

Enhancing number and algebra skills of primary students with learning disabilities or low mathematics achievement through a smartphone application

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Abstract

Number and algebra are important for learners of all ages. However, mastery of number and algebra skills, especially for children with learning disabilities or low mathematics achievement, are challenging and require their great efforts. This research aimed to develop a smartphone application for learning number and algebra, to investigate the efficiency of the developed application, to determine students' achievement and improvement in learning number and algebra as well as their satisfaction towards learning through the application. Utilizing two steps of purposive technique, 104 primary school students with learning disabilities or low mathematics achievement in three southernmost provinces of Thailand were recruited to participate in the study. The efficiency of the developed application was determined by the criteria of E1/E2 equal to 80.00/80.00. Data in pre- and post-test were analyzed with t-test to examine a significant improvement after the students learned number and algebra through the smartphone application while the students' responses in questionnaire were analyzed with descriptive statistics (i.e., mean [M] and standard deviation [SD]) to determine their satisfaction towards learning through the application. Interview sessions were conducted with 10 teachers to gain an insight into how the students enhanced their number and algebra skills. The results showed that the developed application was efficient at 82.32/84.53 as compared with a standard criterion of 80.00/80.00. Moreover, the students' post-test score was significantly greater than pre-test and greater than 60.00% criterion at the significant level of 0.05. The results also indicated that the application showed positive effects on the students' improvement in number and algebra skills and their satisfaction towards learning through the application, which was at high level (M=3.97, SD=0.63).

Keywords: number and algebra, learning disabilities, low mathematics achievement, smartphone, application

INTRODUCTION

Mathematics is considered as the essential subject taught in all levels of education that can support students to establish basic math skills for their daily life. Soares et al. (2018) claimed mathematics, as the science of number, is part of student's routine. However, numeracy concerns the knowledge and skills that require effective teaching and support to provide students with various mathematical demands of real-life situations (PIAAC Numeracy Expert Group, 2009). Number and algebra are considered as the salient

learning area in mathematics that all primary school students must learn to possess numerical knowledge, to understand sense of numbers, fractions, decimals, percentages, operation of numbers, and properties of numbers as well as to be able to solve problems of number and operation. Importantly, they are expected to analyze situations or problems as well as write and solve the problems in linear equations. Therefore, it is greatly necessary for primary school students to develop number and algebra skills from their primary level. Ministry of Education Thailand (2018) enforces teaching and learning number and algebra for all primary school

Contribution to the literature

- This study highlights how and in what ways the appropriate use of technology combined with well-prepared lessons can enhance students' number and algebra skills. This new technology-mediated teaching can provide the students with fruitful learning opportunities to sustain their learning all the time and support individual differences.
- Most importantly, learning on the application, as the influential and efficient educational invention, facilitated development and improvement of students' number and algebra skills, which promote assimilation of numerical knowledge understanding sense of number, and operation of number.
- As a result, the students can solve problems in number and algebra and to adopt or adapt methods for resolving problems in realistic situations.

students to assist them to have an overarching foundation in different ways, that is, to use varying methods for problem-solving, to have mathematical and technological knowledge skills, to process appropriately, to give reasoning for decision-making and present conclusions suitably, to use mathematical language and symbols for communication effectively, to present mathematical concepts appropriately and accurately, to connect different contents of mathematical knowledge with other relevant disciplines as well as to achieve ability of creative thinking.

With the importance of number and algebra, teachers should teach all students these contents appropriately to develop and improve their number and algebra skills. However, despite its essence, students in an ordinary classroom are different, i.e., some students have learning disabilities. Students with learning disabilities commonly have either one or more disabilities of fundamental process of psychology concerning with understanding, language usage, speaking, or writing. Their disabilities normally appear through abilities of listening, thinking, speaking, reading, writing, spelling, and arithmetic calculation. The students with learning disabilities can learn as good as their encounters; however, they face some difficulties in their learning, which in turn affect negatively to their mathematical learning (Office of the Basic Education Commission, Ministry of Education Thailand, 2011). When considering the learning content of number and algebra, which is the significant content in learning mathematics, Hord et al. (2022) presented an intricate portrayal of students with learning disabilities encountered in their research on algebraic pedagogy and learning. Specifically, they highlighted the challenges faced by the students in equation-solving, particularly in comprehending the principle of distribution, understanding the procedure for distributing terms and the appropriate sequence of steps to undertake. These factors are particularly crucial in the learning of numbers and algebra, as they significantly impact the successful acquisition of other mathematical content. Arayawinyu (2010) postulated that the students with mathematical learning disabilities have difficulties in learning all mathematics contents since they had issues in counting,

