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Research paper

Potis Calculia: Learning Resources Platform for Dyscalculia

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Abstract

Dyscalculia is severe difficulty in making arithmetical calculations. The population of dyscalculia children are comparably lower than other
Disabilities such as the down syndrome, hence the resources for are highly insufficient. However, since the population is elevating slowly, the gap in learning resources has to be addressed. This research proposes an integrated learning platform using website that offers learning materials specific for dyscalculia children. The development methodology takes into account understanding the brain process in effort to help the children to overcome their disabilities. Evaluation results showed positive feedback among the users and will be continuously improved to ensure they have equal opportunities in learning.

Keywords: *Dyscalculia; Learning.*

1. Introduction

Dyscalculia is a term for specific learning disabilities related to Mathematics. Students with this problem may have trouble understanding the real-world meaning of numbers, memorizing basic mathematical facts, or acquiring simple problem-solving skills. This type of disability is affecting approximately 5% to 6% of the current population worldwide [1]. Nonetheless, this type of disability does not reflect the intelligence level of the children because many of them outshine in non-mathematical subjects such as arts and music [2]. There are many possible causes in brain dysfunction such as genetic factors and environmental influence, as well as the interaction between the two. However, unlike dyslexia, research in dyscalculia is still in its infancy stage as very little is known about how the brain represents mathematics [3].
According to the statistics shown in Fig. 1, dyscalculia is not a common disability for the public. The lack of commonality has made it difficult to find relevant information on the Internet. Parents of children with dyscalculia are also forced to enroll their children under the professional guidance courses currently available on the market. These courses, of course, are very expensive. The reason why this research takes place is to improve awareness of this symptom in today's society and to help diagnose children with computational disabilities and give these children a targeted training platform that allows them to have the calculation capability they need in real life.
Children suffering from dyscalculia disabilities are weak in number senses, and they are often unable to understand quantities or concepts such as biggest vs. smallest. In real life, this problem is reflected when they have problems in performing simple monetary transactions. Dyscalculia children may understand the logic behind math but they will have difficulties when dealing with the mechanics of maths. In other words, they do not know how to apply what
they understand when solving even simple mathematical problems.
Furthermore, these children also struggle with working memory. For example, they often find it hard to hold numbers in mind when solving math problems. A five (5) cents may look like a ten (10) cents but after few seconds the value will totally change into a different number.

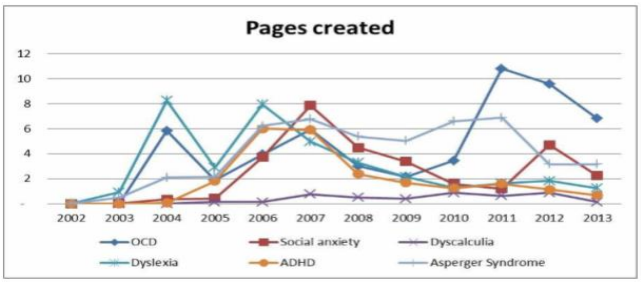

Fig. 1: Statistics showing rate of common disability known by public [4]

A qualitative study by [5] described that the essential way of refining our understanding of the behavioural and neural characteristics of dyscalculia is through better educational interventions. Unlike dyslexia, to date there are no medical or operations to help overcome dyscalculia, and even no specialized teaching programs have been developed to teach dyscalculia children.
A descriptive research by [6] described the frequency of four possible associative cognitive factors for mathematical problems: planning skills, naming speed, short-term and/or working memory, and attention among the students with developmental dyscalculia. The findings showed there were shortages in naming speed (in particular, in naming numbers), which was the most frequent explanation of math problems among children with dyscalculia abilities. This is followed by deficits in short-term/working memory as well as planning skills. Meanwhile, deficit in attention was identified as the least frequent factor. All four cognitive factors in learning math disabilities are illustrated in Fig. 2.

