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DysScreen: A MOBILE-BASED APPLICATION FOR SCREENING OF DYSLEXIA FOR YOUNG CHILDREN

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ABSTRACT

Early identification of dyslexia is crucial for timely intervention to mitigate the disorder's impact on the affected individuals. Despite its prevalence, dyslexia often goes undetected, especially in its early stages, leading to various academic and psychological well-being issues. This paper presents the development and evaluation of DysScreen, a mobile-based application designed for screening dyslexia in children from 4 to 9 years old. The development involved a comprehensive project lifecycle, including planning, requirement gathering, design, and implementation. Essential requirements were identified through questionnaires and a review of the literature and the Paediatric Protocol, creating functional features such as multilingual support, screening test questions, and detailed result reports. The design was visualised using Unified Modeling Language (UML) diagrams to ensure clarity and precision in functionality. Findings from 30 respondents during user testing indicated that DysScreen holds significant potential to aid parents, guardians, and educators in the early detection of dyslexia among the target age group, providing valuable insight for early intervention. This work contributes to the field by offering a scalable and accessible solution to addressing a critical need in dyslexia screening.

Keywords: Dyslexia screening, specific learning disorder (SLD), individuals with reading difficulties, phonological unawareness

INTRODUCTION

Dyslexia is a neurodevelopmental disorder characterised by difficulties with accurate and fluent word recognition and poor spelling and decoding abilities (Snowling & Hulme, 2024; Snowling et al., 2020). It is also associated with several other difficulties, such as taking notes from classes, telling left from

right, following sequential instructions, telling time, remembering words, phrases and names and many others. These obstacles usually arise from deficiencies in the phonological aspects of language. In other words, they are the outcome of how the dyslexic's brain interprets the graphic symbols, or letters, about their sounds or phonemes in a particular language. People with dyslexia may also encounter issues with reading comprehension and may have limited exposure to reading, which can hinder the expansion of their vocabulary and background knowledge (International Dyslexia Association, 2020). There is no evidence of a correlation between dyslexia and intelligence quotient (I.Q.). However, their difficulties in reading and many other aspects, essential skills one should have in life, have become impediments to their academic success.

Challenges in the classroom for people with dyslexia tend to lead to emotional issues such as low self-esteem, trouble making friends, extreme frustration, and being accused of being lazy or not trying hard enough. These difficulties typically persist into adulthood, affecting personal and professional decisions as people with dyslexia struggle to adapt to environments that do not accommodate their cognitive characteristics (Huang et al., 2020). Recent statistics reveal an estimation of 10% (Abu Omar, 2024) or 1 out of 10 people having dyslexia around the world (Diena, 2023). In an earlier study, Zauderer (2022) estimated that 780 million people out of the 7.8 billion world population in 2022 have dyslexia. The Ministry of Health Malaysia estimates that 4 to 8% of the school-going children in the country have dyslexia, and more boys are affected than girls (Ministry of Health Malaysia, 2023). There are more dyslexic cases than down-syndrome or spastic; the ratio is one dyslexic case in every 20 students, compared to one down-syndrome case in every 600 or one spastic case in every 700 (Hussin, 2012).

Despite its prevalence, dyslexia often goes undetected, especially in its early stages, leading to neglected issues already mentioned above. Therefore, early screening and detection are crucial for mitigating the long-term impact of it. Early detection allows for timely interventions, which is essential for a favourable prognosis and for reducing the challenges associated with the disorder (Hettiarachchi, 2021). Screening, as a quick assessment to determine the likelihood of dyslexia, can be conducted at young ages before starting school (Sanfilippo et al., 2020). The goal is to identify children who are at risk; hence, specific types and amounts of support needed can be provided (Schelbe et al., 2021).