meaning of number, basic arithmetic, and mathematical symbols. Previous studies indicated difficulties in learning mathematics such as fundamental concepts of mathematical terms and learning procedures, deficits in sense of number, visuospatial representations, working memory, attention, self-regulatory skills, and numerical and arithmetic deficiencies in counting and calculation (Chinn, 2015; Geary, 2010; Hornigold, 2015). Therefore, the development of number and algebra skills, particularly for students with learning disabilities, is of considerable necessity.

In Thailand educational context, the National Statistical Office Thailand (2023) reported in 2022 that the number of children with learning disabilities aged two-four is 3,274, accounting for 42.20% of children with disabilities. Additionally, the number of children aged five-17 with learning disabilities is 46,364, accounting for 40.50% of children with disabilities. This indicates a substantial proportion of children with learning disabilities compared to other types of disabilities in Thailand. Students with learning disabilities are the learners who rely on educational special needs and require appropriate learning interventions for enhancing their learning. The learning disabilities become critical issue that needs an urgent solution especially for students in primary school level because they have disabilities in learning, literacy, and arithmetic, i.e., they are unable to achieve learning outcomes at their age. The problems in learning of students with learning disabilities are embedded in the beginning of school-age and tend to be more appeared in advanced levels. Because of that, learners with this problem need appropriate specialized instructions. Hence, it is considerably important for teachers to understand how to cope with learners with learning disabilities to avoid negative effects on their learning.

Some factors like large-size classroom, limitation of resources, and learners' different styles, which teachers have faced in teaching students with mathematical learning disabilities obstruct a success in teaching and learning as teachers cannot fully pay an attention to learners individually. Juithong et al. (2015) proposed the guidelines in mathematics learning management for learners with learning disabilities including:

- (1) to provide a variety of mathematics learning activities to support students' preferences and interests,
- (2) to arrange learning activities based on difficulty levels, i.e., from simplicity to complexity,
- (3) to support students' self-confidence and abilities,
- (4) to provide opportunities for students to learn by touching, observing, listening, body movement through concrete teaching materials,
- (5) to employ repetitive, concise, and understandable instructions,
- (6) to orchestrate mathematics learning activities based on individual difference, i.e., corresponding to students' learning,
- (7) to promote a sense of accomplishment in participating mathematics learning activities,
- (8) to advocate collaborative learning and peer's assistance,
- (9) to create relaxing, safe, and enjoyable learning environment, and
- (10) to integrate authentic assessment and provide immediate feedback, i.e., using reinforcement and compliment.

Other than that, National Governors Association Center for Best Practices, Council of Chief State School Officers (2010) suggested teachers to apply the actionable 10 practices including, explicit instruction, contextual teaching, precise mathematical vocabulary, error analysis, mathematical discourse, multiple representations, constructive feedback, reversibility tasks, flexibility tasks, and generalization tasks, to facilitate more comprehensive concepts and skills among students with mathematics learning disabilities. Park et al. (2020) supported idea that the use of checklists is useful for teachers to promptly identify ways to select and integrate evidence-based strategies in teaching mathematics for students with learning disabilities.

The researchers realized that the development of effective learning tool has potential to solve problems of learning number and algebra among students with learning disabilities or low mathematics achievement in a particularly to the current age of technology influencing human's life. The development of available technology can bring advantages of mathematics learning for students with learning disabilities (Hughes, 2019). Kaczorowski and Raimondi (2014) clarified the use of technology-assisted orientation in mathematics teaching and learning that can enhance understanding of mathematics and mathematical outcomes of students with learning disabilities. Previous studies have shown potential in using tablet devices and applications to facilitate the fulfillment of learning needs for students with learning disabilities (Hord et al., 2022). Tablet devices are regarded as essential technological assets within the special education classroom due to their

