Screening Program for Learning Difficulties in Arabic Speaking Students: Design Considerations for Educational Interfaces

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Abstract. The aim of this paper is to detail the creation process of a screening program for Learning Difficulties (LDs), with the goal of alleviating distractions in the interface while retaining essential elements for measuring cognitive abilities and behavioral responses. The program is designed to screen general populations of children ages between 4 and 9 years –with and without Learning Difficulties- and measures five cognitive abilities. Design considerations for accessibility and usability in each component are described. Particular emphasis in the design of this screening system is given to the cognitive effort involved in interacting with the forms, which are affected by the interface's complexity and the navigation structure (i.e. breadth and depth of the information architecture). The assumption was that focusing on designing interfaces that are intuitive and accessible for individuals with LDs would facilitate access to a wider population of children who do not have any LDs or have limited proficiency in interacting with computers because the program was intended for launching across the geographical region of Saudi Arabia, in metropolitan cities as well as rural areas.

1 Introduction

The emergence of mobile computing and pervasive systems such as mobile phones, handheld games and laptops have transformed the life of many kids around the world. In recent years, technology has become an essential part of the learning process; however, children are not the same when it comes to learning aspects in any classroom and non-classroom contexts. Some children face problems in their learning due to Learning Difficulties (LD) or cognitive disabilities that that are caused due to biological factors [1]. Children having LDs perform significantly below than average in their academic career because of the difficulties they have acquired since their birth [2]. Furthermore, LDs often lead to reduced development of the social, academic and

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practice oriented abilities [3].

At present there are several different definitions for learning difficulties. [3] pointed out that often researchers find it problematic to define the group of general learning difficulties. Due to which, many prefer not to distinguish between the subgroups whose cut-offs are not clear. Manifestations of Learning Difficulties include continuous clue seeking, poor verbal memory, lack of confidence, social and emotional skills, underdeveloped logical reasoning, abstract thinking and motor [4, 5, 7]. Children with learning difficulties have different profiles [6] or specific profiles that are different from others [1]. Even though children with LD have different profiles they can still exhibit some common signaling features namely slower cognitive development and poor problem solving skills [8], low self-esteem [9], possess fear of making mistakes and exhibit unacceptable behavior [4], lack confidence on decision making, problem in grasping and remembrance of abstract concepts, difficulty in obtaining instruction and keeping the learning, dependence on peers for obtaining information and taking actions and higher chances of getting distracted due to environment around them [1,4, 5, 6, 9,10]. Cognitive abilities have direct impact on the learning in any classroom and non-classroom environment. Evidence from behavioral and educational sciences indicates that early diagnosis and intervention could be key to achieving greater independence in learning [11]. Psychologists, neurologists and educational researchers have concluded that early detection of the learning difficulties is essential for the future of suffering children, their parents and schools. Children suffering from LD can only be provided with support if their learning disabilities can be identified. To solve this problem, screening techniques are used in practice. Educational psychologists, neurologists and highly trained educators use different screening techniques for example, Weschler Intelligence Scale for Children[12] and Woodcock-Johnson Tests of Cognitive Abilities-III[13]

Existing techniques and instruments for performing the process of diagnosis and screening of various LDs is both time consuming and resource intensive. The main challenges in performing the detection of learning difficulties is that it requires manual process of testing which is often lengthy and tedious, highly trained professionals, cost and time intensive. In order to counter the challenges of cost effectiveness and large scale screening, educational researchers and practitioners have coined the need for developing computer based screening software that can diagnose LDs among children on a large scale. However, this goal is not easy because all screening related needs must be delivered in a computer-based format so as to ensure flexibility, consistency and adaptability [14, 15]. In this end, educational practitioners have argued the need for developing automated screening software's for the early diagnosis of LD. This kind of automated screening should be capable of performing large scale screening tests without the need of highly trained neurologists, psychologists or educators. Overall goal of such automated screening software is to perform large-scale parallel diagnose experiments of large number of participants in cost effective and timely manner. It has been estimated that more than 10% of the world's population suffers from some kind of disability [16]. This means that the spectrum of users who are going to benefit with the research on developing screening software for the diagnoses of the LD's in young children is enormous. However, Arabic speaking users are not yet addressed by academic or industrial research. To date, to our best knowledge there do not exist any computer-based screening software normalized for Arabic-speaking children, apart from CoPS which was specific to Kuwait and limited in its scope of assesment. There has been increase in the development of educational software's in Arabic language however, remedial and screening programs for children with LDs is scarce in number [17]. Furthermore the heterogeneity of research on developing screening software for the diagnosis of LD has resulted in the need for introducing standardizations or design considerations for educational interfaces aimed at children with LDs. Design considerations for educational software developed with Arabic interfaces have been reported in studies that examine visual aspects of the design [18,19]. However, there is an inadequate understanding of design considerations specific for screening software aimed at children with LDs in non-English context, particularly language and cultural considerations. The discipline of Human Computer Interaction (HCI) can play an important role in developing screening software, quality standards and formulating design considerations for educational interfaces aimed at children with LD's. The role of HCI becomes even more important because design considerations and standards must be understandable and meet the needs and expectations of the software designers. Through this paper, we would like to generate a popular sentiment among the academic and industry circles that studying design consideration for any educational interface aimed at children with LD's is essential not only for an individual but for the whole community and society.

