

Astro Arithmetic - A Simple Game Application for Developing Mental Arithmetic for First Grade Elementary Students Using The Challenge-Based Learning (CBL) Framework With Swift UI

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ARTICLE INFO

Article history:

Received July 20, 2023
Revised August 16, 2023
Accepted August 18, 2023

Keywords:

SwiftUI;
Math phobia;
Mental arithmetic skills;
First-grade students;
CBL Framework
Games.

ABSTRACT

Mathematics is one of the fundamental sciences that underlies the rapid development of technology and knowledge in the present era. Counting is a basic skill that should be acquired and mastered since elementary school. However, the reality is that many first-grade students still struggle with their counting abilities. Some of the problems include lack of motivation for learning, ineffective learning methods, and math phobias. Math phobia refers to a condition where students feel disturbed and stressed when confronted with anything related to mathematics. The factors contributing to math phobia include triggering events, influence from others, and conventional teaching methods in schools. One way to address this issue is by developing students' mental arithmetic skills, as it has been proven to be highly beneficial in shaping their thinking process. Recognizing the potential of utilizing technology, a simple interactive game using Swift UI can be developed to enhance first-grade students' mental arithmetic skills, providing them with an enjoyable learning experience in mathematics.

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1. INTRODUCTION

Mathematics is a fundamental science that plays an important role in the world of education and is one of the key disciplines underlying the rapid development of technology and knowledge in the present era [1]. Counting is a fundamental knowledge in mathematics that should be learned and mastered during school years. According to the data obtained, when first-grade elementary students are presented with math problems in the form of pictures, such as adding with illustrated toothpicks, 36 out of 40 students answered correctly, or 90% answered correctly. However, when presented with problems in the form of numerical symbols or without using illustrated pictures, only 20 out of 40 students answered correctly, or 50% answered correctly [2]. This becomes a problem because during exams, first-grade students will be presented with problems in the form of numerical symbols, and it can be challenging if they are not accustomed to solving problems without illustrated pictures. There are several factors that contribute to this, including difficulties in learning arithmetic operations due to lack of practice in solving problems without illustrated pictures, low learning motivation, inadequate learning methods for first-grade students, and the presence of math phobia.

Mathematics phobia is a condition in which students experience psychological disturbances in the form of fear or anxiety towards mathematics [3]. This is typically felt by students when confronted with mathematical concepts or tasks, causing them to feel disturbed and stressed. There are several factors that contribute to the emergence of mathematics phobia. First, there are triggering events that make students afraid of mathematics. For example, when students make mistakes in solving math problems, they may be required to solve a large number of problems within a specific time frame as a punishment for their wrong answers.

This can cause students to feel stressed and develop a trauma towards mathematical tasks. The second reason is the influence of others. Phobia is closely related to feelings or emotions that trigger fear or anxiety [4]. Teachers are one of the key factors, along with parents, intelligence, and environment, in preventing and overcoming mathematics phobia. The perception of others that mathematics is very difficult can greatly influence the students' own perception. The third reason is the use of conventional teaching methods **by school teachers**. Sometimes, teachers are limited by time constraints and can only use monotonous approaches and strategies in teaching mathematics. However, one of the important roles of mathematics is to enhance individuals' abilities and intelligence in various aspects of life. The fourth reason is the lack of interest of students **in mathematics** [5]. Students' learning difficulties are often caused by a lack of interest in learning mathematics, which results in them not paying attention to the material and struggling to understand the concepts. In some cases, students simply memorize formulas or concepts without truly understanding them. As a result, they find it difficult to apply those concepts in different situations because low interest fundamentally affects the learning process and outcomes. The quality of learning interest is directly related to the quality of learning outcomes achieved.

Research efforts have been made to develop mental arithmetic through the development of a basic arithmetic adventure 3D game application. Based on the research, pretest results showed an average score of 56, while posttest results showed an average score of 72. Furthermore, a questionnaire was conducted with 20 elementary school children aged 7-11 years as respondents, resulting in an index percentage of 85.2%. Another study aimed at developing mental arithmetic involved the design of a mathematics learning media using the snake and ladder method, where a questionnaire was given to 24 students who showed a high level of satisfaction with an average score of 92.99% "Very Satisfied" for each question item. However, the game applications designed by the two previous studies did not allow players to actively participate and engage with the game through various interactive elements.

Astro Arithmetic is a game application designed to enhance the development of mental arithmetic skills among first-grade elementary students. This application is built using the Swift UI framework, providing an interactive and engaging learning experience. It aims to improve students' mathematical abilities, boost their confidence in learning mathematics, and provide a platform for enjoyable math learning.

The game features puzzle challenges that can be solved by answering questions presented through drag and drop mechanics. By actively engaging with the interactive features, users can learn and practice arithmetic skills while having fun, without feeling like they are in a traditional learning environment.