Historically, dyslexia has been diagnosed through comprehensive psycho-educational assessments conducted by psychologists or educational specialists. These assessments typically involve tests measuring various cognitive and linguistic skills, including phonological awareness, rapid automatised naming, word reading, spelling, and working memory. The Wechsler Individual Achievement Test/WIAT (Wechsler, 2012) and the Woodcock-Johnson Tests of Achievement (Woodcock et al., 2001) have been widely used to assess reading abilities and identify people with dyslexia. The manual checklists or I.Q. reading assessments are often conducted at Dyslexia Centers with associated fees (Che Pee et al., 2015) such as *Ujian Pengesanan Awal Disleksia Malaysia* by the Dyslexia Association Malaysia (Jumadi et al., 2018) and the Dyslexia Early Screening Test (DEST) by Fawcett and Nicolson (Shibghatullah, 2017). In recent years, dyslexia screening has also used digital tools such as the Malaysian Young Adults Dyslexia Screening Test or MaDIST (Mohamad Hazawawi & Hisham, 2014).

While many tools are available, the screening and assessment of dyslexia come with several challenges. Screening tools can sometimes lead to false positives or negatives, which may result in unnecessary anxiety or missed diagnoses. Screening results must be followed up with comprehensive assessments. Many standardised tests are based on norms developed in English-speaking countries, which may need to be validated for children from diverse linguistic or cultural backgrounds. This provides insight into the need for local context screening tools.

Furthermore, comprehensive assessments can be costly and inaccessible to all students, particularly in underfunded educational settings. The distance added to the cost as the tests are conducted at specific centres and administered by educational psychologists or specialists, particularly for those living in rural or underserved areas. This study aimed to address these challenges by developing a new mobile-based dual-language dyslexia screening tool that caters for Malay and English-medium caregivers. The mobile platform will overcome the distance barrier and allow more parents or teachers to self-screen their children or students.

RELATED WORK

Dyslexia assessment and screening have evolved significantly, with various tools and applications being developed to aid diagnosis. Snowling and Hulme (2020) emphasise the critical importance of oral language in understanding reading disorders, highlighting the progress made in comprehending the causes of dyslexia and related learning disorders. This underlines the necessity of considering language skills in dyslexia assessment. In an earlier study, Snowling and Hulme (2012) emphasised the importance of early identification for timely interventions to support individuals with dyslexia. Adlof and Hogan (2018) focused on assessing phonological awareness in children with dyslexia, introducing a new tool to evaluate phonological skills and differentiate between children with and without dyslexia. The study highlights the importance of utilising innovative assessment tools to enhance the accuracy of dyslexia screening. Furthermore, Ekstrand et al. (2021) discuss the effectiveness of eye tracking in assessing cognitive processing demands during reading, providing insights into alternative assessment methods for dyslexia. Such technological advancements offer new avenues for more precise dyslexia evaluations.

In the context of dyslexia assessment in adults, Singleton et al. (2009) mention the Dyslexia Adult Screening Test (DAST) as a conventional screening tool, emphasising the need for tailored assessments for different age groups. A recent study (Tiruchttampalam & Ross, 2024) on dyslexia in adults suggests that a screening tool in one's spoken language is more accessible to administer and helpful in identifying students at risk of dyslexia. Additionally, Sadusky et al. (2021) highlight the lack of validated dyslexia screening tools for adults, indicating a gap in the current assessment practices that predominantly focus on children. Addressing this gap is crucial for accurate dyslexia identification across all age groups. In conclusion, recent literature underscores the progress in dyslexia screening and assessment, emphasising the importance of early identification, innovative assessment tools, and tailored approaches for different age groups. Incorporating advancements in technology, language assessment, and adult-focused screening tools can enhance the accuracy and effectiveness of dyslexia assessments, ultimately leading to better support and interventions for individuals with dyslexia.

Integrating technology into dyslexia screening and assessment has led to the development of several innovative tools and applications that make the process more accessible and efficient. Table 1 compares some of the most commonly used dyslexia screening and assessment tools, highlighting their purpose, target age group, administration method, key features, strengths, and limitations.

