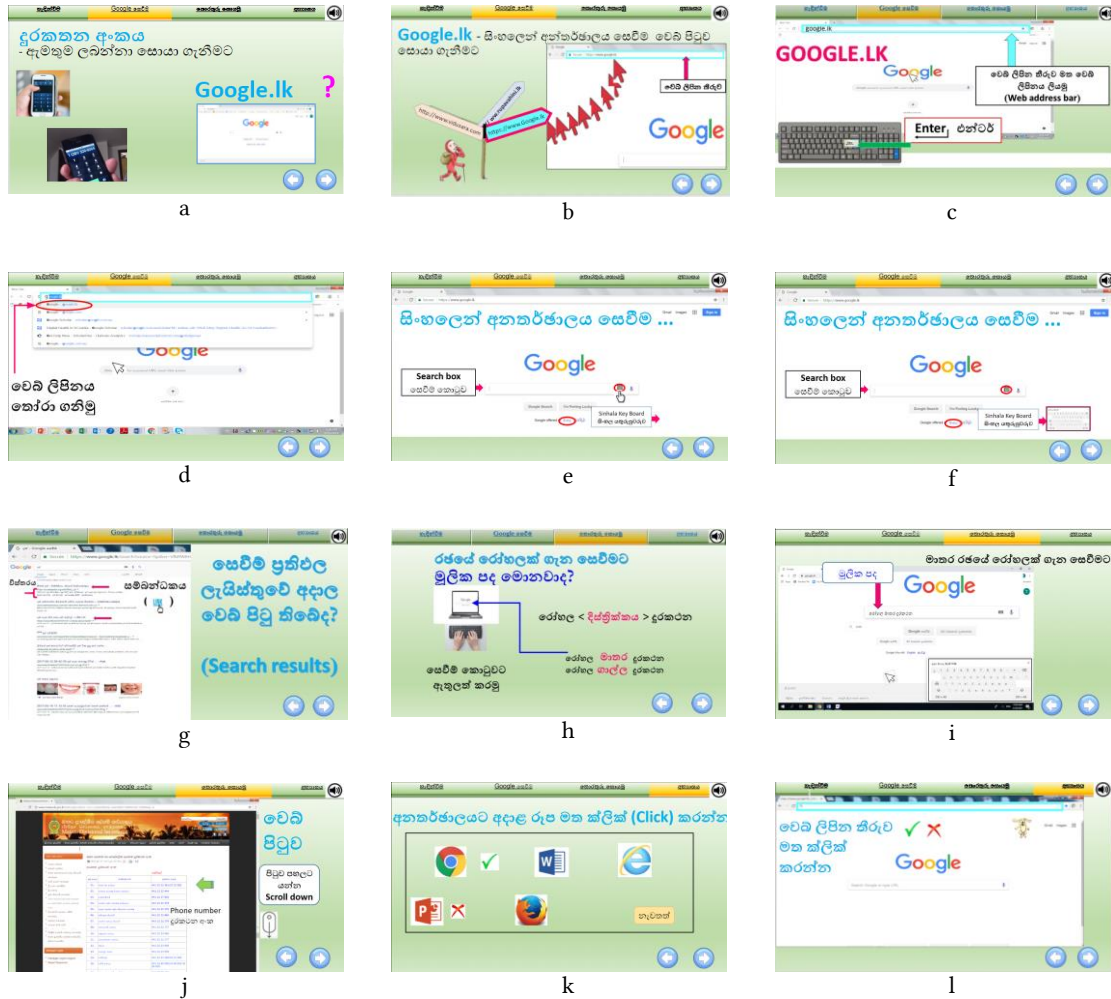


Figure 2: Pages from the Learning tool in PPT format (Introduces a- web address, b-address bar, c-typing web address and executing, d, e, f- Google Sinhala virtual keyboard, g- search results list, h & I-key words to search phone number of a hospital, j- scroll and find the phone number in a web page, k & l-exercise to find web browser icons and the web address bar)

Two Sets of Practice Exercises: Module 2 of the eLearning tool includes two sets of practice exercises. The same content is included in both sets of exercises; one with instructions and the other without instructions. The first set of exercise items designed with instructions in text and audio formats are intended to help practicing web search skills. The second one, designed without instruction, is planned to rehearse the Google search process on their own, memorizing what they learned.

The contents of the exercises consist of practice items for identifying the web browser icons, the web address 'Google.lk' and elements on the Google search pages, and typing the web address and clicking on 'Enter key', typing a given keyword in the search box, clicking on a link in the search results page, clicking on the back arrow at the resulted web page to navigate back to the search results page. As a motivator to follow through the exercise pages, each page includes figures set to be animated when the response is correct. For example, Figure 2k & Figure 2l show selected two exercise pages. Figure 2l gives instructions in text and audio formats, while visualizes the web address bar

using a blinking blue color frame to support the learners' memory. Furthermore, the correct response is marked with a tick symbol and also rewarded with an animating picture, to motivate and engage them in practice exercises.

Module 3 of eLearning Tool – introduce a web page resulting from web search

Participants were interested in web pages about cooking rice on different menus and related health issues. They wanted to search for “බත්” (rice), showing their interest in diet [72]. The researcher further specified the keyword as “බත් ගුණ” (rice good effects). Although they have the ability to integrate simple search terms with the information need, this suggests the need to learn search strategies with two or more keywords. This was addressed in the final workshop (W3), with three examples about finding information about a health center close to them in the eLearning module 3. It includes instructions for learning web search in Sinhala to find a contact number of a health center/hospital close by. It suggests possible keywords and a search strategy and instructs to type the keyword in the search box (Figure 2h & Figure 2i). Then it directs the learner, through the search results page to a web page, employing animations to demonstrate the process of actions employed in search of information (a phone number).

