Exploring the Acceptability of Graphical Passwords for People with Dyslexia

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LIFT: an eLearning Introduction to Web Search for Young Adults with Intellectual Disability in Sri Lanka

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Abstract. For users with intellectual disability new to the Internet, mastering web search requires both conceptual understanding and supported practice. eLearning offers an appropriate environment for both self-paced learning and authentic practice since it can simulate the types of interactions encountered during web searching. Yet eLearning approaches have not been explored towards supporting young adults with intellectual disability (YAWID) to search the web or supporting them to learn web search. This paper presents a study that examines the experiences of 6 YAWID learning to search the web with LIFT, an eLearning tool designed with a specific focus on supporting memory through mental models and practice exercises. The content and approach of LIFT are tailored to the Sri Lankan context, incorporating the use of the Sinhala virtual keyboard for Google search and culturally relevant metaphors. We collected a range of observations as the participants used the eLearning tool, subsequently independently searched for information online, and finally described the Google search process to a teacher. We surveyed their understanding through drawings they created about the Internet and Web search. The findings establish the significant potential for eLearning to engage and support YAWID learn web search, with a realistic environment for safely practicing web search and navigation. This study contributes to human-computer interaction by integrating three aspects of eLearning: accessible interface, content, and interactive practice, also accommodating web search in the Sinhala language. It acknowledges that understanding specific users is critical if interaction designs are to be accepted by their users.

Keywords: Interaction Design, eLearning, Web Search, People with Intellectual Disability, Sri Lanka, User Experience.

1 Introduction

While the rapid development of mobile devices has helped the Internet extend its reach to developing countries. The lack of appropriate training opportunities on the web search for young adults with intellectual disability (YAWID) means that they do not use the web to access information. YAWID are able, with specific computer skills training programs [1] and regular training [2, 3], to learn digital skills, including those to interact with web search interfaces [4]. Information and Communication Technology (ICT) applications that match with learner needs, such as the use of multimedia in instruction for YAWID, support better engagement in learning [5]. In addition to the benefit of learning independently of the skills and pace of an educator, learning web-search in an eLearning environment offers opportunities for practical experience that can be easily transferred to real use [6]. Further research is needed to establish how YAWID in developing countries would engage with and respond to these eLearning experiences if they were made accessible and culturally relevant. We, therefore, designed an eLearning tool called LIFT (Learn Internet skills Facilitated with Technology), introducing Google.lk to search the web in the Sinhala language [7]: Sinhala is used by most people with ID in Sri Lanka as their primary language. LIFT, which was designed for YAWID to develop and apply web search skills, includes both instructions for conceptual understanding and activities to practice, all self-contained in the learning structure. It introduces Google to search the web, since people with intellectual disability (ID) have been previously found to favor Google's simple interface [8].

This study investigated the effectiveness, engagement, and satisfaction aspects of the LIFT through observations, as well as collecting participants' and their teachers' views and expressions during a three-day session. The study sought to answer the following research questions:

RQ1 (Effectiveness): How can the LIFT tool contribute to the learning of web search skills for YAWID?

- How do mental models support understanding and memory about the elements and their functions in Google search by YAWID?
- How do YAWID perform with increased web search abilities during the last two days of the web search workshops?

RQ2 (Engagement): What LIFT features engaged the YAWID?

- What brought enjoyment and self-actualization, in learning for YAWID?

RQ3 (Satisfaction): How satisfied are the YAWID and their teachers about the LIFT tool?

- What are the views of special education teachers about LIFT introducing Google search in a technological environment?

While we report on short-term evidence of learning as an indicator, our focus is on the interaction, effective engagement, and satisfaction, concerning user experience. We observed how participants use LIFT, practice, and explain Google search. Instead of assessment, we asked participants to draw their learning experience about the Internet and web search process, and then to demonstrate the search process to a teacher. Because

of teachers' critical role in continuing to support the development of ICT skills at school, we collected the opinions of participants' teachers about the LIFT.

"Human-computer interactions are always situated within someone's life, values, and needs" [9]. This study fills a significant gap in current research targeted at supporting YAWID to search the web. It contributes to the field of human-computer interaction by investigating the user experience of a support approach that pays attention to three aspects of eLearning: accessible interface, content, and interactive practice, also accommodating web search in the Sinhala language. It highlights that observing participant's behavior when applying freshly learned skills and collecting their drawings about their ideas and expression [10] is more appropriate than inquiring whether they can perform different functions through the search process or assigning a search task to complete, at least in this context.

