Calculic Kids© Mobile App: The Impact on Educational Effectiveness of Dyscalculia Children

Mazeyanti M Ariffin, Fiqa Azureen Abd Halim, Noreen Izza Arshad, Mazlina Mehat, Ahmad Sobri Hashim

Abstract: ***Unlike Dyslexia children who faced difficulties in reading, Dyscalculia children have difficulties to understand numbers and math. Commonly, Dyscalculia children have issues to comprehend fundamental math concepts such as numbers, math operations, math symbols and math facts. Based on the current literatures, Dyscalculia signs are shown as early as 4 years old and appropriate interventions should be introduced in order to address their difficulties in learning math. Hence, this paper aims to report the findings obtained from effectiveness test of a mobile app called Calculic Kids©. In brief, Calculic Kids© is a mobile app specially customised for Malaysian Dyscalculia children. Quasi-experimental with pre- and post-test was performed in order to assess the effectiveness of Calculic Kids©. Two special education teachers and seven Dyscalculia children had participated in this study. The outcomes of this paper are on the usability and effectiveness in terms of knowledge enhancement. Descriptive analysis and one-sample t-test were performed from to the collected data. Based on the outcomes, it was noted that the Calculic Kids© is effective and has potential to be used in classrooms to improve the performance of Dyscalculia children in Malaysia.***

Keywords: Children, Dyscalculia, Learning disability, Mobile Application, Calculic Kids©

I. INTRODUCTION

Globally, around 7% to 8% of children aged between 3 to 17 years old have difficulties towards learning or better known as learning disability (LD) [1]. Meanwhile, in Malaysia, approximately 129,550 of Malaysians are diagnosed as LD (Welfare Department of Malaysia) where around 10% to 15% are primary schoolchildren. In general, LD refers to the disability of an individual's brain to grasp, process, analyze and store information due to neurologically-based issues [2]. Commonly, these disabilities impede the fundamental learning abilities such as reading, writing and counting. There are various type of LD including Autism, Dyslexia, Dysgraphia and Dyscalculia. Each of these types manifested different signs and the individual that have it faced learning issues in different learning aspects such as listening, writing, spelling and counting.

Revised Manuscript Received on May 22, 2019.

Mazeyanti M Ariffin, Computer & Information Sciences Dept, Universiti Teknologi Petronas, 32610 Sri Iskandar, Perak

Fiqa Azureen Abd Halim, Computer & Information Sciences Dept, Universiti Teknologi Petronas, 32610 Sri Iskandar, Perak

Noreen Izza Arshad, Computer & Information Sciences Dept, Universiti Teknologi Petronas, 32610 Sri Iskandar, Perak

Mazlina Mehat, Computer & Information Sciences Dept, Universiti Teknologi Petronas, 32610 Sri Iskandar, Perak

Ahmad Sobri Hashim, Computer & Information Sciences Dept, Universiti Teknologi Petronas, 32610 Sri Iskandar, Perak

In this paper, the authors focus only on Dyscalculia. Although, many educators had acknowledged Dyscalculia globally, awareness on Dyscalculia among Malaysians is still at infancy. As at to date, specific data or official statistics on Dyscalculia in Malaysia is still missing.

Instead, the Welfare Department of Malaysia grouped the Dyscalculia statistics under the Dyslexia spectrum although both faced different learning issues. As at to date, a research done by [3] has reported the statistics of

Dyscalculia in Sabah is 7.33% from the sample size of 448 children. Due to this, the development of any technology-related learning tool particularly mobile app for Malaysian Dyscalculia children is also scarce. Hence, one of the aims of this paper is to investigate any existing mobile apps in the market for Dyscalculia children. Later, this paper also reported on the development of a mobile app called Calculic Kids© as well as the findings obtained from the usability and effectiveness tests.

This paper is segmented as follows: part 1 the Introduction, part 2 The Literature Review, part 3 the Methodology, part 4 The results and part 5 The Conclusion.