2 Software for Children with Learning Difficulties

The popularity of educational technology has grown so high that children with and without disabilities (e.g. children with LD) are now using it for their betterment. Children with LD face difficulties in their memory, attention, perception, concentration and logical reasoning. Due to which, more focus should be given to the alternative forms of representing problem, text or any abstract concept. Visualizations often attract children with LD's[1]. This very need has resulted in the development of advanced educational interface technologies such as virtual reality and tangible interfaces. Recently, academic research has witnessed the increasing interest in exploring advanced interface technologies for aiding LDs among young children.

The concept of virtual reality has been much explored as an educational technology that aide the learning and educational experience through entertainment [23, 24, 25]. Tangible interfaces have been expanded in the domain of education technology by creating systems that are immersed in our physical environment. Tangible interfaces have enabled educators to go beyond the traditional screen-based applications for PC's [26]. The use of tangible interfaces as means for educational technology that supports learning for children with special needs is based on the fundamental theories governing human behavior. For example,[27, 28] argued that tangible interfaces for educational purposes are based on the behavioral learning theories and traditional use of desktop computers. Similarly constructivist-learning theory states that there should be more control on the learning when tangible interfaces are used. [7, 20, 27] investigated the use of multi-sensory and tangible interfaces in order to enhance the learning experience among LD children. [29, 30] have concluded that multi-sensory experience provided by such tangible interfaces has a positive impact on the cognitive and learning abilities of LD children. [6] has provided the guidelines for product designers who are interested in developing educational technology and other ICT that enhances learning among young children. Some of the salient features of these guidelines include considering a kinesthetic approach for enhancing the learning experience through physical activity, increasing the use of visualization compared to text so that children with LD can grasp the abstract concepts easily, using different forms of representation for presenting the information to young children, and instructional scaffolding.

3 Screening Software

The majority of existing research on developing screening software for identifying children at risk of having LDs is targeted towards the developed world. These existing screening programs focus only on subsets of difficulties that constitutes LDs, hence they possess only limited focus and do not really address the real problem. Most common difficulties addressed by existing screening program are attention, phonological processing deficits and short term memory problems [31]. Screening programs are meant for providing comprehensive assessment and enabling educators with robust indication about the specific learning deficits. However, it has been seen that most screening programs partially address the problem of identifying children at risk of having LDs and lack an element of comprehensive assessment. This resulted in the limited applicability and effectiveness of existing screening programs. At present, there exists only one screening program for Arabic speaking children named CoPS that has been developed based on normative data of 4-8year old children population in Kuwait. Due to its limited scope of cognitive abilities and normative testing, its applicability to wider Arabic speaking populations was a concern once it was launched as a screening tool by practitioners in Saudi Arabia. Furthermore, there exist gaps in our understanding on the kind of LDs present in the Arabic population especially the Saudi Arabian population.

In recent years, Saudi Arabia has experienced the increasing need for developing standardized screening instruments for the detection of LDs. There has been several efforts in this regard, however due to large number of schools, districts and education governing bodies, screening instruments are pretty diversified and these are mainly performed by the specialist in LDs. Every school is using their own battery of manual tests and educational psychologists do not posses any formal or standardized method of assessing LDs in young children. In order to bridge the existing gap in understanding the LDs present in Arabic population and develop a reliable screening program for Saudi population, a research project was launched. The aim of this research project was to evaluate the feasibility of developing a computer based screening program that can facilitate the normative assessment among Saudi population. The screening tool developed through this project is very practical and convenient for the educators so that they can screen significant number of LDs among the young children aged between 4 to 9 years. Computer based screening is effective compared to manual screening process not only because of its cost effective nature but due to the chances of greater recognition of cases than with voluntary reporting of LDs by parents and educators. In the first phase of this project, we have developed the computer-based assessments so as to collect data for developing normative testing. Additionally, normative testing program was developed keeping in mind the age-related cut-off scores indicating low, average and high ability skills. These computerized screening programs are available on the computers in the public schools so that children between 4-9 years can participate in such tests. This arrangement also ensures that useful quantitative data is collected in an easy and cost efficient manner, which can also alert educators about any possible LDs among the participating students.

