

DESIGN OF AN ANDROID-BASED QUIZ GAME APPLICATION FOR INTRODUCING GCD AND LCM USING THE LCM METHOD

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Abstract

Learning Greatest Common Divisor (GCD) and Least Common Multiple (LCM) concepts often presents challenges for students due to conventional teaching methods that are less interactive and engaging. This study aims to design and develop an Android-based quiz game application for introducing GCD and LCM concepts using the Linear Congruential Method (LCM). The proposed application was developed as an interactive educational medium to improve students' understanding and learning motivation through a game-based approach. The Linear Congruential Method was implemented to randomize quiz questions, ensuring varied question sequences and reducing repetition during gameplay. The application consists of several main features, including a home page, quiz gameplay, learning materials, high score tracking, and developer information. Additionally, immediate feedback mechanisms were integrated to indicate correct and incorrect answers, enabling students to learn from their mistakes directly. The implementation results show that the application successfully provides an interactive and engaging learning experience for students in understanding GCD and LCM concepts. Furthermore, the integration of question randomization using LCM contributes to creating a more dynamic learning process and increasing user engagement. Therefore, the developed application can serve as an alternative educational medium to support mathematics learning in a more effective and enjoyable manner.

Keywords: educational game; gcd and lcm; linear congruential method (lcm); android.

1. INTRODUCTION

Educational games have become one of the effective and engaging learning methods, particularly in the context of children's and adolescents' education. By integrating game elements into the learning process, students can engage actively and enjoyably, which ultimately enhances their understanding of the subject matter. One mathematical topic that often presents a challenge for students is the Greatest Common Divisor (GCD) and Least Common Multiple (LCM). Both concepts are important mathematical foundations that are frequently applied in various everyday situations. However, students' understanding of GCD and LCM is often inadequate due to insufficiently engaging teaching methods. Therefore, innovative solutions are needed to address this problem [1].

According to [2], a game is an activity that involves interaction between players with the goal of achieving a specific outcome within a set of defined rules. Games can be physical, mental, or a combination of both, and can be played individually or in groups. In the digital context, games have grown rapidly with the emergence of various types of games accessible through different devices such as computers, consoles, and smartphones. Educational games are a type of game specifically designed for educational purposes, where players can learn while playing.

The Greatest Common Divisor (GCD) is the largest number that can evenly divide two or more numbers without leaving a remainder. GCD is used to simplify fractions or determine optimal division. On the other hand, the Least Common Multiple (LCM) is the smallest number that can be evenly divided by two or more numbers. LCM is commonly used in time calculations, scheduling, and various other applications requiring synchronization. One of the main problems in teaching GCD and LCM is the tendency toward conventional teaching methods that are insufficiently engaging for students. This causes students to lose interest and struggle to understand these concepts. Furthermore, the lack of interactivity and practicality in teaching also poses an obstacle, as students do not receive an enjoyable and applicable learning experience. To address these problems, the development of an Android-based quiz game application becomes an innovative and effective solution. This application is designed to introduce the concepts of GCD and LCM through an engaging interactive game. With an interactive approach, students can learn to determine GCD and LCM in a fun and applicable way. The game will present various quiz questions that players must answer, with immediate feedback to help students understand their mistakes and improve their comprehension. Furthermore, competitive and rewarding game elements will motivate students to continue learning and practicing.

Previous research was conducted by [2] The findings showed that the presence of an Android-based educational game application for basic mathematics learning, particularly GCD and LCM, significantly increased students' interest in learning. This attractively packaged and non-boring game successfully made students more enthusiastic in their studies. Furthermore, the application was proven to help students better understand the concepts of GCD and LCM through an interactive and enjoyable learning experience.

Subsequently, further research was conducted by [3] That study focused on developing an exam question randomization application using the Linear Congruent Method (LCM). The main objective was to overcome the weaknesses of conventional exam administration, which is susceptible to question leakage and cheating. By applying LCM, exam questions can be randomized so that each participant receives a different set of questions, reducing the likelihood of cheating.