3.5 Data Collection and Analysis

During the workshops, attention was drawn to establishing complete familiarity with the data, and reflecting on the participants' learning needs. We also focused on how the participants enhanced their web search abilities by interacting with the human-computer interface and sequencing through Google search (recalling the search procedure). As seen in the previous section, reflecting on our observations at the end of each workshop provided knowledge of how the support can fit their process of learning to interact with web-search, which served in our iterative learning-aid design.

The data collection was in a mixture of semi-structured interviews and observations [24, 30] recorded in the form of notes in tables. As the collection of observation data was extended over three workshops, an observation checklist was used to minimize the risk of inconsistency and to take rapid notes. Referring also to evidence from related literature [39, 115], the observation checklist included basic skills related to computer use and web search (starting a search process, interacting with the search results page, and navigating to resulted web pages). On the checklist, assigned marks: 1 for their performance without support (independent), 2 for performance with guidance, and 3 for performance with individual support. Further to the checklist, observation notes took the form of analytic notes, scratch notes, and detailed descriptions; some of them were recorded immediately following the workshops.

Qualitative data from observations and semi-structured interviews collected throughout the three workshops that were also used in the reflections on instructional strategies, formed the basis of analysis, the results of which we contribute in this paper. The data was coded and analyzed employing the grounded theory approach [23] and thematic analysis [12].

The analysis utilized an open coding approach, through which we break down, examine, compare, conceptualize and categorize data. The iterative coding process proceeded from the beginning, parallel to data collection, which formed the base for the following sessions in this study. Data was thoroughly examined and manually coded (conceptual labels were assigned), focusing on interesting features related to the research questions. Then the codes (concepts) that are connected to the same phenomenon were identified with constant comparisons reflecting on “properties of the concepts and the dimensions of the phenomenon it represents” and were grouped into categories (more abstract concepts) [23]. Ongoing discussions with the experienced co-authors searching for, reviewing, and defining themes were focused on the trustworthiness of the analysis [77].

4 RESULTS

Participants were novices to the internet. From the IT literacy diagnostic session, we were able to develop an understanding of the participants' existing ICT abilities (Table 1 and Table 2), in particular, those that would be necessary for using mainstream web search engines. The iterative participatory approach in the workshops allows revealing the users' perspective for identifying strategies that can support the participants interacting with the human-computer interface and sequencing through Google search. This led to iterative improvements to the instruction plans and ultimately to the design of the accessible and usable eLearning tool to describe the web search process (Figure 2).

In this paper, we present the results of the qualitative thematic analysis to provide young adults with ID's perspective on Google search and associated support requirements. The first theme, “application of existing abilities”, describes previous experiences that supported the participants to enhance their abilities to search the web. The second theme, “basic skills to match with learning needs”, covers the skills they could develop with the provided support. The third theme, “conceptual understanding”, includes points of misconceptions that need attention to familiarize people with ID with the web search process. The fourth theme, “animations to facilitate visual memory”, focuses on mental models integrating animations (how an interface element is supposed to work) that can be appropriated in supporting to memorize Google search user interface's elements and functions. The fifth theme, “promoting active engagement”, highlights how collaboration between learners can be encouraged by the learning tool.

4.1 Application of Existing Abilities

Participants had no previous experience in web search. As a result, they approached the web search tasks with their existing abilities to work with computers. They had previously interacted with computers, working with MS-word, Paint, language learning programs, and games in their learning environment at schools. Most of the participants had about five years of computer experience through their school period. They had experienced the use of a mouse, a keyboard, and other basic skills, which we list in detail in Table 1 and illustrate in Figure 3. As a result, instead of requesting to learn everything about computer systems, they had specific questions about the web search process. For example, participants asked “where to click” expecting that there was an icon to click to start web searching. To work with the address bar or with the search box, they needed to learn about the functions of the address bar and search bar, and that they have to click on it to bring the cursor there before typing, as they did with other programs. Some participants already knew how to locate and use the backspace key in the Google Sinhala keyboard, demonstrating their ability to apply personal meanings, constructed with previous experience interacting with smartphones or tablets.

Participants’ existing awareness about health issues would have also helped them identify their health information needs and search the web for health information during the web search workshops. Interviews during the IT literacy diagnostic session highlighted that they had a general understanding of values related to day-to-day health. Some participants knew about the importance of selecting healthy foods with less sugar and oil. One of them (participant 9), mentioned that “frequent eating of short-eats (fast food) is not good”. Within this context, participants demonstrated the ability to define their own information needs. For web search, some participants did not just type the words/health topics suggested by the researcher, instead, they inserted related keywords to search what they had already learned on that health topic at the school. For example, in the second workshop, participant 1 wanted to search with the keyword ‘food pyramid’ to find information about a balanced diet. Furthermore, we could observe that participants were more comfortable with following the links from lists of familiar health topics in web pages than with Google search results lists of truncated titles accompanying a description text/snippet.

Some participants demonstrated an understanding of information authority, possibly gained from their environment (TV or print advertisements): in the second workshop, participant 2 identified the advertisements inserted in the text of a website as not relevant. She said “they are of no value”, pointing to the advertisements.



Figure 3: Participants interacting with computer and web search

4.2 Basic Skills to Match with Learning Needs

The research approach allowed us to elicit that they can increase their abilities to search the web with the support aligned with their cognitive level and specific learning needs demonstrated as they interacted with the web-search interface. Additionally, each new version of the learning tool in progressing workshops seemed to be better supporting them.

Table 3 presents the performance of two participants who showed great improvement, two with intermediate improvement, and two others who did not improve as much throughout the three workshops. We observed that participant 1 (P1) and participant 6 (P6) could perform hardware-related functions independently. The functions, similar to what they had experienced in navigating through language learning programs installed on their computers, were rapidly performed independently by those who showed great improvement. Participants who showed intermediate improvement (P2 & P3,) could independently perform those functions in the third workshop. The other two participants with slight improvement (P8 & P9) learned such functions progressing slowly through the three workshops.