Table 1

Comparison of The Existing Dyslexia Screening and Assessment Tools

Tool Name	Purpose	Target Age Group	Administration	Key Features	Strengths	Limitations
Dynamic Indicators of Basic Early Literacy Skills/DIBELS (University of Oregon, 2022)	Screening	K-6	Teacher-administered	Measures early literacy skills (measures early literacy skills)	Quick to administer; strong predictive validity for reading success	Limited to early literacy skills, thus, may not identify older students at risk.
Shaywitz Dyslexia Screen (The Yale Centre for Dyslexia and Creativity, 2022)	Screening	K-3	Teacher-administered	Teacher observations on language development and behaviour are research-based and easy for teachers to use.	Quick to administer; subjective; relies on teacher observation	It may need a follow-up assessment.
Predictive Assessment of Reading (Wood et al., 2006)	Screening	K-3	Computer-based; web-based	Assesses phonemic awareness, phonics, vocabulary, and comprehension; predictive; engaging for children.	Quick to administer.	Focusing on the early years may not fully diagnose dyslexia.
TOPEL (Lonigan et al., 2007)	Screening	Preschool (3-5 years)	Examiner-administered	Assesses phonological awareness, print knowledge, and vocabulary.	Comprehensive for early literacy; valid for pre-schoolers.	Requires trained examiner; time-consuming.
CTOPP-2 (Wagner et al., 2013)	Assessment	4 to 24 years	Examiner-administered	Measures phonological processing abilities: awareness, memory, and rapid naming.	Comprehensive	Requires trained examiner; not a quick screening tool
Woodcock-Johnson IV (Woodcock et al., 2001)	Assessment	2 to 90 years	Examiner-administered	A broad assessment of cognitive abilities and academic skills, including reading.	Highly comprehensive and suitable for detailed diagnosis.	Lengthy administration requires specialised training

WIAT-III (Wechsler, 2012)	Assessment	4 to 50 years	Examiner-administered	Wide range of academic skills, including reading and phonological processing.	Comprehensive; beneficial for both children and adults.	Lengthy; requires a skilled administrator.
GORT-5 Wiederholt & Bryant (2012)	Assessment	6 to 23 years	Examiner-administered	Oral reading fluency and comprehension.	Strong focus on reading fluency; provides detailed diagnostic information	Does not assess other cognitive skills.
Lexplore	Screening	K-12	Computer-based (eye tracking)	Reading fluency comprehension.	Innovative, quick, non-invasive.	Require specific equipment.
Nessy	Screening	5 to 12 years	Computer-based, interactive game	Phonic, memory, and reading speed.	Engaging child-friendly; includes intervention.	It needs to be more comprehensive.
Dyslexia Screening Test App (Neurolearning, 2023)	Screening	Seven years above	Mobile apps	Reading and spelling, combined with reading assessment, incorporate video	Personalised scores, performance recommendations, flexible	Lengthy launching time; poor interface; lengthy test; complex result; expensive.
Dyslexia Test & Tips™ (Joling, 2020)	Screening	Children & adults	Mobile apps		Provide score, easy to interpret result; straightforward interface; easy to use; quick; comprehensive; support multi-languages.	Use the old version on the Android platform.
Dyslexia Quiz (BulletMap Studio, 2020)	Screening	All ages	Mobile apps	Users identify symptoms of dyslexia and how it affects them through an interactive quiz.	Quick results anytime, anywhere; use straightforward Yes/No answers to questions; visually appealing interface	Navigation is quite troublesome; it needs compatibility issues.

The insights gained from the above studies and tools are used to guide the development of DysScreen.

METHODOLOGY

The study was conducted according to the best practices in mobile application development, which consists of the systematic steps shown in Figure 1.

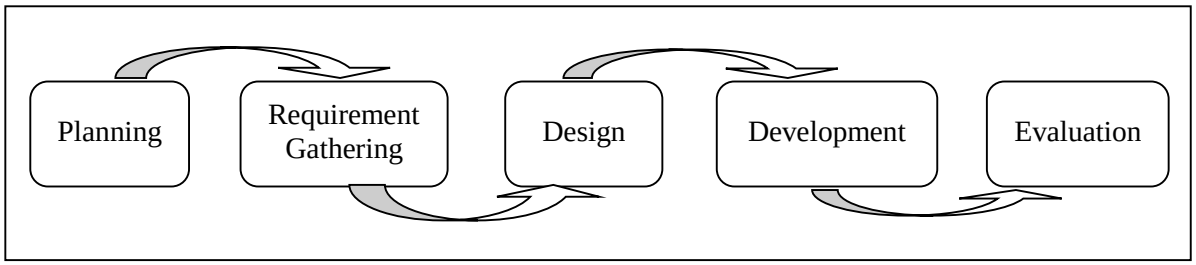


Figure 1

The Mobile Application Development Process (source: Flora, Wang & Chande, 2014)

