Modeling the Need for Decision Support Systems for Dyslexic Children using BMC

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***Abstract*—Dyslexia is a learning disability that causes difficulties to read and understand written language. Dyslexia is caused by a phonological processing problem whereby children who are diagnosed with dyslexia have trouble manipulating the language. Dyslexic children also face problems learning in regular classes. If this is not identified early, the children will be lacking in their development thus losing their self-esteem. This paper highlights on the initiative that is proposed for the Ministry of Health in Malaysia towards enhancing the current medical practice of diagnosis and treatment processes for dyslexic children in Malaysia through the implementation of decision support systems (DSS). Early readings have been done to understand DSS in clinical field, dyslexia and its' assessment procedures. A Business Model Canvas (BMC) was created to highlight the main components to carry out this project. The authors conclude with suggestions of future work for next paper.**

Keywords—decision support systems; dyslexic; dyslexia; healthcare; business model canvas

I. INTRODUCTION

Dyslexia is a type of learning disability. According to [12], dyslexic individuals visualize the world quicker than the non-dyslexic individuals. Dyslexic brains have huge cognitive advantages over normal brains. In fact, dyslexic people have the ability to see things differently. It is common for individuals with dyslexia to have learning difficulty that causes problems with certain abilities to learn, such as reading. Hence, they are encouraged to explore and be exposed to various kinds of fields such as arts, programming, or others in order for them to find their hidden talent. Dyslexic people tend to be bad at arithmetic, adding and subtracting numbers. As soon as this dyslexic people began to see patterns in mathematics, they could see patterns that other people could not see [10].

By having a decision support system (DSS), crucial questions on how to identify information needs, what is the relevant data and how to organize it and able to make decision wisely towards the treatment of a dyslexic child will be addressed.

This paper will present a business plan using Business Model Canvas, which helps to identify the business needs and Value Proposition Canvas as a tool to identify the customer's needs.

II. PROBLEM STATEMENT

It has been observed that the current formal assessment done by healthcare providers in Malaysia to diagnose dyslexia are still using manual procedures. Hence, this paper aims to provide the requirements for decision support systems (DSS) towards enhancing psychological assessment of diagnosing dyslexia, help the professionals in making decision on identifying dyslexia, improving before and after diagnostic processes and also to assist in identifying stages of dyslexia at early age. By doing the study will assist the decision makers in implementing DSS for dyslexic children in the future.

III. LITERATURE REVIEW

A. Decision Support System in Clinical Field

A clinical DSS is a widely used technology designed to guide healthcare practitioners in establishing protocols and best practices towards improving patient care [6]. Clinical DSS are knowledge-based systems, which involve the use of patient data and a series of reasoning techniques to generate treatment options and care planning [8].

By the end of any diagnosis and treatment in healthcare, health examinations results, also known as reports are to be produced. A health examination package may compose of various examination items such as physical examination, laboratory tests, endoscopies, radiological studies and others. In the clinical fields, the report generated based on the interpretation from these health examination results is one of the most important works of health examinations [7]. Results gathered from multiple sources need to be interpreted entirely to get the overall view of a patient's health condition and this work is tedious for the clinicians. Thus, clinicians tend to simplify some of the processes according to their own experience rather than following the proper guidelines in making decision, which may potentially threaten the health examination reports. This issue has raised the need to implement clinical DSS. However, in order to have an intelligent clinical DSS, the knowledge base and reasoning algorithm needs to be maintained continuously [7].

To improvise the decision making process and application of law in medical practice focusing on psychiatry in emergency department, [9] presented a design and development of a mobile DSS to guide the clinicians, which enables quick and accurate access to relevant information using recommended procedures and correctly documenting medical events and

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procedures followed. This is because observation of patient for a prolonged period of time is not relevant for an emergency department, as it requires efficiency in decision-making and treatment especially if patients harm themselves or others, or refuse treatment. By using DSS, healthcare providers are able to quickly identify and apply correct procedures based on applicable laws to reduce the chance of taking incorrect actions resulting with associated risks, hence preserving the patients and their rights [9].