2 Background and Related Work

2.1 Intellectual Disability Definition and the Context of Sri Lanka

The American Association on Intellectual and Developmental Disabilities (AAIDD) [11] defines intellectual disability (ID) as " a disability characterized by significant limitations in both intellectual functioning and in adaptive behavior, which covers many everyday social and practical skills. This disability originates before the age of 18". Focusing on capacities and interests along with the level of support required, Sitbon et al. [12] present the executive function perspective to understanding intellectual disability. The executive function standpoint would be suitable for gaining an understanding, with an ability-based as well as a traditional design point of view. This approach could guide designers to understand users with ID, relative to their level of achievability, and define their potentials and experiences for leveraging them in new technology designs. Participants are therefore introduced in section 3.2., in terms of their existing abilities with MS Word, Paint and Language learning digital tools, rather than through their ID diagnosis.

People with ID and how they are supported in Sri Lanka is a new area of national significance in the educational sector advancements, integrating technology to promote active learning. Sri Lanka, for example, is at the beginning of undertaking fundamental changes in its education sector, integrating technology with teaching; learning facilities available in schools in Sri Lanka vary greatly, with very few facilities in village schools. Students with "special learning needs" (including mild to severe ID) are mostly attending special units in formal or special schools. The language of instruction in special education is Sinhala or Tamil. Most special schools have specially trained teachers, computer labs for ICT training (MS Word & Paint), and language learning programs on computers. There is, however, no support for online learning. Participants in the research presented here were from special schools with these facilities; they had not used the Internet before and neither had their teachers and parents were reported to be familiar with web searching for their information needs.

2.2 eLearning for People with Intellectual Disability

eLearning can be used to enable people with diverse abilities to learn at their own pace and from a convenient place, access learning materials whenever they need, both online and offline [13], with a supporter or independently. Such educational approaches need a "match between designer and learner models" to engage the learner by addressing their needs, both in terms of interface and contents [14]. Interactive content and interface for example can be developed using technologies such as PowerPoint slides and multimedia to present learning content in a visual and auditory form [15].

Interaction Design of eLearning content. Cognitive theories emphasize the learner's process of knowledge construction through interactions between existing understandings and the new learning experience [16, 17]; the use of metaphors in instruction support learners to process new knowledge using working memory.

Constructivism maintains that people gain new knowledge based on their prior experiences [18]. That means learners create mental models related to their real-world experience and integrate that experience in constructing new knowledge. The introduction of mental models in training can therefore provide opportunities for conceptual understanding where learners can draw links between those representations (designer mental models) and their pre-existing mental models (user mental models). Mental models introduced by the designers, when matched with those user mental models, support interactions with the user interface, and can also improve learning effectiveness. For example, people with previous experience with a typewriter may gain a conceptual understanding of the computer by aligning the functions of the typewriter and computer. Effective mental models can also support the interactions between humans and computers. Uther and Haley [19] found mental models to be helpful to neurotypical learners in a training program on how to use the back button in web navigation. Attention to the user's mental models, through close observations, can be helpful for designers to identify any misconceptions in new designs.

Presenting eLearning content using metaphors, icons, and visual cues, with consistently arranged interface elements, may support a learner's memory [20]. Visual metaphors help to describe or learn new things by comparing them to a well-known thing and developing new mental models [21]. Multimedia images can also act as rewards for learners, offering aspects of persuasive design to support engagement in learning activities and so achieve learning objectives [22, 23]. In LIFT, we describe functions and the elements in Google search using images along with animations to support users' creation of mental models about the Google search process. Drawings can be powerful to elicit user mental models [24, 25]. From drawings about the Internet, Zhang [24] identified mental models with a technical view, functional view, process view, and connection view. LIFT leverages all these four views to introduce the Internet and describe web search. For example, the LIFT tool introduces the functional view of the Internet, providing needed information, by introducing web search for health information. It describes web search advancing the process view or search engine centered view; it presents the search engine as the center of the web to reach the needed information.

Accessible content accompanied by interactive practice exercises draws learners to practice, cementing what they have learned to help memorization. Marshall and Wilson [26] presented their eLearning tool with interactive practice queries for neurotypical users: sequencing questions, visual identification questions, visual multiple-choice questions, and fill-in-the-blank questions that involve what is described in the content. They aimed to support the learners' confidence and satisfaction by providing these questions related to the learned content. In contrast, the approach developed here is different/new in that young adults with ID are guided in their learning using two sets of practice exercises, with and without guidance to repeatedly do and practice the Google search process until they can automatically complete the web search process [27], and effortlessly apply new knowledge.

Interaction Design of eLearning interface. The interface element of a system determines 'to what extent the system is easy to use'. Sung and Mayer [28] report that navigational aids and signaling aids in an eLearning design for neurotypical people contributed to improving their learning outcomes. Navigational aids such as site maps, concept maps, and outlines support how learners navigate through the eLearning tool and know where they are in a lesson. Signaling aids to direct the learner to the points on the learning content include: highlighting the important text and use of animating objects.