significant instructional implications, particularly the advantages they provide for students with learning disabilities (Johnson, 2013). Furthermore, Shah (2011) revealed that special education instructors can leverage accessible applications to deliver targeted instructional interventions aimed at supporting individuals of specific learning disabilities. Therefore, designing an appropriate instruction utilizing technology such as smartphone or tablet for mathematics learning could support diversity of lessons, creation of activities in different difficulty levels, promotion of interactive learning, individual difference, establishment of a sense of success, encouragement of collaborative learning, creation of supportive learning environment, and integration of authentic assessment and prompt feedback. Consequently, an integration of technology such as tablet or smartphone application in designing mathematics learning management for students with learning disabilities, which aligns with Juithong et al. (2015) suggestions should be carried out for supporting teaching and learning students with learning disabilities by designing diverse activities ranging from simple numerical and mathematical skill exercises to more complex tasks. This approach aims to engage students in confident interaction with instructional media by means of tactile screen interaction. Accessible content and clear instructions accelerate student engagement, as relevance to daily life is integrated into the instruction, fostering an enjoyable learning experience, and providing continuous assessment and reinforcement through interaction with the application. However, time spent on the use of tablet or smartphone among these students should be controlled to prevent negative impact on their learning and their socialization.

With the above-mentioned explanation, therefore, this research aimed to develop a smartphone application to enhance number and algebra skills, which is considered to be the abilities in learning number and algebra of primary school students with learning disabilities or low mathematics achievement and find the efficiency of the developed application, to determine students' achievement in learning number and algebra and their satisfaction towards learning through the application as well as to explore how students enhance their number and algebra skills. It is anticipated that the present study would create more opportunities in number and algebra learning, which may be pertained to other academic subjects and enable students with learning disabilities to think meaningfully, resolve problems effectively, be able to expand their knowledge to more advanced level, and live contentedly in society.

MATERIALS & METHODS

Research Design

This research employed mixed-method research design, that is, quantitative method with quasi-

experimental research design was used to determine the students' achievement in learning number and algebra and satisfaction towards learning through the developed application among the students with learning disabilities or low mathematics achievement while qualitative method was used to gain an insight of how the students enhanced their number and algebra skills through interviewing teacher participants.

Participants & Samples

The participants were 10 in-service teachers from 10 schools in the three southernmost provinces of Thailand. Purposive technique was used to select them to take part in here underlying upon two criterions, as follows:

- (1) readiness of schools and
- (2) willingness to permit the researchers to conduct research on the students with learning disabilities or low mathematics achievement.

The samples were 104 primary school students with learning disabilities or low mathematics achievement from 10 schools selected by purposive technique. 25 students with learning disabilities were chosen using a screening protocol of learning disabilities provided by the Office of the Basic Education Commission, Ministry of Education Thailand (2013) while 79 students with low mathematics achievement were chosen using mean [M] score of their mathematics achievement (i.e., less than 80.00%) in two semesters of 2020 academic year to identify their low level of mathematics achievement.

Instruments

Research instruments used are, as follow:

1. The developed smartphone application for learning number and algebra of primary school students with learning disability or low mathematics achievement including seven learning units (i.e., cardinal numbers, comparison of cardinal numbers, addition, subtraction, multiplication, division, and mix problems in addition, subtraction, multiplication, and division), which was validated by the experts and found that the application adequately covers all relevant aspects of the guidelines for learning management of students with learning disabilities and its efficiency of E1/E2 equals to 82.32/84.53. This application created characters with different postures by Adobe Illustrator based on students' daily life situations. The application uses a microphone and cardioid, as well as audacity for voice recording and editing, respectively. These enable the application to have responsive functions and provide students with feedback. Then, all components were combined in articulate storyline and the contents were separated into units, adhering to interactive functions, which were in alignment with the guidelines for learning

management of students with learning disabilities.

2. 35 items of pre- and post-test (parallel test) were used for assessing mathematics achievement in learning number and algebra. The tests were validated by experts, who determined that the pre- and post-test adequately cover all relevant aspects of number and algebra skills being measured. The reliability levels of the pre-and post-test were at 0.89 and 0.92, respectively. Each item in the pre- and post-test showed its level of difficulty between 0.40 and 0.70 and level of discrimination power between 0.30 and 0.80.
3. An interview protocol for interviewing teacher participants to gain an insight of how the students with learning disability or low mathematics achievement enhanced their number and algebra skills. Questions depended on two aspects, that is,
 - (i) contents and design of teaching and learning activities, and
 - (ii) learning through the developed smartphone application, which affected the improvement of students in learning number and algebra.Prior to the use of protocol, interview questions were examined for content validity by the experts and their feedback were used for rectification.
4. A questionnaire for assessing the satisfaction of the students with learning disability or low mathematics achievement towards learning through the application was validated by the experts. It was found that the questionnaire adequately covered all relevant aspects of assessing satisfaction towards learning through the application and its reliability level was at 0.94.

