



EduGame Maru: Application for Early Mathematics Learning as an Alternative for Optimizing Cognitive Ability for 4-6 Years Children

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Abstract

Mathematics teaching process in kindergarten must adapt to the pandemic situation which requires learning from a distance. This research develops an Android-based application for learning mathematical concepts, named EduGame Maru, consisting of five types of games: recognizing numbers, algebra, statistics, geometry, and probability. This research aimed to create an interactive, innovative, and practical application as a digital medium. The method used in this research was the R&D model, with 4D development (define, design, develop, and disseminate). The EduGame Maru application received a validation result of "very feasible for use," with 3.36 points from media expert validators and 3.64 points from material expert validators, so the average was 3.50. Meanwhile, during the testing at Kindergarten Labschool, Universitas Pendidikan Indonesia, Serang Campus, the EduGame Maru application got 3.56 points from the teacher's assessment. In this case, the EduGame Maru application not only trains cognitive abilities but also helps children to understand early mathematical concepts by applying the NCTM (National Council of Teachers of Mathematics) principles. Therefore, it can be concluded that EduGame Maru can help teachers and parents optimize the cognitive aspects of children aged 4-6 years, especially early mathematical concepts during online learning.

Keywords:

EduGame Maru, Cognitive Aspect, Early Mathematics, NCTM

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Abstrak

Proses pengajaran matematika di TK harus beradaptasi dengan situasi pandemi yang mensyaratkan pembelajaran secara jarak jauh. Penelitian ini membuat sebuah aplikasi pembelajaran konsep matematika permulaan berbasis android yang diberi nama EduGame Maru terdiri dari 5 jenis permainan yaitu mengenal bilangan, mengenal aljabar, mengenal statistik, mengenal geometri dan mengenal probabilitas. Tujuan dari penelitian ini untuk menciptakan sebuah aplikasi sebagai media digital yang interaktif, inovatif dan praktis. Metode yang digunakan dalam penelitian ini adalah metode R&D model pengembangan 4D (define, design, develop and disseminate). Aplikasi EduGame Maru mendapatkan hasil validasi "sangat layak digunakan" dengan poin 3.36 dari validator ahli media dan poin 3.64 dari validator ahli materi sehingga rerata adalah 3.50. Adapun saat ujicoba aplikasi EduGame Maru di TK Labschool UPI Serang mendapatkan poin 3.56 dari penilaian guru. Aplikasi EduGame Maru tidak hanya melatih kemampuan kognitif, akan tetapi juga membantu anak untuk memahami konsep matematika permulaan dengan menerapkan prinsip NCTM (The National Council of Teachers of Mathematics). Oleh karena itu dapat disimpulkan bahwa EduGame Maru dapat membantu guru dan orang tua dalam mengoptimalkan aspek kognitif anak usia 4-6 tahun khususnya konsep matematika permulaan terutama saat pembelajaran daring berlangsung.

Kata Kunci:

EduGame Maru, Aspek Kognitif, Matematika Permulaan, NCTM

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INTRODUCTION

During the Corona Disease 19 (COVID-19) pandemic, changes in people's living habits lasted more than two years. Since early 2020, implementing work and study-from-home activities has encouraged the government and society to implement digital reforms in Indonesia. Here, skills in using digital technology really support life processes, including the education process for early childhood. For them, distance learning during the pandemic relies heavily on digital technology prowess, both from teachers and parents. In addition, teachers must be creative in preparing interactive teaching materials to stimulate children's enthusiasm to keep learning during the pandemic (Shofiyah et al., 2021).

However, the reality on the ground is inversely proportional to the expected ideal process. The researchers' empirical study results in interviews with several teachers revealed that the learning process from home in early childhood education institutions experienced various limitations and obstacles. These comprised technological stuttering, both from teachers and parents, limitations of digital learning media, barriers to supporting facilities, to the less-than-optimal aspects of child development. Hence, one of the things that have decreased is the aspect of cognitive development. Supporting these conditions, the findings from a research literature study with the title "*Achievements of Early Childhood Development in Kindergarten during Online Learning during the COVID-19 Pandemic*" (Wulandari & Purwanta, 2021) concluded that almost most children's developmental achievements in several aspects during online learning experienced a decline, including the child's cognitive development.