Seo and Woo [29] found that the eLearning design guidelines should acknowledge the capacity of the short-term memory of students with special needs when designing computer-assisted teaching programs. The application of new technology together with such specific design guidelines [30] in the iterative development process of LIFT [7] aimed to increase the accessibility of the design to learners with ID.

It is the blended approach in the eLearning environment that encourages interactions between the eLearning tool, teacher, and learner [31]; provision of on-site support would be supportive for young adults with ID in eLearning, at least until the learners become familiar with the learning interface and content. eLearning tools can be significant, in a blended learning environment, for both the supporters (teachers, family members, or carers) and the learners. Supporters can be relevant for the learners' needs as well as the subject content the learners can learn at a pace that suits them, updating with continued practice with a low trainer-trainee ratio [32]. In developing countries, access to eLearning would be applicable, in general when YAWID practicing web search, and as they need support from their cares and others who are also new to Internet and web search. An initial approach introducing an eLearning tool for practicing Google search would benefit both YAWID and their special education teachers, towards lifting digital inclusion.

3 Methodology

This study investigated the user experience of LIFT along with its interface, content, and interactive practice activities, to further scrutinize the effectiveness, engagement,

and satisfaction of its iteratively developed interactions for young adults with ID (YAWID) [7].

3.1 The eLearning Tool - LIFT

The design of the LIFT tool in PPT (Microsoft PowerPoint) format for its target users: new Internet users with ID, who want to learn web search in the Sinhala language using Google search, resulted from iterative participatory design research with YAWID in Sri Lanka [7] and draws on the research team's expertise and field experience in supporting people with ID using online technologies. Arachchi et al. [7] present the full iterative design process that highlighted the applicability of mental models, animations and images, for supporting conceptual understanding and visual memory by YAWID. PowerPoint was selected as a widely used presentation software to create attractive designs, which supports digital story-telling, and can be converted to LMS-supported versions. PowerPoint is also widely accessible, quick, and easy to use, making the LIFT approach easily replicable in other languages, and transferred to new topics of interest. The LIFT tool covers interface elements and functions in Google search through to selecting a link from the search result list and visiting the corresponding web page. The tool includes an introduction to the Internet and two modules: Module 1 describes the Google search process, and includes a series of activities to practice the web search process; Module 2 presents search strategies to find a web page with a phone number of a health center.

Fig. 1 shows the knowledge graph for the concepts introduced in the LIFT, with the relationships between the concepts illustrated using three types of arrows: a) has (e.g. a web page has a web address), b) leads to (e.g. web address leads to a web page), and c) correlation (e.g. between browser and address bar, the address bar and search box).

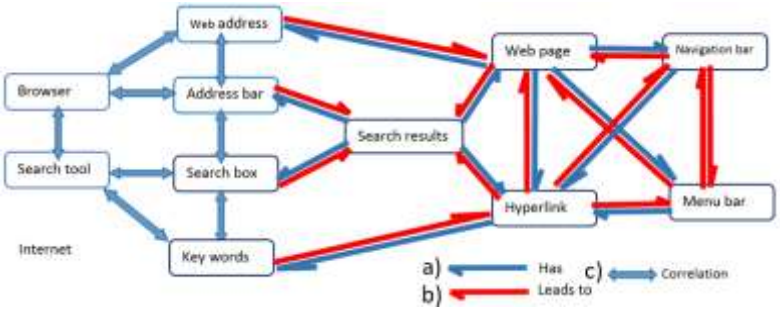


Fig. 1. Knowledge Graph for learning web search and navigation

These concepts have explicit and implicit relationships. Implicit relationships include relationships due to co-location and interaction (**Table 1**). This study observed participants' performance in web search focusing on these relationships (listed in **Table 3**), which are covered in the LIFT, as they were not all possible to study. One such example is the relationship between the address bar and the search box that is converting the

address bar to a search box, in the Google Chrome home page, which did not function in Google.lk.

Table 1. Relationships between the concepts presented in the Knowledge Graph

		Concepts	Abilities of the Learner
Explicit Relationships		Browser and address bar	-Finds address bar in the browser
		Browser and search tool	-Finds browser to start a search
		Web address and address bar	-Types web address in the address bar
		Web address and web page	-Knows web address of web page
		Search box and address bar	-Types keyword in the address bar
		Search results and web page	-Identifies listed search results
		Web page and hyperlink	-Uses links to go to web page
Implicit Relationships	due to Co-location	Search tool and search box	-Finds search box in the search window
		Search results and hyperlink	-Finds hyperlinks among search results
		Keyword and hyperlink	-Finds suggested keywords with links
		Web page and menu bar	-Locates menu bar in web pages
		Web page and navigation bar	-Locates navigation bar in web pages
		Hyperlink and navigation bar	-Finds navigation bar links to web pages
		Hyperlink and menu bar	-Finds menu bar links to web pages
	due to Interaction	Search tool and keywords	-Knows search tool needs keywords
		Keyword and search box	-Types keywords in search box
		Browser and web address	-Knows browser needs a web address
		Address bar and search results	-Knows Address bar brings search results
		Search box and search results	-Knows search box brings search results
		Menu bar and navigation bar	-Knows both direct to web pages

The LIFT used interactive buttons, sound (audio descriptions), and animated images developed in Microsoft PowerPoint. LIFT was designed using guidelines [30] which enabled us to align the content and interface of our design with both learning theories and usability guidelines.