The background study and literature review during the planning phase helped me understand the domain and determine the issues, aims, scope and significance. A proposal for the solution was produced, and a new mobile-based application called DysScreen was proposed to address the issues related to accessibility. In addition, DysScreen focuses on Malay and English mediums and follows the Ministry of Health (MOH) Malaysia's Paediatric Protocol (Muhammad Ismail et al., 2018) to address the limited availability of screening tools that cater for Malaysian context. The review of the existing apps, the protocol and the inputs gathered from the caregivers gave insights into the DysScreen requirements and its content (see Table 2). These requirements are set with different priorities, i.e. whether they are mandatory (M), desirable (D) or optional (O).

Table 2

Functional Requirement of DysScreen

Requirement ID	Functional Requirements Description	Priority
DAS_01	**Select Preferred Language**	
DAS_01_01	Users can select their preferred language, either Malay or English.	D
DAS_02	**Take the Assessment and Screening Test**	
DAS_02_01	Users can take the test to assess the child.	M
DAS_02_02	Users can view the indicator to know how many test questions are left.	D
DAS_02_03	Users may press the speaker icon to let the application read out the question.	O
DAS_02_04	Users may tap the back or forward button to view the previous questions or move to the next question.	D
DAS_03	**View Test Result**	
DAS_03_01	Users can view the personalised result after each test is completed.	M
DAS_03_02	Users may choose to send the result in report format to their email address by keying in it.	D
DAS_04	**View Dyslexia Information**	

DAS_04_01	Users can view the information about dyslexia, including basic information about dyslexia and tips on how to help a child with dyslexia at home, preschool or primary school.	D

During the design phase, the visual model of the apps was created using a standard language for modelling software and systems, i.e. the Unified Modeling Language (UML) (Booch. Rumbaugh & Jacobson, 2017). The UML diagrams illustrate the apps's structure and behaviour. Figure 2 shows one of the diagrams, the use case diagram. The requirements gathered from the previous phase are transformed into use cases and other diagrams to clarify what is needed.