II. LITERATURE REVIEW

Learning Disability (LD)

Learning Disability or Learning Disorder (LD) refers to the inability of an individual to receive, store, process, analyse and store the information due to the brain deficiency[4]. Commonly, the brain deficiency affects the individual's ability to learn such as writing, reading, speaking, spelling and counting. There are many types of LD such as Dyslexia, Dysgraphia and Dyscalculia. In general, Dyslexia is related to difficulties in reading, Dysgraphia related to difficulties in writing while Dyscalculia is related to counting. [5]–[7] It was estimated that 2.4 million of Americans schoolchildren were diagnosed as LD [8]–[10]. Meanwhile, in Malaysia, it was reported that 29,810 schoolchildren enrolled in special education schools [11]. Although the statistic is alarming, research on LD is still at scarce in Malaysia. Hence, one of the aims of this paper is to evaluate on the effectiveness of the use of mobile app called Calculic Kids© for Malaysian Dyscalculia children.

Dyscalculia

Dyscalculia refers to the difficulties of an individual to comprehend fundamental math concepts such as math operations, number facts, number systems, sequence and time [12].

Dyscalculia children demonstrated several distinct characteristics such as (1) difficulties to comprehend value and amount, number lines, positive and negative value, carrying and borrowing concepts, (2) difficulties to articulate math operations (3) demonstrates difficulties in understanding fraction and (4) having trouble to perceive symbols of adding, subtracting, multiplication, or dividing [13]. Table 1 explained in details the characteristics of Dyscalculia according to age [14].

Table. 1 Characteristics of Dyscalculia according to age

Age	Signs
4 – 6 Years old	- Difficulties in basic number counting - Unable to memorize the number sequence - Difficulties in determine which objects are bigger or smaller - Difficulties in objects counting - Difficulties in connecting the number concept to the symbolic form (example: 5 = five) - Difficulties in number comparison which numbers are bigger or smaller - Poor in sense direction such as right or left.
7 – 12 Years old	- Difficulties in reading and writing numbers - Trouble in familiarized with mathematical vocabulary - Difficulties in comprehension of math operation symbols - Confusion in array number and confusing with the number sequence - Trouble in written and mental arithmetic operations - Problems in learning and memorization of mathematical concepts - Trouble in recalling number facts and using appropriate algorithms in order to add, subtract, multiply or divide - Trouble in adding, subtracting, multiplying or dividing 2-digit numbers, decimals and fractions - Difficulties in geometrical concepts - Troubles in time concepts such as hours, days, months and years.

Based on Table 1, it shows that Dyscalculia children manifested different signs at different age and these signs become more visible as they grow older. Hence, early detection is crucial in order to help these children to comprehend math. Research shown that providing an early intervention and treatments to Dyscalculia children could overcome their difficulties in learning math [14] . This is also supported by experts in educational psychology and paediatrician from the interview sessions conducted in preliminary study.

Mobile app for LD

With advancement of technology, there were numerous studies on the utilization of technology-based learning tool to support LD in learning such as the works of [15]–[18]. It was found that the technology-based learning tool such as mobile app has potential to be leveraged to support LD students. This may due to the appealing factors in mobile app such as strategic instruction [19], [20] colorful background and immersive sound [21], language [22] as well as a good platform to support for multisensory learning [23]. According to [24] Dyscalculia children should utilize mobile learning to make learning process easier. In additional, Mulligan also suggested that Dyscalculia children could easily adapt to this method of learning. Furthermore, there are studies that suggests mobile applications could support LD children to practice number scale activities and can logically enhance their mind mapping capacities [23]. Meanwhile, [19] suggests that Dyscalculia children could learn better through instructive amusements and fun provides by mobile apps. Hence, this study attempts to assess the usability and effectiveness of using a mobile app called Calculic Kids© towards knowledge enhancement.

Existing mobile apps in the market for LD

Figure 1 illustrates the number of mobile apps according to LD types. From Figure 1 it shows that majority of the mobile apps (n=250) were developed for Dyslexia children. Meanwhile, 14 mobile apps were developed for Dysgraphia and only 49 mobile apps were developed specifically for Dyscalculia children. This finding suggests that there is a lack of awareness on Dyscalculia. Ref [23] summarized list of mobile apps for Dyscalculia children which are available in the market and ref [23] discussed on the development of Calculic Kids© which was designed and developed for Malaysian children. Based on ref[23], the Calculic Kids© is customized to suit the Malaysian children i.e in terms of selection of graphics, fonts, colors, hints and language. These elements in Calculic Kids© were carefully chosen with the guidance from the educational psychologist, special education pediatrician and special education teachers. In essence, Calculic Kids© is aim to develop a mobile app specifically for the use of Dyscalculia children in Malaysia. This paper is intended to evaluate and assess the Calculic Kids © in terms of its usability and as well as its effectiveness to improve the performance of Dyscalculia children.