B. An Overview on Dyslexia

A common myth regarding dyslexia is that people with dyslexia read and write letters and words backward. For example, 'was' is perceived as 'saw'. Children with dyslexia may have trouble decoding words, which affect their learning process and literacy such as the ability to read words fluently. They may also have trouble with reading comprehension, sentence structure, writing and understanding words [5]. Parents and teachers may get frustrated when they are not able to help the children get the right education, as they are not aware of the disability and diagnose at an earlier age.

Main component of dyslexia is auditory confusions that impacts auditory processing. Children with dyslexia may take longer time to read. By not identifying it sooner, they would not be able to read even until they are 12 years old [11]. Early observation can be done on the child's spelling ability. Most of them can only memorize words but not able to spell when writing a sentence or paragraph [11].

Dyslexia also can be traced by analyzing sound. Dyslexic individuals often face difficulties in memorizing names, letters, the sequence of the alphabet and also the arithmetic. It affects many areas in their lives and not just their reading capabilities [5].

According to Dyslexia International studies, 1 out of 10 people in the world population, which are equal to more than 700 million children and adult, have dyslexia. According to a researcher in National Institution of Health who conducts scientific systematic studies on dyslexia for 28 years, dyslexia impact 20% of people in US country but it comes with different stages from mild to moderate to severe to profound. While in Malaysia, according to the Department of Statistics Malaysia and the Department of Social Welfare [1], the amount of Malaysian population with learning disabilities that includes Dyslexia is about 35%.

C. Dyslexia Assessment Evaluation Procedures

When doing the assessment of dyslexia, it is important for doctors to identify the processing skills because children with dyslexia have difficulties with information processing [10].

Diagnosing dyslexia starts by collecting information gained from observing, interviews and testing that can be done by parents, teachers, medical officers and an education assessment specialist. Dyslexia is suspected when difficulties arise in relation to a child's development, health or attention. Relevant tasks and interpreting the information collected should be the responsibility of a professional who has knowledge with the essential features of dyslexia at various stages in the development of literacy skills. This professional should also have expertise in knowledge about the influence of language development and behavior on literacy learning. Normally, school psychologist or speech-language pathologists are responsible to handle these tasks [3].

D. Issues in DSS and its Recommended Actions

For DSS to be accepted by users, the issue of processing speed or the time taken for data to be gathered and analyzed, and provide usable information needs to be taken care of. A clinical DSS that fails to function in a timely manner is described as an interrupter [6]. By including end users in the design process of the system and allowing them to perform sufficient usability testing prior to bringing up the application into the production may eliminate the chances of having errors and inefficient DSS.

In the case of using technology acceptance model (TAM) for clinical DSS in hospitals, the role of healthcare professionals is perceived to be less significant in hospital setting as it implies that medical treatments are conducted by IT system. The healthcare professionals are less likely to use DSS because interactivity with system makes them think of losing control over medical process [8]. If the suggested options and guidelines from DSS are against their autonomous practice in hospitals, they are most likely to feel threatened by DSS thus less likely to use it. Based on an empirical finding in [8], implementing clinical DSS is perceived the same by the healthcare professionals in Malaysia, which is a challenge that needs to be addressed by the hospital administrators. Providing continuous training programs is one of the initiatives suggested to motivate and improve their knowledge on the functions of DSS.

IV. Methodology

This study intends to enhance the psychological assessment of using decision support system that may help psychotherapist to diagnose dyslexia more efficiently. In order to achieve the research aim and purposes, a literature review is conducted to synthesize the theories, methods, instruments, and the findings of past researchers regarding above-mentioned topic. Various online databases including Google Scholar, Springer, Clinical Key for Nursing and IEEE libraries were used to retrieve journal papers and conferences proceedings. A qualitative method was also adopted in this study, whereby an interview was conducted with a close group of people from different background. Two of the five participants are parents who had experience going for diagnosis of their children, one of the participants are nurse in Pediatric department, one is a medical officer who previously worked in Pediatric department, while another one is a special needs teacher. Other than that, several existing online assessments on dyslexia were evaluated to find out on the features of how the evaluation is done.