4 Test Design

In order to access the cognitive abilities of children, a prerequisite for the diagnosis of the LDs, children should be engaged in set of tasks that can potentially tap their cognitive abilities. However, due consideration should also be given to address the accessibility and usability of the computer-based screening program. The first step in the preparation of the test tasks was to study the existing literature on ability tests on LDs in Arabic. We performed a thorough review of these existing ability tests and calculated a list of 85 tasks that were essential for our proposed screening program. Due to the larger number of test tasks, we decided to organize the tasks into key categories which were short memory, perception, language, attention and verbal and non-verbal reasoning. The screening of the short-term memory requires a battery of tests that can effectively evaluate the child's capacity to retain and manipulate the information for short and long intervals. The abilities related to verbal and non-verbal reasoning were tested through the use of figures, words and visio-spatial tasks. The language component was tested through direct assessment of age-appropriate phonological processing tasks, as well as grammatical structures uttered by the screening program and a block of sentences are visually presented (in form of pictures) so as to depict the actual event described in the event. The task related to finding the semantic similarities actually tap the comprehension skills of the children with LDs. Auditory and visual attention were assessed with stimuli designed for interactive responses by the child.

5 Design Considerations of Educational Interfaces

In this section, we describe visual and interaction design considerations and include example(s) of interfaces designed within components of our screening program.

5.1 Visual Short Term Memory Screening

In this screening task, the child is exposed to a pre-defined number of images for a duration corresponding to the level of progress in the program, and then is requested to select the images that he/she viewed to assess visual working memory abilities. Instructions are presented to the child in spoken form as well as written in a speech cloud on the right side of the interface. Selection of elements on the screen was supported with consistent hover feedback by highlighting the element with a yellow border, and consistent selection feedback by highlighting the element with green border as depicted in Figure 1. The screening program increases in difficulty by presenting sets of images that are increasing in both quantity and complexity. Thus, a visual progress bar supported progress tracking in the screening task which was especially important for children with attention deficit problems.

Fig. 1. Interface Design for Memory Assessment.

A similar approach was adopted in measuring visual short-term memory with letters, numbers, and words as shown in Figure 2.

Fig. 2. Visual Feedback and Progress Tracking.

5.2 Auditory Short Term Memory Screening

With auditory screening, it is essential to keep visual distraction at a minimum. Also, since some children may have comorbid difficulties such as attention deficit disorders, the presentation of audio stimuli should be preceded by a note or pause so that interaction or presentation of the tested materials is initiated by the child's action of clicking or indicating that he/she is ready because audio stimuli is presented only once and not repeated in the session. The design of the interface for recording responses to the audio stimuli also has its own considerations. For example, in an exercise for entering numbers that were spoken to the child without being presented visually, the keypad for entering the numbers is presented on the screen and numbers' entry from the keyboard is disabled to control for variability in numeric keypad designs as shown in Figure 3. This was especially important because this program was designed to collect normalized data for the Saudi population and it was deployed for use across the kingdom using the existing labs in schools, which had varied facilities, and the designs of keyboards could not be controlled and kept consistent. Therefore much of the character-entry screening exercises involved on-screen interface.

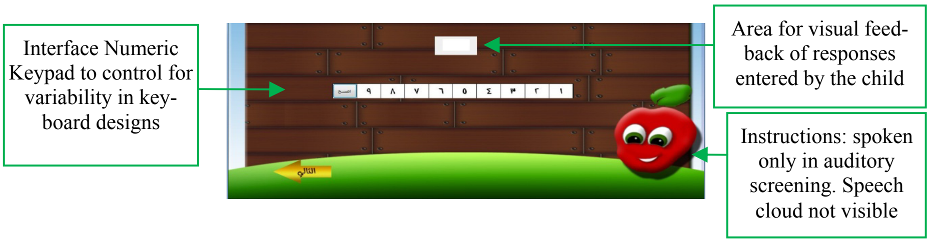


Fig. 3. Auditory Attention Assessment.

5.3 Assessing Upper Limits of the Child's Cognitive Ability

An approach for presenting five levels of increasing difficulty was adopted in the design of tasks throughout the program. The program was adaptive in the sense that three consecutive errors would consider the following level beyond the cognitive ability of the child and automatically record the score and move the child to the next level. Increasing the levels of difficulties varied according to the type of skill being measured. For example, in visual discrimination and number recognition, the two tasks for levels 1 and 5 are shown in the figure below to depict the contrast in complexity for the measuring the child's ability. Complexity increased in the number of digits and the similarity of visual appearance between the correct answer and the distracters. All other visual design factors and auditory description were kept constant to control for confounding factors. Another example for visual discrimination in images is shown the visual image with the two tasks in levels 1 and 5 as depicted in Figure 4.

	Level 1 (min)	**Level 5 (max)**
Numeric		
Visual Image		

Fig. 4. Designing consistent interfaces for increased complexity in cognitive tasks.