2. RESEARCH METHODS

2.1. Linear Congruential Method (LCM)

The Linear Congruential Method (LCM) is one of the simplest and most widely used algorithms for generating pseudo-random numbers. Despite its simplicity in implementation, this method can produce sequences of numbers that appear random and is used in various applications such as Monte Carlo simulations, computer games, cryptography, and other computational needs. LCM operates on simple yet effective mathematical principles, using linear and modulus operations. Essentially, LCM uses a recursive formula to generate random numbers [4]. This formula is expressed as:

$$X_{n+1} = (aX_n + c) \bmod m \quad (1)$$

Description:

X_{n+1}	: is the newly generated random number,
X_n	: is the previous random number,
a	: is the multiplier,
c	: is the increment,
m	: is the modulus, and
n	: is the index of the random number sequence.

This process begins with an initial value known as the seed (X_0), which is the first number in the sequence of random numbers to be generated. The choice of seed value is crucial because the sequence of random numbers produced by LCM depends entirely on the seed value used. With the same seed, LCM will always produce the same sequence of random numbers, which is a characteristic of pseudo-random numbers. However, by changing the seed, the generated sequence also changes, providing the desired random variation. One reason LCM is popular is its simplicity and efficiency. This method involves only basic arithmetic operations such as multiplication, addition, and modulus. Since these operations can be performed quickly by a computer, LCM is highly efficient for generating large quantities of pseudo-random numbers. Furthermore, LCM is easy to implement in various programming languages, making it widely used in various applications that require random numbers [5].

However, LCM has several limitations that need to be noted. One of its limitations is its finite period or cycle. The period of LCM depends on the selection of parameters a , c , and m . Theoretically, the maximum period of LCM equals the modulus m , but this period is only achieved if the parameters are chosen correctly. If these parameters are not selected properly, the generated random numbers will have a short cycle and predictable patterns, which is far from ideal in many applications. The selection of parameters a , c , and m must satisfy several conditions to ensure maximum period and produce good pseudo-random numbers. One of these conditions is that the modulus m should be large, typically chosen as a prime number or a power of two, to extend the period. The multiplier a must be chosen such that the generated numbers have a good and uniform distribution. The increment c should be relatively prime to the modulus m to ensure that the entire range of random numbers can be reached [6].

2.2. Game

A game is an activity carried out by individuals or groups for the purpose of entertainment, enjoyment, and the improvement of cognitive, motor, and emotional abilities. In a broader context, games can take the form of traditional games, physical games, or digital games and video games [7]–[9]. As one form of entertainment, games have existed since ancient times and have evolved over time, following the development of technology, culture, and human creativity. Traditional forms of games often involve physical tools such as boards, cards, or other objects. Examples include chess, congklak (a traditional mancala game), and playing cards. In the past, these games served as a means of training strategic thinking skills, enhancing social interaction, and cultivating competitive and cooperative values. Over time, technology has introduced new elements into games that allow the playing experience to become increasingly immersive and complex [2].

2.3. Education

Education is a learning process aimed at developing the knowledge, skills, values, and attitudes of individuals so that they can contribute effectively in their personal, social, and professional lives. Education encompasses a wide range of activities, from formal school instruction to lifelong self-directed learning. In this context, education is an important foundation for the development of individuals and society, as it provides the knowledge and skills needed to face challenges and opportunities in life[10]–[12]. Traditionally, education has most often been associated with formal institutions such as schools, colleges, and universities. In these settings, students receive structured and systematic instruction in various subjects, ranging from science, mathematics, and language to the arts. Teachers or instructors serve as facilitators who transfer knowledge to students, with the aim of equipping them with information and skills relevant for the future [13].

3. RESULTS AND DISCUSSION

After this research was completed, the next stage was the implementation of the system. The designed system comprises a number of pages, each with a specific function. These pages will be presented according to their respective roles.