Clark and Mayer [33] identified that eLearning courses, designed in the form of "multimedia presentations" comprising both words and pictures, can provide a clear meaning for learners. The images and short videos included in LIFT, therefore, aim to support YAWID in creating mental models and to memorize the concepts and Google search functions new to them (**Fig. 2**). Clark and Mayer [33] highlighted six types of graphics relative to their functions: decorative, representational, organizational, relational, transformational, and interpretive. Motivational graphics were included in the design of LIFT to keep learners engaged. Those graphics are the animating images displayed as an award for the correct performance, further to the feedback with right or wrong marks at the web search practice pages (**Fig. 3**).

Learners' navigational requirements were addressed by including a navigation bar at the top of each page; the navigation bar directs the learners to the introduction and the first page of each module and the exercises. To avoid accidental multiple clicks, the forward navigation button was set on each page to be displayed and blink at the end of the audio description, signaling the user to click on it [7]. Similarly, the audio button was set to display at the end of the audio track (**Fig. 2**).

We designed two sets of Google search practice exercises in the LIFT tool for the participants to practice the search process. One set includes instructions about what to do on each page; the other presents the same interface without instructions. Both practice exercises aim to help learners memorize the web-search process (**Fig. 3**).

(a) (b) (c)

(d) (e) (f)

Fig. 2. a-b) Home page and the first page of module two, c) The page introducing the Internet, d-f) Selected pages from module one, describing search process

(a) (b)

(c) (d)

Fig. 3. Selected practice exercise pages in the LIFT: a) Exercise page with instructions to type the web address, b) Exercise page without instructions to type the web address, c-d) exercise pages with instructions.

We also integrated the teachers' advice to use red color in the animating arrows and circles, to attract and engage the learners on the important concepts. The teachers also advised the addition of simple English terms into the text, having read the transcripts of the audio descriptions.

3.2 Participants and their Context

Participants (P) were 6 young adults with ID, 2 female and 4 male recruited from two special schools in Sri Lanka, and from the group of people who contributed 6 months earlier to iterations of LIFT. Selection criteria included: aged 18 - 30 years, able to read and spell to some extent in their mother tongue 'Sinhala', verbally communicate, and use a computer. Given the qualitative approach of this study, 6 participants is a sufficient number and align with previous studies such as Nielsen's [34].

Before the study commenced, participants demonstrated their current level of abilities developed by working with MS Word, Paint, language learning tools, and web search. Participants were able to use the power button and start the computer; independently use the keyboard and mouse; type their name and other words on the computer; independently navigate through multimedia language learning programs using menus, and forward and backward buttons; locate and click on the close button and close the window after working and shut down the computer by clicking on the power button on the screen. As observed in other studies [32, 35], people with ID did have weak retention of the learned ICT skills over months; we identified our participants had not retained those skills from the iterative design sessions, having not accessed the Internet after that. Their parents, although not included in the study, were not reported to have previous experiences with searching the web for information.

Teachers from the two special schools were specially trained and familiar with the ID levels. They are involved in teaching ICT skills to the YAWID who participated in this study. They helped with participant selection. The teachers had not previously used the Internet for finding information. They were present during all the learning sessions, advising on the specific requirements of YAWID. They reflected and provided ideas about the design/use of LIFT and its applicability and significance in the context of supporting YAWID. They were not involved in data collection.

3.3 Procedure

The study followed procedures approved by the Queensland University of Technology Human Research Ethics Committee (approval number- 1400000673), as well as the ethical guidelines of the two special schools. This research considered ethical issues, including voluntary participation and informed consent, right to withdraw, and confidentiality. The study proceeded with the consent from the principals of the special schools, parents, and YAWID after they were informed about the study; the procedures of taking notes and photographs, and the level of participant involvement. Six YAWID signed the easy-to-read consent form, formally indicating their consent to participate.

The study was conducted in the participants' familiar computer labs in the participants' schools in two phases over four consecutive days.

Phase 1- Training (Day 1, 2 & 3). The training session consisted of three hours per day for the first three days of the study. Health topics were introduced for practicing Google search based on the importance of those topics for life, their interest as stated in the literature, and its relevance for introducing the web to find information.