Data Collection

The researchers developed a smartphone application for learning numbers and algebra for primary school students with learning disabilities or low mathematics achievement. After examining the efficiency of the application and fulfilling the criterion, the researchers arranged an orientation session to instruct and suggest to the students and teacher participants on how to use the application.

The students were required to take pre-test on mathematics achievement in learning number and algebra followed by learning the target contents through smartphone or tablet while teacher participants took a role of facilitator to support the students' learning. Learning management through this application took no longer than one semester or as appropriate according to individual learning pace of students. The learning of the students was facilitated by teachers who monitored students' attendance through the application to ensure that learners indeed attended sessions via application.

After the students completed all activities in the application, a post-test on mathematics achievement in learning number and algebra was given to the students. Additionally, the researchers interviewed the teacher participants to investigate their opinions on how the students with learning disabilities or low mathematics achievement enhanced their number and algebra skills. Finally, the students were provided with a questionnaire to rate their levels of satisfaction with use of application.

Data Analysis

1. The efficiency of the smartphone application for learning number and algebra of primary school students was examined by comparing with the efficiency standard criterion of 80.00/80.00.
2. Data of pre- and post-test on mathematics achievement in learning number and algebra with proof of normal distribution were analyzed with inferential statistics, i.e., paired samples t-test to determine a significant difference between pre- and post-test mean scores and one-sample t-test to compare the students' post-test mean score with the standard criterion of 60.00%.
3. Content analysis was used to analyze the teacher participants' responses in the interview to understand how the students with learning disabilities or low mathematics achievement enhanced their number and algebra skills.
4. Descriptive statistics, i.e., M and standard deviation (SD), were used to analyze the data from the questionnaire to determine the students' satisfaction towards learning through the developed application. Five levels of satisfaction used to identify the extent to which the students were satisfied with their usage of the developed application were, as shown in **Table 1**.

Table 1. Levels of satisfaction

Ranges of satisfaction levels	Meanings
4.21-5.00	Very satisfied
3.41-4.20	Satisfied
2.61-3.40	Neutral
1.81-2.60	Unsatisfied
1.00-1.80	Very unsatisfied

RESULTS

Results are divided into five parts, as follows:

1. The development of the smartphone application for learning number and algebra of the students with learning disabilities or low mathematics achievement.

The researchers designed the lessons on the developed application for learning numbers and algebra for primary school students. The teaching and learning process were in line with Juithong et al. (2015) instructions of mathematics learning for students with



Figure 1. Examples of learning activities in unit one: Cardinal numbers (Source: Authors' own elaboration)



Figure 2. Examples of learning activities in unit two: Comparison of cardinal numbers (Source: Authors' own elaboration)



Figure 3. Examples of learning activities in unit three: Addition (Source: Authors' own elaboration)

learning disabilities. The main purpose of this invention was mainly to enhance number and algebra skills of the students with learning disabilities or low mathematics achievement. Seven learning units and examples of learning activities on the application in each learning unit are presented in **Figure 1**, **Figure 2**, **Figure 3**, **Figure 4**, **Figure 5**, **Figure 6**, and **Figure 7**.

2. Examining the efficiency of the developed smartphone application of learning number and algebra for the students with learning disabilities or low mathematics achievement.