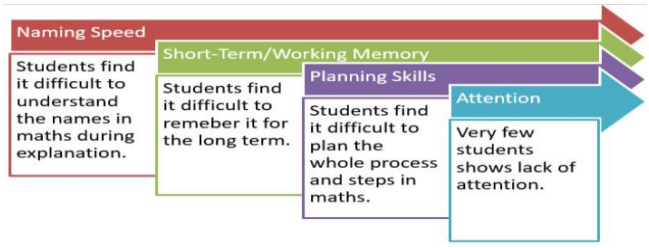

Fig. 2: Four possible associative cognitive factors of math problems [6]

Nonetheless, on the positive note, research has shown that kids with dyscalculia mostly benefit from multisensory instruction in maths. It helps a child to use their senses in helping them to learn skills and understand concepts. Moreover, mathematical concepts must be systematically educating the children to achieve a stronger connection to what they are learning about. Although this may seem like a harder choice, it is possible through patience and constant help to the children throughout the teaching and learning process. As such, more awareness and research focusing in learning disability should be taken to help the children who are facing this problem. This type of scenario should not be neglected because it will affect the students' motivation. Therefore, planning and actions are crucial in helping these children to achieve their true potential.
The remainder of this paper proceeds as follows. Section 2 reviews system similar to the proposed work: Potis Calculia. Section 3 presents the architecture and Section 4 presents the implementation of Potis Calculia. Section 5 discusses evaluation of Potis Calculia and finally Section 6 concludes with some indication for future work.

2. Related Areas

There is an unambiguous relationship between numerical and non-numerical quantitative dimensions in adult dyscalculics with started off as a child [1]. Dyscalculia, a specific learning disability that impacts the approximate number of objects in visual scenes (the so called 'number sense' system) and disability to discard the irrelevant size information when comparing numerosity. One notable work on education systems related to learning mathematics is the AAAMaths website as shown in Fig. 3. Table 1 shows the development of the proposed Potis Calculia website in comparison with AAAmath website. With this comparison, it is hoped that the proposed Potis Calculia website would be able to offer more benefits.

Fig. 3: Interface for AAAMaths system

Dyscalculia is affecting the ability to acquire school-level arithmetic skills, affecting approximately 3-6% of individuals worldwide [5]. The goal of this research is to enhance the ability of dyscalculia children to learn the necessary numbers and how to deal with it.
More research has been carried out by [5] regarding external factors such as poor teaching, low socio-economic status and behavioural attention problems [7]. Tasks should be more organized and be broken down among the groups in the analysis, building and implementing parts. [8], for instance, studied dyscalculia predictors based on the knowledge among teachers. There are many core deficits that lead to numerical and arithmetic deficits [9] as in dyscalculia, among which is the information deficit [10], visual perception deficit [11], and order processing deficit [12].

Table 1: Comparison between AAAMaths and Potis Calculia

AAAMaths System	Potis Calculia System
No registration	Registration
Users kindergarden to eight grade	Focused (7 to 9) years old
Variable chapters	Limited chapters
Supports 100 languages	Only supports English
No tutor	Have tutor to check
No interactive function	Many interactive functions
Variable exercises	Limited exercises
Limited colours used	Variable colours for children
Only for tablet media size	Website size vary on media use

3. Potis Calculia

Potis Calculia is a web-based system to help kids aged from seven to nine who are facing dyscalculia to learn math. It will be used to help kids learn mathematics through visual aids and attractive learning. The system is designed to help in reducing anxiety among kids with dyscalculia when they are dealing with mathematics. In addition, Potis Calculia also focuses to help dyscalculia kids to relate mathematics in real life scenarios. Fig. 4 shows the index interface for Potis Calculia website.