Day 1. Participants were trained to use the LIFT tool, using the menus, forward and backward buttons, and replaying the recording.

Day 2. Participants used the LIFT tool, the content and practice exercises that incorporate metaphors, animations, and audio recordings, to learn and practice the Google search process (**Fig. 4**-a). They used the LIFT tool and learned the web-search process up to locating a website from the search results list and visiting it, and then performed the practice exercises. They learned that the rewards, in the form of checkmarks or animated images, meant they were correct. They repeated the practice exercises until successfully performing the task.

Day 3: Participants using Google.lk to search for health information were observed. They were asked to select one of the provided health topics in the Sinhala language such as a specific disease or medical problem, diet, nutrition, healthy foods, exercise, a particular doctor or hospital, dental health information [36] in Sinhala terms), and use it for a web search using Google.lk. They also searched for the topics that interest them (e.g. teeth, healthy foods, food pyramid, sleep and rest, exercise, and diseases - in Sinhala terms). Participants proceeded independently unless they requested support, or were not attempting anything for more than 4 minutes. In these cases, they were advised to use the LIFT tool as a guide.

Phase 2- Demonstrating Knowledge (Day 4). Participants were assigned two tasks: draw what they learned from the LIFT [10], by saying "now you are going to draw what you learned. You can draw anything you learned from LIFT", and describe the web search process to another person, using Google.lk (**Fig. 4**- b and c).

3.4 Data Collection

We collected the data mainly through observations during the four-day session. While participants were being trained to use the eLearning tool and to do a Google search (Day 1 & 2), observations aimed to explore how they interacted with the LIFT tool content and practice activities. Participants' Google search performance on Day 3 and 4 were recorded as an indication of the effectiveness of the LIFT tool. Observations focused on the knowledge graph relationships (**Fig. 1**) of learning web search and navigation, and whether they were performed independently or with guidance.

During the sessions, we noted a range of behaviors and attitudes, presented in **Table 2**, as suggested indicators of usability and engagement by existing literature [22, 37].

The non-textual strategy of collecting participants' drawings [10], empowered participants to actively voice their inner senses, in terms of establishing what they had learned about Google search and their mental models.

The views of the two special education teachers were collected to determine their satisfaction with the LIFT tool, as they are involved in teaching ICT skills to the participants. Teachers gave their views about satisfaction, from their perspective as teachers, from that of their participating students in the classroom, and from that of the future of their participating students in the digital society.

Data were coded and grouped into categories, for which different themes were assigned [38, 39]. Interpretations were made with the participation of all coauthors to identify participant needs so that future research involved in educating and designing for young adults with ID with the same level of abilities can be attended to.

Table 2. Participants' facial expressions and body language, to identify attitudes during the sessions

Design elements	Observations	Implications
Courseware screen Colorful images and clear sounds	being encouraged to try again, focus their attention for a long time	great interest [22]
	stares and looks attracted	draw the attention [22]
	comments, smiles, laughter, or positive body language	enjoyment and engagement [37]
	sighs, and looking around the room	lack of enjoyment and frustration [37]

(a) (b) (c)

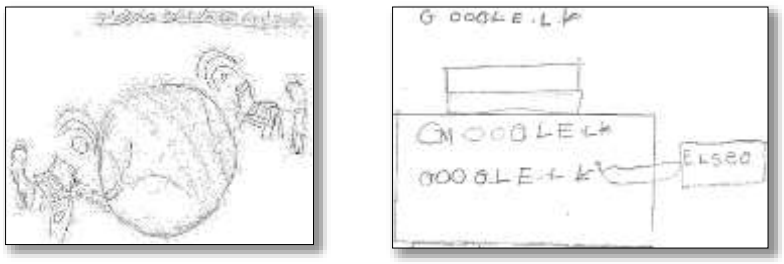
Fig. 4. a) Participant practicing web search using the eLearning tool (Day 1, 2 & 3) b) Participants drawing about the Internet and web search process (Day 4) c) Participant describing Google search process (Day 4)

4 Findings

Overall, our observations suggested that the LIFT tool did indeed support learning, in terms of user engagement and satisfaction.

4.1 **Effectiveness**

Participant drawings (without looking at the eLearning tool) were used to explore what they had learned from the eLearning tool. Participant 2 (P2) drew the picture about the Internet (**Fig. 5** -a) and described in Sinhala that the drawing shows "the Internet connects computers located in different countries", and also mentioned in Sinhala in the title of the drawing ("අන්තර්ජාල සම්බන්ධතාව රටවල් අතර"). While the drawing has similarities with the picture presented in LIFT (**Fig. 2** -c), P2's drawing demonstrates a new mental model integration, with the creativity of adding his country and two persons interacting with computers located in two different countries. P2 included the Wi-Fi icon in the drawing, demonstrating an understanding that Wi-Fi connects computers. P1's drawing (**Fig. 5** -b) demonstrates how he learned to enter a web address in LIFT illustrating his mental models of the relationship between a web address and the address bar, and the use of the "Enter" key to execute the search.