Observations during the first workshop (W1) revealed the ability of most of our participants including P1, P4, and P6, to use the mouse and perform the single and double click. But others needed guidance (scored 2). They were guided by prompts such as “now you have to click/double click” and they followed it (e.g. Mouse use by P2, P3, P7, and P10 at W1 and W2). Those who scored 3 (e.g. P5, P8, and P9) needed individual support. They were supported with physical assistance to orient to the browser icon and carry out double-click and learn the temporal interval between two clicks.

This study identified four (4) primary functions for which the participants needed specific attention and support. As shown in Table 3, these functions are: 1) identifying the URL and where to type it, 2) locating the address bar, typing the URL, and executing the URL access, 3) executing the search after having typed keywords, and 4) identifying the results page, and clicking on links to go to relevant web pages. All the participants except P6 needed individual support to identify the URL and where to type it and then type the URL. They needed individual support provided verbally together with demonstrations pointing to the address bar in Google Chrome with the finger, demonstrating cursor movement towards it, and clicking on it before typing. Furthermore, they needed support to locate the letters from the keyboard to type the URL. This understanding of our participants’ learning needs, provided insights for developing the learning aid in print format. The printed aids included pages visualizing the address bar in a relevant section from a screen print with verbal description and so on. They were used in guiding the participants (if they took more than 4 minutes to perform a function independently) in the second workshop (W2) but were helpful only to P6 and P7 in performing this particular function. Participants could type the web address in the appropriate place when the researcher showed the printed page in which Google.lk is written in large letters and the address bar is highlighted on the page. Also, workshop 2 introduced the URL suggestions, on typing the first letter of the URL. In the third workshop, participant 6 (P6) could perform this independently. P6 typed the letter G in the address bar and selected the correct web address from the list of addresses suggested in Google Chrome, as ‘web address suggestions in Google’ was presented on another printed page. The ability to identify the URL from the suggestions helped P6 to proceed without typing the full address in the address bar.

Identifying the Google Chrome web browser icon, finding the Sinhala keyboard icon, typing keywords in the search box using Sinhala keyboard, execute the search, and navigating back to search results page from web pages to select another, were identified to be somewhat easier for most of the participants, as they were able to follow the guidance (e.g. P1, P4, P6, P7 and P10 in the first workshop, and P2, P3, and P5 in the second workshop) or to perform independently (P1, P4, and P6 in the third workshop). P8, P5, and P9 could follow this in the third workshop with the guidance of the interactive multimedia PowerPoint presentation. Almost all participants could perform scrolling the page with guidance that reminded them they can find more information towards the bottom of the page, also integrating their previous experience working with MS Word. P1 could independently perform this function. To remind them about the scrolling function in web search, we added an instruction to find a phone number, by scrolling down through a web page (Figure 2j).

In the following workshop, a few participants demonstrated what they had learned from the 1st workshop, by performing some of the functions independently: P6 could identify the Google Chrome web browser icon, and find the Sinhala keyboard icon at W2. P1 could execute the search at the third workshop. At the 3rd workshop, the guidance using a Microsoft PowerPoint presentation that includes an audio recording and timely animated illustrations was helpful for the participants to learn what the address bar is (40%), and to learn how to follow the search results page produced by the Google search for the keywords that they searched (60%). Participant 1, who could independently perform all the other functions except identifying URL, typing URL in the address bar, and executing, needed individual support in workshops W1 and W2; in W3 he/she could perform these with the guidance provided using the eLearning tool. Participants were new to web search in the first workshop. The reduction of the needed support during the workshops confirms that participants possess the capacity to increase their abilities to search the web with appropriate support and continued practice, similar to the observations in other domains [57]. The decrease of the need for individual support in the third workshop confirms that the availability of teaching aids, focusing on basic skills to search the web, with “good visual/auditory” and step-by-step support that matches their level of understanding, would be appropriate. At the end of the 3rd workshop, some participants still required support in some areas. This may be due to the long duration between the workshops, implying that they would be better supported with continued practice.

Table 3: Performance of selected participants throughout the workshops (W)

Functions completed in the web search process	Scores greatly improved			Scores intermediately improved			Scores slightly improved		
	P1- W1 W2 W3	P6- W1 W2 W3	P2- W1 W2 W3	P3- W1 W2 W3	P8- W1 W2 W3	P9- W1 W2 W3	P1- W1 W2 W3	P6- W1 W2 W3	P2- W1 W2 W3
<i>Hardware-related</i>									
<i>Start computer</i>									
Orient to power button in computer	1	1	1	1	1	1	1	1	1
Press on power button in computer	1	1	1	1	1	1	1	1	1
<i>Terminate computer</i>									
Use mouse, move and locate cursor onto target area and shutdown	1	1	1	1	2	2	3	2	2
<i>Software-related</i>									
Identify Google Chrome web browser icon	3	2	1	2	1	1	3	2	2
Double click on web browser icon to start	1	1	1	1	2	2	1	2	1
Identify URL and where to type it	3	3	2	3	2	1	3	3	3
Type URL in address bar and execute	3	3	2	3	2	1	3	3	2
Find Sinhala keyboard icon	2	2	1	2	1	1	3	2	2
Type keyword in search box using Sinhala keyboard	2	1	1	2	1	1	2	2	1
Execute the search	3	2	1	2	2	2	3	2	2
Identify the results page, and click on links to go to web page	3	2	1	2	2	3	2	3	2
Scroll the web page to see more	1	1	1	2	2	1	2	2	2
Navigate back to the result list to select another	2	1	1	2	2	1	3	2	1
Close web browser after working	1	1	1	1	2	2	1	2	2

1 - Score 1 (performed independently) 2 - Score 2 (performed with guidance) 3 - Score 3 (performed with individual support (physical help))
W1 - Workshop 1 (guidance- Verbal descriptions by the researcher) W2 - Workshop 2 (guidance- Print aids with verbal descriptions by the researcher)
W3 - Workshop 3 (guidance- eLearning tool designed with animated illustrations and audio recordings in PPT format)

4.3 Conceptual Understanding

We observed indications that emphasized the importance of conceptual understanding of the functions and the elements related to the Google search process to avoid mental model mismatch. Conceptual understanding is a form of a mental model, which can be both misled and prompted by analogies to what people already know (prior experiences). It can be for example misled by transposing knowledge from a different context, and prompted by using appropriate metaphors.