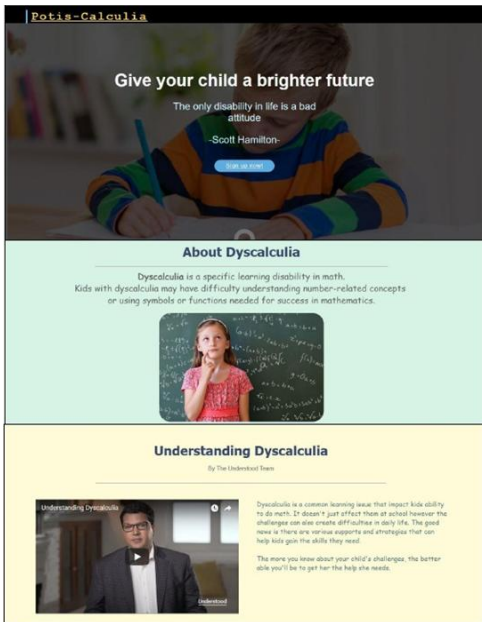

Fig. 4: Main interface for Potis Calculia

Potis Calculia was developed in a game-based format for kids to accumulate points every time they complete the game. Questions will be designed based on the foundation of numeracy from knowing numbers, counting to calculation. Parents or guardians can login to the system to check on their children's progress. It consists of various types of classes and exercises according to provided chapters such as learning basic numbers from zero to nine as well as the operators. Furthermore, since the website is of free usage, it reduces the pressure on parents because regular systems in the market are costly. Potis Calculia will record child-specific data to monitor the child's progress. In this system, the tutor will be required to create an account for themselves first. Only after an account is created, the tutor will be able to create accounts for their students.

Through the website, the tutor will be able to monitor their students' progress in completing the quiz and exercise provided. Moreover, tutor is able to send reward message to their students to motivate them to complete their daily lecture and exercises. In addition to that, the tutor will be able to monitor the date, time used and the score obtained of the student. In Potis Calculia website, every webpage is designed in a similar layout design. Every pages contain a header which shows different navigation function to enable user to navigate easily. A footer is shown also in every page of the site.

A big background image is displayed when the user first access the website. A button showing 'Sign-up now' is showed in the index page for new users to register themselves before using the website (refer Fig. 5). When guests scroll down the index page, the webpage shows some information regarding on dyscalculia issue for users to understand more on this disability.

Fig. 5: Sign-up page for tutors

After registration, the guest will become a valid user of the website. The 'Login' button is shown in the header of the website (Refer Fig. 6). To login, the user will need to input their username and password. If the username or password is incorrect, a pop-up box will appear to notify the user and the user will need to input the correct username and password again. A welcome alert will also show up when the user successfully logs in to the website.

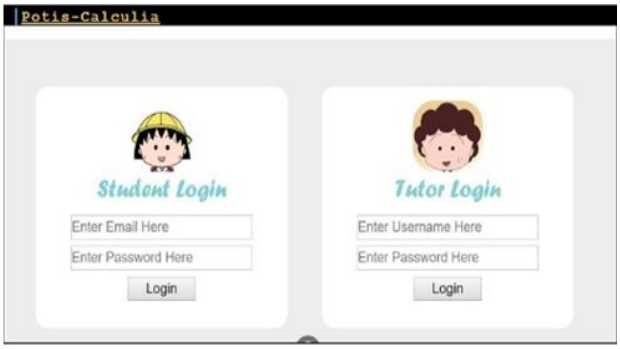

Fig. 6: Login page

3.1. Tutor View

When a tutor signs in to the website, the tutor main page will show the profile of the students under their supervision (Refer Fig. 7). The tutor can view their student's name, age, email and the reward given for them. The left panel of the website will display the name, email and total number of student under their supervision.

Fig. 7: Tutor main page

When the tutor needs to check on the students' progress on their exercise, the tutor can click on the 'Student Progress' button on the left side of the page. The tutor can monitor their student's start time and end time of the student accessing the exercise page. Moreover, the tutor can check on the marks they obtain and the submit date of each exercise they complete. Fig. 8 shows the progress page.

Fig. 8: Student progress page

A tutor can also provide reward for their respective students as a motivation for the students to learn mathematics. By doing so, the tutors can trigger the 'Provide Reward' button on the left side bar of the tutor main page. After clicking the button, the tutor will be directed to the reward page and the tutor will need to click on the 'Click Me' button to access to the update reward page. Tutor can insert the reward message through the update reward page and click on the submit button afterwards. Fig. 9 shows the reward page.

