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PRELIMINARY IDENTIFICATION OF LEARNERS WITH DYSCALCULIA IN MALAYSIAN MAINSTREAM PRIMARY SCHOOL AS INITIAL ANALYSIS FOR EARLY INTERVENTION

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Abstract

The rapid growth in technological impresses even the most visionary ones. Computer related products are available on our fingertip, it is impossible to imagine a world without it. The new terms that have hardly recognized a few decades of history like Internet and Virtual Reality (VR) are now parts of our lives. However, our hunger for evolution is not satisfied, we are still exploring for better ways to benefit from new technologies. The born of Augmented Reality (AR) is a promising area to insert computer assets into our lives. The basic idea of AR is to superimpose sense enhancements over a real-world environment. It is a perfect solution as it combines the advantages of both virtuality and reality. AR is mostly used in adding computer generated visual enhancements into real life applications. It is clear that AR will be in our lives more and in the near future, it will be indispensable from our daily life. In the most recent years, AR had inspired into the evolution of children with learning disabilities. Thus, the motive of this study conducted to identify learners who are suffering from dyscalculia through screening instrument as the based of early intervention. The methodology used in this study was based on two screening instrument, Mathematics Learning Ability (MLA) and Mathematics Learning Performances (MLP) conducted on students. Findings also showed that the students had difficulties on memory, abstraction, sequencing processing, motor and visual perception. Findings on the plausible assistive digital technology, found the visual-based fusion technology such as Augmented Reality (AR), would enable dyscalculia learners to undergo an experiential learning approach that would make learning mathematics meaningful. The aim of this study is to emphasize importance of AR in the life of learning disabilities children. Further, our study not only extends the capabilities of the current situation, but also presents a need of AR application through visual based fusion in a user friendly environment for dyscalculia learners to increase engagement in learning of mathematics.

Keywords— *Dyscalculia, Augmented Reality (AR), Mathematical under achievement, Learning Disabilities*

I. INTRODUCTION

Learning process begins at birth to lifelong. There are learners, who perform well in their academic studies while some struggle to achieve. A few discover that completing their school task is simple, while some may find the experience to be challenging. Although, many explanations to explain why some learners do not perform satisfactorily, one of it could be caused by learning disabilities (LD). LD associated with an unexpected difficulties boundary with primary learning skills known as Dyslexia (reading, speaking and listening), Dysgraphia (writing) and Dyscalculia (mathematical skills) (Hammill, 1990). Dyscalculia is a term used to describe the difficulties on the ability of learners to count or apply numbers concepts. Dyscalculia is known as inability to obtain a suitable and appropriate competency in mathematics (Butterworth, 2013) and inability to form mathematical relationships successfully (Kucian & Aster, 2015). Dyscalculia originates from Greek

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and Latin words, which mean "counting badly". The prefix "dys" from Greek means "badly" and root "calculia" from Latin "calculare" means "to count". There are several terminologies used to describe the mathematics learning disabilities. There are authors in the field that uses the term "acalculia" and dyscalculia as synonyms (Ruth, 1986).

Table 1: Terms used to describe Dyscalculia and Acalculia

Study	**Terms**	**Description**
(Bryan & Bryan, 1982)	Dyscalculia	Difficulty in mastering mathematical concepts and/or computations
(Dahmen, Hartje, Büssing, & Sturm, 1982)	Acalculia	Complete or partial inability to deal with numbers due to a focal lesion
(Singer & A.Low, 1933)	Acalculia	Difficulty to perform basic arithmetic operation

The Table 1 shows that the authors had differentiated acalculia from dyscalculia based on different perceptions. Whilst, acalculia was described as inability of the entire system of the individual to calculate (Nicolosi, Harryman, & Kresheck., 1978); dyscalculia was described as the inability of a part of the system, which led to the impairment of the entire system (Košč, 1981). Doubtless that dyscalculia is affected by the same deficit in the brain, basically in the intra-parietal sulcus (IPS) (Wilson & Dehaene, 2007). Besides that, a number of dissimilar terms were used to describe mathematics under-achievement by these types of learners. Table 2 shows the terms used to describe mathematics under achievement.

Study	Terms
(Kosc, 1974)	Development Dyscalculia
(Geary, 1993)	Mathematics Disabilities
(Lewis, Hitch, & Walker, 1994)	Specific Arithmetic Difficulties
(Koontz, 1996)	Arithmetic Learning Disabilities
(McLean & Hitch, 1999)	Specific Arithmetic Learning Disabilities
(Jordan & Montani, 1997)	Mathematics Difficulties
(Temple & Sherwood, 2002)	Number Fact Disorder
(Eroglu, Toprak, & Urgan, 2012)	Mathematics Disorder

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(Butterworth, 2003)	Dyscalculia
(Butterworth, 2003)	Number Blindness

A person have difficulty to perform operations involving mathematics, either they themselves or others will normally label them as poor or under-achiever in mathematics. Under achievement in mathematics very often occur due to lack of motivation, unapproachable teaching method, unsettling classroom environment and inappropriate instruction (Butterworth, 2013; Wilson & Dehaene, 2007). However, if these factors are not the causes of difficulty in performing operations involving mathematics, then the person is experiencing a learning disability in mathematics or what is termed as dyscalculia.

When a person has difficulty to execute operations in mathematics, either they themselves or other will normally label them as poor in mathematics (Miundy et al. 2017). Normally, occur due to lack of motivation, unapproachable teaching method, unsettling classroom environment and inappropriate instruction (Brian Butterworth 2013; Wilson & Dehance 2007). However, if this are not the cause likely it regards of dyscalculia.

Naturally for a person with dyscalculia, would feel the process of learning mathematics been an intimidating task, furthermore when they do not have the right intervention (Monuteaux, Faraone, Herzig, Navsaria, & Biederman, 2005). An early intervention may help to reduce the later impact remaining in adulthood (Goswami, 2006)

Corresponding with (Wilson, 2019), the best approach for a remediating of dyscalculia would be to identify the areas where the child has a difficulty and the intervention should try and target at these areas. As an example a person difficulty could refer to basic mathematical abilities such as understanding the meaning of numbers where by it need a remedied by strategies emphasizing on understanding or on memorizing mathematical facts so it should one on which it could help by drill-type interventions.