5.4 Language Considerations and Familiarity in Visual Designs

Design elements in the program's interface and in the spoken instructions were considered to reflect familiar objects in the local context. Moreover, images that were related to words that need to be identified by the user were were carefully selected to avoid ambiguity such as the images chosen for the task depicted in Figure 5. The word 'camel' in the local context can be expressed in two words (إبل) and (جمل) and both of them end with the same letter, so the answer for finding the shared 'last letter' of the three images would be valid whether the child considered the first or second word for identifying the camel.

Fig. 5. Selection of words and matching images.

5.5 Inclusion of Animated Elements

Since accessibility guidelines suggest avoiding animated elements that distract users, it was ensured in the design that animations were included only in essential areas of the interface. For example, a timed task involving visual exploration of a grid of numbers to search for specific numbers included an animated timer so that users are aware of the remaining time (Case A in the figure below). This inclusion of an animated element was based on the assumption that benefit gained from the visual feedback obtained from this animation outweighs the distraction that it may incur. Moreover, it was believed that if the animated timer in the way it was designed (i.e. minimal design and placement in secondary location on the screen) distracted the users then this type of user would be more prone to be distracted from maintaining their focus on the task itself (i.e. selecting the numbers from the grid) and this distraction would consequently trigger the user to re-focus rather than remain distracted. In contrast, when the cognitive ability being measured was related to non-visual abilities, animation was avoided as in the example in Case B of Figure 6. In this series of 5 tasks, the child is requested to select the number representing the number of hits that he/she hears in the activity of hammering a nail. Although the action can be animated for realism, it was kept static so that attention is directed to the auditory stimuli and not supported by visual clues to help the child keep track of the number of hits.

6 Evaluations and Deployment

User acceptance testing was conducted on a sample of children ranging between 4 to 9 years of age. Consent was obtained from the parents and school of the participating

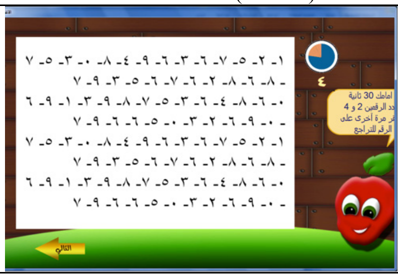
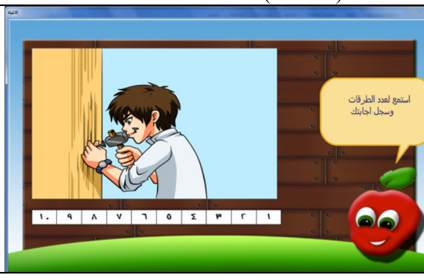
With animation (Case A)	Without animation (Case B)
	

Fig. 6. Animated elements on interfaces.

child. Sessions were recorded using Tobii Studio software which measure the visual attention of users, interaction logs, as well as their behavioral measures such as time on task, and patterns of mouse movements, and backtracking actions in completing tasks. Key findings from these evaluations were related to the timing of presentation of stimuli, visibility of elements in some interfaces, synchronization of audio and visual cues, and lack of progress tracking. These issues were addressed in the final version of the software before the testing was launched across the country. The program was deployed for use in public schools to collect normative data of cognitive profiles of children in the 4 to 9 year old segment of the population in five regions in the kingdom to ensure geographical coverage of regions in the northern, southern, eastern and western regions of Saudi Arabia. These regions and the size of the samples in which data was collected are shown in Table 1.

Table 1. Normative Data Collection.

Region	Sample size
Central region (Riyadh)	188
Eastern Region (Damman)	243
Western Region (Jeddah)	24
Southern (Jazan)	157
Northern (Jouf)	166
Total Sample for Normative Data	778

At the deployment phase, an online support system was established to address technical difficulties that teachers in public schools would encounter. It was observed that enquiries and technical problems experienced by users that were related to operational issues such as installation and exporting the data exceeded the usability problems reported. This suggests that the design of the tasks matched to a large extent the needs of the users and the expectations of designers in terms of appropriateness in accommodating the variability in technical proficiency and familiarity with automated systems.

7 Conclusions

Designing interactions in educational contexts needs to take into account the abilities and needs of the target user population. This becomes more critical when the system is designed for a heterogeneous population that includes individuals with and without LDs. To examine design considerations specific to educational interfaces for screening individuals with LDs, we drew upon usability and accessibility guideline adherence in a case study involving the design of an automated screening software program developed for Arabic-speaking children in the 4 to 9 age bracket. It was found that design considerations were crucial for ensuring accurate screening of cognitive abilities. Furthermore, usability assessments in the deployment phase indicated that designing with considerations specific for individuals with LDs facilitated a more accessible and usable system for a wider population thus supporting a universal design approach for this context of use.

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