Heuristics for Evaluation of Educational Application (Let's Find Letters) for Children with Dyslexia

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Declaration

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Approval

This paper titled **"Heuristics for Evaluation of Educational Application (Let's Find Letters) for Children with Dyslexia"** by Harshita Bandodkar and Priyanka Purty is approved, in partial fulfillment of the requirements for Masters of Design degree in Communication Design.

Guide: 

Heuristics for Evaluation of Educational Application (Let's Find Letters) for Children with Dyslexia

Abstract

According to Dyslexia Association of India, "Dyslexia is a Neurological Condition that is characterized by difficulties that mainly affect the ability of a child to read, write and spell" [1]. Even though there are multiple detection centres and correction facilities available, most cases go unnoticed as they are expensive and unaffordable for people from lower economic classes which leads to most children dropping out of schools in pursuit of manual labour on being deemed as 'not so bright'. 'Let's find letters' is an application under development designed by Poonam S. Wagle, a communication design student and Sasupilli Madhuri, a computer science student currently pursuing PhD on developing educational aids for children with dyslexia.

Since the application is under progress, a heuristic evaluation of the same was needed.

This paper presents a heuristic for evaluation of educational games for children with dyslexia in India in terms of usability, game experience and pedagogy. This has been achieved by a comprehensive study of existing heuristic evaluations for computer games, mobile games and educational games. This paper also explores some myths and assumptions researchers may have about dyslexia as the pedagogy of these category of games depends on it.

Keywords- Dyslexia, Heuristic, Computer, Mobile & Educational Games, Sequential & Visual Spatial learning

Introduction

Dyslexia is a Greek word where 'Dys' means problem and 'lex' means words or languages. It is a reading disorder characterized by trouble with reading despite normal intelligence affecting different people to varying degrees. Problems may include difficulties in spelling words, reading, writing words, sounding out words in the head, pronouncing words when reading aloud and understanding what one reads. Dyslexia could either be developmental or acquired which is caused by trauma or injury to the brain. 'Let's find letters' focuses on developmental dyslexia.

Studies using Functional Magnetic Resonance Imaging (FMRI) has shown that dyslexics use a different part of their brain to process information compared to non- dyslexics, causing either one of these deficits: visual, auditory, or visual-auditory, impeding phoneme awareness that causes phonological deficit.

Usability heuristics are identified usability principles that trained evaluators use to assess the goodness of software design. This paper presents a heuristic for evaluating educational games in terms of usability and game experience. The methodology presented is based on a study on a series of existing

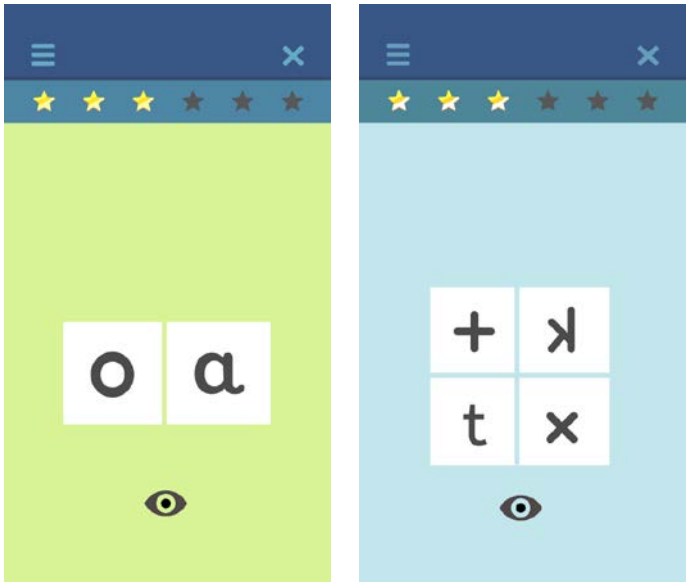

Figure 1

Figure 2

heuristics such as HEP, PLAY and GameFlow, the Criteria for Designing Educational Computer Games from Nicola Whitton and HEEG: Heuristic Evaluation for Educational Games [3].