Participants were in some instances able to spontaneously leverage their prior knowledge and experiences. For example, in W1, participant 6 tried to memorize the Chrome icon by comparing it to a visual mental model of a CD. Similarly, some participants' ability to identify the 'backspace key' in the Google Sinhala virtual keyboard was supported by their knowledge of the delete icon on smartphones, with participant 6 rapidly identifying the "Delete" key in the virtual Sinhala keyboard and saying "My father use it on the phone". Similarly, participants used the physical keyboard for typing the URL, applying the conceptual understanding, that 'the keyboard helps the user to input words to the computer', being supported with the previous experience gained through typing their names in MS word.

However, at times, participant's prior experiences misguided their conceptual understanding. For example, when the browser started with the default search engine (<https://www.google.com/>), participant 1 said "What to do now". Then, with the view to go to Google.lk, he tried to find an icon among the icons for Google images, Gmail, etc. at the top right corner of the page. Participant 1, who accidentally clicked on the icon linking to 'Google images' said happily "I found it", and then tried to find the icon for the Sinhala virtual keyboard in the Google search box. It seems to connect to their experience of searching for an icon in the Ribbon on the top of the page of MS Word and Paint. This suggests the need to increase the conceptual understanding related to the designer model with different URLs, to avoid mismatch, similarly to Nielsen [74]'s observations. As another example, in W3, Participant 1 took the keyword activity a step further and searched for his/her name, then questioned why it does not retrieve information about his/her name on the web. This was identified as a misconception of the web as a source of knowledge in a similar fashion to a person they know (perhaps a teacher or a parent). The researcher clarified the need of adding someone's name to the web, to be included in the search results list.

The language used in the interface also led to misguided understanding. After typing the keyword in the search box, participants needed to be reminded how to execute the search. Some of the participants wandered searching for a place mentioning the term "ඇතුළු වන්න" ("Enter") in the search page, without paying attention to the term "Google සෙවීම" ("Google search"). In Sinhala, two words are standing for "search: the verb form ("සොයන්න" - action verb - find - instructing to lookup, locate or seek out) and the noun form ("සෙවීම" - noun-verb - the activity of looking thoroughly to find something or someone) [41, 46, 66]; participants would more easily interpret the verb form of "search" ("Google සොයන්න", for "search Google") on the button for executing the search after typing the keyword. This may result from a mismatch between the designer model and the user model. Participants were supported to execute the search with the conceptual understanding of the designer model; they were advised to click on "Google සෙවීම" (Google search) or press the "Enter key".

Furthermore, our instruction aimed to help conceptual understanding about where to click to display the keyboard icon to get the Google Sinhala virtual keyboard, addressing the user and the designer mental model mismatch. The designer placed the word "සිංහල" ("Sinhala" in Sinhala) below the Search box for the user to click on and get the keyboard icon (Figure 2e) which would be more informative if it had been presented as "සිංහල යතුරුපුවරුව" ("Sinhala keyboard"). The guidance in W1 (verbal description by the researcher) and W2 (verbal description with print material) was helpful to learn the designer mental model as understood by participants who showed great improvement.

Prior experiences could also be leveraged as part of the support provided by making the analogies explicit. To type in Sinhala in the Google search bar, most of the participants could learn how to find the icon for the Google Sinhala virtual (on-screen) keyboard in the Google.lk search box. Using the Google Sinhala keyboard involves moving across two sets of letters by clicking on an icon that represents a "Home", "Shift" or "Ctrl + Alt". Some participants learned this application when we described it as similar to the usage of the shift-key on a real keyboard, while others developed it with continued practice.

Although our participants were new to web search, we leveraged their previous experience with phone and computer use, when describing the concepts of the web address and keyboard. Our participants were familiar with the phone. They knew how to use a phone number, and one participant said his/her father's phone number. The eLearning tool in PPT format illustrated that the web addresses connect them to new web pages, in the same way that the phone number connects them to whom they want to talk to (Figure 2a). Identifying the web address, and locating where to type it were difficult for most of the participants in W1 and W2, however, they showed better performance with the illustrated guidance provided in W3.

4.4 Animations to Facilitate Visual and Associative Memory

Our qualitative observations included indications that participants had built mental models by integrating personal meanings and their previous experiences. The visuals and animations incorporated in the eLearning responded to difficulties and opportunities that we had identified in previous workshops, and for participants to create mental models that integrate visual and associative memory. We created dynamic animations according to guidelines by de Koning and Jarodzka [27] and Lowe [60]. Participants who showed the least improvement benefitted the most from the eLearning tool with animations to support visual memory; when presented in W3 they could perform several steps without waiting for individual support (researchers' physical support) (scored 2).

We visually introduced the suggestion list of key search terms and URLs (Figure 1d & Figure 2d) and links in the search results page (to help the participants create mental models that support memory. This suggests a mental model of selecting the URL from the options suggested in a dropdown list, which was also supported by their previous experience of selecting font size in MS Word from dropdown lists. As another example, at the search results list, participants started reading the description texts (or snippets) attached to the titles linked to the web pages. They needed support to understand the vertical arrangement of search results. Our eLearning design responded to this with animations (moving arrows directed to the links from one result to another below (Figure 2g) aimed at visualizing the vertical form of gathering information at the search results page [72]. Although this study did not focus on finding specific information, we observed how participants read web pages in which they showed an interest. On these pages, they started reading from the first line instead of browsing down through the headings to locate some relevant information. This is consistent with previous research which pointed that they may seek and gather information horizontally, rather than vertically [72]. We added this instruction in our eLearning tool to familiarize them with scrolling down to find a phone number of a health center on a web page (Figure 2j).