V. Findings

The findings are discussed according to sections as follows:

A. *Interviews*

An interview was conducted during this study. After the interview session, key points on suggesting the enhancement in diagnosis and treatment of dyslexic children using system are extracted. The questions asked during the interviews are as followed:

- What are the procedures to diagnose dyslexia?
- What are its' post-diagnose treatments?
- How does Specialist identify and make decisions on patient's dyslexic condition?
- Based on treatment that has been done, is there any improvement for those school-aged children?
- How long does the treatment process take?

Based on the interview questions, the procedures handled by the qualified specialist and therapist, are identified as follows:

- Informal assessment: The informal assessment is done through observation of learning abilities at home and school. Parents will then bring their children to the Dyslexia center once the symptoms of dyslexia are shown.
- Formal assessment: The formal assessment is done through an interview, which will be conducted by doctors. For diagnosing school-aged children, doctor will normally ask questions to their parents. In the middle of interview, doctor will also ask a few questions to patient to get some feedback.
- After the interview is done, doctor will do an analysis and calculate mark of the 'yes' and 'no' to determine the problem by stages of mild, moderate, severe or profound.
- If the result is positive, doctor will assign those school-aged children to a particular therapist. Therefore the dyslexic children can have an appropriate education treatment.

It usually takes about 6 months or more for children to be able to improve in their learning process. Then, patient may need to go for a check-up to analyze the progress. According to one of the participants, children at the age of 12 years old are still on treatment even when they have been diagnosed with dyslexia for years at an earlier age. In most cases, dyslexia is detected during the school growing aged or in late primary school when students are still having difficulties to read and write. However, it is considered normal if kindergarten aged children are not able to read and write.

B. *Studies on Existing Online Assessment Evaluation (Informal Assessment)*

This section focuses on studying the existing online assessments for diagnosing dyslexia. Most of the online assessments are available in European countries and using English language. The following are some online websites of dyslexia diagnostic:

- https://www.testdyslexia.com/
- https://shengchifoundation.org/ld/dyslexia-program
- https://www.dyslexicadvantage.org/dyslexia-test/
- https://www.dynaread.com/online-dyslexia-test
- http://www.beatingdyslexia.com/online-dyslexia-test.html

Based on the online assessments sites mentioned above, we are able to know how assessment of diagnosing dyslexia is done, what area to be assessed, the result of assessment, the stages of dyslexia, and also receive personal consultation from their expertise owner of online assessment. Most consultation will be done locally at their centers. These online assessments require guidance from adults. Parents and teachers can use it to diagnose for their children or student having dyslexia.

The drawbacks of those online assessment evaluations are that the result from the evaluation can be misleading. Some people might not have dyslexia, but other factors such as age, or stress level may cause them to key in incorrect answers influencing their assessment results.

VI. Proposed Solution

The proposed project is planning to implement decision support system for dyslexia patients of school-aged children in Malaysia. The purpose of this project is to help contribute towards health and education empowerment.

A. *Business Model Canvas*

Figure 1 below shows nine blocks of Business Model Canvas (BMC) based on the business proposed. Business Model Canvas is a simple tool for designing Innovative Business Models which is a simple graphical template describing nine essential components: customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure.

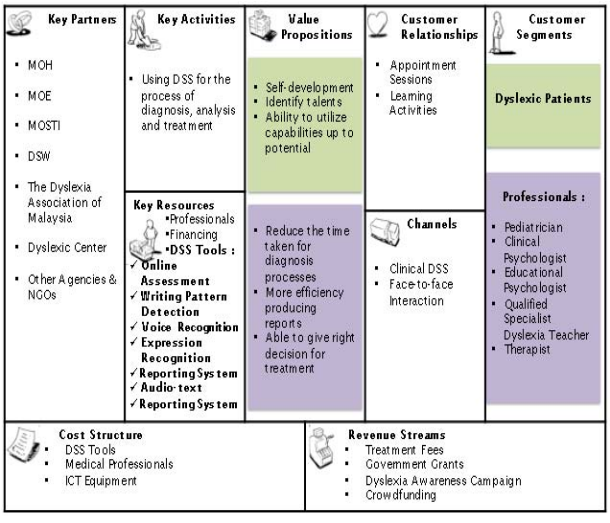

Figure 1. Business Model Canvas (BMC)