A. Augmented Reality in Learning Disabilities

AR has an inspiring potential in bring experiential and location based learning to learners by supplementing existing worlds rather than creating news ones. In keeping up abreast with fourth industrial revolution, AR had applied in diverse of learning disabilities. AR has a great possibilities to enhance the living of those with learning disabilities as a result an intuitive tool capabilities of bringing the displaying context closely connected to digital learning that engage in learning more readily. There is currently a small but promising evidence base for AR interventions for learners with difference learning disabilities (Antonioli et al., 2014; Walker, Z., Rosenblatt, K., & McMahon, 2015)

Currently, teachers segregate children afflicted with the disorder from the mainstream by labelling them as "slow" or assigning them to a less challenging classroom. Thus, these children should taught in ways tailored to their unique learning styles to ensure they are capable of succeeding at school and beyond. However, this implicated by the current education system that lacks both the much-required early screening for children with disabilities and teachers well equipped in teaching and handling those with special needs.

In Malaysia, dyscalculia is a medical phenomenon that is less visible compared to much-touted Autism, Dyslexia or ADHD, thus rendering a large portion of parents to be oblivious of their child's suffering from it. Facing and subsequently accepting the realization of the possibility of their child being unable to perform mathematical tasks, as other children may be tough, despite being a disorder or neurological condition that is no cure.

Competency in mathematics is an essential component to every learners to understand the higher level mathematics intelligible in basic mathematics utmost important. The mathematics difficulties in

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students evidence weakness in memory and remembering arithmetic facts. This can be overcome by adopting an appropriate intervention application. The responsive to intervention usually rectify the mathematical difficulties of learners.

The aim and objective of this research study to explore mathematics learning difficulties and suggest the remedial measures suitable for primary school learners. Mathematics learning difficulty termed as Dyscalculia affects learners' ability to understand basic number concepts and its application.

Thus, this study conducted with the objective of developing and validating instruments that systematically measure identify learners having dyscalculia, and subsequently proposing remedial measures. We believe that the findings will aid in determining the objectives and understand on current obstacles faces by dyscalculia learners. Helping a student to identify his or her strengths and weaknesses is always the first step for them to move ahead.

1. Implication of Augmented Reality in Learning Disabilities

There are many advantages when integrating AR technologies into the teaching and learning process. The advantages of AR in education indicate that there is significant potential to integrate AR in teaching and learning, especially for the subjects that require the learners to visualize as in Table 3.

Table 3: Research been conducted on AR to support a variety of disabilities with AR

Author (s)	**Design**	**AR Features**	**Participant's Characteristic**	**Data Analysis**	**Outcome**
(Richard, Billaudeau, Richard, & Gaudin, 2007)	Experimental Study **Study 1 -** To investigate children performance and behavior in using AR techniques **Study 2 -** To examine specific attitudes and behaviours of children with cognitive disabilities approach with AR techniques	AR Marker: Rigid paperboards with eight printed square marker patterns	Ninety-three (93) children and 11 cognitive function disorders (light mental deficiencies, trisomy, autism, elective cognitive difficulties, psychologies disorders, and development invading disorder (Aged: 7 to 11 years)	Not stated (comparison of percentages)	Study designed based on non-immersive recreational and educational AR application that allows children to handle 2D and 3D plants in a simple intuitive way. It enable the children match task of vegetable entities such as fruits, leaves, flower and seeds using sensory channel (visual, olfactory and auditory) in decision-making. **Study 1** 82 percentage children

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					showed interest, amusement, motivated, focus in using AR tool inspire and positive feedback from post observation questionnaire. In 30 seconds, more than 80percentage able to link between the models and entities to be paired. Half of aged 10-11, did not show the same interest as the youngest and disable children **Study 2** Disabled children promote interest and reveals tracks reflection concerning mental perception. Disabled children took 10 minutes to complete the pairing task and had speech difficulty and misunderstanding instruction. Through observation, disable children shows enthusiastic and motivated when using the application and

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					encouraging results promoted towards disabled children.
(Escobedo et al., 2012)	To improve developmental aspects including psycho-motor, cognitive, and affective aspects	AR System	Developmental Disabled (Aged 8 to 11 years)	Mixed Method approach and Multi-phased affinity analysis	Study demonstrate that MOSOCO facilities practicing and learning social skills, increase both quantity of social interaction, reduces social and behavioral missteps and enables the integration of children with autism in social groups of neurotypical children.

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(Brandão, Cunha, Vasconcelos, Carvalho, & Soares, 2015)	To design and develop GameBook to assist children with ASD to recognize and acquire emotions by engaging their attention and motivation, increase their competence	3D AR Avatar with different facial expression	Autistic Spectrum Disorder (Autism)	Quantitative data collection Convenience non-probabilistic sampling Case Study: Mixed mode method	Study focused on a GameBook, Tobias adventures to a zoo park for ASD children. A character named Tobia's designed to captivate the ASD children attention and to empathize with them. The character promotes expression by special details in an avatar with lips and eyes. The players can read the story and interact with it. The story will describe scenarios whereby Tobias interact with animals, and real world situations associated with emotions. Five (5) different scenarios designed to involve the children contacting with different environment and will create some emotional reaction on Tobias. GameBook aim to increase ASD children engagement

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					with promoting their memory, cognitive and social skills allowing reinforce facial expression recognition.
(Escobedo, Tentori, Quintana, Favela, & Garcia-Rosas, 2014)	To investigate whether AR able to trigger positive emotions and continues attention towards autism children during the therapy	**AR Game:** Mobile phone/ Smartphone (Android) Physical tags with accelerometers and vision based techniques	12 low functioning children with Autism (aged 3 and 8)	Qualitative data Mixed mode Affinity diagram to analyze Grounded theory method	Study was designed to look into how AR able to support during therapy for autism children. Observation done for three (3) months to understand the attention management strategies (prompts and rewards) during therapies sessions. Involve Pre-deployment (two weeks), Deployment (five weeks) and Post-deployment (one week). Result show low functioning autism students able handle AR in a mobile device and engaged in the therapy. 62

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					percent children improve on selective attention and 45 percent increase on students time remained consecutively on task by using Mobile Object Identification System (Mobis). AR in autism therapy potentially easy interaction and the children able to move the therapy away from desk to live environment without assists by teachers.
(Bhatt, De Leon, & Al-Jumaily, 2014)	To enhance social interaction and hand eye coordination in Autism children to be comfortable around unfamiliar people Games: Emotions Game and Happy Minion Game Questionaire	AR Game Marker Based Tracking (Pretend Play)	Autism Spectrum Disorder (ASD) Aged: 10 to 15 years with right handed	Question air	Study examined effects of gamified towards ASD children on Emotion Game and Happy Minion Game. Feedback on Happy Minion Game found to be fulfilling as the scoring system kept track of achievements and allow for goal setting next time the game refreshed. While the Emotions Game was more exciting and appealing to play with as were able to see