(a) (b)

Fig. 5. a) Drawing about the Internet (P2), b) Drawing about address bar, web address, and pressing on the "Enter" key (P1)

The eLearning tool introduced how to use keywords related to the information that they needed to search from the web. Participants were interested in searching the web to know more about health topics they had studied at school. They also suggested their own topics and keywords, in line with their interests and daily living information needs; P2 for example, wanted to search for "Thala", a film currently on theatre. He wanted to find and show it to his friends. P3 had learned the keywords introduced to search for telephone numbers of hospitals in a nearby town (**Fig. 6**). These are written correctly, however, this participant is still learning to use spaces in between the keywords.

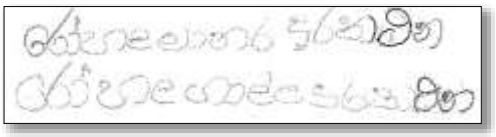


Fig. 6. P3's presentation of keywords to search a phone number of a hospital

Table 3 shows the specific functions where participants demonstrated ability and/or independence in the last two days of the web search sessions. All participants had developed abilities by day 3, and continued to develop their autonomy by day 4.

Table 3. Participants' abilities to perform web search functions after learning web search with the eLearning tool

Relationship between concepts (functions)	P1		P2		P3		P4		P5		P6	
	D3	D4	D3	D4	D3	D4	D3	D4	D3	D4	D3	D4
Browser and search tool (Finds browser to start search)	X	X	X	X	X	X	O	X	X	X	X	X
Browser and address bar (Finds address bar in the browser)	X	X	X	X	X	X	X	X	X	X	O	X
Web address and web page (Knows web address of web page)	X	X	O	X	X	X	O	X	O	X	O	X
Browser and web address (Knows browser needs web address)	X	X	X	X	X	X	X	X	X	X	X	X
Web address and address bar (Types web address in address bar)	X	X	O	X	X	X	O	O	O	X	X	X
Search tool and search box (Finds search box in search window)	X	X	X	X	X	X	X	X	X	X	X	X
Search tool and keywords (Knows search tool needs keywords)	X	X	X	X	X	X	X	X	O	X	X	X
Search results and web page (Identifies listed search results)	O	X	O	O	X	X	X	X	O	O	O	X
Search results and hyperlink (Finds hyperlinks among search results)	O	X	O	O	O	X	O	O	O	O	O	X
Web page and hyperlink (Uses links to go to web page)	O	X	X	X	X	X	O	O	O	X	X	X
Web page and menu bar (Locates menu bar in web pages)	X	X	O	X	X	X	O	X	O	X	X	X
Keyword and search box (Types keywords in search box)	X	X	X	X	X	X	X	X	O	X	X	X
Browser and web address (Knows browser needs web address)	X	X	X	X	X	X	X	X	X	X	X	X

P- participant, D3- Day 3, Abilities to perform: X-Independently, O-with guidance

4.2 Engagement

Participants engaged in learning the search process, following the eLearning content and interactive practice activities. The application of persuasive design principles [22] in the eLearning tool made the learning environment fun. The interactive practice exercises on the web-search process attracted the learner because they rewarded completed actions, as in a game. Participant's smiles and continuing engagement in the activity showed they enjoyed the rewards and praises in multimedia form. They continued showing one another the rewards they were receiving, thus motivating one another to continue and repeat the exercises.

Another indication of their high level of engagement is they spontaneously repeated many of the practice exercises, such as selecting the correct image of the browser icon

for starting a web search, and, finding correct letters from the keyboard to type the URL Google.lk. The latter was the page where they stayed for the longest and the most repeated practice activity. Participants liked being supported to find the next letter to type, as animations in letters in the capital form (GOOGLE.LK close to the address bar) had been time set to blink the next letter, parallel to their typing (**Fig. 3** -a & b). On this page, participants enjoyed receiving the reward of 'a flying butterfly' for correctly typing the URL and then performing the click on the Enter key, smiling and showing one another, and engaging others.

Participants showed interest in the activity by extending the activities and suggesting searches using their keywords. P2 was fascinated by the eLearning tool itself and wanted to learn how to create such a PPT document and asked to save the LIFT tool in PPT format to his documents folder in File Explorer, used in the school ICT activities.

The teachers' positive feelings confirmed the value of learning support in an accessible form that incorporates multimedia. Visuals with animations and audio descriptions drew teachers' attention identifying those features with the easy-to-navigate interface to be effective in learning applications for YAWID. The relationship between the link and the resultant web page was described using a prompting arrow from a link to an image of a new web page displayed once clicked on the link (**Fig. 7** -a).