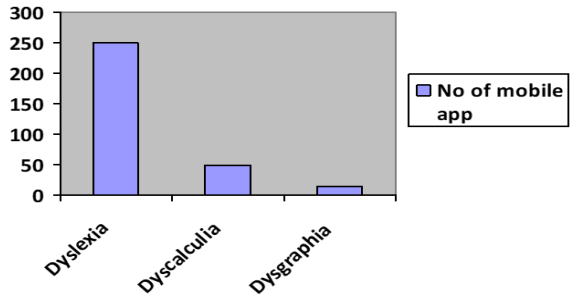

Fig. 1 No of mobile app in the market

III. RESEARCH METHODOLOGY

Figure 2 shows on the methodology of this research work. Quasi experimental design with pre-test and post-test were performed to the Dyscalculia children in Persatuan Dyslexia Ipoh, Perak in order to assess Calculic Kids© effectiveness.

The Persatuan Dyslexia Ipoh was selected due to the availability & logistic factor which is easily accessible. The effectiveness tests include the usability and the evaluation of knowledge enhancement.

In usability test, authors adapted the questions from Intrinsic Motivation Inventory proposed by [25]. Two Intrinsic Motivation Inventory subscales were modified which were Interest/Enjoyment and Value/Usefulness. These subscales were selected and adapted to suit the research context. Two special education teachers and seven Dyscalculia children (aged between 6 to 10 years old) were involved in the usability test. These two teachers were selected due to their experience and expertise in teaching the Dyscalculia children. Additionally, the seven children were selected since they were diagnosed as Dyscalculia by the educational specialist.

To assess the knowledge enhancement, a pre- and post-test sessions were conducted to these children. The Dyscalculia children were asked to answer simple mathematics questions i.e additional operation and subtraction operation. These questions were designed and constructed with the guidance from the LD teachers. Once the Dyscalculia children answered the pre- test, they were given the Calculic Kids© mobile app to explore. The post-test was conducted after three weeks of intervention. The result of the knowledge enhancement was analysed by using descriptive analysis and one-sample t-test. The hypothesis is as shown below. The null hypothesis was evaluated by using one-sample t-test.

Ho: There is no significant difference between pre-test and post-test scores of Dyscalculia children after using Calculic Kids©.

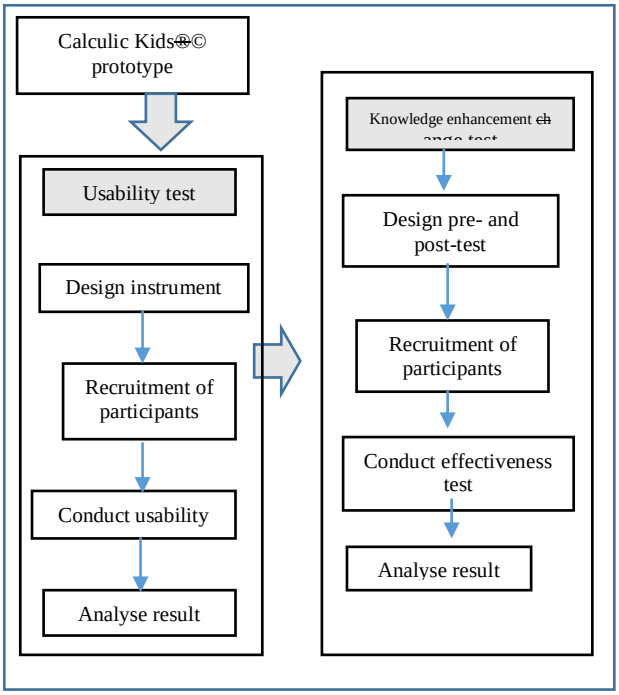

Fig. 2 Methodology

IV. RESULTS

Usability Testing

The usability testing was done on the seven Dyscalculia children and two teachers. The user-testing on the usability of Calculic Kids© was done to gauge the Dyscalculia children experience towards Calculic Kids©. The usability testing was done through distribution of survey forms. Table 2 shows the result on the usability testing conducted to Dyscalculia children.