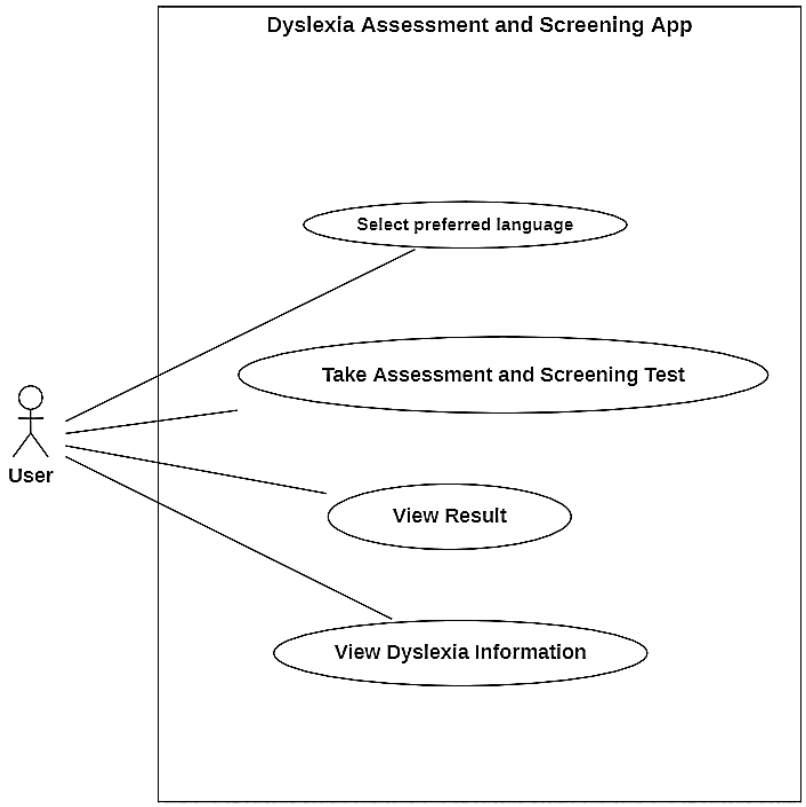


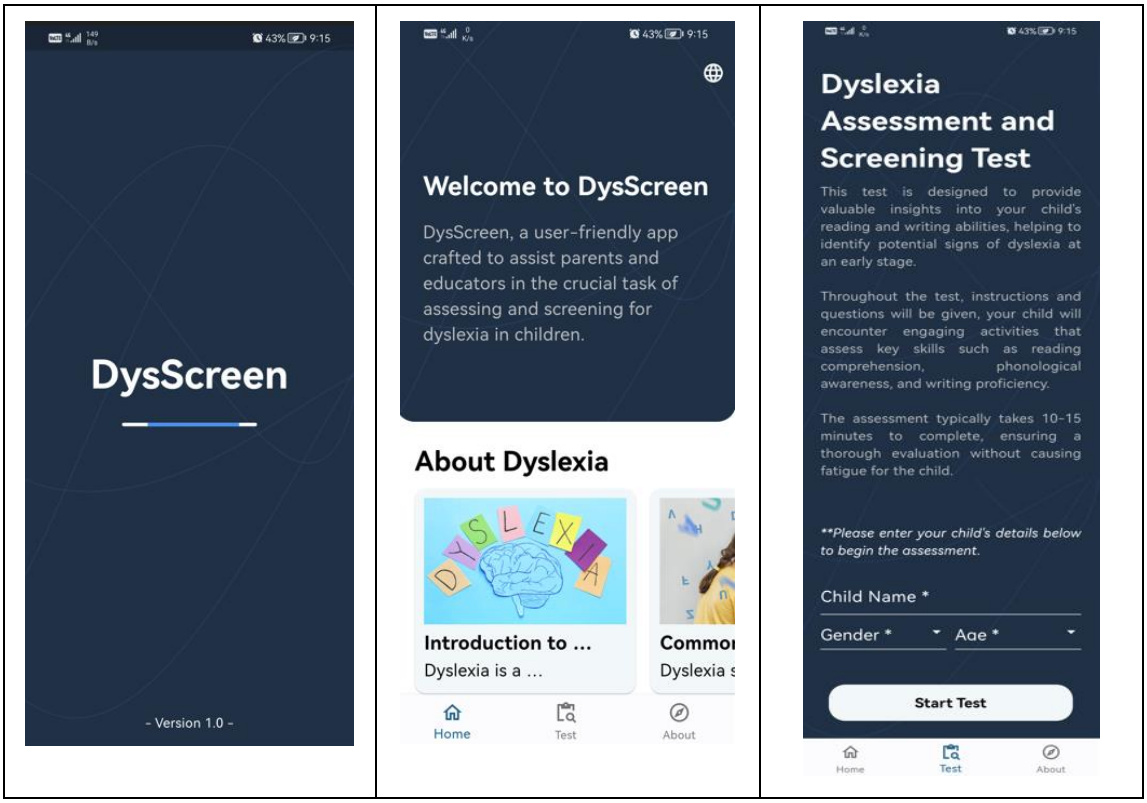
Figure 2

Use Case Diagram of DysScreen

The above figure illustrates the connections between the use cases and the actor (caregivers). The major use cases are "Select Preferred Language", "Take Assessment and Screening Test", "View Test Result", and "View Dyslexia Information". The "Select Preferred Language" use case enables users to choose the preferred language they want to use for the app, either in Malay or English, once they launch it. In addition, through the "Take Assessment and Screening Test" use case, users can take the dyslexia assessment and screening test. Upon completing the assessment, users can view their test results. In addition, the "View Dyslexia Information" use case enables users to view the information about dyslexia.