According to Kahfi (2021), in his research, the online learning process during the COVID-19 pandemic impacted children's cognitive development, which has decreased due to obstacles. It is because the learning process had minimal direct reciprocal interaction to transfer values that could optimize changes in children's behavior and knowledge (Suseni et al., 2021).

The decrease in cognitive development and the existence of several obstacles in the

learning process at the early childhood education level become urgent and must be overcome immediately. Moreover, in the cognitive aspect that emphasizes knowledge and skills, it must be mastered by students, one of which is knowledge of early mathematics. According to Roliana (2018), it is essential to introduce early mathematical concepts at the early childhood level, especially the introduction of the concept of numbers. Through the introduction of early mathematics, children are expected to solve problems in carrying out daily activities. The scope of concept introduction for children starts from recognizing numbers and number symbols, concepts of big and small, few and many, to recognizing patterns and counting.

Moreover, early mathematical concepts for children are not only skilled in understanding calculations and recognizing numbers but are also further expected to be optimal in their critical thinking skills, which can support their intellectual potential. According to the National Council of Teachers of Mathematics (NCTM) (in Ulfah & Felicia, 2019), early mathematical concepts include five mathematical content standards for early childhood. The standards that children can learn cover numbers and number operations, algebra, geometry, measurement, data analysis, and probability. As mentioned by Clements et al. in *Early Childhood Mathematics: Promoting Good Beginnings*, this introduction to early mathematics is packaged in the experience of matching, comparing, grouping, sorting, or serializing.

However, challenges in teaching mathematical concepts emerge during this pandemic, and special strategies are required to adapt to new habits (Wiguna & Ekaningtyas, 2021). According to Arnidha et al. (2021), the challenge faced by teachers is regarding virtual teaching skills and the strategies needed in the form of using applications in mathematics learning to help teachers and parents support children's practical learning through digital technology. In line with the challenges described, digital technology has not been utilized in classroom activities of mathematical conditions. Thus, when learning online, teachers, parents, and children need alternative learning media that strengthen initial mathematical concepts with

sufficient material through practical media (Zaini & Dewi, 2017). In this case, practical and digital technology-based media will motivate and grow children's enthusiasm to be more interested and enthusiastic about participating in distance learning.

Referring to the study results entitled *"The Role of Parents and Teachers in Guiding Online Learning During the COVID-19 Pandemic"* (Ermawati et al., 2022), parents need to prepare supporting facilities in the online learning process, such as adequate mobile phones. Teachers can also take advantage of WhatsApp groups, zoom, google meet, and google drive. Teachers always give serious attention to students so that students remain enthusiastic about participating in online learning. In addition, the use of the application can be accessed with Android when online, which was previously downloaded from the Playstore to be used as an alternative in attracting children's interest. It helps children better understand the concepts presented in the application. Another study by Ashim et al. (2019) entitled *"The Need for Mathematical Communication and Mobile Learning Settings in Problem Based-Learning to Improve 4C Capabilities in the Era of Disruption"* explained that the use of mobile learning-based learning media is one solution to keep up with technology developing today. The Android-based virtual trigonometry application aims to make it easier for students to understand trigonometry concepts and train students' mathematical communication because it is equipped with PBL learning steps. Through mobile learning-based learning, the hope is to create a better quality of education, where teachers and students can keep up with technological developments and improve 4C skills in this disruption era (Ashim et al., 2019). Moreover, research on the importance of increasing children's enthusiasm for Android-based learning media entitled *"Application of Learning Media Recognition of Numbers and Letters for Early Childhood Using Android-Based Augmented Reality"* (Aprilia & Rosnelly, 2020) resulted that 3D AR animation display is a something new for children so that they become enthusiastic and easily understand the concept of numbers and letters.

In the explanation above, it can be concluded that technological stuttering is indeed a problem in the implementation of learning at home, so technological innovation is needed to develop creative and innovative learning media. To make it easier for teachers and parents at home, the researchers created a learning application called EduGame Maru. In this game, children will be taught and given material about early mathematical concepts. This Android-based game consists of five games that recognize numbers, algebra, statistics, geometry, and probability. The researchers used this technology to provide innovation and optimize the learning enthusiasm of children aged 4-6 years.