Table. 2 Result of usability testing (Dyscalculia children)

Questions	Agree (%)	Disagree (%)
App is attractive	100	0
Easy to use	100	0
Font type is clear	86	14
Color is suitable	86	14
Will play the app again	100	0

Majority of the Dyscalculia children responded that the application is attractive, and motivational. In addition, they commented that the application is easy to be used as they could recognized the symbols used such as the arrows and home images. All except one of them opine that the font is readable All except one agreed to the color used, while one of them wants more of colorful images. Foremost, all are excited to play with the app again, in future.

Moreover, the observation is done to observe how the Dyscalculia children responded to the application when they used the application. Based on the observation, majority of Dyscalculia children had fun during the session conducted by continuously tried all the available sections in the said app.

Additionally, user- testing was also conducted to the Dyscalculia teachers to further understand the effectiveness and usability of the Calculic Kids©. Two teachers were involved in this testing phase. Table 3 shows the result from the user- testing of the teachers.

Table. 3 Result of usability testing (teachers)

Questions	Agree (%)	Disagree (%)
App is helpful	100	0
Will use Calculic Kids© in class	100	0
Ease of use	100	0
User interface is appropriate	50	50

Both teachers responded that the application is helpful in order to assist Dyscalculia children to learn and thereon wish to use the application as their support tool in classrooms. They also mentioned that the application is user friendly. One of the teachers agreed that the user interface design of this application suits Dyscalculia children. In addition, one of the teachers suggests using video instead of images.

From Table 3, it shows that both teachers agreed on the value added that Calculic Kids© offers. In the interim, these teachers also agreed to apply Calculic Kids© in their classrooms. Collectively, both agreed that the design of the Calculic Kids© is suitable and satisfy the need of Dyscalculia children.

Effectiveness testing

The effectiveness testing was conducted after the completion of usability testing. The participants of the effectiveness test involved seven Dyscalculia children from Persatuan Dyslexia Ipoh, Perak. The effectiveness test was performed with the assistance from the teachers in Persatuan Dyslexia Ipoh, Perak. As mentioned earlier, this study utilized Quasi experimental research design involving pre- and post-test. Both test questions were designed and constructed with the help from the teachers. The teachers also involved with the evaluation of both test in order to avoid bias.

Pre-test

Table 4 shows of the pre-test results of Dyscalculia children. From the table, it shows that about 71.45 scored within the range of 51-75 marks, while only 14.28% of the children scored below average. Meanwhile, the remaining 14.3% scored full marks during the pre-test, while, the mean value for pre-test is 75.00. From Table 7 it was noted that majority of Dyscalculia children obtained between 26-50 marks in their pre-test. This shows that majority of Dyscalculia children are at average prior to the Calculic Kids© intervention.

Table. 4 Pre-test result

Mark (%)	Percentage (%)
0-25	0
26-50	71.4
51-75	14.3
75-100	14.3

Post-test

Meanwhile, Table 5 shows the post-test results of the Dyscalculia children. Interestingly, all students managed to score more than average. From Table 5 it was noted that majority of Dyscalculia children scored between 75-100 marks in their post-test. Two Dyscalculia children scores between 51-75 marks. From the result, it shows that all children had improved their knowledge after they used Calculic Kids©. Hence, it shows that Calculic Kids© has potential to be used for Dyscalculia children to assist them in learning math.

Table. 5 Post-test result

Mark (%)	Percentage (%)
0-25	0
26-50	0
51-75	28.6
75-100	71.4

Figure 3 shows that approximately 85.71% of the Dyscalculia children improved their performance after using Calculic Kids©. Only 14.29% does not shows any improvement after the intervention.