(a) (b)

Fig. 7. LIFT Interface elements to engage the learner a) Support to identify the functions of the search results list, b) Exercise to click on browser's back button

Participants responded to the moving red color arrow pointed to a link (**Fig. 2** –e) by investigating the search result list to find a more appropriate link. They learned that the pointer changes its shape to a hand symbol at the link and recognized it during the practice exercises. With an animated red color circle around the back arrow (**Fig. 7** -b), participants rapidly practiced clicking on the browser back button to move back from the resultant web page to the search results page.

Teachers also praised the content arrangement and interface design that supported enjoyment while learning. Teacher (T1) highlighted: "It is very simple. Clear and pleasant, practice exercises are interactive and motivating".

4.3 Satisfaction

Participants expressed their satisfaction with LIFT informally with happy facial expressions. They extended on what they had learned, by sharing their learning experiences with one another. Special education teachers were impressed by LIFT as a guide for

them to support young adults with ID in terms of learning the Google search process and finding information from the web. As one teacher said (T1): “I also really like to know about web search in Sinhala. It is a good topic, searching for health information.” Teachers identified that practicing the web search process, particularly in a technological environment with a real interface without needing Internet access, was helpful for participants. A teacher voiced (T2): “They can practice without internet access also. It is good to learn with technology. Rather than written on a book or described on a blackboard. Learning to navigate is also supported while content presents web search process”.

LIFT was conceived to be a driver for reinforcing cognitive abilities linked with idea production, visual memory, self-confidence, independent learning, and gaining knowledge on new topics. As it introduces web search for information, teachers highlighted that it will influence the life of YAWID in many ways. “It is good to see their effort describing the search steps. Now they are suggesting new topics to search for. They are very happy and this has motivated them to read. They have learned that they can find some information from the Internet. If they have access to the Internet at home also, it will be helpful”.

The interactive practice exercises were identified as enjoyable and engaging for the YAWID to practice the Google search functions and familiarize themselves with the Google search interface. T2 added “Practice exercise for typing Google.lk in the address bar was designed very well, matching with their needs and in an appropriate level. I liked it very much. Its technology strengthened their hand and eye coordination in using the keyboard”.

5 Discussion

We designed LIFT to provide an accurate, accessible, and engaging environment for YAWID in Sri Lanka to learn how to search the Web in their native language, Sinhala. The cultural implications of the LIFT program and related support approaches are discussed here.

5.1 ICT for Learning ICT

The LIFT practice exercises help learners visualize and memorize each page and element in a Google search sequence even without internet access. Keskinova and Ajdinski [40] report that people with ID are best at integrative abilities, which would be very important for them to transfer what they learn offline to online web searching. The importance of this type of flexibility in implementing eLearning tools has been emphasized by Lim et al. [41].

This investigation shows that the eLearning tool with the facility to learn and repeatedly practice the Google search process in an ICT environment has helped the participants. Those participants with increased skills were able to show their new abilities by describing the search process and the related concepts to another person, and by demonstrating the Google search for health information (**Table 3**). This finding strengthens

the idea that YAWID's visual memory is better than auditory memory, as Keskinova and Ajdinski [40] previously highlighted, having observed "very good ability for visual memory, and a lot of problems with the ability of auditory memory", in their study that engaged participants with mild ID in special elementary schools and a control group with typical development, from a mainstream elementary school.

Hence, this suggests that the guidelines presented by Arachchi et al. [30] should incorporate these new findings by introducing new guidelines with specifications to multimedia designs; this would increase the comprehensibility of the learning content designs, to keep the learners' attention.

5.2 Training Supporters

Learning online processes in an eLearning environment would be important in the Sri Lankan context, as it can support educators with an offline practice option. It was previously highlighted that the availability of on-site support would increase learner engagement with real-time feedback, which would only be possible with proper training opportunities for supporters: their teachers, parents, and/or caregivers [42]. The eLearning tool we designed would be helpful for supporters to become familiar with Google search in Sinhala and how to search for health information in the Sinhala language, without constant Internet access. LIFT would provide a structure to teach these concepts, and, would address the issues related to different learners obtaining support from different supporters [41]. Internet use especially for finding health information is not a familiar activity for most people living in Sri Lankan villages. The teachers, as well as parents /carers of YAWID from such contexts, would be supported in helping them to learn how to conduct web searches, and especially will become aware of the Internet's usefulness for finding information on topics related to their health.

5.3 The Benefit of the Accessible eLearning Tool Integrating Mental Models

Accessible interface/content would support enjoyment, self-actualization, and therefore engagement in learning. This eLearning tool not only tells and shows the web-search process but also, the learner can experience each step in web-search offline, with the interactive practice exercises. This LIFT design complies with the philosophy of the learning object design strategy introduced by Lao Tze in the 6th century: "If you tell me, I will listen. If you show me, I will see it. If you let me experience, I will learn" [41]. As noted by Lim et al. [41], like learning mathematics, learning web search is comparable to the flow of a stream; YAWID need scaffolding, such as what we have designed in LIFT that serves for participants to learn and practice different steps in the Google search process.