The app's user interface is designed using Figma. Figma is a cloud-based design application that creates user interfaces (U.I.). It is equipped with a vector graphics editor and prototyping tools, thus facilitating the creation of high-fidelity and interactive prototypes. DysScreen is designed to look and function like a user test or survey. It features a menu bar with a Home, Test, Result and About screen. Questions used

in the test were developed based on the guidelines provided in the protocol. The fully functioning DysScreen was developed using Dart and Flutter. Dart is reliable, clear, fast, easy to use and compatible with several programming languages, including Java, JavaScript, and Python. Meanwhile, Flutter offers a high level of interoperability with existing programs and features that make it ideal for constructing interactive applications, such as a GPU for graphics work and support for gesture recognition and bi-directional communication between devices and apps. Figure 3 shows several screenshots of the DysScreen interface.

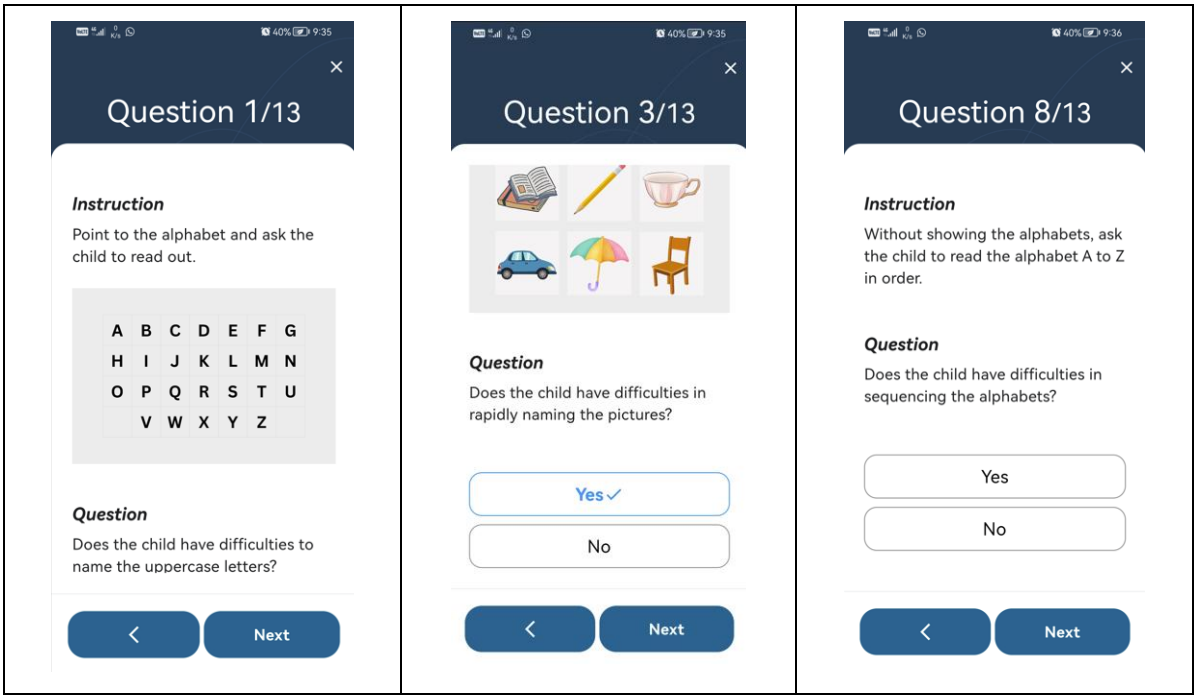


(a) (b) (c)

Figure 3

The Landing Page (a), Introductory Page (b) and Registration Page (c)