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					their own reflection in the background clearly and mirror the virtual face at same time. Children felt boring after sometime but accepted based on the children developing. Two games had be used in Autism therapy session specifically focusing on social interaction and hand coordination. Emotion Game needed some enhancement in adding more interactive game for ASD children; popup praising; face recognition for ability to interpret human expression.
(Khan et al., 2017)	To provide real-time spelling assistance based on user voice input with backend support by speech to text cloud service.	AR Marker using AR Smart Glass or Smartphone with voice input camera	Dysgraphia Students	Not stated	Study presented to address the spelling mistake issue and provide assistance in spelling to avoid the core-writing problem. Augmented Reality based Dysgraphia Assistive Writing Environment (AR-DAWE)

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					model able to assist in phonological irregular words if the children able to speak the regular words correctly. AR-DAWE will recognize the word and will provide exact spelling to the students on notebook using 3D text. AR-DAWE consist of client (hardware and application layer) and cloud component (single speech to text conversion component). AR-DAWE could be able to help dysgraphia students in spelling with exciting way besides motivate learning for those are.
(Cascales-Martínez, 2017)	To determine the feasibility of using a multi touch tabletop system for applied mathematics learning in primary education with students special needs. Convenience	AR Markerless Tabletop comprised video projector and two cameras with stereoscopic view	Twenty two (22) students with SEN : Two students (2) delayed maturation; Five students (5) ADHD; Eight students (8) learning disorder; Five students (5) learning disabilities;	Quasi Experimental design with pre-post test without a control group Kendall coefficient of concordance	Study designed on AR tabletop focused on mathematics learning, understanding and managing money, coins and banknotes. Pilot study approach using tabletop system related to European

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	sample		Two students (2) mild mental retardation (aged 6 to 12)		monetary system effective, attractive and motivating towards children with SEN. System supports multitouch interaction while allowing cooperation interaction, visualization and manipulation with coins and notes. The tabletop design able to transform any type of table into interactive system such as virtual shopping simulation game. Besides, an AR book was develop as a guide to explain the advanced features of the tabletop software. Learning improvement using tabletop system and the application evaluation impact tested using pre and posttest and motivation achievement questionnaire; results indicated that application was

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					effective as a learning tool and motivating among SEN.
(Mohd Zainuddin, Zaman, & Ahmad, 2010)	To identify the criteria in developing an AR Book for the deaf students.	Sign language video marker and 3D model marker	Three (3) achievers deaf Students aged 12 years / Year 5 (1 male and 2 female)	Qualitative method	Study focused on a visual perception for deaf students and teachers who teaches deaf students in learning science year 5 using preliminary AR Book. It consist of three (3) features such as basic. Version, multimedia side by side and multimedia integrated. There were three set of AR Book and students / teachers are able to choose their preferences in AR book by using smiley icon. Combination of maker suitable sign language maker video and all participants agreed that words should be simple language; place Malay and English language side by side; use of short sentences; 2D and 3D images used to describe certain words; color/

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					highlighted words to explain difficult words. Marker for sign language is subject be avoided and the 3D marker model work better with text or the 2D picture
(Ghare et al., 2017)	To enhance current education system using AR	AR Mobile with inbuilt camera	learning disabilities, communication disorders, emotional and behavioural disorders, physical disabilities, developmental disabilities and deaf	Not Stated	Study designed to proposal informative augmentable content in teaching with various type of interaction include touch based, gesture based and voice based interaction.
(Sabaris & Scaringi, 2017)	To explore AR utility in communication and learning of Down Syndrome children	AR Mobile	Fifteen (15) adult Down Syndrome divided into three group level of cognitive maturity	Not Stated	Study designed, executed, evaluated and consisted in the visit of three groups of subjects with this pathology to two museum in the city of Bilbao assist by AR mobile application with geopositioning application to help with spatial orientation and pattern recognition to visualize a video. High emotional impact are determinant on attention and

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					concentration during pattern recognition but spatial orientation related to long term memory needed additionally evaluation due to talking texts produced tiredness and overload in participants. Participate more maturity able interpret the function and move about. Thus AR, presents possible improvement in learning and communication in Down Syndrome.
(Lin, Yu, Chen, Huang, & Lin, 2016)	To investigate the effect of literacy learning via MAR for ADHD compare to attention deficit divided into three parts	AR Mobile Application	Male Twins with Attention Deficit Hyperactivity Disorder (ADHD) and reading disabilities Age : 11 years and 1 month	ABA model (A: Baseline, B: intervention , A: maintenanc e phase) Descriptive and qualitative Kolmogoro v Smirnov test	Study focuses on the effects of MAR on word recognition learning Chinese Literacy (read the words and select the correct the word to blank line) with interactive effect and corresponding video. MAR teaching materials are significant effects observed in the intervention and maintenance

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					phase by the scores for two (2) students. MAR also able to attract their interest and attention through visual and auditory feedback via experiencing different sensory stimulation activities.
("Apps to Support Kids with Dyslexia," 2006)	To stimulate children interest towards learning Chinese language/ characters and strengthening their proficiency	AR game (Android & IOS)	Dyslexia	Not stated	Study developed an application uses five classic tales to stimulate children's interest towards corresponding strokes of Chinese characters in order to move to next level with the assistance of cards which provide access to 3D content via AR.
(Persefoni & Tsinakos, 2016)	To engage, motivate and support students who suffering from reading disabilities on Greek language.	AR Mobile Application with inbuilt camera	Dyslexia Aged : 6 years	Not stated	Study enhanced existing schoolbook into AR application to provide visual and auditory help in exercises and reading activities in Greek. Application able to store the answers given by the students to the book exercise and

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					teachers able to access to their answers and create their students portfolio for evaluating their progress and also students can interact with teacher by message. Application does not required special computer skills.
(Singh, Shah, Peter, Sahu, & Kapoor, 2015)	To investigate comprehensive approach whether traditional learning or ARET on education efficiency, level of interest, level of development and pronunciation	AR Mobile Application inbuilt camera	Learning Disabilities (dyslexia, behavioral problems, ADHD and slow learners) Kindergarten children Age above 3 and below 6	Quantitative	Study developed a prototype called Augmented Reality Education Tool (ARET) consists of 3 modules (Alphabets, Numbers and Shapes) and able identify correct alphabet or number and augmented the corresponding objects. These tracks points uniquely to each flash card and difference between the neighboring pixels. Words taught using ARET are 10 words (apple, cat, dog, goose, hat, kita, lion, mouse, orange and queen). Total time of teaching words with or without ARET each 30