The findings in **Table 2** showed learning process outcome based on the activities and exercises in each learning unit, which was tried out with 104 third-grade students (25 learning disabilities and 79 low



Figure 4. Examples of learning activities in unit four: Subtraction (Source: Authors' own elaboration)

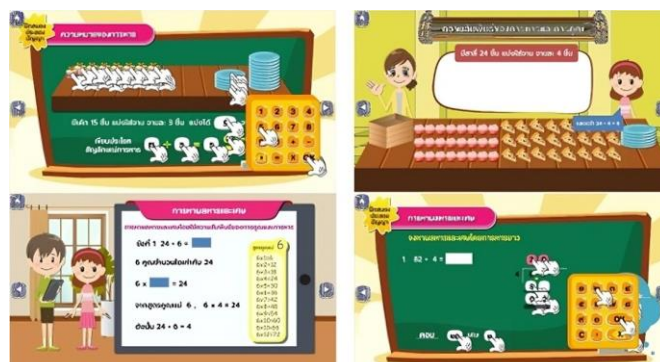


Figure 6. Examples of learning activities in unit six: Division (Source: Authors' own elaboration)



Figure 5. Examples of learning activities in unit five: Multiplication (Source: Authors' own elaboration)



Figure 7. Examples of learning activities in unit seven: Mix problems in addition, subtraction, multiplication, & division (Source: Authors' own elaboration)

mathematics achievement students) to find the efficiency of the developed application.

After the students learned the seven learning units on the developed application, it was found that the students' percentage of mean score from activities and exercises was 82.32 and their percentage of post-test mean score was 84.53, which fulfilled the requirement of standard criterion of 80.00/80.00.

This evidence implied that the developed application was efficient for the students with learning disabilities or low mathematics achievement to learn and practice in learning numbers and algebra.

3. Determining mathematics achievement in learning number and algebra of the primary school students with learning disabilities or low mathematics achievement.

The results, as shown in Table 3, showed pre- and post-test mean scores of the students with learning disabilities (n=25) and students with low mathematics achievement (n=79).

Firstly, the results indicated that the post-test mean score (M=28.80, SD=3.37) of students with learning disabilities was significantly greater than their pre-test

Table 2. Efficiency of developed smartphone application for learning number & algebra of students with learning disabilities or low mathematics achievement

Score	Scores from activities & exercises in each sub-content							Total mean score (30 scores)	Post-test: 35 scores
	Activity 1: 30 scores	Activity 2: 30 scores	Activity 3: 30 scores	Activity 4: 30 scores	Activity 5: 30 scores	Activity 6: 30 scores	Activity 7: 30 scores		
Mean score	25.54	24.82	25.09	24.61	24.50	24.04	24.28	24.70	29.59
Percentage of mean score	85.13	82.72	83.62	82.02	81.67	80.13	80.93	82.32	84.53

Note. E1/E2=82.32/84.53

Table 3. Mathematics achievement in learning number & algebra of primary school students with learning disabilities & low mathematics achievement

Groups	n	Test	Mean	SD	t	df	Sig. (2-tailed)
Students with learning disabilities	25	Pre-test	21.48	6.48	7.42*	24	0.00
		Post-test	28.80	3.37			
Students with low mathematics achievement	79	Pre-test	24.08	5.30	12.84*	78	0.00
		Post-test	29.84	2.26			

Note. *At 0.05 level of significant

Table 4. Comparison between post-test scores & standard criterion of 60.00% of students with learning disabilities & low mathematics achievement

Groups	n	Post-test mean scores	t	df	Sig. (2-tailed)
Students with learning disabilities	25	28.80	11.59*	24	0.00
Students with low mathematics achievement	79	29.84	34.73*	78	0.00

Note. Test value=21 scores (60.00%) & *at 0.05 level of significant

mean score ($M=21.48$, $SD=6.48$), $t(24)=7.42$, $p=0.00$ with the effect size of 0.70 as determined by G*power program. In the same way, the findings showed that the post-test mean score ($M=29.84$, $SD=2.26$) of students with low mathematics achievement was significantly greater than their pre-test mean score ($M=24.08$, $SD=5.30$), $t(78) = 12.84$, $p=0.00$ with the effect size of 0.49 as determined by G*power program. The significant improvement for both groups of students indicated that the developed application could enhance the students' achievement in learning numbers and algebra in both groups.

As the results in **Table 4**, the students in both groups showed significantly greater differences in post-test scores (i.e., the students with learning disabilities ($M=28.80$; accounted for 82.29%) and the students with low mathematics achievement ($M=29.84$; accounted for 85.26%) as compared with the standard criterion of 21 scores, which was accounted for 60.00%. This could imply that the developed application was effective and useful for students with learning disabilities and low mathematics achievement to develop and improve their number and algebra skills since they outperformed scores on the post-test mathematics achievement in learning number and algebra as compared with the standard criteria of 60.00%.

