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The Development of Adaptive Learning Application to Facilitate Students with Dyslexia in Learning Malay Language

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Abstract:
Students with dyslexia are described as regularly having difficulty in language processing skills such as phonology, spelling, reading, and/ or writing. This difficulty is not only affecting their learning but may reflect their engagement behaviour in class. As an intervention, traditionally teacher will assess the student and assign them to a designated class according to their difficulty level. In addition, the teacher will also use multiple learning interventions such as multisensory materials and education application during class to attract the student's attention. However, it is challenging for the teacher to personalise the intervention individually based on their cognitive and engagement level. Despite the variety of materials used, it is difficult to constantly observe and maintainstudent'sengagement without the teacher's intervention.This research, therefore, issuggesting a computer-based application that utilizes an adaptation of cognitive and engagement to support teacher's role.Hence, in this paper, we introduce the ALMo-DML to facilitate the learning ofthe Malay languagefor students with dyslexia. ALMo-DML is an adaptive learning approach that considers both the cognitive and engagement states of the students and intervenes with the learning automatically. This paper describes the concept of adaptation in the ALMo-DML, methodology, and the development of the application.

Keywords: *adaptive learning, dyslexia, intervention, application.*

1. INTRODUCTION

In the trend of Industry 4.0 with sensor-based and artificial intelligence, education platform is one of the impacted areas. The education developmentevolved from passive classroom interaction to the massive open online sources(Maria, Shahbodin, & Pee, 2018). Towards the Education 4.0, there are nine trends being discussed among scholars(Aziz Hussin, 2018). One of the important elements that needs to be highlighted is personalised learning with flexible tools and techniques.

However, personalised learning for students with a learning disability such as dyslexia needs full teacher interference. Through the traditional teaching approach, the teachers were burdened to create

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individualized learning methods based on the diversity of student's pace(Dzalani & Shamsuddin, 2014). Therefore, relying on the teachersthemselveswithout technology support would be a challenging tasknot only for the teachers but also for the students with dyslexia. Thus, towards Education 4.0, students with dyslexia should be prioritized in facilitating themselves to cope with the difficulty by utilizing the technology.

The purpose of this paper is to introduce the adaptation approach for personalised learning for students with dyslexia. Dyslexia is defined as a specific learning disability that is characterized by difficulties with accurate and/or fluent word recognition, poor spelling, and decoding abilities(Lyon, Shaywitz, & Shaywitz, 2003). Despite the presence of the difficulties,learning can be supported through proper teaching strategies and interventionssuch as multi-sensory activities(Subramaniam & Che Mat, 2013), computer application (Rello et al., 2014), and games (Franceschini et al., 2015). Although the result from these studiesreceived promising feedback from teachers and parents, they missed a few important components such as personalisation andcontent flexibility. Therefore, this paper is suggesting the adaptation approach to acquire personalisation and content flexibility through the development of the adaptive application for students with dyslexia.

The key contribution of this paper is the implementation of adaptation through the development of the adaptive application for students with dyslexia. We begin with a brief overview of the existing literature related to approach or intervention that are available for students with dyslexia. Section 3 discusses the proposed model that applies an adaptive approach and its components. Section 4 explains the methodology involved in the development of the application model. Section 5 presents the adaptive application model. Finally, the evaluation planning for the proposed application model is discussed.

2. RELATED WORK

In this section, we conceptualize the theory of dyslexia, the difficulties,and current approach availableto help in minimizing their difficulties.

2.1 Dyslexia Concept

Dyslexia is identified as a specific learning disability that affects word recognition, poor spelling and decoding abilities, and later reduces reading experience (Lyon et al., 2003).Dyslexia also can be categorized into three subtypes(Tonnessen & Upptad, 2015). The first type is visual dyslexia which implicates the confusion of the alphabets and syllables, the second type is auditory dyslexia that affects segmentation of phonemes (sound) and graphemes (alphabets), and finally, the third type is correlating difficulty which affectswriting difficulty. Therefore,students with visual dyslexia can be intervened using audio, while students who lack in audio can be taught using visual instruments. As for correlating difficulty, the help should be given using both audio and visual interventions.

2.2 Difficulties and Interventions

Several difficulties were reported to be experienced by the students. These include the phonological deficit, reading difficulty, spelling difficulty, and many more (Vender, 2017). Phonological deficit is one of the cognitive problems experienced by students with dyslexia(Ramus & Szenkovits, 2008). This is a condition that impacts listening and speaking skills due to a lack of phonological awareness. Utilizing speech and sound such as repetition, picture naming, and word

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production can help the student (Fawcett, 2002).