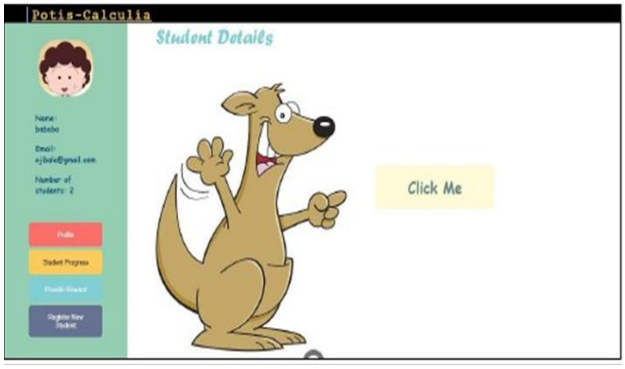

Fig. 9: Reward page

Next, only a tutor is able to register a new student account. By doing so, the tutor will need to click on the 'Register Student Button' on the left side of the Tutor Main Page. The tutor needs to input the email, name, password and age of the student through the registration form. Therefore, students will be required to sign-in through their email and password. If the email is already registered, the pop up alert will notify the tutor to try another email.

3.2. Student View

When a student signs in to the website, the student will be directed to the student main page. On the left side of the website shows the name, age, email and reward given by their respective tutor. On the main body, the website shows all the chapter and exercise provided for the students to learn Math. Students can choose which chapter they which to proceed after understanding the chapter description shown. Fig. 10 shows the student's main page.

Fig. 10: Student main page

Fig. 11 shows the first interface of the students' view when the students access the lecture's page. The page provides the lecture given for the students to learn about that chapter. After completing the chapter, the student can click on the 'Exercise' button on the left to proceed with the exercise given for that lecture.

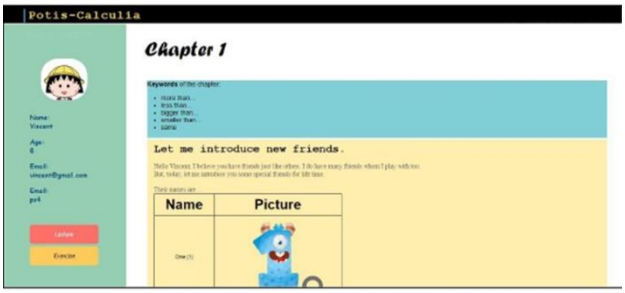

Fig. 11: Tutor page

Fig. 12 shows the interface when the student clicks on the exercise page. When the student clicks on the 'Start Quiz' button, the student will be required to complete a set of exercise as shown in the figure. After the student completes a question, the 'Check Answer' button is for the student to check whether their answer is correct. If the answer is incorrect, the correct answer will be revealed for the student. Next, click the 'Next Question' button to proceed to the next question.

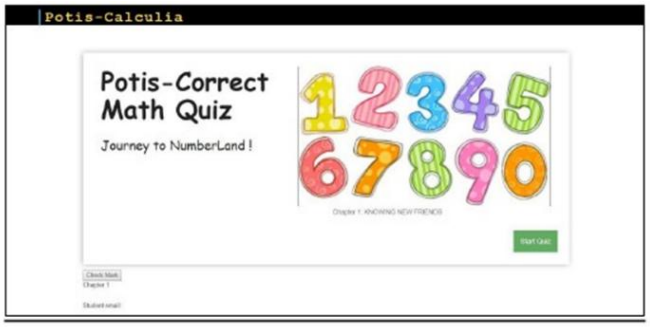

Fig. 12: Exercise page

After the student completes the exercise, the student can view the score as the 'Check Mark' button is to view the start time, end time, date and their overall marks upon completion.