METHODS

The research method used in this research was R&D (Research and Development), using the 4D development model by Thiagarajan (Panggabean in Gustiana et al., 2020). The flow of the 4D model consisted of *define, design, develop, and disseminate*, used to produce a product in the form of an Android-based children's game application.

Based on the stages above, the research procedure using a 4D model to create the EduGame Maru application is as follows:

Table 1. R&D Research Procedure with 4D Model

Stages	Achievement Indicator
Define	Data on the needs of teachers and students
Design	Storyboards and prototypes
Develop	The final development in the form of an interface ready to be validated and tested
Disseminate	Publication and dissemination of advice application

For the time and place, the research was conducted for eight months at the Kindergarten Labschool, Universitas Pendidikan Indonesia, Serang Campus. The research subjects were early childhood education students aged 4-6 years. Meanwhile, the object of this research was the feasibility of

the EduGame Maru application to develop children's cognitive aspects in early mathematics.

The researchers employed several instruments to collect data, including literature studies, empirical studies, analysis of the achievement level of child development, and data collection techniques in the form of closed questionnaires with a scale of 1-4. This questionnaire obtained score data from learning materials, media assessment questionnaires, teacher assessment questionnaires, and student response questionnaires. Interviews and filling out questionnaires were carried out online through WhatsApp/Google Form and offline in the environment around the researchers by implementing health protocols. The analysis techniques were both qualitative and quantitative

RESULTS AND DISCUSSION

This research developed a new product in education using the EduGame Maru (Mathematics Fun) application to recognize early mathematics for children aged 4-6 years. The Android-based application was developed based on the 4D development model, consisting of:

Define

The define stage determines and defines field needs with the development carried out. The analysis carried out was literature and empirical study in interviews with kindergarten teachers and parents of children aged 4-6 years in the environment around the researchers' residence. The challenges found were related to the lack of skills of teachers and parents towards digital technology. It resulted in a decrease in the development of cognitive aspects in children, especially in the introduction of early mathematics. In addition, there were no practical learning facilities or media that could be sufficient for early mathematics learning according to the needs of children aged 4-6 years.

According to field needs, this analysis encouraged the researchers to develop the form of the EduGame Maru application as a practical medium for teaching early mathematics to children aged 4-6 years by referring to the five mathematics learning

standards from NCTM. The application contents are an introduction to the concepts of numbers, algebra, statistics, geometry, and probability.

Design

The researchers reformulated the application design through storyboards and prototypes based on the defining results. The application content format includes the main menu with five initial mathematical concepts in the form of knowledge and games about numbers, algebra, statistics, geometry, and probability. Each math concept has three types of games designed according to their age group. The application contents raise the theme of epidemic animals in Indonesia. It was chosen as the mascot of each mathematical concept and aimed to introduce Indonesia's wealth through endangered animals.

The storyboard contains all the elements used in the application display, ranging from images, audio, text, video, background, color composition, and size, designed through storyboards. The following is the storyboard of the main menu page, introduction to basic mathematics, and the EduGame Maru application:

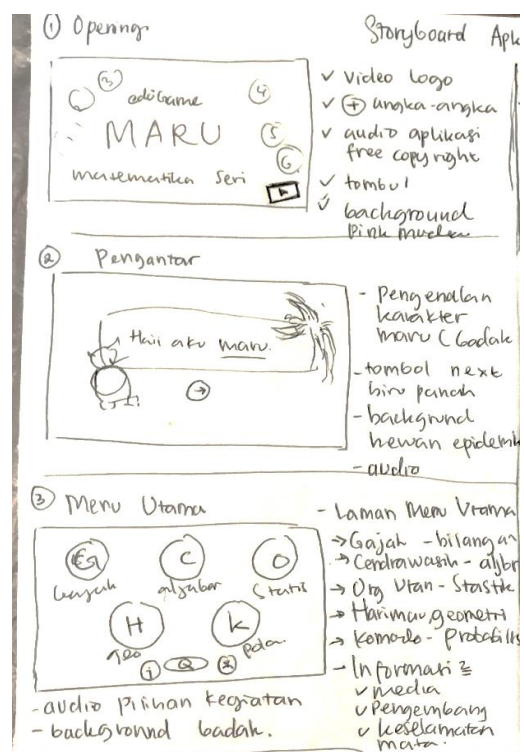


Figure 1. Main Menu Storyboard

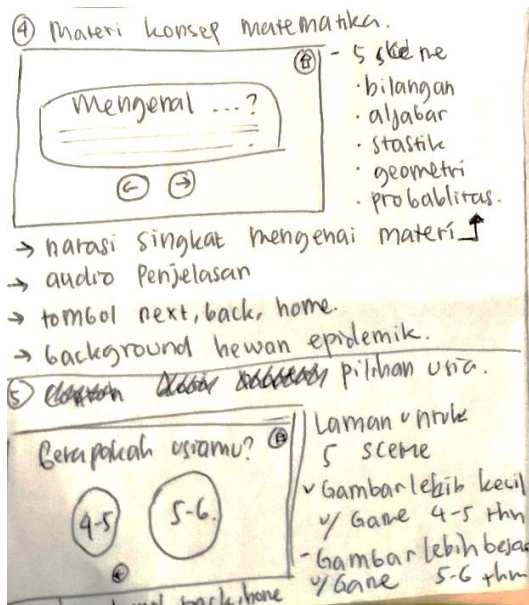


Figure 2. Storyboard for Early Mathematics Introduction

The page design of early mathematics introduction material is divided into five scenes. The design used is the same, but the first scene contains material for number recognition, the second is algebra, the third is statistics, the fourth is geometry, and the fifth is probabilities.

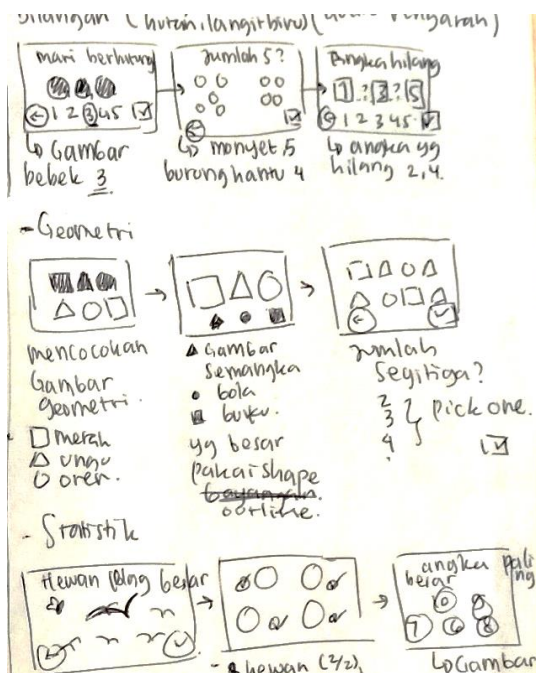


Figure 3. Storyboards of Three Types of Games, Tiered from Each Material

Before starting the game, there is an age grouping, followed by three types of tiered games.

Furthermore, the prototype is a real storyboard design, which is continued at the mapping stage of each part. This stage is related to adding commands or scripts to the software used. The software used in this development consisted of Articulate Storyline 3, which is useful for making prototypes with html5 final results. The following is the prototype of the EduGame Maru application:



Figure 4. Main Menu Prototype on Edugame Maru Application

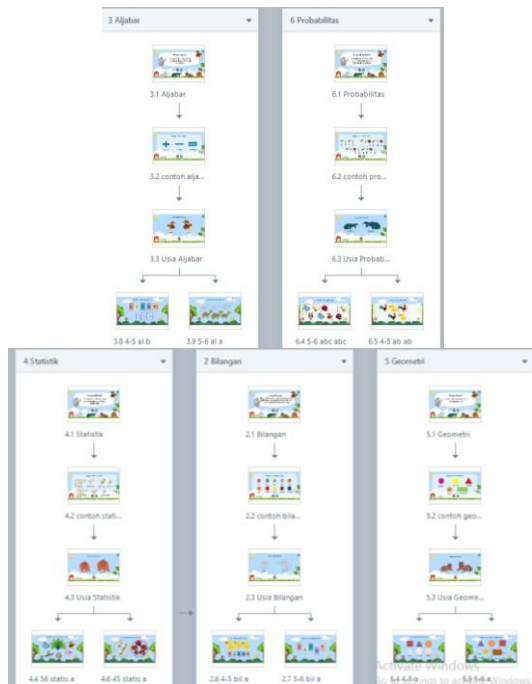


Figure 5. Prototype Materials and Games for Introduction to Early Mathematics in the EduGame Maru Application