Reading difficulties also affect students with dyslexia (Stein, 2018). Failing to identify the sounds of the word is reported as one of the reasons for reading difficulties. Students with dyslexia also exhibit a slow, inaccurate, and effortful reading due to the limitation of mentioned skills (Vender, 2017). Therefore, as an intervention, the teacher would use a flash card activity and measure the times taken in identifying the objects.

However, traditional practice with pen and paper alone is not sufficient to ensure the success of the students especially students who have a prolonged reading failure(Regtvoort & Leij, 2007). This is because students with dyslexia can easily be disengaged with the learning especially in their problematic area(Rose & June, 2009). As a result, games and computer-based learning have been proposed as supporting material in teaching the students. These interventions were reported to be a success not only in improving the designated skill, but had also increased the students' attention (Kast et al., 2011).

2.3 Technologies for learning intervention

Technology that supports the intervention for students with dyslexia is emerging in today's world. Games-based application and computer-based application are actively developed by scholars to help students cope with their difficulties. Games is a method of teaching that interactively helps the students to not only learn but also motivate them(Reid, 2011).Other technologies introduced for students with dyslexia were computer-based application. In one research conducted by Kast et al. (2011), the computer-based learning was specifically used to investigate the spelling behaviour of the students with dyslexia and without dyslexia. Using this technology, the spelling of the students with dyslexia were improved to reach the same extent as the control group (Kast et al., 2011).

Based on the literature studies, we developed a technology that utilizes computer application for students with dyslexia. Before the application was developed, we created a learning model which comprises components for the adaptation process. In this paper, we are proposing an adaptive learning model for students with dyslexia (ALMo-DML).

3. ADAPTIVE LEARNING MODEL FOR STUDENTS WITH DYSLEXIA

This section introduces the Adaptive Learning Model for students with dyslexia. This model incorporates an adaptation of the cognitive and behavioural elements into a learning model to facilitate the students in learning the Malay language. Figure 1 shows the activities involved in the ALMo-DML.

3.1 Cognitive Identification

Cognitive relates to reading ability that is measured using exercise activity. The language processing skills such as phonology, spelling, reading, and writing were assessed for their prior knowledge in the Malay language. All four exercises were assessed in the Exercise Model. This syllabus was derived from Literacy and Numeracy Screening test (Ministry of Education, 2016).Guidelines from a manual for the checklist for Dyslexia programme were also referred to in developing the learning content (Ministry of Education, 2011).

3.2 Engagement Behaviour Prediction

Besides cognitive, this model also identifies the engagement behaviour of the

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student while interacting with the learning content. The process of identification happens in Behaviour Processing Model. In this component, the webcam acts as a tracker to capture the images of the student's frontal face.The images were predicted using a machine learning approach to determine the engagement state of the students.The engagement state result will either be engaged or disengaged.

3.3 Adaptation Decision Rules

The output from both Exercise Model and Behaviour Processing Model are temporarily stored in the Student Model. It contains individual learning style which comprises the student's knowledge, demographic, and behaviour. The demographic needed include name and age. The adaptation of the ALMo-DML was based on the output from cognitive and behaviour. Therefore, there will be two adaptation decision. The first is the academic decision which decides the cognitive process involving increasing or decreasing the problem difficulty. Whereas the second decision takes in the affective decision which decides the behavioural intervention to catch the student's attention.

3.4 Adaptation Intervention

Finally, the Teaching Model is the model that serves the personalised intervention based on the decision made in the Expert Model. This model implements the decision that has been made by the previous components. It involves changes of activity, with hint, feedback, and attention given specifically based on the profiles earlier.

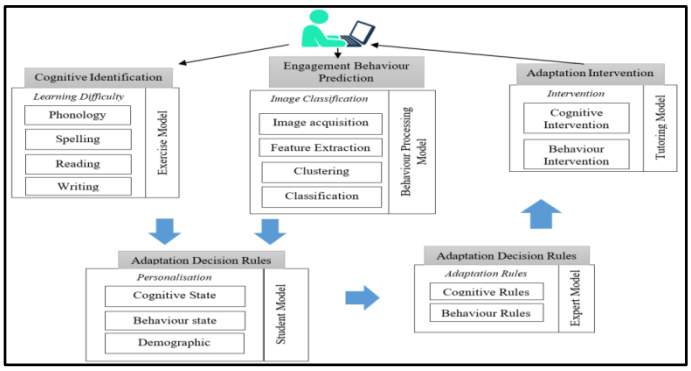

Figure 1. The adaptive learning model for students with dyslexia (ALMo-DML).

4 METHODOLOGY OF THE DEVELOPMENT OF APPLICATION

The development of the ALMo-DML application has adopted the ADDIE methodology(Branch, 2004; Rosly & Singh, 2011). ADDIE is an acronym for Analyse, Design, Develop, Implement, and Evaluate. ADDIE was chosen as it suits the development of the learning courseware.