The decrease in the need for individual support in the 3rd workshop provided some indication that the animations were effective, but also more broadly confirmed that the availability of teaching aids with “good visual/auditory” and step-by-step support that matches their level of understanding would be appropriate. In this context, Li-Tsang et al. [56], Li-Tsang et al. [57] reported similar findings.

4.5 Promoting Active Engagement

At the end of the workshops, it was interesting to note that participants were discussing in groups about Google search and helping each other. Figure 4 illustrates some of the participants' behavior, discussing keywords in the search box and the search results page (without going back to the Google home page), and discussing the Google Sinhala virtual keyboard that we introduced in our instruction.

To respect and build on participant's interests, they were given some freedom to search for topics they were interested in. Participants used keywords related to their day-to-day activities to search. The keywords were simple terms related to their interest including health, names of clothes, and foods that they prefer e.g. “rice”, “pineapple”, and “mango”. They were also interested in searching for songs and films. Participant 6 searched for ‘කුටුම්භය’, the title of a Sinhala film. Searching for their interests offered them the challenge to identify useful keywords concerning these topics. Deciding new keywords for web search is inherent to the core model of web search, and we observed participants spontaneously collaborating to solve this challenge.

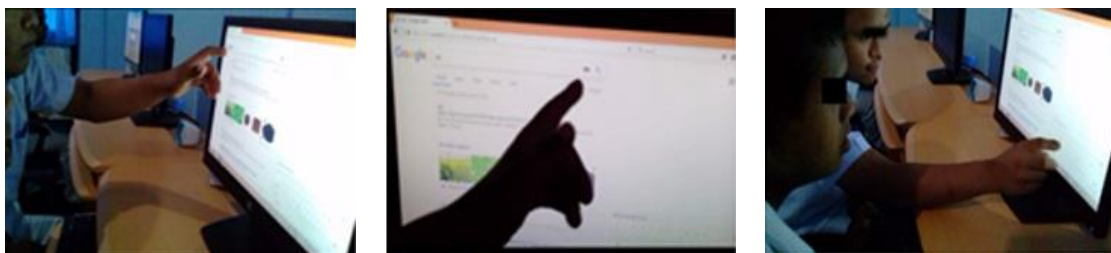


Figure 4: Participants were actively learning to search the web

This behavior, exploring further on their interests by supporting each other in groups suggests that group learning may be an opportunity to support continuous practice, as the participants who had mastered the skills were expanding and sharing their knowledge [61]. The iteratively developed eLearning tool would guide this collective engagement in learning.

5 DISCUSSION AND IMPLICATIONS

5.1 Understanding Participants' Existing Abilities and Knowledge Through Engagement

The abilities and the qualities that have observed when our participant interacted with human-computer interfaces in web search imply that some people with ID are capable of learning basic knowledge and skills for web search, and of using digital tools for guidance. This may be an important opportunity for individuals with ID to broaden their potentials using the Internet resources for life improvement.

Participants' existing abilities should be considered in the design of eLearning tools for learning web search. Avoiding cluttering the program with the knowledge they already have will allow the learner to feel competent and to relate to the learning materials. It is through direct and personal engagement that we learned that our participants had already developed basic skills to use a computer, such as using the mouse, keyboard, and identifying icons. Participants could find icons for the eLearning programs installed on the computers and follow them independently. They demonstrated their knowledge about navigating forward and backward, in those eLearning programs. On MS Word, they could find the save icon to save what they typed, close the window (using the close button at the upper right-hand corner), scroll down using the side-scrolling bar. Previous research [39, 115] has also reported the capabilities of people with ID to increase basic skills to use available technology. This suggests that it will be important to engage with participants from the stage of designing eLearning programs, as the participants' existing abilities and their learning needs could be identified while they interact with computers and web search as well as with the new design.

5.2 Motivating Web Search as per Information Acquisition with Relevant Topics

This study sought to identify how young adults with ID can be supported to engage in web search. Although they were new to web searching, they were interested in the task when the Internet was introduced as an information source. Our study focused on increasing abilities to search the web for health information. While learning tools should build on learner's intrinsic motivation, they also need to provide the learners with examples of tasks in a frame of information acquisition. Searching for entertainment is very motivating and often used in web search learning [58]. However, this is rarely a good example of acquiring new and useful information through search, and participants can be side-tracked easily (i.e. they could find irrelevant search results equally entertaining). Similar to Latteck and Bruland [53]'s observation in supporting health information access, we found that health topics relevant to daily life were very motivating for our participants' engagement in web search. They had learned about daily life good health practices at school; also some had previous experiences related to their healthy life (e.g. food habits - controlling cholesterol and sugar levels). The interest they showed by searching for those topics, reading through the snippets in the search results page and the text in the webpages indicated their desire for knowing more. This need for being informed is a right, as the United Nations Convention on the Rights of Persons with Disability [105] articulates, and would be supported with increased skills to search and with accessible information sources. The ability to search for the information they need may empower them to support each other in their community [61]

Our participants learned the purpose of keywords as directing to what they want to search and kept on expressing their interests as keywords to search more and applying them in their search. This intrinsic ability was also similarly reported in Sitbon et al. [99]'s findings, which showed that digital natives with ID could identify an information need and express it. Their ability to relate web search to their daily lives and interests, or to what they had learned at school, provided genuine information access tasks, rather than researcher suggested keywords. With this motivation, participants insisted on learning through the web pages they found; this also provided a strong case for understanding when a search result page is relevant to the query or not. This aligns with the behavior of digital natives reported by Sitbon et al. [99], who observed participants "clicking on results to peruse the content and make a more informed relevance decision" on search results pages.