Literature Review

The dual-route theory of reading aloud [4] was first described in the early 1970s. This theory suggests that two separate mental mechanisms or routes, the lexical and sub lexical routes, are involved in reading aloud. Both the routes contribute to the pronunciation of the read content. The lexical route is the process where an adept reader can recognize known words by sight alone, through a lookup into their mental database or lexicon of stored words that follow the letter-to-sound rules and its pronunciation is retrieved. The non-lexical or sub lexical route is the process where the reader can identify the constituent parts of a written word like letters, phonemes and grapheme, decode the association between these parts, build a phonological representation and sound it out. It is this sub-lexical route that dyslexic children rely primarily on during reading where they can decode non-words accurately albeit slowly. Other research concludes that there are common properties between reading disorders and Attention Deficit Hyperactivity Disorder (ADHD) including deficits with lexical route processing, sub lexical route processing and rapid reading.

Linda K. Silverman states that children with Dyslexia are visual spatial learners that learn holistically and not step by step[5]. Visual imagery plays an important role in the student's learning process as the individual is processing primarily in pictures rather than words and ideas are interconnected like a web. In most cases, the visual spatial learning style is not addressed in school and these students' self-esteems suffer. These children are highly perfectionists, which means that they cannot handle failure. They usually refuse to attempt trial-and-error learning because they cannot cope with the failure inherent in traditional teaching methods. They have an all-or-none learning style (the aha phenomenon).Concepts are quickly comprehended when they are presented within a context and related to other concepts. Repetition is completely unnecessary and irrelevant to their learning style while rote memorization and drill are actually damaging for visual spatial learners, since they emphasize the students' weaknesses instead of their strengths. Sincere praise adds a great deal of encouragement.

The students are usually disorganized and miss details, whereas most teachers stress on organization and attention to detail. The student is highly aware of space but pays little attention to time, whereas school functions on rigid time schedules. Spatial learners often excel at activities such as Legos, computer games, art or music.

Games and other Educational aid

During the course of our research, multiple learning applications for children were studied, of which the application suite, "Endless Learning" (Figure 3) by developer Originator stood out because of the following features:

1. The application allows exploring without the scope of making errors

2. Every task is followed by a sentence which uses the rhyming words used in the task

3. The Guide Character pronounces and speaks out the letter sounds, whole words and also syllables as the words are formed

4. The sound and animation of the letter is activated every time it is touched

5. Glowing lights, cheers by children and applause follow every successful task

6. Letters are personified and are given an animated character. They make the sound of their corresponding phonemes

Figure 3

Heuristic Evaluation for educational aids for children with special needs should be updated based on psychological needs and cater to visual spatial abilities of children with dyslexia. Available HE is based on average users.

Heuristics for Designing Enjoyable User Interfaces: Lessons from Computer Games: Thomas Malone, 1981

Malone has conducted three empirical studies about what people like about games concluding that there were three main heuristics that need to be taken into consideration in designing enjoyable user interfaces: challenge, including a goal whose outcome is uncertain; fantasy, embodying metaphors with physical or other systems that the users already understands; curiosity utilising optimal level of informational complexity and audio-visual effects.

Usability Heuristics for User Interface Design: Jakob Nielsen, 1994

Nielsen and Molich [6] introduced a method to be used with their set of usability principles (Table 2) called the heuristics which serve as design guidelines or principles for good interaction design and the aim is to find problematic aspects of the design in order to improve it. This method uses evaluators to find usability problems or violations that may have a deleterious effect on the user to interact with the system. Typically, these evaluators are experts in usability principles, the domain of interest, or both. In the evaluation process, finding flaws earlier rather than later reducing usability errors, which may be more costly to rectify once the application or system is complete, is preferable. This is where Heuristic Evaluation (HE) is applicable because of its capabilities to detect errors at early stage with the help of the experts.

Usability Heuristics for User Interface Design by Jakob Nielsen was used for 'Let's find letters' by Sasupilli Madhuri with favorable results. The research included three experts (Table 3) from the field of dyslexia namely, a research scholar, a counselor and a psychology professor (Figure 4). The result might have been slightly biased as all the experts were from a single domain (there were no experts from user interface and experience) and they could have had certain presumptions as research on Dyslexia in still on going and the conclusions on how dyslexic children perceive information is uncertain.

Usability Heuristics for User Interface Design	
Visibility of system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place.
Recognition rather than recall	Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use	Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalist design	Dialogue should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Help users recognize, diagnose,and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Table 2

Evaluator	Profession	Experience with Dyslexia
1	Professor (Psychology)	5 years
2	Research Scholar (Psychology)	5 years
3	Counsellor	10 years

Table 3

To yield fair results, it would be ideal to include one expert who has worked extensively in the field of research for dyslexia, one expert on user interface design and one professional who has worked closely with dyslexic children.