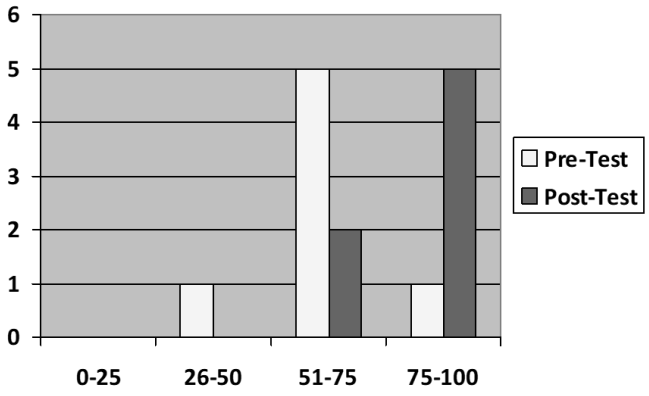

Fig. 3 Pre-Test and Post-Test

Although strong conclusion cannot be made based on the descriptive analysis, however it shows that Dyscalculia children responded well on learning through technology. In order to make strong conclusion, hypothesis evaluation was made based on the pre- and post-test result. The hypothesis is as follows

Ho: There is no significant difference between pre-test score and post-test scores of Dyscalculia children after using Calculic Kids©.

The null hypothesis was evaluated by using one-sample t-test. Table 6 shows the result of one-sample t-test.

Table. 6 One-sample t-test result

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CorrectAnsPostT	7	92.86	12.199	4.611

One-Sample Test

	Test Value = 75					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CorrectAnsPostT	3.873	6	.008	17.857	6.58	29.14

From Table 6, it shows that the research finding is statistically significant. Thus, the null hypothesis is rejected. There exists an evidence that suggests that the scores of pre-test is different from the post-test. This finding suggests that the performance of the Dyscalculia children is improved upon using the Calculic Kids©. This conclusion is made at the significance level α=0.05. Hence, it can be concluded that using technology such as mobile app could assist the Dyscalculia children to develop their interest in math and thereon improve their knowledge in math.

In summary, majority of the participants agreed that the Calculic Kids© is appropriate in teaching and learning process for Dyscalculia children. Additionally, the effectiveness testing also shows that there is positive improvement discovered in Dyscalculia children after they used Calculic Kids©.

Additionally, observation was also conducted during the Calculic Kids© intervention session. From the observation, it was noted that six out of seven children were highly motivated when interacting to Calculic Kids© although the post-test session has ended. They seem~~ed~~ enthusiast to explore all sections on their own without requesting any helps from the researchers and their teachers. The observation suggests that these children were motivated by ~~to~~ Calculic Kids©.

V. CONCLUSION

Based on the effectiveness testing, it is suggested that Calculic Kids© is effective in supporting learning of math among the Dyscalculia children. Additionally, the Calculic Kids© also received positive perception from the teachers. Hence, it shows that Calculic Kids© has potential to be used in classrooms. Moreover, it is our inspiration to make them interested to learn math so that they are not left out and have a fair chance to excel in life like any other children.