5.3 Exposing Relationships ("What Happens When You Click")

Websites or computer applications are made up of different pages/screens, and often learners would learn about them separately. However, learning a continued process, such as web-search, involves familiarity with each element in each interface/page of the process and their functions, as well as the relationships between the interfaces/pages. For example, we found that participants were struggling to understand what to do on the search results page; participants continued reading the text at the Google search results page instead of selecting a link to find more information. This is consistent with Harrysson et al. [39] who observed problems with picking out a link from a large amount of information among the participants with ID. Modesto and Ferreira [67] observed similar behavior in web search (starting to read the search results page) among their participants, who were also used to select Google as their search tool. We addressed this by introducing the links in the search results page using moving arrows and images, also

aligning the animations to the audio descriptions in our eLearning tool, in agreement with Stock et al. [101] who have pointed out the importance of the timing of visual cues to attract attention.

Kushal Khan and Locatis [49] note that fewer links not embedded in text reduces cognitive load and supports search performance among novices, while Crudge and Johnson [25] suggested that result lists with summaries would be helpful for novices in selecting the relevant results. As such, participants would be supported with a conceptual understanding of the organization of the results page, its elements, and functions, especially about the connection between each search result and its related web page. Such support with an eLearning approach for increasing abilities of people with ID to learn web search, including practices for the search results page, has not previously been reported in the literature.

We offered descriptions on how to find links and the functions of links, also applying animations. Moving arrows pointing to the links were used to help them create visual memory about links. A popping-up image of the linked web page, from the link, was used to show that the link brings them to the website with more information. Sitbon [99] reported on some participant's anxiety with navigating to new pages, pointing to participants needing reassurance about what would happen when clicking on a link. It was indeed also important in our eLearning to account for relationships between different interfaces/pages in the search process along with the descriptions of different elements and their functions on each page in the search process. Such interactive eLearning tools, which can offer practical exercises for the learner to experience the outcomes of interactions and practice web-search offline, can provide an additional dimension to learning.

5.4 Scaffolding with Metaphors

Metaphors make use of existing conceptual models from the real world, for making the new design familiar to the user [73]. We observed indications that metaphors and animation were useful to provide accurate mental models of Internet concepts to people with ID. Gossen [37] notes that metaphors are important for describing the functionality of search user interfaces. Gossen [37] mentions that visual metaphors (e.g., Shop metaphors – a shopping basket in eCommerce) are very important for creating a familiar environment in the search interface. This environment leverages similarities with the physical world to provide the user with “how-to” knowledge about interacting with the user interface. Nielsen [73] also suggested the use of metaphors from the real world in his usability heuristics. Islam and Tétard [42] similarly highlighted the importance of selecting metaphors familiar to the user to enhance interpretation accuracy.

Mashal and Kasirer [63] report that visual metaphors can be advantageous as they are understandable at a comparable level with neurotypical people. Buehler et al. [17] highlight the importance of the use of more concrete icons and metaphors, related to their life experiences, for supporting people with ID with accessible interface designs. Furthermore, Karreman et al. [47] support the idea that metaphors used in describing the learning content for people with ID need to be familiar to them. Establishing from the two broad categories of mental models: emphasizing informational aspects (Internet users identified the Internet as a library) and emphasizing the connectivity and structure (Internet users identified the Internet as a superhighway) of the Internet, Bruce [14] highlights the need for ‘reality anchors based on non-digital models’ to better describe new systems to the learner. A participant in our study, who had access to computers and CDs at home, identified the icon for Google Chrome comparing it with a picture of a CD, showing the ability to memorize the Google Chrome icon drawing on the knowledge of similar visualization from the world around, without much effort to learn and remember. Engagement during the early stages of designing new content is important for identifying metaphors that are personally relevant to participants. Furthermore, metaphors are important in presenting conceptual models about the elements including: the web address, the address bar, the search box, the back and forward navigation arrows, and the role of the search results page, providing links to the web pages with information on the searched topic.

According to a study about memory performance among people without ID throughout three months, Gehring et al. [35] concluded that “recognition memory is superior for pictures at all intervals”, and that “the difference in favor of pictures diminishes only slightly if at all, over 3 months. We note, however, that there is still a remaining difference between the first workshop, where most participants acquired entirely new skills, and the following iterations, where they refreshed their memory with the help of the updated learning aids.

5.5 Computer-Based Learning Tools with On-site Support.

This study contributes an understanding of how to introduce web search interface elements and their functions, through a procedural approach and exercises to practice basic skills. This supports previous research in this area, projecting the potentials of basic skills training programs with a step-by-step approach [56, 57]. Our participants were engaged in the practice exercises that provided a learning environment as they were performing web-search online. They practiced the process repeatedly as if they were playing a game. As also stated by Seale and Cooper [92], we confirmed that these specific learners need on-site support at least until they get familiarized with the learning content and the practice activities. In achieving that, the computer-based approach with the eLearning tool would be helpful

for both the supporters to be acquainted with the subject for providing appropriate support, and the learners to continue practicing at their pace at any time with a low trainer-trainee ratio [57]. This would be particularly applicable in developing countries, but more generally when people with ID are seeking support from their carers and others who may be not familiar with the Internet and web search.

Hence, this paper contributes a broader understanding of how people with ID enhanced their web-search abilities, a most essential survival skill, also highlighting the insights that were useful in designing an eLearning tool for them to learn and practice web search. This can provide the basis for further research on strategies to better include people with ID in web-search for information.

5.6 Methodological Considerations

Engaging people with ID in participatory design, or co-designing and evaluating technological designs, have been reported widely in previous research. Most of these have used early prototypes as probes in participatory design, in a design after design fashion [13], to ensure that the perspectives of people with ID are encouraged [100]. Our approach similarly recognizes individual abilities and learning needs of people with ID who may find it difficult to voice them in typical research designs. Our iterative participatory approach not only fully engaged the participants, but also offered them new knowledge while allowing us to gain insights about specific interaction and sequencing issues connected to web search from their perspective. An interesting parallel to this is the TechShop approach by Bayor et al. [9], which centered on the aspect of learning about their participants' skills through teaching them. They approached people with ID with TechShops for a mutual learning experience, in which researchers learned about the participants' interests and abilities to interact with technology, and the participants were supported for advancing their interests and abilities to interact with technology. However, in our iterative participatory approach, we take one step further, learning about both their abilities and how they wish to learn, as well as exploring the possibility for them to learn independently in the future. This empowered ability-specific training for people with ID has been highlighted significantly in previous research [115].