3.1. Implementation of Linear Congruential Method

The implementation of the Linear Congruential Method (LCM) in this study was applied to randomize quiz questions within the Android-based educational game application. The main objective of using this method was to prevent repetitive question sequences and provide users with a more varied and engaging learning experience. By implementing question randomization, students are less likely to memorize the order of questions, thereby encouraging better conceptual understanding of Greatest Common Divisor (GCD) and Least Common Multiple (LCM) material rather than relying on repeated answer patterns. The Linear Congruential Method operates using a recursive mathematical formula to generate pseudo-random numbers, where each generated number is determined based on the previous number and a set of predefined parameters. In this application, the generated random values were used to determine the index of quiz questions stored in the question database. As a result, every game session can display a different sequence of questions, even though the same set of materials is used. This mechanism improves variability in the learning process and minimizes user boredom during repeated gameplay sessions.

The implementation process begins with the initialization of a seed value as the starting point for random number generation. Subsequently, the LCM formula generates a sequence of pseudo-random values that correspond to available quiz questions. The selected parameters, including the multiplier, increment, and modulus, were adjusted to ensure a more uniform distribution of question sequences and to minimize repetition within a single session. Through this approach, the generated quiz order becomes more dynamic and systematic while maintaining computational efficiency suitable for mobile-based applications.

Furthermore, the use of the Linear Congruential Method contributes to enhancing the interactivity and educational effectiveness of the application. Since users encounter different question orders in each session, students are encouraged to repeatedly practice and strengthen their understanding of GCD and LCM concepts. This implementation aligns with the objective of educational games, which is to create a fun, interactive, and effective learning environment while maintaining students' motivation and engagement throughout the learning process.

3.2. Application Interface Implementation

a. Home/Splash Page

The display shown in the figure below is the main/splash page of the educational game application. On this page, users are presented with three main buttons: Play, Information, and Developer. The Play button is used to start the quiz game, Information contains explanations about the material or how to use the application, while the Developer button displays information about the team or individual who created the application.

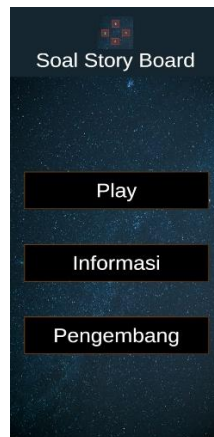


Figure 1. Home/Splash Page

b. Play Page

The figure below shows the Play page of the application. On this page, there are three main buttons: Game, High Score, and Back. The Game button is used to start the quiz, while High Score displays a list of the highest scores achieved by users. The Back button functions to return to the previous page.



Figure 2. Play Page

c. Page Game

The figure above shows the quiz page within the game application. On this page, the user is given a question, namely "The GCD of 27 and 36 is ...", and is asked to select an answer from four available multiple-choice options. The display is designed to be interactive and simple so that students can easily understand and focus on answering the questions. Button Back button is provided to return to the previous page[14]–[16].

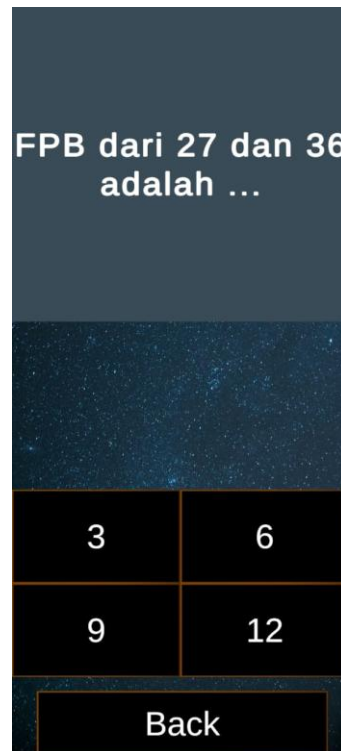


Figure 4. 3 Game Page

This figure shows the display when the user successfully answers a question correctly. The question shown is “The GCD of 60 and 72 is ...”, and after selecting the correct answer, a "CORRECT" notification appears with a green background as an indicator of success.