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					and 20 minutes. Study shows that age group below 3 was the most interested using ARET. Survey conclude that age group less than 3 or 3 with most interest in using ARET. Age group more than 3 or less 6 mostly benefited from ARET. Overall improvement in pronunciation shows 33%, in learning efficiency 41.7% and interest in education 16.7%. Result shows there is a significant improvement through learning alphabet approach using ARET.
(Reardon, Wright, Cihak, & Parker, 2016)	To create a technical framework that allows for multiple different Experiments in order to facilitate independence, self-sufficiency and address poor employment outcomes in adulthood	AR using wearable Google glass in Android Client cloud configuration	Intellectual and Developmental Disabilities (I/DD) Three (3) participate Two males and one female aged 19 – 29 with IQ score between 57 and 63	Three phases using testing cross validation SVM	Study demonstrate results on I/DD students using context aware AR interface instructional prompts delivery via a wearable independently as intervention on three different skills comprised with three tasks. A student with an AR wearable

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					performing new task can ask for next step at any point in the task sequences. Ability to provide information appropriate to the situation using simple audio command as “Okay Glass, what’s next?” which will triggers the app. The user snap a picture and uploads to the cloud server, an image and audio instructional prompt is provided via Glass display and built-in speaker within 5 - 10 minutes. Intervention was introduce for Task 1 while Task 2 and Task 3 remained in baseline. Once the criterion reached in Task 1: probe data collected for remaining task. Intervention was introduce to Task 2 while Task 3 remained in baseline. Once criterion reached in Task 2 the intervention was introduce

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					to Task 3. Task 2: Students learned to download a copy of their prepaid student Account Statement.The result cross validation testing accuracy above 93% with SVM cost C=5.9 . Task 3: Geometry with Tangrams, students was ask to identify place and rotate colored geometric shapes on the table had 20 steps. I/DD students successfully learned three different skills using the AR application. Providing intervention with context aware instructional AR wearable all three students were able to achieve skills to mastery for all three relevant vocational tasks independently at 100% correctly.
(Vinumol, Chowdhury, Kambam, & Muralidhara	To stimulate interest and attention for effective	AR Markerless using OCR	Mild Learning Disability (Dysgraphia)	Not stated	Study demonstrate a prototype named

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n, 2013)	learning through experiential learning				Augmented Reality Dysgraphia Assistance Writing Environment (AR-DAWE) Interactive Text Book able to addresses spelling issues.The application consist on five modules: Video capture, video display, image processing (convert frames to tiff), character recognition and AR. It converts user speech into text and show the correct spelling through AR generated contents. It motivate learning in an exciting way for those who are usually avoid writing activity and it able to assist them in writing activity real time. Analytical result shows AR able to help children to learn, remember and gain knowledge interactively.
(Aziz, Aziz, Paul, Yusof, & Mohamed Noor, 2012)	To simulate interest and attention	AR courseware Via Cloud Computing using Smartphone or AR glasses with	Attention Deficit Hyperactivity Disorder	Not stated	Study is to explored the possibility of providing AR

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		application	(ADHD)		based education for ADHD students via cloud computing. Advantages of using AR education with low cost, centralized, better resources and content utilization. Issues may cause such as network quality of service, data format and security need to be carefully addressed to ensure smooth content delivery.
(Ramli & Zaman, 2011)	To motivate students in learning basic reading	AR Courseware	Down Syndrome	Acceptability and Usability Test	Study designed a proposed usability evaluation methodology framework for AR BACA SindD courseware. This courseware has five modules which including AR Flashcards, storytelling, read together, mind test and learn ABC modules. The evaluation methods as guidance to perform the usability evaluation that towards the special needs childrens.

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(Lee, Lin, Chen, & Chung, 2018)	To focus on the standard nonverbal social cues to teach children with ASD, how to appropriately reciprocate when they socially interact with others.	AR marker with tabletop role-playing game (AR-RPG)	Autism Spectrum Disorders (ASD) Two (2) boys and one (1) girl aged 7 to 9 years	Multiple Baseline Design Across Single Subject	Study resulted that AR-RPG designed to help children with ASD to increase their social interaction skills and attention towards recognize and understand the social greeting behaviors of others and appropriate manner to greet people.
(Kim et al., 2017)	To improve indirect/ direct physical activity with aim of providing a supplementary learning tool connected with movement	AR System	Developmental Disabled (mental and physical disorder, language impediments, sensory impairments and other learning disorder)	Not Stated	Study designed with type of activities selected from a textbook for disabled children related for Q-sorting. Twenty-four activities (24) activities chosen and divided into four categories as competition, basics, instrument and cooperation. Q-sorting process used to identify disabled children preferences for different physical activities from 24 pictures cards. The favorite cards for each module are repeated six (6) times and the

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					results were sorted on the analyzing screen. physical activities are constructed according to children preferences and their self-determination. The system is to improve developmental aspects including psycho-motor, cognitive, and affective aspects
(Gonzalez-rodriguez, 2016)	To develop a framework to connect different interaction devices to different learning object.	AR marker with camera/accelerometer inside small mobile devices	Autism or cerebral palsy (cognitive and mobility-related disabilities)	Not Stated	Study explores the use of AR techniques to improve the motion interaction mechanics with computer accuracy of the limbs during therapeutic training sessions.
(Carvalho, Brandão, Cunha, Vasconcelos, & Soares, 2015)	To improve social interaction and communication skills of children with ASD	AR Mobile such as a tablet, smartphone or laptop with inbuilt camera	Autism Spectrum Disorder (ASD)	Mixed Method Non-probabilistic sampling	Study focused on a serious GameBook Tobias adventures to a zoo park for ASD children. A character named Tobia's designed to captivate the ASD children attention and to empathize with them. The character promote expression by special details

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					in avatar with lips and eyes. The players can read the story and interact with it. The story will describe scenarios and Tobias interaction with animals and real world situations will conduct the children to become involved on functional contents associated with emotions. The game includes a total of five (5) different scenarios designed to involve the child contact with different environment and will create some emotional reaction on Tobias. GameBook aim to increase ASD children engagement with promoting their memory, cognitive and social skills allowing reinforce facial expression recognition.

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II. METHOD AND DATA

The present research conducted as quantitative research study to generate data using questionnaire as research instrument. The respondents are learners from mainstream primary national school in Malaysia who begins learning mathematics at the age of seven (7), the stream are referred to as Year or Standard 1 to 6. Year One (1) to Year three (3) are classified as level one while Year 4 to Year 6 are considered as level two. In Malaysia, the education scenario learners promoted to the next year regardless of their academic performance. Referring to, (Sadock, Sadock, & Sadock, 2017) a child with mathematics difficulty can be identified when the student at the age of eight (8) years old. Thus, (Dehaene & Wilson, 2007) explained that learners with dyscalculia can be diagnosed when they began their formal school education. Hence, the researchers approached those learners at age ten (10) years old in Year 4.