4. The results from interviews with the teacher participants to understand how the students enhanced their number and algebra skills presented, as follows:

- Aspect of contents and design of teaching and learning affecting improvement of number and algebra skills among the students with learning disabilities or low mathematics achievement.

Results from interviews reveal that the learning activities on the developed application were appropriate for the students with learning disabilities or low mathematics achievement. The application provided them with diverse learning activities using real situational context and employed the same aged characters with the students to provide stories and games for learning. The students used sensational skills, i.e., touching screen to interact with the contents they were learning on the application. The application encouraged the students to practice thinking skills and intelligence. The learning activities designed on the application supported the students to think and practice, and they would receive positive feedback while they were learning on the application. Moreover, difficulty

levels of the learning activities on the application arranged in ascending order, i.e., from easy to difficult levels in different main learning units such as cardinal numbers, comparison of cardinal numbers, addition, subtraction, multiplication, division, and mix problems in addition, subtraction, multiplication, and division. Other than that, students were instructed step by step in each learning unit, for example, the students could learn summation of two values followed by summation of three values and solving problems of addition, respectively. Therefore, the students learned and created an understanding of the target contents on the application continuously in a step-by-step manner while the teacher participants played the role of facilitator. With the integration of concrete learning activities and familiar situations, pictures, and friendly persuasion, it became accessible and understandable for the students to use the application for learning. Besides, the students could learn the different contents on the application more effectively due to the provided explanation and examples on the application. For this reason, the teaching activities on the application enabled the students with learning disabilities or low mathematics achievement to enhance their number and algebra skills. Because of the exposure to learning on the application, the students were able to write, read, understand, compare, add, subtract, multiply, divide, analyze, demonstrate methods to solve problems, and have an awareness in accuracy of answering the problems. The teachers' responses from the interviews are exemplified, as follows.

Excerpt 1: "In the classroom learning management, I observed that students were highly attentive and engaged in learning. This could be attributed to the content embedded within the application, which simulated situations closely related to their experiences. Additionally, the characters within the application were of similar age to the students, contributing to their engagement. I noticed that students found learning enjoyable and were able to continuously engage with the material as it progressed from simpler to more challenging content, allowing them to keep pace with the curriculum. I believed this application was highly suitable for students with learning disabilities or those with low mathematics achievement."

Excerpt 2: "I believed this application had the potential to generate more interest and

engagement in learning for students with learning disabilities or low mathematics achievement compared to traditional methods. This was primarily due to the engaging content embedded within the application, as well as the interactive nature of the learning process, which required students to actively engage with the application throughout the learning session. Moreover, the hands-on experience provided through screen interaction further enhanced their involvement."

- Aspect of learning through the developed smartphone application affecting improvement of number and algebra skills among the students with learning disabilities or low mathematics achievement.

Results from interviews reveal that learning through the smartphone application showed positive effects in enhancing number and algebra skills among the students with learning disabilities or low mathematics achievement in different manners. The learning activities designed in the application were unique since its pattern was attractive and colorful. Also, the situations implemented in the application corresponded with students' real-life circumstances and the contents of the application were concrete. Moreover, the characters adopted on the application were related to the students in terms of age so that they could take a role-play of their favorite characters. Since the students learned on their smartphone, they did not have to be embarrassed whether they could not keep up the class as well as their peers. This would increase the students' self-confidence and supports learning capacities. Besides, the application was designed with a step-by-step format that could reinforce the students' interaction with the target contents. Under the calculation practice function, the students could select menus to fill in the selected numbers, to operate calculation as well as to solve problems conveniently. However, teaching and learning on the application needs teachers or parents to take a role as a facilitator to observe problems that occurred and to facilitate the students during learning. Teachers should take a central role in assisting the students with some problems they faced during learning, also could manipulate a suitable time allocation. Importantly, teachers must provide additional learning activities, e.g., pair work or group work, which advocate interaction in classroom together with learning on the application. One of the most remarkable benefits of learning through the application was that students could review and practice

the contents, which they had insufficient understanding as frequently as they desired on the application. With the clarification, the application was not only efficient, but it was also convenient for the students with learning disabilities or low mathematics achievement to choose when, where, and how they learned number and algebra.