Heuristics for interface design (ID)	
ID1	Visibility of system status
ID2	Match between system and the real world
ID3	User control and freedom
ID4	Consistency and standards
ID5	Error prevention
ID6	Recognition rather than recall
ID7	Flexibility and efficiency of use
ID8	Aesthetic and minimalist design
ID9	Help users recognize, diagnose, and recover from errors
ID10	Help and documentation

Table 4

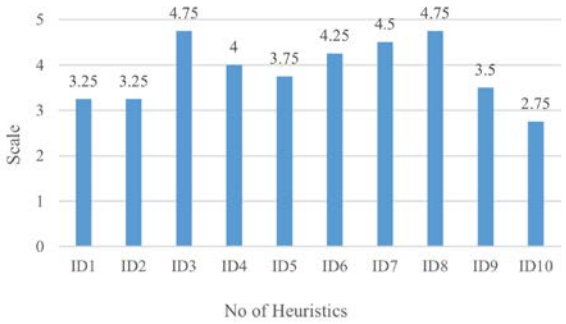

Figure 4

An interpreted Demonstration of Computer Game Design: Chuck Clanton, 1998

Clanton highlighted that HCI of a game can be divided into three levels, User Interface that typically used for the perceptual and motor level that he called game interface, Game mechanics, the second level or the 'physics' of the game that resembles the functionality in an application's User Interface and the third level known as game play, the 'things' that makes the player strive to achieve a goal.

Video Game Heuristics: Melissa A. Federoff, 2002

Federoff in 2002 created a list of heuristics based on her study at a game development company. The list of heuristics covers three areas of computer games, namely, game interface, game mechanics and game playability. Federoff listed 13 game interface issues and one game interface and play issue. Game mechanics covers two issues by itself and one issue of game mechanics and play and 23 issues of game play.

Heuristics for Evaluating Playability HEP: Heather Desurvire, 2004

Desurvire et. al. created the heuristics that are best suited to evaluate general issues in early development phase with prototype or mock-up. The HEP heuristics were based on the current literature and reviewed by several playability experts and game designers. There are four areas of game heuristics; game play, game story, game mechanics and game usability. The playability evaluator performed the Heuristic Evaluation for Playability (HEP) while focusing on how each heuristic was supported or violated and then defined the playability issue. Alternative solutions for resolving the playability issues were generated by both the evaluator and the game designer.

User testing is the benchmark of any playability evaluation, since a designer can never completely predict user behavior. HEP seems to be very useful for creating highly usable and playable game design, particularly in the preliminary design phase prior to expensive prototypes as it facilitates thinking about the design from the user's point of view.

Playability Heuristics for Mobile Games: Hanna Korhonen, 2006

Since the existing game heuristics focused on general games and not with mobility issues, Korhonen developed heuristics that focused on mobile games. He grouped the game usability into several subgroup, GU1-GU5 are related to visual design and how information is presented, while heuristics GU6-GU8 deal with how navigation is arranged and the controls used for navigation and controlling the game characters. Other heuristics are related to other important aspects like getting feedback and how the game can help the players to concentrate on playing the game.

Game Playability Principles PLAY: Heather Desurvire, 2006

The intention of the study was to adapt existing usability principles to game design. The combination of Strategy & Challenge and Usability principles were notable because they suggested that some dimension of difficulty is a desirable component of the user experience. Players were more favorable to games with lower Usability difficulty and some amount of Strategy & Challenge difficulty that reward skill and did not rely on rote memory. The pacing of learning was a major factor in differentiating a good game from a bad one. The principles in the Game/Story Immersion category addressed the value of a compelling supporting story and a realistic environment with the responsibility of sparking a player's imagination. With the PLAY HCI-focused set of Principles, games can be developed in a manner that achieves game developers' highest goal: to create a highly entertaining, engaging, immersive, challenging and

fun game experience.

Principles for Video Game Design: David Pinelle, 2008

In 2008, Pinelle defined game usability as the degree to which a player is able to learn, control, and understand a game based on an early informal survey of usability problems cited in critical games reviews and on playability heuristics. Pinelle argued that existing game usability does not address issues of entertainment, engagement and storyline and there was a need to design a set of heuristics that focuses on game usability for video game design process improvements. Pinelle stated that the main goal of the study was to develop heuristics that could be used to specialize in inspecting usability problem for video games. The ten usability heuristics developed are attended to help designers avoid common usability problem seen in video games.