There are many successful screener been developed by the experts to identify dyscalculia learners such as Butterworth Screener (Brian Butterworth 2003) available from GL Assessment, DysCalculiUM (Beacham & Trott, 2013) and The Screening Test (Gliga & Gliga, 2012) available from Tribal 2010 but these screeners are not available for open access, not economical and lack in reporting of reliability and validity. It is preferable to use paper and pencil for testing primary school learners (Geary, Bailey, & Hoard, 2010; Jordan, Kaplan, Locuniak, & Ramineni, 2007). In regards to it, the following research indeed screening instrument developed by (Nagavalli, 2015) as the based to investigation in identifying the existence of dyscalculia learners among mainstream primary national government school in Malaysia.

The study was conduct in two phases. In phase one, the screening instrument consists of twenty (20) items, which uses two (2) way closed-ended questions. Each item provides two alternatives (yes/no) using image choices scales as responses through supporting learners judgements. This screening instrument used to measure the Mathematic Learning Ability (MLA) of individual student on five dimension that includes (1) visual perception and processing difficulty (2) sequential processing difficulty (3) abstraction difficulty (4) memory difficulty (5) motor difficulty. Mathematics assessment is to measure the Mathematics Learning Performance (MLP) of individual learners on five dimension that includes (1) visual perception and processing difficulty (2) sequential processing difficulty (3) abstraction difficulty (4) memory difficulty (5) motor difficulty.

After phase one is conducted in classify the potential student to be dyscalculia. The learner were assessed again in phase two with MLA with 30 items and MLP with 20 questions. The purpose of this test is to identify errors made by an individual student on the basis of mathematics. The scoring procedures given as key to the tests were followed to quality the data collected. Each item corresponds to 3 point rating scale and score 2,1 and zero. The tick mark implies scoring as 2, 1 and zero. Maximum marks for screening test were 60. Those who scored more than 30 were regarded as dyscalculia learners.

A. Analysis and Result

Statistical analysis is great use in analysis data. Analysis of the data is as important as any other dimension of the research process (Harris, 2008). The purpose of analysis is to summarize the completed observation in such a manner that they yield answers to the research question. Regardless of how well the study conducted, an inappropriate analysis can lead to inappropriate conclusions. An attempt made to analyze and interpret the collected data, which deals with the statistical analysis of the data with reference to the objectives that formulated.

Table 4: Gender type participate in study

Gender	Frequency	Percent (%)
Boy	**32**	**64**
Girl	**18**	**36**
Total	**50**	**100**

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The screening instrument was distributed within 50 children from a primary national school in Klang, Selangor, Malaysia. Among them were 32 boys (64 percent) and 18 girls (36 percent). The children were aged ten (10) years old in year 4.

1. First Phase of the Study

The study adapted a screening instrument, which screens the difficulties of an individual student in various dimension of Mathematics Learning Ability (MLA). The study classified under five (5) different dimensions related to mathematics difficulties on visual perception and processing difficulty, sequencing processing difficulty, abstraction difficulty, memory difficulty and motor difficulty.

The Mathematics Learning Ability (MLA) screening instrument comprised of two parts namely a part on the personal data and the other was a screening instrument with twenty (20) items. This screening instrument designed to screen the mathematics difficulty of an individual student on five (5) different dimensions.

Table 5: Dimension of MLA Components

No.	Dimensions	Components on MLA
1.	Visual Perception and Processing Difficulty in Mathematics Disability	An individual who has difficulty in transposition, makes omission when writing or copying numbers and unable to make sense of time and direction and reversals / isolations made when copying numbers.
2.	Memory Difficulty in Mathematics Disability	An individual who has inconsistent auditory memory, visual memory and inability to recall and recognise words.
3.	Sequencing Processing Difficulty in Mathematics Disability	An individual who has difficulty in recalling number sequences or order of activities, events, shapes and colours, reproducing sequencing order on demand, and applying rules or formula.
4.	Abstraction Difficulty in Mathematics Disability	An individual who has difficulty with application of mathematical processes to solve problems, or is only capable of recalling details but not the main idea.
5.	Motor difficulty in Mathematics Disability	An individual who has difficulty in drawing, writing and expressing using motor skills. An individual who exhibits difficulty when performing mathematical operations or calculations. They understand numbers and their relationship to one another but finds it hard to do any kind of calculation that requires

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		manipulating numbers and mathematical symbols.

The purpose of this test was to screen the dyscalculia learners. Each item provided with two alternatives yes represent ☺ or no represent ☹ obtained on the test booklet itself. The learners have to read each items carefully and respond to it on any of the two responses given against that item. There was no time limit for this test but generally, thirty (30) minutes was sufficient for answering the entire item. Most of the learners could complete the test within the allocated time.

Table 6: Screening Instrument on MLA

No.	Screening Dimensions	Item Numbers	Total Items
1.	Visual Perception and Processing Difficulty in Mathematics Disability	Q1, Q5, Q13, Q18	4
2.	Sequential Processing Difficulty in Mathematics Disability	Q8, Q12	2
3.	Abstraction Difficulty in Mathematics Disability	Q3, Q4, Q6, Q14, Q16	5
4.	Memory Difficulty in Mathematics Disability	Q2, Q7, Q10, Q15, Q17, Q19	6
5.	Motor Difficulty in Mathematics Disability	Q9, Q11, Q20	3

Table 7: Screening Instrument on MLA Result

Item Numbers	Percent (%)	Mean	Std. Deviation
Q1	8	0.08	0.274
Q2	28	0.28	0.454
Q3	26	0.26	0.443
Q4	8	0.08	0.274
Q5	26	0.26	0.443
Q6	8	0.08	0.274
Q7	3	0.06	0.240
Q8	30	0.30	0.463
Q9	6	0.06	0.240
Q10	18	0.18	0.388
Q11	42	0.42	0.499
Q12	12	0.12	0.328
Q13	14	0.14	0.351
Q14	36	0.36	0.485
Q15	14	0.14	0.351
Q16	48	0.48	0.505
Q17	42	0.42	0.499

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Q18	10	0.10	0.303
Q19	44	0.44	0.501
Q20	8	0.08	0.274

The major screening item MLA results of the study shows that the learners confront inability as below:

Question no. 16: Sometimes I cannot solve it when it comes to answering questions with fractions. Answer to this question classified according to the inability on abstraction difficulty with m=0.48;sd=0.505 (48%). Abstraction in Mathematics is essentially fundamental of mathematical ideas that closely related to the real world and their learning involves empirical concepts. Learners may able to recall details but not the main idea.

Items	**Mean**	**Std. Deviation**
Visual Perception and Processing Difficulty (Q1, Q5, Q13, Q18)	0.145	0.196
Sequential Processing Difficulty (Q8, Q12)	0.210	0.321
Abstraction Difficulty (Q3, Q4, Q6, Q14, Q16)	0.252	0.248
Memory Difficulty (Q2, Q7, Q10, Q15, Q17, Q19)	0.253	0.208
Motor Difficulty (Q9, Q11, Q20)	0.247	0.494

Table 8: Analysis Score on MLA

Question no. 19: I do not know how to draw geometric shapes like rectangles. Answer to this question is associated with inability on memory difficulty m=0.44;sd=0.501 (44%).