REFERENCES

1. "Child Trends Data Bank: Learning Disabilities, Indicators of Child and Youth Well-Being," 2016.
2. A. Ranpura et al., "Trends in Neuroscience and Education Developmental trajectories of grey and white matter in dyscalculia," Trends Neurosci. Educ., pp. 1–9, 2013.
3. W. Ken Keong, V. Pang, C. Kin Eng, and K. Tan Choon, "Prevalence Rate of Dyscalculia According to Gender and School Location in Sabah, Malaysia," in 7th International Conference on University Learning and Teaching (InCULT 2014) Proceedings, 2014, pp. 91–100.
4. B. Butterworth, "Developmental Dyscalculia," Handb. Math. Cogn., vol. 8994, no. 00, pp. 455–468, 2005.
5. R. A. Reeve and C. Waldecker, "Evidence-Based Assessment and Intervention for Dyscalculia and Math Disabilities in School Psychology," Handb. Aust. Sch. Psychol., 2017.
6. B. Butterworth, S. Varma, and D. Laurillard, "Dyscalculia: From brain to education," Science (80-.)., vol. 332, no. 6033, pp. 1049–1053, 2011.
7. A. Drigas, M. . Pappas, and M. Lytras, "Emerging Technologies for ICT based Education for Dyscalculia: Implications for Computer Engineering Education.," Int. J. Eng. Educ., vol. 32, no. 4, pp. 1604–1610, 2016.
8. C. Cortiella and S. H. Horowitz, The state of learning disabilities: Facts, trends and emerging issues. New York: National Center for Learning Disabilities, 2014.
9. G. Teresa, "An Overview of Research on Learning Disability," vol. 17, no. 1, pp. 927–942, 2015.
10. T. O. Monei, "A systematic review of interventions for children presenting with dyscalculia in primary schools.," UNIVERSITY OF THE WESTERN CAPE, 2016.
11. A. H. Fiqa Azureen, M. A. Mazeyanti, and S. K. Sugathan, "Towards the development of mobile app design model for Dyscalculia chidlren in Malaysia," in MATEC Web of Conferences, Malaysia Technical Universities Conference on Engineering and Technology (MUCET 2017, 2017.
12. S. Bugden and D. Ansari, "Probing the nature of deficits in the 'Approximate Number System' in children with persistent Developmental Dyscalculia," Dev. Sci., vol. 19, no. 5, pp. 817–833, 2016.
13. B. Butterworth, S. Varma, and D. Laurillard, "Dyscalculia: From brain to education.," Science (80-.)., vol. 332, no. 6033, pp. 1049–1053, 2011.
14. A. Plerou, "Dealing With Dyscalculia Over Time," Icicte, no. 2008, pp. 1–12, 2014.
15. P.-L. Weng and T. Taber-Doughty, "Developing an App Evaluation Rubric for Practitioners in Special Education," J. Spec. Educ. Technol., vol. 30, no. 1, pp. 43–58, 2015.
16. K. Georgouli, I. Skalkidis, and P. Guerreiro, "A framework for adopting LMS to introduce e-learning in a traditional course," Educ. Technol. Soc., vol. 11, no. 2, pp. 227–240, 2008.
17. Z. A. M. Hussin, "Learning Disabilities in Children," Malaysian J. Child Heal., vol. 10, no. 1, pp. 9–18, 1998.
18. N. Z. Mohamed Zain, M. Mahmud, and A. Hassan, "Utilization of mobile apps among student with learning disability from Islamic perspective," 2013 5th Int. Conf. Inf. Commun. Technol. Muslim World, pp. 1–4, 2013.
19. M. W. Ok, M. K. Kim, E. Y. Kang, and B. R. Bryant, "How to Find Good Apps: An Evaluation Rubric for Instructional Apps for Teaching Students With Learning Disabilities," Interv. Sch. Clin., p. 1053451215589179-, 2016.
20. M. Shin and D. P. Bryant, "A Synthesis of Mathematical and Cognitive Performances of Students With Mathematics Learning Disabilities A Synthesis of Mathematical and Cognitive Performances of Students With Mathematics Learning Disabilities," J. Learn. Disabil., vol. 48, no. January, pp. 96–112, 2015.
21. T. Nagavalli and P. Juliet, "Technology For Dyscalculic Children," Salem, pp. 1–10, 2015.
22. O. Poobrasert and W. Gestubtim, "Development of assistive technology for students with dyscalculia," 2013 2nd Int. Conf. E-Learning E-Technologies Educ. ICEEE 2013, no. i, pp. 60–63, 2013.
23. R. Skiada, E. Soroniati, A. Gardeli, and D. Zissis, "EasyLexia: A Mobile Application for Children with Learning Difficulties," Procedia Comput. Sci., vol. 27, no. Dsai 2013, pp. 218–228, 2014.
24. M. Mohd Ariffin, F. A. Abd Halim, and S. K Sugathan, "Towards a Mobile App Design Model for Dyscalculia Children in Malaysia," in Zulikha, J. & N. H. Zakaria (Eds.), Proceedings of the 6th International Conference on Computing & Informatics (pp 467-472). Sintok: School of Computing, 2016, pp. 1–6.
25. R. Ryan and E. Deci, "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions.," Contemp. Educ. Psychol., vol. 25, no. 1, pp. 54–67, Jan. 2000.