Development

Development is the stage of converting the prototype results in the form of html5 into an Android-based application through Java and Web2Apk software, with Apk/AAB format. The application developed was then validated by two validators, media experts and material experts. The application assessment instrument used for media experts, material experts, and teachers adopted the learning media assessment outline developed by Wahono. The assessment questionnaire consists of 25 items using a scale of 4, with a maximum total score of 100. Following are the validator's assessment results of the EduGame Maru application:

Table 2. Validator Assessment Table

Validator	Score	Average
Media Expert	84	3.36
Material Expert	91	3.64
Average		3.50

Based on the validator assessment, the EduGame Maru application was declared "very feasible for use" with notes of minor revisions in some parts of the audio director,

character consistency in the introduction of early mathematical concepts, and scripts or commands in some navigation buttons, which were not appropriate. The results of this validation were then used as material for evaluation and improvement before the testing. After making improvements according to suggestions from the validator, the application was ready to be tested on children and teachers. The testing was conducted at the Kindergarten Labschool, Universitas Pendidikan Indonesia, Serang Campus to teachers and students with ten children, two children in the 4-5 year age category and eight children in the 5-6 year age category. The following is the documentation for testing the EduGame Maru application at Kindergarten Labschool, Universitas Pendidikan Indonesia, Serang Campus:



Figure 6. Testing Documentation

The test results proved that children were enthusiastic when trying the EduGame Maru application, understanding the concept of numbers (0-9), knew algebra (signs +, -, and =), recognized simple statistics, geometry (square, rectangle, equilateral triangle, circle, and star), and recognized probabilities (possibility based on observed patterns). Children's enthusiasm aligned with independence in operating the features in this application, such as the arrow to the right (for the next), and they were more excited when they succeeded in answering correctly through positive affirmations in the form of voice notifications "Yeay, it worked! Great!" and the appearance of animated stars. This affirmation is what triggered the child to want to try again.

Therefore, during the testing, two children in group A with the initials A and J both looked enthusiastic but were still accompanied in using the features in this application. It was influenced by the emotional maturity and concentration level of the child. However, in general, the cognitive aspect of

understanding early mathematical concepts was good.

Meanwhile, group B consisted of eight children, i.e., L, K, A, B, C, D, E, and F, who were much more independent than group A. Thus, the observer divided into small groups with two children. The children looked active, asking how to play and answering the observer's questions correctly regarding the screen display, such as animal names, numbers, the number of objects, number symbols, the meaning of symbols in algebra, statistical concepts, and the probability of the next pattern to appear. In addition, the children were very expressive and repeatedly asked when the EduGame Maru application could be accessed on the Play Store. Thus, it can be concluded that all group B from the testing activities carried out at Labschool Kindergarten, Universitas Pendidikan Indonesia, Serang Campus could optimize cognitive aspects, especially in the introduction of early mathematical concepts referring to the five NCTM principles.

Then, the teachers were given the opportunity to assess the feasibility of application content with the cognitive needs of children aged 4-6 at Kindergarten Labschool, Universitas Pendidikan Indonesia, Serang Campus. The assessment results achieved by the teacher were 89, with an average score of 3.56. It means that this application is feasible to be used as an alternative to optimizing the cognitive aspects of preschool children during online learning at school with teachers or at home with parents. The EduGame Maru application is an Android application-based learning media innovation needed during a pandemic like today. A very good design and the concept were well packaged, although some things still needed to be readjusted from the application related to the order of the types of tiered games according to age and difficulty.

The evaluation results from the validators and teachers became the final improvement for the EduGame Maru application. The following is the user interface for the EduGame Maru application:



Figure 7. Opening Video Screen Display



Figure 8. Main Menu Display



Figure 9. Choice of Age Group

Entering the page for a material introduction to mathematics and games, the following is the display of material and games on the introduction of the concept of numbers.



Figure 10. Number Materials and Games (continue)



Figure 10. Number Materials and Games (end)

In the material presented for the introduction of numbers, several pictures are shown where children can know how to count from numbers 1 to 9. As an educator or teacher in early childhood education, it will certainly be a child's interest to be enthusiastic about learning to count. Children aged 4-6 years can count well if their teacher prepares interesting media as teaching materials. Furthermore, below is the display of material and games regarding the introduction of algebra concepts.