Question no. 17: I was able to complete all mathematical exercises but I failed in the tests and quizzes. Answer to this question classified according to the inability on memory difficulty with m=0.42;sd=0.499 (42%). Memory in Mathematics involved auditory memory and visual memory to recall and recognize.

Question no. 11: Even though I knew the answer for mathematics calculation, I could not explain how it was obtained. Answer to this question based to inability on motor difficulty m=0.42;sd=0.499 (42%). Motor in mathematics involves the motor skills and visual motor integration.

The mean scores of the dyscalculia learners in visual perception and processing difficulty is m=0.145;sd=0.196 which indicated 14.5% difficulty found in this dimension. In sequencing process, the mean score found to be m=0.210;sd=0.321 that shows 21% of difficulty. m=0.252;sd=0.248 is the mean score of abstraction indicating 25.2% difficulty. m=0.253;sd=0.208 mean score in memory difficulty show 25%. In motor difficulties m=0.247;sd=0.494 is the mean score that indicate 18.7% of difficulty.

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Table 9: Screening Instrument on MLP Along With Item Number Based on Dimension

Screening Dimension	Item Numbers	Total Items
Visual Perception and Processing Difficulty	Q1, Q2, Q3, Q4	4
Sequential Processing Difficulty	Q5, Q6, Q7, Q8	4
Abstraction Difficulty	Q9, Q10, Q11, Q12, Q13	5
Motor Difficulty	Q14, Q15, Q16	3
Memory Difficulty	Q17, Q18, Q19, Q20	4

Table 10: Screening Instrument on MLP Result

Item Numbers	Percent (%)	Mean	Std. Deviation
Q1	40	0.40	0.495
Q2	42	0.42	0.499
Q3	34	0.34	0.479
Q4	38	0.38	0.490
Q5	34	0.34	0.479
Q6	34	0.34	0.479
Q7	38	0.38	0.490
Q8	32	0.32	0.471
Q9	60	0.60	0.495
Q10	46	0.46	0.503
Q11	46	0.46	0.503
Q12	50	0.50	0.505
Q13	34	0.34	0.479
Q14	36	0.36	0.485
Q15	36	0.36	0.485
Q16	40	0.40	0.495
Q17	52	0.52	0.505
Q18	36	0.36	0.485
Q19	48	0.48	0.505
Q20	34	0.34	0.479

Table 11: Analysis Score on MLP

Items	Mean	Std. Deviation
Visual Perception and Processing Difficulty (Q1, Q2, Q3, Q4)	0.385	0.358
Sequential Processing Difficulty (Q5, Q6, Q7, Q8)	0.345	0.315
Abstraction Difficulty	0.501	0.329

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(Q9, Q10, Q11, Q12, Q13)		
Motor Difficulty (Q14, Q15, Q16)	0.373	0.391
Memory Difficulty (Q17, Q18, Q19, Q20)	0.425	0.264

The mean score of the learners in Visual Perception and Processing difficulty is m=0.385;sd=0.358 which indicate 38.5 % difficulty. In sequential processing difficulty, the mean is found to be is m=0.345;sd=0.315 that shows 34.5 % of difficulty. m=0.501;0.329 mean score in abstraction difficulty show 47.2% of difficulty. The mean scores of the motor difficulty are m=0.373;sd=0.391 which indicate 37.3% difficulty is found in this dimension. In memory difficulty is m=0.425;sd=0.264 is the mean score that indicate 34% of difficulty.

Table 12: Compare Means Paired Sample T-Test Statistics between MLA and MLP

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	MLA - Visual	.84	50	.934	.132
	MLP- Visual	1.54	50	1.432	.202
Pair 2	MLA - Sequence	.42	50	.642	.091
	MLP - Sequence	1.38	50	1.260	.178
Pair 3	MLA - Abstract	1.26	50	1.242	.176
	MLP - Abstract	2.36	50	1.509	.213
Pair 4	MLA - Memory	1.52	50	1.249	.177
	MLP - Memory	1.70	50	1.055	.149
Pair 5	MLA - Motor	.56	50	.644	.091
	MLP - Motor	1.12	50	1.172	.166
Pair 6	Total MLA	4.34	50	3.360	.475
	Total MLP	8.10	50	4.979	.704

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	MLA - Visual & MLP – Visual	50	.173	.230
Pair 2	MLA - Sequence & MLP - Sequence	50	.531	.000
Pair 3	MLA - Abstract & MLP – Abstract	50	.145	.315
Pair 4	MLA - Memory & MLP – Memory	50	.167	.246
Pair 5	MLA - Motor & MLP – Motor	50	.450	.001
Pair 6	Total MLA & Total MLP	50	.459	.001

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	MLA - Visual & MLP – Visual	-.700	1.568	.222
Pair 2	MLA - Sequence & MLP – Sequence	-.960	1.068	.151

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Pair 3	MLA - Abstract & MLP – Abstract	-1.100	1.810	.256
Pair 4	MLA - Memory & MLP – Memory	-.180	1.494	.211
Pair 5	MLA - Motor & MLP – Motor	-.560	1.053	.149
Pair 6	Total MLA & Total MLP	-3.760	4.552	.644

Paired Samples Test

		Paired Differences				
		95% Confidence Interval of the Difference				
		Lower	Upper	T	df	Sig. (2-tailed)
Pair 1	MLA - Visual & MLP - Visual	-1.146	-.254	-3.156	49	.003
Pair 2	MLA - Sequence & MLP - Sequence	-1.264	-.656	-6.354	49	.000
Pair 3	MLA - Abstract & MLP - Abstract	-1.614	-.586	-4.298	49	.000
Pair 4	MLA - Memory & MLP - Memory	-.605	.245	-.852	49	.398
Pair 5	MLA - Motor & MLP – Motor	-.859	-.261	-3.761	49	.000
Pair 6	Total MLA & Total MLP	-5.054	-2.466	-5.841	49	.000

A paired t-test was run on a sample of 50 learners to determine whether there was a statistically significant mean difference between the mathematics difficulties when participants in MLA compared to MLP. This output provides useful descriptive statistics for the two groups that were compared, including the mean and standard deviation, as well as actual results from the paired t-test. Looking at the Mean column, you can see that those learners in MLA shows lower difficulty at the end of the observation compared to those who in MLP but only memory was the other way.