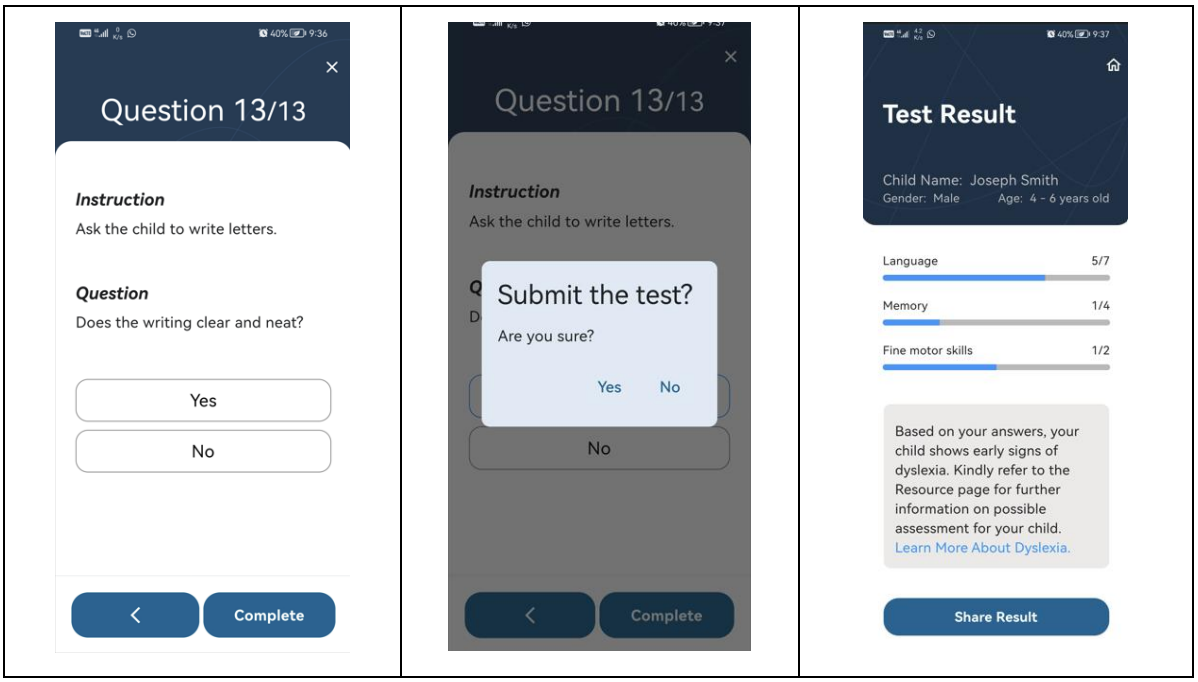
The above figures are the first three pages of the apps. DysScreen is designed for children in 2 different age groups, i.e. kindergarten children (4 to 6 years old) and lower primary school children (7 to 9 years old). Questions for the first group's age focus on language, memory, and fine motor skills. In contrast, the second group's age has additional questions on attention and visual skills, as suggested by the MOH's protocol. These questions are used to identify early signs of dyslexia in children. There are 13 questions for the 4 to 6-year-old group and 25 for the 7 to 9-year-old group. Upon completing the registration, users can start taking the test. Figure 4 shows 3 out of 25 test interfaces. The caregivers carry out the tasks with the children, observe their responses and answer whether the questions are Yes or No, while Figure 5(a) shows the last question page for the first group age. Upon completion, users will be asked to confirm the submission of their answers (Figure 5(b)). The Result page (Figure 5(c)) displays the score achieved for each tested aspect and a simple analysis of the results. Users can share the results with their email or WhatsApp or screenshot them for future reference.



(a) (b) (c)

Figure 4

The Test Interfaces



(a) (b) (c)

Figure 5

The End of Question page for 4 – 6 years old category (a), Confirmation to Submit page (b) and Result page (c)

The usability of the DysScreen prototype was tested by 30 respondents who are caregivers or those who have access to children in the target age group. Respondents were recruited to use the apps beforehand and were requested to complete the questionnaire. The questionnaire has five sections to test the ease of use, design and aesthetics, content clarity, functionality and capability and overall satisfaction.