Excerpt 3: "I liked this application because students could learn without worrying about being left behind their peers. During the learning process, I facilitated many students who had slow understanding or difficulties in learning. I found that students were still motivated to practice without worrying about not keeping up with their peers because learning was individualized, and no one knew each other's learning status. I believed this application effectively addressed the differences among students."

Excerpt 4: "I found this application offered significant advantages as students could learn anytime and anywhere. I realized some students were unable to practice within the designated class time, so I assigned them to self-directed learning at home. I entrusted their parents to supervise and guide the students' usage of the application that enabled them to keep pace with their peers in the next learning units."

5. Determining satisfaction of the students with learning disabilities and low mathematics achievement towards learning number and algebra through the application.

The results in **Table 5** presented the satisfaction of the students with learning disabilities and low mathematics achievement towards learning number and algebra through the application. The key findings demonstrated that the students felt free to access to the application anytime ($M=4.26$, $SD=0.59$), followed by they were very satisfied with the activities on the application, which are various and support the concept of student-center ($M=4.21$, $SD=0.52$), and they believed that the application is appropriate for learning individually or in school, respectively ($M=4.13$, $SD=0.57$). To conclude, the students with learning disabilities or low mathematics achievement perceived their overall satisfaction towards learning number and algebra through the application at a satisfied level ($M=3.97$, $SD=0.63$).

Table 5. Satisfaction of students with learning disabilities & low mathematics achievement towards learning number & algebra through application

Items	M	SD	Levels of satisfaction	Rank
1. Outlines and objectives of the contents are appropriate.	3.90	0.63	Satisfied	7
2. Contents on the application are fully covered the current curriculum.	3.91	0.59	Satisfied	6
3. Teaching with the application promotes reasonably thinking.	3.90	0.72	Satisfied	7
4. Teaching with the application encourages students' learning.	3.87	0.75	Satisfied	9
5. Teaching with the application has appropriate learning process.	4.06	0.50	Satisfied	4

Table 5 (continued). Satisfaction of students with learning disabilities & low mathematics achievement towards learning number & algebra through application

Items	M	SD	Levels of satisfaction	Rank
6. Explanation and examples on the application are precise.	3.87	0.69	Satisfied	9
7. Learning through application promotes students' understanding of knowledge.	3.77	0.71	Satisfied	12
8. Students can make understanding & revision on their own through application.	3.96	0.59	Satisfied	5
9. Students feel free to access to the application anytime.	4.26	0.59	Very satisfied	1
10. Activities on application are various & support concept of student-center.	4.21	0.52	Very satisfied	2
11. Evaluation and assessment on the application are appropriate.	3.83	0.66	Satisfied	11
12. Application is appropriate for learning individually or in school.	4.13	0.57	Satisfied	3
Overall	3.97	0.63	Satisfied	

DISCUSSION

The development of smartphone applications for assisting students with learning disabilities or low mathematics achievement for learning number and algebra at primary school level achieved the required target aim of this study. The present study showed the empirical proof of the use of application that could improve the students' post-test mean score on mathematics achievement in learning number and algebra, which was significantly greater than pre-test and the standard criterion.

Furthermore, the teachers' interviews indicated positive effects in enhancing the students' number and algebra skills. It is inferred from the evidence in the research findings that the developed application could uplift students' mathematics achievement in learning numbers and algebra due to unique features on the developed application. The application was invented and designed specifically for the students with learning disabilities or low mathematics achievement with attempts to arrange the learning activities from easy to difficult levels, to implement touching-oriented support, encouraging confident communication through contents and understandable instruction, to support accessibility with relevant real-life situations, to create friendly learning environment, and promoting positive reinforcement. The concepts for developing the application are in line with Juithong et al. (2015) guidelines in learning management for students with learning disabilities, which served learning activities that should be various, start from simple to complex tasks, build up confidence in learning, integrate concrete materials, use concise and understandable instruction, be aware of individual difference, provide a sense of success, create happy and enjoyable learning environment, employ authentic assessment with immediate feedback as well as support encouragement and compliment. These characteristics are also supported by Park et al.'s (2020) who proposed ten evidence-based practices, which are beneficial for mathematics teachers to select proper strategies for teaching students with learning disabilities or low mathematics achievement and to fit learning objectives of mathematical contents and student's grade levels.