Playability Heuristics for Educational Games (PHEG) Initial Stage: Hasiah Mohamed & Aziah Jaafar, 2010

The main goal was to compile and categorize heuristics evaluation that were being used to evaluate computer games based on developed heuristics that cater to usability and interface issues. Overall seven heuristics were developed based on the demand of computer games used by users irrespective of their age and gender, either for leisure or educational purposes for computer games in general, mobile games, Massively Multi-player Online Role-Playing Game (MMORPG) and video games. Since computer games have been and can be used for educational purposes (teaching and learning), thorough inspection of usability problem needed to be done and specific evaluation criteria needed to be developed.

Heuristic Evaluation for Educational Games (HEEG): Marcelo B. Barbosa, 2015

This paper presents a heuristic for evaluating educational games in terms of usability and game experience. The methodology presented is based on a study on a series of existing heuristics such as HEP, PLAY and GameFlow, and also the Criteria for Designing Educational Computer Games from Nicola Whitton. HEEG: Heuristic Evaluation for Educational Games is a mechanism that can be applied to quickly identify problems and improve general quality in games. Results obtained at the academic project points out that HEEG provides a starting point for game's evaluation, identifying qualities and specific problems of usability, immersion, design, and game play diverging from other heuristic by focusing on the assessment of educational games.

Analysis

When designing an intervention for dyslexia, specification should be made as there are different kinds and degree of dyslexia. Furthermore, more research should be done on how dyslexia differs from poor reading.

The Heuristics Evaluation for educational aid for children with dyslexia is not sufficient and needs further research. This will also depend on specific dyslexia.

The current traditional educational system caters more to sequential learners but studies have found there are a significant number of people that are visual spatial learners. Also, research suggests that dyslexia is a symptom of a predominant visual spatial learning. The Heuristics Evaluation and the present traditional education system should be updated to include this category of learners.

Visual Thinking Strategies (VTS) allows teachers to teach reading with the use of complex visuals, rather than the print and individual text forms used in the past.

The existing heuristic evaluations are insufficient to evaluate educational games for children with dyslexia or other special needs since they are based around average users (sequential learners). As discussed earlier, children with dyslexia or other special needs are different from average learners who have visual spatial characteristics and the heuristic evaluations have to be upgraded to include these children making a point to avoid the myths surrounding dyslexia.

Related content and context based learning is more effective for long term retaining in children with dyslexia than rote learning which emphasis on repetition which may cause boredom, stress and motivation among dyslexic children.

Qualitative progress rather than quantitative score should be used since dyslexics are sensitive and have low self-esteem. Low quantitative scores might not motivate them and may cause them stress.

Proposed Heuristics for evaluation of Educational Games for Children with Dyslexia	
Exploration and Immersive	The players are encouraged to explore
	Background sound is subtle and immersive. Avoid loud sound.
	The players are nudged in performing the task
	Help and hints are provided with sound, action and highlights. It doesn't involve visual text.
	The game nudges the player
	There is option for hint request
Error-prevention	Error of fail is less/null
Pacing	Pacing is dynamic. The players are free to take as much time and explore
	There is no time limit for completing the task
Guide figure	Presence of a character that helps and guide the players
	Character doesn't take the attention of the game
Parental control/Child Lock	There is child lock/parental control
Motivation	There are surprises in the game designed to be discovered randomly by the player
	The Game is not intimidating
	The Game is captivating
	Shows encouragement visually and audibly
	The Game show qualitative progress rather than quantitative score
Pedagogy	Sound of the character and letters are relevant
	The contents are shows in relation to other contents and are contextual
	Scope for exploration and self learning
Visual Design	Shows game progress with contextual visual-spatial picture
	Use of cool colours for less stress on the eyes
Scalability	Adaptable and scalable to their languages

Table 5

Conclusion

HE for Dyslexia Educational aid depends on specificity of dyslexia therefore the study should specify the type and degree of dyslexia it is focusing on and more studies should be done on developing a multi sensory educational aid. Further studies should be done on visual spatial ability and its strengths and weaknesses in order to update the present general education system.

Information and Communication Technologies play a major role in our lives. If they are not designed for specific needs, it may increase the gap between average user and those with special needs which would leave them devoid of even more resources. Technology design should be inclusive in terms of accessibility and usability.

The purpose of this paper was to check whether heuristics that cater to average users could be applicable to evaluate learning aids for children with dyslexia and other learning disorders and we learnt that they aren't sufficient. Our traditional education system caters to sequential learners and emphasises on repetition and keeping track of quantitative scores which serve as demotivating factors for dyslexics and needs to be updated to include visual spatial learners.

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