5.7 Supporting Abilities in a Challenging Environment

As noted by Williams [110], "neither a physical nor a cognitive disability stops someone from learning and achieving, if they get the right support". People with ID are very interested in learning and surfing the Internet resources, recognizing their difficulties and aiming at overcoming them [85], without being discouraged by the errors they make [86]. In contrast with studies that focus on participant's barriers to access the search engines and the Internet, our supported approach motivated them to identify and utilize the existing Google search technology. This study demonstrates that, notwithstanding the challenges reported in the literature about interface interactions and cognitive functions in web search (including defining search query or recalling the web search sequence), most of our participants were able to increase their basic abilities to engage in Google search.

The eLearning tool was iteratively developed with introductions to supportive features/elements in search interfaces, including URL and keyword suggestions that may provide support with correct spelling and new search terms, hand symbol displayed on the link (titles of the search results), buttons (search button) or icons (keyboard icon) signaling to click-on, search results description texts (or snippets) with key terms highlighted, and the Google Sinhala on-screen/virtual keyboard to type directly in the local language (Sinhala) regardless of the limitations of the physical keyboard available. The sequence of describing the search process and the two sets of practice exercises (with and without support/advice on what to do on each page) helped the participants recall "what to do next" in the sequence of functions occurring in the search process.

We suggest that in addition to existing forms of support, new supportive functions could prompt the user to recall the search sequence. Other possible considerations include understandable labels on icons and autocomplete set to be displayed only after typing the first three/four letters. This four-letter limitation would overcome the problem identified by Modesto and Ferreira [67], where non-relevant terms appeared in autocomplete suggestions [102]. Keyword input using the Google Sinhala virtual keyboard was found to be more accessible with onscreen clicks. It supports a more focused typing experience, keeping eyes on the screen, and helps notice the auto-suggestions at the search box, addressing the difficulty to focus on the screen while typing [67].



"Spelling is a prerequisite to expressing vocabulary in writing" [103]. We included people with ID who can read and spell to some extent in our study. Ability to spell showed to be supportive in typing keywords. Participants needed to apply their spelling ability for selecting correct letters from the keyboard and clicking on them, in which they need to know the letters that represent the sound of the keyword, and not necessarily insisted on writing on their own memorizing the characters. Hence, participants' handwriting abilities were not considered.

With their capacity to read, our participants identified advertisements displayed in-between the web page contents to be of no value. Sitbon et al. [99] report that people with ID at the search results page used strategies pursuing relevancy decisions; they have focused on images attached to the results list, read the titles, and/or tried to find key

terms from the query in the description texts (or snippets). Hence, beyond introducing the supportive features of the search results page and the usage of description texts (or snippets) with highlighted keywords for assessing the relevancy, introducing quality labels in the websites and promoting their availability, especially on websites about health topics, would be supportive.

5.8 Accessibility Guidelines

According to Lewis [55], people with ID experience problems with web search, as people without ID do, however with greater severity. Sitbon et al. [99] note that “defining the information need as a correct query, correctly spelling search words, selecting a relevant link from a large selection, recalling procedures and sequences” are acting as common obstacles for them in this regard. Web developers, designers, and trainers must address these issues to include people with ID. Further research on challenges and opportunities for people with ID on the web can inform cognitive accessibility guidelines (COGA) to accommodate the diversity of accessibility requirements (e.g. searching for and accessing information, learning, communication, shopping, etc.) [19]. It will be important to focus on specific interactions (e.g. with the search results page) and functions (e.g. a participant tried to find an icon to go to a specific country page from the Google Homepage). This will in turn contribute to people with ID experiencing a sense of belonging, and increased self-efficacy in web search.

We highlight that early engagement with people with ID is important for increasing awareness of and reflecting on the existing models and experiences, with which they may approach existing as well as new technologies and designs. During web search workshops, we identified that misconceptions and/or mental model mismatch created challenges for our participants: they searched for an icon at the top of the Google.com web page (being unfamiliar with the web address bar and its functions) to switch to Google.lk to search Google in Sinhala, they refused to click on “Google සෙවීම” (“Google Search”) button, claiming that the button label is not relevant, and they were stuck at the search results page. As mentioned in the menu design guidelines to help users by Whittenon [109], web search home pages with language selection options placed in a familiar location, i.e. top of the screen, would be helpful. According to Web Content Accessibility Guidelines (WCAG) 2.1 W3C Recommendation 05 June 2018, accessible buttons in websites need to provide labels that describe the purpose of the button [50], such as “search Google” instead of “Google search”. For supporting the users at the search result list, further to the design of the Google search results displaying the titles in blue color, indenting the description text (or snippet) by one tab stop would make the title more explicit. Participants are attracted to the results accompanied by pictures (e.g. listing videos in the search results list), as observed by Sitbon et al. [99]. This implies that placing a related picture sized at least “44 by 44” CSS pixels [50] and linked to the resulting web page (acting as an icon large enough to easily click on) before the description text (or snippet) would also be helpful for the users [11], who find it difficult to differentiate search results in the list and to find the link. Furthermore, an informative and concrete icon/metaphor (e.g. ,  or any other symbol also with appropriate text hovers) to denote “Open-in-new-window / linked to new web page” can be introduced at the link, for visualizing that it directs to another page; it should be in a standard size so that it is accessible to users with ID [17]. Applications of these metaphors should be introduced to people with ID for their proper usage. Clearer definitions and instructions in W3C Cognitive Accessibility (COGA) guidelines on adopting standard text metaphors and image metaphors (symbolic images) can be helpful for designers and developers, as otherwise they may be interpreted differently.