Figure 11. Algebra Material and Games

Children will recognize addition, subtraction, and simple measurements in this algebra game. This game is presented with colors and pictures of animals that attract children's attention to play the game. Next, below is the display of materials and games regarding introducing simple statistical concepts.



Figure 12. Statistics Material and Games

In simple statistical concepts, children will know to distinguish between the largest and the smallest and the most and the least. This game is presented with pictures of animals so that children can easily understand and feel challenged to try. Next, below is the display of materials and games regarding the introduction of geometric concepts.

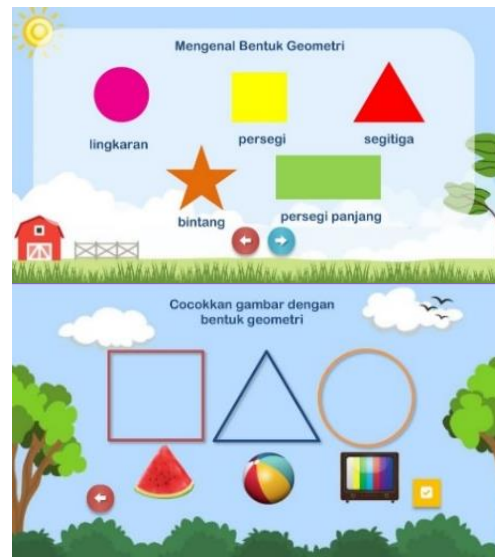


Figure 13. Geometry Materials and Games

In geometry games, children are directed to find out flat shapes by matching images that match geometric shapes. Children will feel more aware of many things by displaying objects around them by connecting them with geometric shapes. Children will also

find it easier to remember this way. Finally, below is the display of materials and games regarding introducing the concept of probability or pattern.



Figure 14. Probability Materials and Games

This probability game aims to teach children to recognize patterns. The image display presented is in the form of cute animal images so that children can be more interested and excited when playing EduGame Maru.

Based on the testing results, the EduGame Maru application can be used to introduce early mathematics to children in an innovative, informative, and fun way. It is because it is in accordance with the characteristics of the children, and the introduction concept was then packaged through games in accordance with the children's development.

Disseminate

This stage is the last stage of application development to be accepted by users by disseminating and socializing the application. This application developed will be useful later for students, teachers, and parents to teach their children about mathematics lessons. After going through the previous three stages, the EduGame Maru application carried out the product dissemination stage to the general public, which Android users can access through the Google Play Store. The following are the search results and the age rating of the EduGame Maru application

(<https://play.google.com/store/apps/details?id=com.jalankita.maru>).



Figure 15. Dissemination of the EduGame Maru Application on the Play Store

Discussion

The urgency of developing android application as an alternative media for Early Childhood Education (ECE) is indeed in accordance with current conditions in which learning is constrained due to Covid-19 (Andini et al., 2018; Nirmala & Annuar, 2020). Especially learning mathematics which requires concept cultivation and interesting learning (Annas et al., 2022). The composition of EduGame maru media content using NCTM learning principles is very essential considering that algebraic content, statistics, geometry, and probability numbers have proven to be components that have been the focus of several previous studies (Kencanawaty et al., 2021; Pourdavood et al., 2020).

The EduGame Maru application was declared as appropriate to use from various aspects because it used several interface elements and references to previous similar applications (Ratniasih et al., 2014; Pratama & Maulani, 2017; Purwaningsih, 2018). The test results also show interest and suitability with the needs of students and are proven to improve learning outcomes. This supports several previous research results where Android-based applications have proven effective (Febriani et al., 2020; Rahayu & Irawan, 2021). Teachers and learning developers are expected to continue to see digital-based learning for ECE as an alternative that is worthy of being developed and used to improve the quality of learning.

CONCLUSION

The conclusion from the results and discussion described previously is that the EduGame Maru application is an e-learning application that can train early childhood cognitive abilities. The EduGame Maru application not only trains children's cognitive abilities but also helps children know and practice early mathematical concepts. This application was created to help parents and teachers teach their children early mathematical concepts in a time of online learning as it is today. Hopefully, this application can be useful for all parents and teachers.

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