In this four-day study, participants could familiarize themselves with the interface, integrating their previous experiences with navigational and signaling aids in eLearning tools installed on computers. Participants could follow the navigational arrows while few needed support due to continuously clicking on the forward button. Therefore, it is important to design the eLearning tool with a signaling aid that reminds the learner when to click on the forward button. We designed the forward button to blink after the

audio recording, played parallel to the animations. Participants were advised to click once on the forward button when it blinks. This could be added as an interface design guideline to the eLearning design guidelines for people with ID presented in [30].

Participants have increased their abilities on web search, especially demonstrating their skills to work with the search results page. They will likely need to continue to seek opportunities to continuously practice and/or to review the eLearning materials [3, 27].

We used mental models in describing the Google search elements and functions in the learning modules; we applied the same mental models in the practice exercises. Participant drawings showed they had created mental models integrating what we presented in the instruction and practice exercises. For example, the presentation of the connection view and the functional view [24] helped to create the mental model that the Internet connects computers, phones, tablets, and those who use them from anywhere in the world, and that the Internet can be used to find information. This shows that mental models are helpful for conceptual understanding and creating memory.

The inclusion of both mental models and practice in LIFT is indeed a good strategy; in that, both are essential for practicing and memorizing each step, and for getting automated in the Google search process [27]. This strategy is already well known and applied for example when a student looks at a teacher describing how to solve a math problem (e.g. 23+18 =) then does the same addition independently.

The LIFT design differs from the eLearning designs focusing on more sophisticated learners [43], as it attends to the needs of learners with diverse cognitive abilities. YAWID would not learn from a video that displays a person describing the web search process, accompanied with PPT slides with static notes [7]. However, some aspects of the theory presented by Zhang et al. [43], such as illustrative video "allow students to view actual objects and realistic scenes, to see sequences in motion, and to listen to narration" are directly applicable to this study and we offered them in the form of mental models, animations and audio recordings.

6 Limitations and implications for future research

Participants for this study were young adults with intellectual disabilities (YAWID) who can use a computer, read their native language, and communicate. Some participants who satisfied the selection criteria for this study, and were interested in this research, left school to join vocational training programs. Most YAWID in Sri Lanka experience limited language ability [44] because they stop applying it after leaving school. These limitations made it difficult to find participants who met all selection criteria, limiting the number of participants for this study to six, which means the quantitative results [45] are purely indicative.

A limited reading ability means disseminating health information in video format would be supportive for people with intellectual disabilities to be informed of health topics. However, early research suggests that interacting verbally with web search engines is attractive for people with ID, but can in some cases cause difficulties and frustrations [46]. Further research that involves a longer duration with more participants

with a greater diversity of support needs and communication abilities may be helpful to improve the generalizability of the results. However, limited access to computers and the perceptions of carers towards working with computers may limit the implementation of the eLearning tool for YAWID to learn how to do a Google search at their home or the centers providing care services.

In Sri Lanka, there are Tamil people. Most of them are attending Tamil language schools. The Tamil virtual keyboard displays English letters and generates corresponding Tamil letters in the search box. People with ID cannot be expected to know these corresponding letters and so limiting the accessibility of the virtual keyboard and as a result the generalizability of our approach. Further research is warranted to establish the applicability of Google virtual keyboards in this and 70 other languages, so as to introduce our approach to do a Google search in local languages on any computer, anywhere in the world.

7 Conclusion and Recommendations

This paper described a multimedia-based eLearning tool, called LIFT, designed for helping YAWID learn the web search process, and explored the experience of participants with ID interacting with its contents, interface, and interactive practice activities to be familiar with web search in the Sinhala language. LIFT includes an accessible interface, content, and interactive practice, which are engaging for the participants. To the best of our knowledge, no previous research employs all three aspects in this domain. Observations indicated that LIFT was meeting its goal of increasing participants' abilities to search the web. Teachers commented that the multimedia approach fits with supporting visual memory.

This study confirms the value of applying the persuasive learning theory that describes the positive impact of using rewards and praising in learning designs. Furthermore, it applies the theory that highlights technology-enhanced, well-designed learning environments can be effective in supporting learners with ID; it helped increase their understanding of new concepts and create mental models related to processes, and especially for engaging them in learning activities [47]. During the learning process, we noted that participants need on-site support until they become familiar with the learning environment. Future research is suggested to explore the long-time effect of the eLearning tool on web-search by people with ID and to identify the onsite support requirements.

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