4. Evaluation

Usability testing is a technique used in user-centered interaction design to evaluate a product by testing it on users. Unfortunately, the team could not find the dyscalculia children nor their parents of them. Hence, the team replaced users to parents who have dysculiachil-

dren. A user acceptance testing was carried out after users have tried out the Potis Calculia website. The questionnaire consists of five questions with number line scaled from one (1) to five (5) (strongly disagree, disagree, neutral, agree, strongly agree) on overall aspects of the website. The questionnaires were distributed through hyperlink of Google form. The analyzed feedback from the users are discussed as follows.

The first question was on the overall concept whether the idea was suitable for dyscalculia children. In this question, users were asked whether website's design would be comfortable for children to use. For example, the vision of buttons, font size and colors of use. Fig. 13 shows the feedback to the first question. The following responses were recorded. Agree (4) has the most vote (14 people, 43.8%) and followed by Strongly Agree (5) with second highest voting (8, 25%). On the other side, there is a total of 12.5% of disagree and 18.8% of neutral. Since there are 12.5% of disagreement, the team will look into the design and try to reduce the disagreement until less than 10% for children to use the website without any disruption.

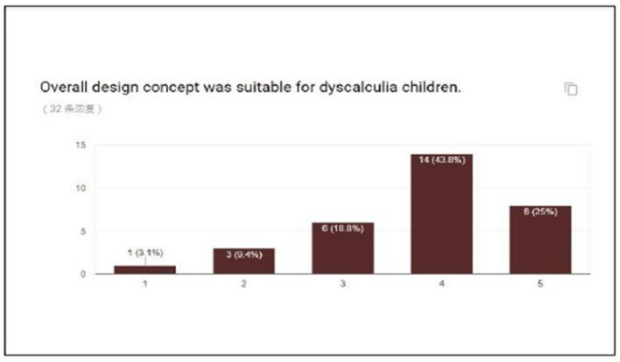

Fig. 13: Overall concept

This second question was designed to assess whether the process of learning speed and chapters are suitable for children. In this case, the team has to bear in mind that the dyscalculia children are eight times or much slower than a non-dyscalculia child. Fig. 14 show the feedback to the second question. The result is being displayed in the graph bar.

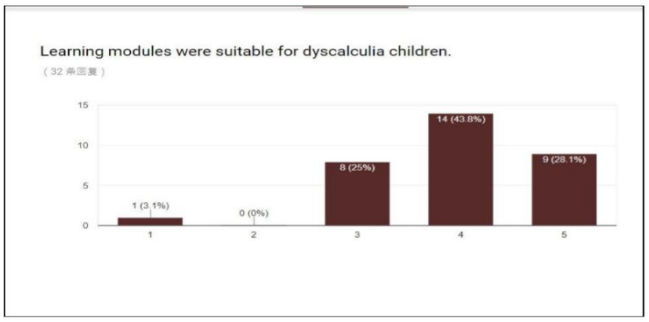

Fig. 14: Learning speed

From the graph, it shows that the majority of the responses agree (23, 71.9%) that learning modules are suitable. Only one (1) user did not agree with the statement. Strongly agree (9, 28.1%) and Agree (14, 43.8%), Neutral (8, 25%), and Strongly disagree (1, 3.1%). Note that even though the majority of responses agreed to statement, the team would not satisfy with the current modules. The team will look into and study further to make a better module for the children.

The third question as shown in Fig. 15 was referenced to a chapter teaching page where student read the lecture. The result is being displayed in a bar graph. From the graph, we can visualize that majority of responses showing agreement (84.4%), very less of neutral (15.6%) and no disagreement. Again, the team should not be satisfied and bear in mind that users were not precisely dyscalculia children nor dyscalculia children's parents. Thus, we would modify at any time with the better description in the future.