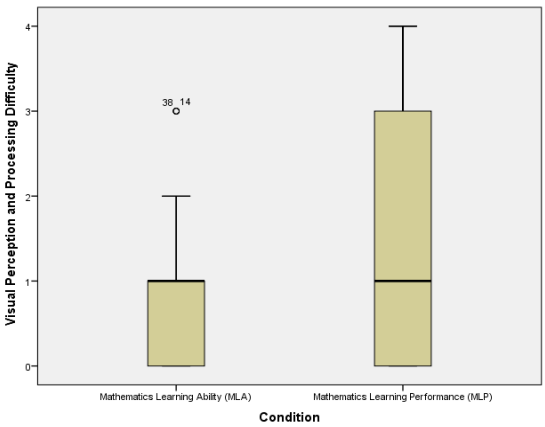

Figure 1: Boxplot Result on Visual Perception and Processing Difficulty in MLA and MLP

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The result a student who has mathematic difficulties in the dimension of visual perception and processing shows m=-0.700;sd=1.568 difference between the two trials on MLA and MLP with a standard error of 0.222. MLA and MLP on visual perception and processing difficulty positively correlated at r=0.173,p<0.05. There was a statistically significant average difference between two variable of MLA and MLP score on Visual Perception and processing difficulty (t49=-3.156,p<0.05). MLA score was -0.700 higher than MLP score at 95%

CI [-1.146,-0.254]. The statistical significant of the pair t-test which is 0.003. As the p-value is less than 0.05, it can be concluded that there is a statistically significant difference between the two variable scores. In other words, the difference between MLA and MLP is not equal to zero.

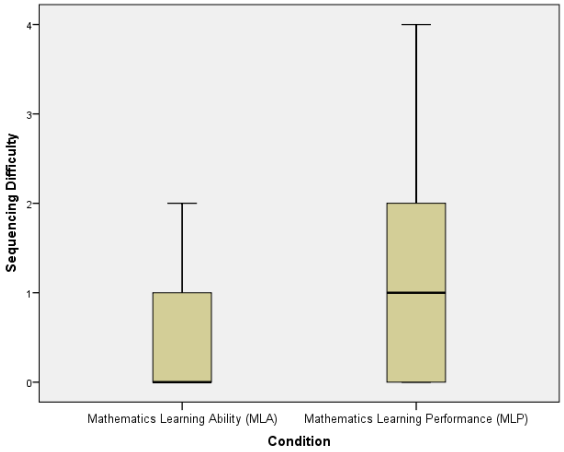

Figure 2: Boxplot Result on Sequencing Difficulty in MLA and MLP

In sequence process difficulty, the result a student who has difficulty in the dimension shows m=-0.960;sd=1.068 difference between the two trials on MLA and MLP with a standard error of 0.151. MLA and MLP on sequential difficulty positively correlated at r=0.531,p<0.05 . There was a statistically significant average difference between two variable of MLA and MLP score on sequence difficutly (t49=-6.354,p<0.05). MLA score was -0.960 higher than MLP score at 95% CI[-1.264,-0.656]. The statistical significant of the pair t-test which is 0.000. It can be concluded that there is a statistically significant difference between the two variable scores as the p-value is less than 0.05.

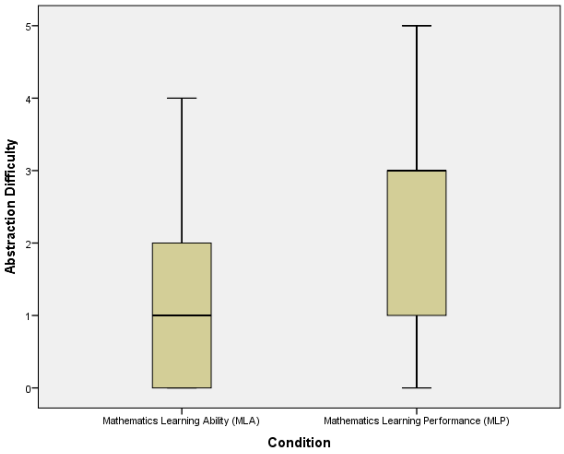

Figure 3: Boxplot Result on Abstraction Difficulty in MLA and MLP

m=-1.100;sd=1.810 shows the result a student who has difficulty in the dimension of abstraction difficulty between MLA and MLP with a standard error of 1.810. MLA and MLP on abstraction

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difficulty positively correlated at r=0.145,P<0.05. There was a statistically significant average difference between two variable of MLA and MLP score on sequence difficulty (t49=-4.298,p<0.05). MLA score was -0.960 higher than MLP score at 95% CI

[-1.614,-0.586]. The statistical significant of the pair t-test which is 0.000. It can be concluded that there is a statistically significant difference between the two variable scores as the p-value is less than 0.05.

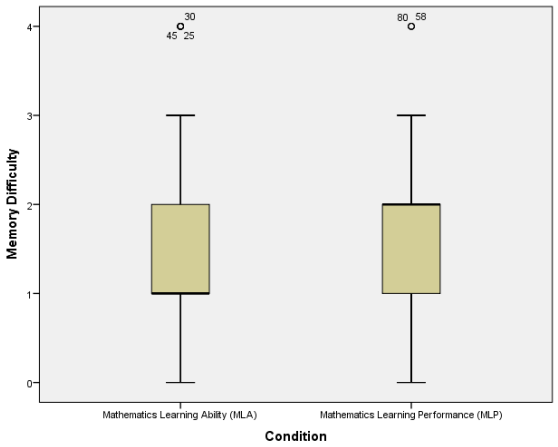

Figure 4: Boxplot Result on Memory Difficulty in MLA and MLP

In memory difficulty shows the result a student who has difficulty in the dimension between MLA and MLP with a standard error of 0.211. In memory difficulty, MLA and MLP are positively correlated at r=0.145,p<0.05. Difference between two variable of MLA and MLP score on memory difficulty (t49=-0.852,p<0.05). MLA score was -0.180 higher than MLP score at 95% CI [-0.605,-0.245]. The statistical significant of the pair t-test which is 0.398. It can be concluded that there is a statistically significant difference between the two variable scores as the p-value is less than 0.05.