Figure 4. Correct Answer

This figure shows the display when the user answers a quiz question incorrectly. The question is “The LCM of 3 and 4 is ...”, and after selecting the wrong answer, the text "WRONG" appears with a red background. The red color is used as an indicator that the selected answer is incorrect, providing immediate feedback so that users can learn from their mistakes.

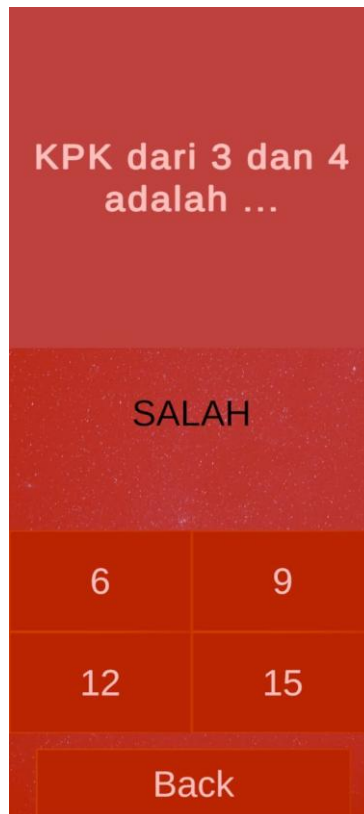


Figure 4. Incorrect Answer Page

d. Information Page

The figure above shows the information page within the application, which explains the basic definitions of LCM and GCD. The explanation begins with a brief definition of both terms, followed by an understanding of multiples and factors. Examples of multiples of the number 3 are also provided to help users understand the material more easily.

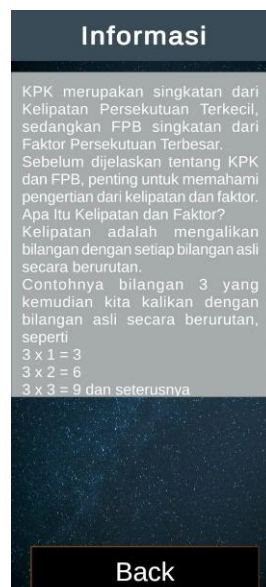


Figure 6. Information Page

e. High Score Page

The display in the figure shows the Score Information page of an application or game. It contains a list of the top three scores, which are currently all zero, indicating that no game activity or achievements have been recorded yet. The “Back” button at the bottom allows users to return to the previous menu.

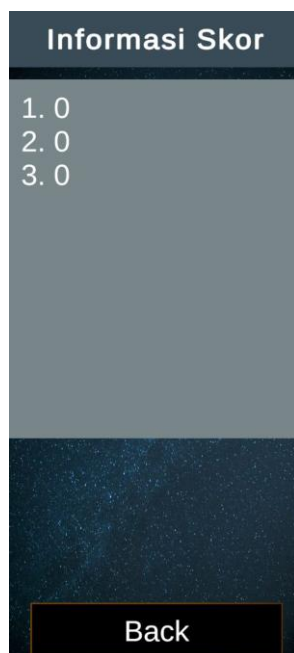


Figure 5. Score Info Page

f. Developer Page

The display in this figure shows the Developer page of the application. This page is used to display information about who created or developed the application. However, the information area is currently empty. There is also a “Back” button at the bottom to return to the previous menu.



Figure 8. Developer Page

3.3. Discussion

The implementation results indicate that the developed Android-based educational game application successfully provides an interactive learning medium for understanding the concepts of Greatest Common Divisor (GCD) and Least Common Multiple (LCM). The application interface was designed to be simple, attractive, and easy to navigate, enabling students to use it without difficulty. Through the Home/Splash Page, users are introduced to the main features of the application, including the Play, Information, and Developer menus, which provide clear navigation and ease of access to learning content. This design approach supports user engagement and improves

usability, particularly for elementary-level learners who require visually appealing and straightforward educational tools.