4.1 Analyse Phase

The first phase of the development was analyse phase. We conducted a preliminary study to get to know the students with dyslexia better in a real setting. We observed the students in the classroom, in the playground, and their interaction with teachers and friends to understand their preferences and difficulties. We also studied the Malay language syllabus in order to create the learning content that suits the student's level.

4.2 Design Phase

In the design phase, we collected the result from analyse phase to create each component of the application. We identified the personas (fictional characters created to represent user types) of the students and the characteristic of the adaptive system.

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4.3 Development Phase

In the development phase, the MATLAB R2017b with image processing toolbox was used to develop behaviour model whereas Scratch applicationwas used to develop the cognitive model. Lastly, we used Python 2.7 to connect both MATLAB and Scratch application.

4.4 Implementation Phase

This is the phase where the applicationwas developed asplanned following the ALMo-DML. The combination of multimedia elements with image classification prediction was implemented. At the end of this phase, the evaluation will be conducted to target users of students with dyslexia aged 7-12 years. However, in this paper, we will not explain the evaluation process as it will be in the next stage of the research work.

5 DEVELOPMENT OF THE ADAPTIVE LEARNING APPLICATION

ALMo-DML is the adaptive learning model developed to facilitate the learning of students with dyslexia. The model is a conceptual process that needs to be translated into an application named DisleksiaBelajar, CerdasBelajar (DBCB).

5.1 Exercise Model

This model identified the cognitive state of the students as shown in Figure 2. There were four categories implemented namely phonology, spelling, reading, and writing. Phonology covered basic sub-topicrelated to vowel, consonant, and syllable exercises.In each sub-topic, the student should answer at least 3 out of 5questions correctlyto achieve mastery. According to LINUS mastery level, less than 3 (< 3) mistakes constitute mastery(Ministry of Education, 2016). Any sub-topic with more than 2 errors were labelled as non-mastery. The level of masteryis important to determine the intervention. The questions for spelling and reading exercise were derived from sub-topicsthat were labelled as non-masteryin phonology exercise.

Figure 2. Activity in the Exercise Model for cognitive identification

5.2 Engagement Behaviour Prediction

A web camera was used to capture the student's engagement behaviour. The face data collected from the camera as shown in Figure 3 were predicted using machine learning classifier to classify whether the displayed behaviour was showing engagement with the learning or not. The engagement prediction was developed in MATLAB using Image Processing Toolbox. The accuracy of the prediction scored more than 95%.

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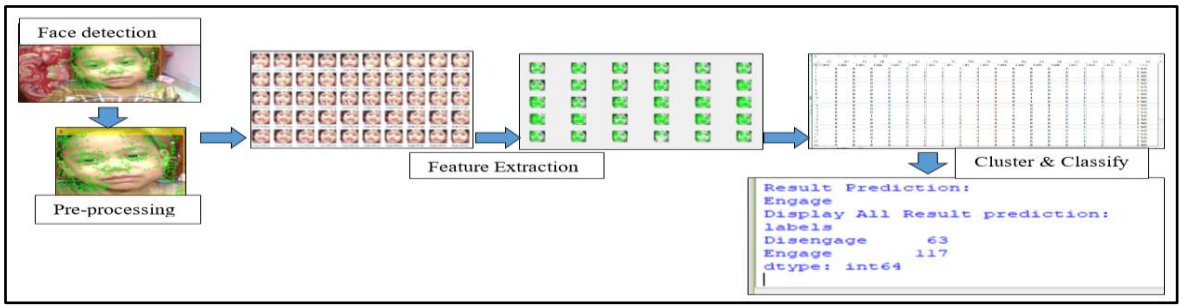

Figure 3. Engagement behaviour prediction from image classification

5.3 Adaptation Decision Rules

Adaptation decision rules were based on student's mastery and the number of errors in every sub-topic of phonology category. Each error was recorded to see the difficulties when answering the exercise. Mastery level was assigned to the topic that scored less than 3 errors. Students who got mastery and were engaged with the system will receive a higher level of difficulty. Students who got non-mastery but were engaged with the system will obtain a similar mastery level but with adaptive intervention. Whereas students whogotnon-mastery and were disengaged with the system will get a lower difficulty level.

5.4 Adaptive Intervention

From adaptation rules, there were two types of intervention namely academic intervention and affective intervention. For academic intervention, the students will receive spelling and reading exercise based on sub-topics that they struggled to master. The level of difficulty was based on the decision made in adaptation decision rules. For the affective intervention, the DBCB employed positive and negative encouragement in the form of audio and text feedback.

3 CONCLUSION

This paper has discussed the development of the application from the proposed model (ALMo-DML). This application was developed to facilitate the student with dyslexia to learn the Malay language. The development of the application, however,have not been evaluated yet. Therefore, in the next process of the research work, we will explain the evaluation of the applications in details.

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