ANALYSIS AND RESULTS

Section A of the questionnaire collects the demographic data of the respondents. The age group distribution of the respondents consists of two groups; 20 out of 30 respondents (66.7%) were aged between 20-39 years old, while the remaining ten respondents (33.3%) were aged between 40-59 years old, and the majority (73.3%) were female, with only 26.7% being male. The largest group of respondents was Chinese, comprising 70.0% of the total, followed by 20% Malay and 10% Indian. Siblings comprised 56.7%, making it the highest represented group, while parents comprised 33.3%; educators and guardians comprised 6.7% and 3.3%, respectively. Twenty-eight out of 30 respondents (93.3%) needed experience using similar apps.

Section B of the questionnaire gathers user experience with the apps. There are 18 questions to which the respondents responded using a scale of 1 to 5: (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly Agree. The responses to all the questions are summarised in Table 3 below.

Table 3

Summary of the Results

No.	Question	Score in %				
		1	2	3	4	5
1.	Overall, I am satisfied with how easy it is to use this app.			10.00	43.30	46.70
2.	This app does everything I would expect it to do.			16.70	40.00	43.30
3.	Using this app is simple.			10.00	30.00	60.00
4.	I feel comfortable using this app.			6.70	26.70	66.70
5.	It is easy to learn how to use this app.			10.00	26.70	63.30
6.	I don’t notice any inconsistencies as I use this app.		6.70	13.30	33.30	46.70
7.	The instructions for every question are clear and easy to understand.			13.30	33.30	53.30
8.	The app runs smoothly. I can go back and forth without a problem.			16.70	26.70	56.70
9.	The questions are straightforward and easy to understand.			13.30	26.70	60.00
10.	The image in the questions helped me conduct the activity with the child.			10.00	40.00	50.00
11.	It was easy to find the information I needed with this app.			13.30	36.70	50.00
12.	The interface of this app is user-friendly (intuitive, easy to navigate)			16.70	33.30	50.00
13.	I like the app's look (including colour, content organisation, font type, and size).			6.70	36.70	56.70

14.	The coverage of this app is adequate to help me find the related information and assess dyslexia.	16.70	30.00	53.30
15.	This app helps assess dyslexia.	10.00	33.30	56.70
16.	The test results and reports generated by the app are precise and useful.	16.70	33.30	50.00
17.	I could complete the assessment tasks easily and quickly using this app.	13.30	36.70	50.00
18.	I recommend this app to a friend.	10.00	50.00	40.00

The scores in Table 3 show the positive feedback from most respondents. Only *inconsistency* aspect receives *Disagree* feedback but the percentage is low, i.e. 6.7%. There is also a small percentage (10 to 16.7%) of *Neutral* feedback from 3 to 4 respondents for each question. Most of the responses are positive, i.e., either *Agree* or *Strongly Agree* to all the aspects being evaluated. The highest score for both *Agree* and *Strongly Agree* feedback is 93.4%, from items 4 (comfortability) and 13 (app look). Six more items receive a score of 90%, i.e. items 1, 3, 5, 10, 15 and 18, which account for *easy to use*, *simplicity*, *easy to learn how to use*, *helpful images* and *usefulness of the app in assessing dyslexia*. Most respondents also stated that they would recommend DysScreen to their friends. Besides, there are six positive responses from the open-ended question in which the respondents used good, very good, great and awesome to describe their opinion about the app; one also stated that the app is user-friendly.

CONCLUSION

In general, this study addresses some issues related to the accessibility of a screening tool suitable for the local context. The evaluation result provides insights into the potential of DysScreen as a useful screening tool for dyslexia. The current version of the prototype still has room for improvement, especially in the Test and Result components. Future work should focus on making this content more comprehensive and reliable. The involvement of educational psychologists and paediatricians will strengthen the effort. An estimated 9.19 million out of the 32.65 million population in Malaysia are children who will serve the country in a few years. These children have the right to literacy skills to be competent learners, enabling them to seek knowledge or join the workforce later on. Early intervention can only be provided after at-risk patients are screened and identified. Unidentified or late intervention cases can only increase chances for people with dyslexia to drop out of schools, leading to various social issues such as higher rates of unemployment, lower earnings, poorer health and higher rates of mortality, higher rates of criminal behaviour and incarceration and dependency on public assistance.

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