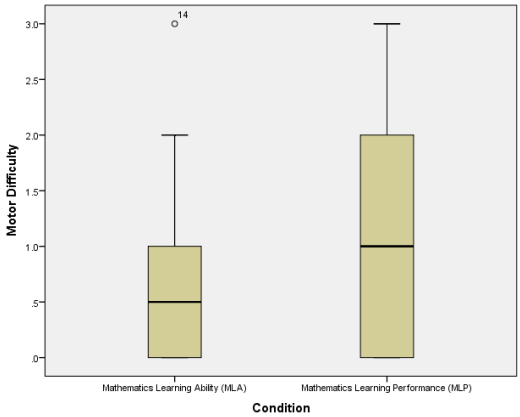

Figure 5: Boxplot Result on Motor Difficulty in MLA and MLP

The result a student who has mathematic difficulties in the dimension of motor difficulty

shows m=-0.560;sd=1.053 difference between the two trials on MLA and MLP with a standard error of 0.149. MLA and MLP on motor difficulty positively correlated at r=0.45, p<0.05. There was a statistically significant average difference between two variable of MLA and MLP score on motor difficulty (t49=-3.761,p<0.05). MLA score was -0.560 higher than MLP score at 95% CI [-0.859,-0.261]. The statistical significant of the pair t-test which is 0.000. As the p-value is less than 0.05, it

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can be concluded that there is a statistically significant difference between the two variable scores. In other words, the difference between MLA and MLP is not equal to zero.

2. Second Phase of the Study

The investigator screened the select two presented 4 percent learners were boys drawn from the MLA and MLP who constituted the sample again to confirm their difficulty in (1) output as numerical difficulty (2) organization/ sequential difficulty (3) motor difficulty (4) language difficulty (5) cognition difficulty (6) visual and spatial difficulty and (7) multiple difficulty.

Table 12: Screening Test Instrument Phase II Along With Components Based on Dimension

Dimension	Components
Output of numerical difficulty	• inability in numbers, reading and writing numbers, operation of numbers • inability in understanding in number sentences or equations • ability in reading digit but unable to recall their place in a large number
Organization/sequential difficulty	• inability in sequencing the numbers • inability in sequencing order on activities, events, shapes and colour
Motor difficulty	• inability performing mathematical operation or calculations • understand numbers and their relationship to on another but inability in performing calculation that manipulating numbers and mathematical symbols.
Language difficulty	• Inability in talking about the mathematical concepts or relationship • ability to read and write numbers but inability to talk about them, remember their names or recognize them during oral
Cognition difficulty	• inability in understanding mathematical ideas and relationships such identifying sequence of larger or smaller numbers not limited in oral or written • inability in understanding math and whole number • inability in recalling mathematical ideas after

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	learning them
Visual and spatial difficulty	• trouble with tasks that requires an understanding of visual images and spatial terms in mathematics and relationships
Multiple task	• inability performing mathematical operations or calculations • ability understanding numbers and their relationship but inability performing any kind of calculation that requires manipulation numbers, objects and mathematical symbols

Table 13: Screening Test Instrument Along With Item Numbers Based on Dimensions

Dimensions	**Item numbers**	**Total**
Output of numerical difficulty	1,6,7,18	4
Organization/sequential difficulty	2,4,8,24,28,30	5
Motor difficulty	26,27	2
Language difficulty	10,13,14,19,23	5
Cognition difficulty	5,15,16,21	4
Visual and spatial difficulty	3,9,11,22,25	5
Multiple Task	12,17,20,29	5

Table 14: Mathematics Assessment on Learning Performance

Dimension	**MLA**		**MLP**	
	Student A	**Student B**	**Student A**	**Student B**
Output of numerical difficulty	100%	50%	100%	100%
Organization/sequential difficulty	83%	67%	40%	40%
Motor difficulty	100%	100%	50%	50%
Language difficulty	60%	60%	100%	20%
Cognition difficulty	88%	88%	50%	50%
Visual and spatial difficulty	50%	50%	33%	33%
Multiple Task	100%	100%	100%	100%

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After conducting the screening for MLA and MLP towards the identity two student partial to be dyscalculia learners were confirmed as learners had scored more than 50th percentile. From the Table 14 shows that the scores on MLA of two learners in motor, language, cognition, visual and spatial difficulty and multiple task difficulty were 100%, 60%, 88%, 50% and 100% respectively. Student A scored 100% and 83% in output of numerical difficulty and organization/sequential difficulty. Hence, student B scored 50% and 67% for output of numerical difficulty and organization / sequential difficulty.

An achievement on MLP were administrated that included items that test on difficulties of the dyscalculia student in output as numerical difficulty is 100% found in this dimension. 40% score of organization / sequential difficulty denoting 40% of difficulties found. Motor difficulty indicating 50% difficulty respectively on student A and B. In language, the percentage score is found to be 100% for student A and 20% for student B. In cognition indicated shows 50% of difficulty. The score indicates the 33% difficulty in visual and spatial and 100% score in multiple task shows 100% of difficulty.

After conducting the screening instrument with MLA and MLP towards the identify of two (2) dyscalculia learners were confirmed as learners had scored more than 50th percentile.

III. DISCUSSION

Through the finding of second phase screening on MLA and MLP it could be summarized that through the screening identified two (2) out for fifty (50) learners in the sample who shown the symptom of dyscalculia which is prevalence of 4 percent had shown the evidence (Butterworth, 2005; Gordana Jovanović1, Zoran Jovanović2, Jelena Banković-Gajić3, Anđelka Nikolić4, 2014). The prevalence of learning disabilities among school learners varies from country to country. The result presented that the designed screening describe the cluster characteristics associated with dyscalculia and to discriminate between learners who display these characteristic have the similar difficulty. This scale, which used in school setting, is a quick and intrusive that provides education professional with the starting point for identifying learners at the risk for dyscalculia.

In a numerate society, it is very important to have an optimum level of number knowledge to survive in the digitizing world. Contemporary researches on dyscalculia are working in this direction with promising results. By conducting research in this field will not only provide an understanding of number concepts which dyscalculia learners lack but will also shed light on the teaching interventions appropriate for them. It will also bring awareness among educationists, parents, administration to understand their needs and implement strategies that may help them to acquire basic arithmetic skills if not complex mathematics.

IV. CONCLUSION

Researchers had tried to explore the causal factors independently such as related on visual and spatial difficulty, memory difficulty. It is important for people around to understand their problem so that they can get the necessary help. Nevertheless, diagnosing at an early stage will not only increase the children confidence level but also able to develop positive attitude towards the subject. Dyscalculia learners can solely be treated but not cured (Lenz, Schuster, Richert, & Jeschke, 2016).

AR is increasingly reaching young users such as primary school and secondary school as their parents and teachers become aware of the technology and its potential for education. Although research has shown that AR systems have the potential to improve learners learning in any field of study, the educator community does not clearly understand the educational impact of AR, nor the factors which impact the educational effectiveness of AR. A list of positive potential underlying will exploit these factors in order to realize the full potential of AR to enrich disabilities learner's lives. Therefore, this identification stuy conducted is successfully evident that early intervention is possible through screening diagnosis using the MLA and MLP instrusment. Future work should investigate how each factor influences the AR learning experience and apply these constructs to designing effective educational AR experience for dyscalculia learners.

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