In addition, teaching with the smartphone application is considered as the new alternative teaching method, which attracts students' attention. The developed application enabled the students to create appropriate learning process through principal teaching that could support students' learning and utilizing the application independently anywhere and anytime both offline and online modes. One of the benefits from the application is to arouse attention of students with mathematics learning disabilities, which could increase added value in themselves and affect their high level of satisfaction towards learning through the application. It is in line with Wu et al. (2012) who claimed in their review of research trend of mobile-assisted learning that the role of new technology has spilled over students' life tremendously. The use of the developed application can facilitate students' learning since it is interesting to students, portable, lightweight, screen-touching operated, convenient for usage and suitable for online learning and that is consistent with Arzarello et al. (2014) assertion in their research report. The use of smartphones or tablet motivated students to learn and that brings positive effects on learning achievement. Other than that, it also promotes self-regulated learning, supports independent access to content knowledge outside classroom extensively, and advocates participatory learning. These are in the same vein with Fabian et al. (2018) who verified that the utilization of mobile technologies yielded favorable reactions from students both in term of their perception of the mobile activities and its improvement of their performance, thereby advocating the learning of mathematics. Besides this, students can learn on their own to get access and gain a variety of contents outside classroom as well as collaborate learning with their friends. Therefore, the use of technology is a great alternative for learning development among the students with learning disabilities and that was supported by Kiru et al. (2017), clarifying that technology-mediated mathematics intervention implemented for students with learning disabilities was beneficial and could enhance students' mathematics achievement. But teaching and learning on the application should be aware of time consumption to prevent students from physical or mental problems such as eyestrain, stress, or obsession with the use of smartphone. For this reason, teachers and parents

should control students' time spent on the smartphone to provide meaningful learning for students with learning disabilities or low mathematics achievement.

CONCLUSIONS

This study highlights the efficiency of the developed smartphone application for learning numbers and algebra for students with learning disabilities or low mathematics achievement. The core emphasis in this study is to utilize the guidelines in learning management of the students with learning disabilities for designing lessons in learning number and algebra of primary school level. In the new age of teaching and learning with technological assistance, the integration of application seems to be remarkable and effective instructions in teaching. Because of this, it is important to highlight how and in what ways the appropriate use of technology combined with well-prepared lessons can enhance students' achievement in learning numbers and algebra. It was found in this study that the design of suitable lessons on the smartphone application for students with learning disabilities and low mathematics achievement supported the students' understanding, their convenience in learning, and caught students' interests. Also, this new technology-mediated teaching can provide the students with fruitful learning opportunities to sustain their learning all the time and support individual differences. What is more important, learning on the application, as the influential and efficient educational invention, facilitated development and improvement of students' number and algebra skills, which promote assimilation of numerical knowledge understanding sense of number, and operation of number. As a result, the students can solve problems in number and operation and adopt or adapt methods for resolving problems in realistic situations. In this study, the researchers designed the specific lessons on the application to investigate its efficiency in learning number and algebra for primary school students with learning disabilities or low mathematics achievement, which was verified to demonstrate the significant positive effects on the students' improvement. This research aims to address and enhance learning opportunities for students with learning difficulties or low academic performance by providing them with learning opportunities that can reduce disparities or learning gaps in the classroom. In the present study, the students specially in this group could learn about numbers and mathematics skills through applications on tablets or smartphones by using the guidelines for teaching and learning for students with learning difficulties to reinforce learning in regular classrooms. This will result in students in this group gaining a better understanding and accurate and appropriate concepts of numbers and algebra, which are fundamental content areas enabling them to learn mathematics in other subjects in the future. However, a limitation of this study

is that teachers can allow students to learn and practice skills through applications to reinforce learning in regular classrooms or outside classrooms according to the differences among learners. Consequently, there should be control over the duration of usage, not exceeding one hour at a time, to prevent adverse effects on students' learning and social development. It is essential for future researchers to design and develop smartphone applications to support the learning of number theory and algebra among students at advanced levels. These skills serve as vital foundations connected to numerous bodies of mathematical knowledge, intersecting with various academic disciplines and real-life situations. It is suggested that future research requires to emphasize teaching abstract content in a more concrete manner and incorporating appropriate learning theories to make teaching and learning more tangible for enhancing students' understanding of mathematical concepts.

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