5.9 The Sri Lankan Context

The volume of content available on the web in local languages (e.g. in Sinhala) is comparatively low. When Google is searched for, say, ‘coronavirus’ (කොරෝනා) it is an advantage, as it helps find helpful information from reliable sources on the first search results page (first ten results). However, when conducting a phrase search for “coronavirus symptoms” in English, it generated 1,490,000 results on Google. A search for the Sinhala language translation of the same concept (“කොරෝනා රෝග ලක්ෂණ”) retrieved only 17,800 search results. When the search query becomes more specific, the number of results drastically dropped, and the number of websites that consider the accessibility requirements of diverse communities, including people with ID, is scarce.

To enhance the accessibility of search pages themselves in Sinhala, a common challenge to address is creating content in the Sinhala language with Unicode. Unicode produces words in different forms which are displayed as phonetically similar, but with inaccurate spelling.

For example, when searched for ‘Sri Lanka’ in Sinhala (ශ්‍රී ලංකා) using Google, the suggested search terms listed at the bottom of the search results include unrelated terms, which may mislead the users with special cognitive needs (ශ්‍රී ලංකාවේ ජනවර්ග, ශ්‍රී ලංකාවේ ඉතිහාසය, ශ්‍රී ලංකාවේ විවිධ ජාතීන් etc.). This is a persistent technical problem, also with some other combinations of characters, which need attention for offering a satisfactory web search experience leading to accessible content in the Sinhala language.

The growing trend in Sri Lanka for providing accessible educational experiences is to create supportive learning environments for enhancing the abilities of people with ID. In this context, while they increase academic and social

abilities in special school environments, they become acquainted with computer technology. This can scaffold them with basic abilities to access the web for their day-to-day needs.

In this context, this study focused on supporting people with ID to enhance basic skills for web search. However, accessing information through interaction with websites presenting content in Sinhala can be addressed in future research. For example, it would be supportive if the information related to the health sector in Sri Lanka was available in local languages. However, Rajapaksha and Fernando [82] report that government websites do not comply with accessibility or usability standards. Also, they report that the active maintenance of supportive features in websites including “contact details, citizen participation, and interconnectedness”, needs attention. Besides, some government websites attend to essential information needs by including downloadable documents in the Sinhala language. Although those documents in PDF format consider accessibility requirements in the content design to some extent, the availability of such content in a more accessible video format would be beneficial for people with ID. Furthermore, attention to the arrangement in the websites, with more informative menus to direct the user to web pages with specific information, would be also supportive. Importantly, we could identify that there are websites, including health-related sites, lacking support for users to trace the current location across multiple web pages, which can be approached with navigation features, such as breadcrumb trail with hyperlinks, navigation bars, or sitemaps [50]. Further research can support the development of a quality improvement plan facilitating access to quality and usable information in Sri Lanka.

6 CONCLUSION

This article presents the support needs and support opportunities that we identified as we observed young adults with ID learn to search the web in Sri Lanka. These emerged through reflections on the observations of three web search workshops iterating the design of an eLearning tool. These insights emerged from close observations and semi-structured interviews in this iterative participatory approach with people with ID, whose individual needs would not be possible to be sound out otherwise. Through this study, we also reflected on how to address people with ID’s specific learning needs in the following workshop material (the learning tool), to offer better support. This iterative participatory approach with preparatory workshops focused on “learning about both their abilities and how they wish to learn”. This was appropriate to identify the participants’ behavior while they acquired procedural knowledge of the Sinhala language edition of Google search. Our findings can inform future ICT training programs in Sri Lanka, including those delivered in the form of eLearning, with content we identified as necessary, and with strategies that we identified as appropriate. Our approach can support the design of future ICT programs in other developing countries.

The originality of this study lies not only in unique insights into how young adults with ID use the Google search engine to search the web in Sinhalese, but also in the unique approach, supporting them to learn web search by leveraging their existing experiences (identified in the IT literacy diagnostic session). Their familiarity with technology helps address the new mental models [116] they need to create as well as broaden their current conceptual understanding [89], thus addressing a unique mismatch. The involvement of a new community, people with ID in Sri Lanka, highlighted challenges from a unique perspective, in composing the queries and accessing the functionality of the search engine interface. This can enrich interaction design for providing a better web search experience for them as well as others. While such a targeted group of participants does not allow us to conclusively recommend specific content or mismatch that need to be addressed for all people with ID, the combined quantitative and qualitative observations, aligned with prior findings, show that audio-visual guidance and continuous training are critical to support independent access to online information. More importantly, our research demonstrates that people with ID can independently access information online and can rapidly transfer their understanding of their own experiences to web search and information access.

While health information provided a thematic scope for the training, we haven’t systematically examined participant’s attitudes towards online health information or delved into the different types of health information they may be able to find. Conversely, participants seemed to be more autonomous in working with websites with simple lists of links than working with the Google search results page, in particular in selecting the links related to the health topics they had already learned at school. This is a good indication that a focus on health information is likely to support participants’ motivation to continue and develop information access skills in a range of scenarios, including web-search.

This study focused only on interactions with Google search interface elements and their functionality, and leaves to future work the assessment of the success of the search results (in terms of their usefulness to the user, for example), browsing behaviors for accessing specific health information, as well as online health literacy and the ability of the participants to successfully process the search results. The effectiveness of the eLearning tool as a full learning program, and once expanded to cover other aspects of online information access, will provide scope for a future study. Further research could also seek to identify interactions in other information domains, such as entertainment, or to

extend this study with a new iteration of the eLearning tool adapted in a different country. Finally, after the workshops, we noted participants supporting each other in learning the Google search process and discussing what they had learned. This points to further research to systematically embed social practice into learning.

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