1) Customer Segments: The customers whom this project aims to serve are primarily the dyslexic patients and the professionals who may consist of pediatrician, clinical psychologist, education psychologist, qualified specialist dyslexia teacher and therapist.

2) Value Propositions: The proposed project will benefit the dyslexic patients in terms of their self-development, talents identification and ability to utilize capabilities up to potential while the professionals can benefit on reducing the time taken for diagnosis, producing efficient reports and the ability to give right decision on treatment.

3) Channels: The above said value propositions are delivered to customers through direct communication such as face-to-face and also through the clinical DSS.

4) Customer Relationship: The customer relationship for this project is appointment sessions for diagnosis between the dyslexic patients and the professionals and the learning activities.

5) Revenue Streams: The revenue that can be gained from this project is the treatment fee, funding from government and other agencies, and the Dyslexia Association of Malaysia and also through dyslexia awareness campaign and crowd funding.

6) Key Resources: The assets required as key resources for this project are professionals, financing and the DSS tools for the professionals to be able to make efficient decision, produce accurate result and to support enhancement of diagnosis and treatment procedures using technology as follows:

- Online assessment evaluation
- Writing pattern detection
- Voice recognition
- Face expression recognition
- Audio-text
- Reporting System

7) Key Activities: The program involves using DSS for the process of diagnosis, analysis and treatment by both the professionals and the dyslexic patients.

8) Key Partners: The key partners and collaborators include the government agencies such as Ministry of Health (MOH), Ministry of Education (MOE) for teaching and learning materials, Ministry of Science Technology Innovation for the technology resources, Department of Social Welfare (DSW), Dyslexic Center, Dyslexia Association of Malaysia and other agencies and NGOs.

9) Cost Structure: The costs incurred for this project are mainly the costs of DSS tools, professionals and ICT equipment.

B. Value Proposition Canvas

Another tool that is used in this project is Value Proposition Canvas (VPC), which is a tool to design, test, build, and manage products and services. BMC and VPC integrate with each other, where VPC zooms into details on two blocks of the BMC, which are Value Proposition and Customer Segments. VPC consists of two components: Customer Profile and Value Map [13]. The VPC based on the proposed project, focuses on the patients and the professionals.

1) Figure 2 below shows the overview of VPC for Dyslexic Children.

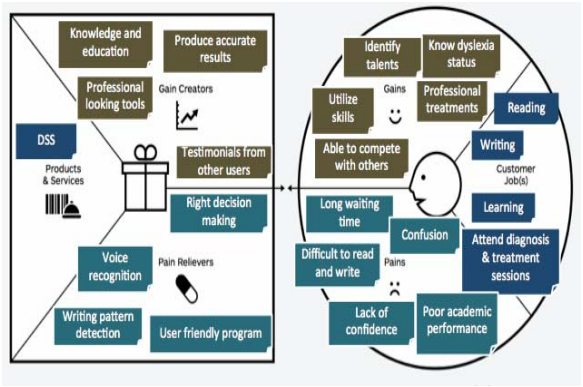

Figure 2. VPC for Dyslexic Children

The detailed of the VPC are as follows:

a) Customer Jobs: The dyslexic children's jobs are reading, writing, learning and improve standards of living by attending diagnosis and treatment session.

b) Customer Pains: Some of the common issues faced by dyslexic children are long duration of treatment, having difficulties in reading comprehension including texts and words resulting in poor academic performance which affects the learning achievements [14]. In addition, the dyslexic patient may also have lack of confidence and have confusion on their talents.