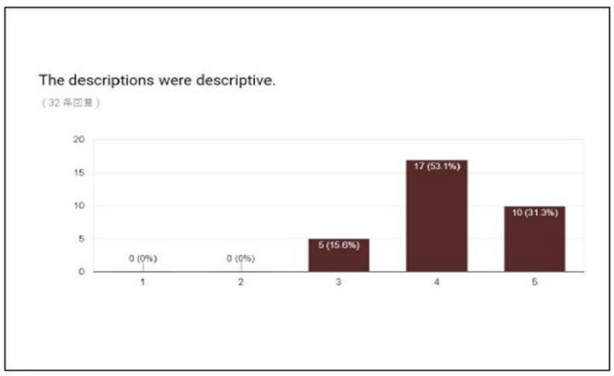

Fig. 15: Learning modules

The fourth question asks the interviewee about Activity page where children get to solve questions according to the lecture they took previously. The result is being displayed in a bar graph. From the chart, the results are stacking up from Strongly disagree (3.1%), disa-

gree (12.5%), neutral (21.9%), agree (25%) and Strongly agree (37.5%). Overall, users responded that they agree, but since there is quite a number of disagreeing and neutral, we would add little more exercises for children to drill their skill. The findings are shown in Fig. 16.

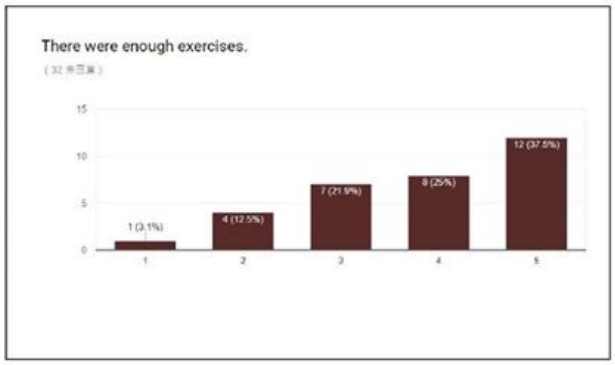

Fig. 16: Student activities

In the fifth and last question, users were asked about the functionality of the website whether the user gets enough interaction so that website is not boring. The responses are shown in Fig. 17 and it is showing there are no strongly disagree but only two disagree (6.3%) and 9.4% of neutral. On the other side, there were total 84.4% of agree and strongly agree on responses. This means, although the majority of users were strongly satisfied, we would try to make better interaction to motivate and increase interest in numbers for dyscalculia children. Until there are no disagreeing users.

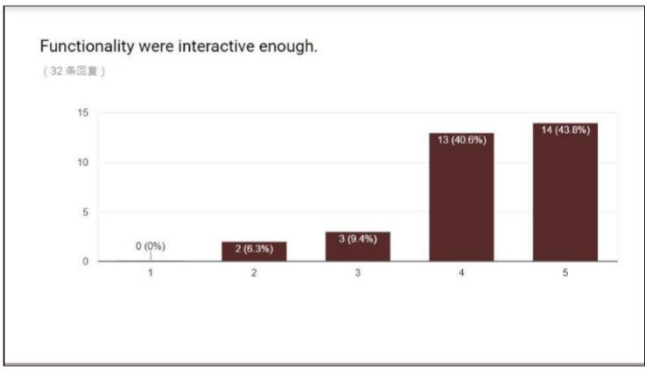

Fig. 17: Interactivity

5. Conclusion and Future Development

The development of the system can be further enhanced into a mobile learning application. Research should be carried out to implement the app to provide convenience for students and tutors in using the system. In addition, Potis Calculia is hoped to get a chabot as part of the system. By that, students can ask their tutors on problems and questions they faced through when doing the quiz. In addition to that, an online group chat can be implemented for tutors to communicate with their students especially when they have more than one student to supervise on. If students do not sign-in to the system in seven (7) days, the system will auto generate an email to their respective tutor to notify them on their student's progress.

In the future, more lectures and exercise should be added into the website for students to further their learning in Math. To conclude, the system development of the Potis Calculia is completed with a thorough based study and planned interfaces. To recall, the overall development of the system is to help kids facing Dyscalculia to overcome their disability when facing numbers. Therefore, although there are some limitations which need to be enhanced, the system has been made to achieve research goals.

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