The Play Page serves as the main gateway for users to access quizzes and review their learning achievements through the High Score feature. The presence of a score system introduces a competitive element that can increase student motivation and encourage repeated learning activities. Such gamification elements are important in educational games because they can create a more enjoyable learning environment while maintaining students' interest in practicing mathematical problems. Furthermore, the availability of a back navigation feature improves the flexibility of interaction, allowing users to move easily between pages.

The quiz or Game Page demonstrates the core functionality of the application by presenting GCD and LCM questions in a multiple-choice format. The interactive design allows students to directly apply their mathematical understanding through problem-solving activities. Immediate feedback mechanisms, such as the "CORRECT" and "WRONG" notifications, play an important role in reinforcing learning outcomes. Correct answers are indicated using green visual feedback, while incorrect responses are marked with red indicators, helping students recognize mistakes and learn from them instantly. This feedback mechanism supports active learning and encourages students to improve their comprehension of mathematical concepts through repetition and practice.

In addition, the Information Page provides supporting educational content by explaining the definitions of GCD and LCM, along with examples of multiples and factors. This feature enhances the learning process by allowing students not only to answer quiz questions but also to review theoretical material independently. Such integration of instructional content with interactive exercises contributes to a balanced learning experience that combines theory and practice. Meanwhile, the High Score Page enables users to monitor achievements, which can foster enthusiasm and create a sense of accomplishment during the learning process.

Overall, the developed educational game application demonstrates its potential as an alternative learning medium for mathematics, particularly in teaching GCD and LCM concepts. Compared to conventional learning methods, the interactive and game-based approach offers a more engaging experience that may improve students' motivation and conceptual understanding. These findings are consistent with previous studies, which reported that educational game applications can increase students' interest and improve comprehension through interactive learning experiences. Therefore, the proposed application can be considered an effective supplementary tool to support mathematics education in a more engaging and practical manner.

4. CONCLUSION

Based on the results of the research and system implementation, it can be concluded that the Android-based educational game application for learning Greatest Common Divisor (GCD) and Least Common Multiple (LCM) was successfully developed and implemented as an interactive learning medium. The application provides various features, including quiz-based gameplay, learning materials, score tracking, and immediate feedback mechanisms that support students in understanding mathematical concepts more effectively. Through an attractive interface and interactive quiz system, students can learn GCD and LCM concepts in a more enjoyable and engaging manner compared to conventional teaching approaches. Furthermore, the implementation of the Linear Congruential Method (LCM) in the quiz system successfully enabled the randomization of questions, reducing repetition and creating a more dynamic learning experience for users. The use of immediate feedback through correct and incorrect answer indicators also contributes to improving students' comprehension by allowing them to recognize and learn from mistakes directly. Therefore, this application can serve as an alternative educational medium to support mathematics learning, particularly in improving students' interest and understanding of GCD and LCM material.

For future research, several improvements can be implemented to enhance the functionality and educational value of the application. First, additional mathematical topics beyond GCD and LCM can be integrated to broaden the scope of learning materials and make the application more comprehensive. Second, adaptive learning mechanisms can be implemented using artificial intelligence techniques to adjust question difficulty based on students' performance and learning progress. Third, multimedia elements such as animations, sound effects, and interactive tutorials can be further enhanced to improve student engagement and learning motivation. Additionally, future studies may focus on evaluating the effectiveness of the application through experimental testing involving students and educators to measure improvements in learning outcomes, motivation, and user satisfaction. The application may also be expanded into a multiplayer or online learning environment, allowing students to compete or collaborate with peers, thereby creating a more interactive and collaborative educational experience.

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