c) Customer Gains: Once the job is done, the children will be able to know if they have dyslexia. Then, the children will be able to identify their talents, utilize skills up to potentials and able to compete with others through the professional treatment that focuses more on learning sessions.

d) Products and Services: The products and services are the DSS solution for diagnosis and treatment of dyslexia.

e) Pain Relievers: The pain relievers of dyslexic children are the DSS tools that will produce the right decision making include voice recognition, writing detection and user friendly program for children to get quick diagnosis and treatment.

f) Gain Creators: The proposed project will benefit dyslexic children in terms of knowledge and education that they will gain once diagnosed and treatment is done efficiently. In line with Malaysia Education Blueprint 2013-2025 [15], student with physical or learning disabilities should receive educational support to ensure that they enjoy the same educational opportunities. By doing diagnosis and treatment through DSS will equip the children with the right education to develop themselves and sustain the quality of their life. DSS will also produce accurate results for patients to know whether they have dyslexia and act as the professional looking tools to

create confident as it will include testimonials from other users.

2) Figure 3 below shows the overview of VPC for the Professionals.

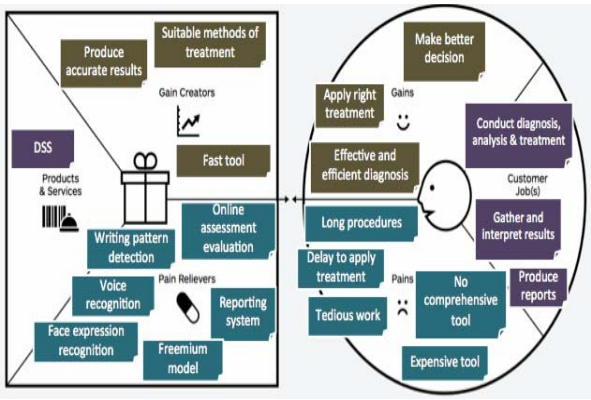

Figure 3. VPC for Professionals

The detailed of the VPC are as follows:

a) Customer Jobs: The professionals such as specialist and therapist need to conduct diagnosis, analysis and treatment of dyslexia and also to produce reports based on the interpretation of results gathered.

b) Customer Pains: The issues faced by the professionals are that the current procedures for diagnosis of dyslexia that include analysis of results are done manually, take longer time and causing delay to apply the right treatment. In addition, there are no comprehensive tools at the moment. This is because the tools are expensive to have. Professionals are also required to produce reports based on the interpretation of results gathered on patient's health condition and this work is said to be tedious.

c) Customer Gains: The professionals aims to perform effective and efficient analysis of diagnosis, make better decision and apply the right treatment.

d) Products and Services: The products and services are the DSS solution to diagnose, analyze and treat dyslexia.

e) Pain Relievers: The pain relievers are the tools that include online assessment evaluation, writing pattern detection, voice recognition, face expression recognition, audio-text and reporting system. In order to relieve the pain of having an expensive tool, a freemium model can be proposed where, a simple and basic services are offered for free for users to try whereas more features will be provided for the premium ones.

f) Gain Creators: By having DSS, the professionals will make better decision when accurate results are produced and the methods of treatment are suitable for patient. The fast tool of DSS will save the time of professionals to identify and apply correct procedures, which reduce the chance of taking incorrect actions resulting with associated risks [9].

VII. Conclusion and Future Work

In conclusion, this paper highlights the importance of using the right method to diagnose dyslexia. Everyone including dyslexic individuals deserves the basic needs of education. By implementing proper treatment methods will help dyslexic individuals to embrace their uniqueness to lead their own life. Hence, it is hoped that the proposed BMC will provide the guidelines on implementing DSS for dyslexic children. It is also hoped that this paper will help drive more research into how dyslexic individuals should be engaged, in order to deliver sustainable results. In this paper, it is important to note that the proposed BMC is a possible model to start with and might not be the final model. The model is created based on readings and understanding of the topics. Hence, this model needs to be validated with the customers and various parties concerned, which have not been done yet.

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