2. METHOD

The development is carried out using a framework called challenge-based learning (CBL). All participants (students, teachers, families, and community members) are asked to identify Big Ideas, ask good questions, discover and resolve Challenges, gain in-depth subject matter knowledge, develop 21st-century skills, and share their ideas with the world as part of the collaborative and hands-on framework [6]. CBL is a constructivist learning approach where problems are presented in case-based learning. CBL is often defined as a teaching method that requires students to actively participate in real or hypothetical problem situations, reflecting the type of experiences naturally encountered in the discipline being **studied** [7]. Case-based learning provides an opportunity to analyze content by first introducing core knowledge domains and encouraging students to explore other knowledge domains that may be relevant to the problem presented in the case. A case is a definition of a realistic problem scenario that is relevant to the subject **matter being studied** [8]. Cases in CBL involve problems related to the students' environment, conditions, situations, or future scenarios. Cases are stories with a message that students can analyze and **consider solutions for** [7]. CBL engages students in learning through **realistic narratives**, providing opportunities for students to integrate multiple sources of information in **an authentic context** [9]. CBL presents students with realistic problem scenarios, or cases, that can be studied retrospectively by examining how the case was solved or interactively by attempting to solve the case [10].

The benefits of using cases in learning are that students can apply theories to real-life contexts, think critically about complex situations, make informed choices of actions to be taken, develop self-awareness, compare and evaluate their perspectives with those of others [11]. CBL helps students transfer knowledge from the learned material [10]. Additionally, CBL bridges the gap between theory and practice [12]. This ensures that students not only possess theoretical knowledge but can also apply it to specific conditions, and they are not only able to perform practical tasks without understanding the underlying principles.

Based on the opinions of experts, it can be concluded that CBL is a complex learning approach closely related to cases in the form of realistic and relevant problem scenarios that integrate multiple sources of information in a contextual manner, where students attempt to solve cases based on their previous experiences and knowledge.

CBL is a learning paradigm closely related to Problem-Based Learning (PBL) [11]. The difference is that PBL does not require prior experience or knowledge related to the subject matter, while CBL requires prior knowledge to support case solving. Although PBL and CBL share common goals, each has unique characteristics. In PBL, problems guide the learning process, whereas in CBL, students are required to use their previous knowledge to solve cases [13].

2.1. Engage

The Engage phase aims to facilitate researchers in visualizing a big and abstract idea and transforming it into a concrete challenge. The following are the steps involved:

1. Identifying big ideas. Identifying important concepts related to the given topic.
2. Identifying essential questions. Formulating relevant questions related to the topic to stimulate curiosity and deepen understanding.
3. Identifying challenges. Identifying challenges that will address the essential questions.

2.2. Investigate

The Investigate phase is a stage of further investigation into the problem or challenge. In this phase, information is collected, research is conducted, and relevant resources are explored to gain a deeper understanding of the topic being studied. Researchers may also interact with experts, conduct interviews, make observations, or conduct experiments to gather the necessary information. The investigation phase is divided into two parts: general investigation and domain investigation.

2.3. Act

The Act phase is a stage of taking action or implementing concrete steps to address the existing challenge. In this phase, the researchers engage in planning, designing, and executing the solutions or plans they have developed based on the research and understanding gained in the Investigate phase. They apply the ideas, strategies, or skills they have learned to overcome the challenge.

3. RESULTS AND DISCUSSION

3.1. Engage

In the Engage phase, researchers explore big ideas and formulate them into a problem or challenge.

Table 1. Engage phase

Idea	Introduce math
Key question	How to make calculations easier and faster?
Problem	Make calculations easier and faster

3.2. Investigate

The investigation phase will be divided into two, namely general investigation and advanced investigation. General investigation is a stage of general exploration conducted to gain a deeper understanding of the problem or challenge they are facing. In this stage, various activities are carried out such as gathering information, analyzing available resources, exploring different perspectives, and identifying aspects that need further study. General investigation focuses on efforts to answer guiding questions, identify key issues, and gather relevant information to understand the context and complexity of the problem. By conducting general investigation, a broader understanding of the challenges faced can be developed and better approaches to solving the problem can be found. This stage plays a crucial role in helping formulate effective strategies and action plans before moving on to the next stage in CBLD. The obtained results are as follows.

Table 1. General Investigation Phase

General Investigation Findings	<p>Fast calculation still remains a challenging task for many people. Based on sources, it is found that the difficulty arises due to several factors, such as dyscalculia, where individuals struggle with difficulties in performing calculations over time, still using traditional calculation methods without knowing how to calculate quickly and efficiently, lack of practice, and low interest in calculation leading to a decision to stop learning calculation.</p> <p>However, if individuals possess the ability to calculate quickly, it can have a tremendous impact on their daily lives, such as facilitating decision-making, enhancing creative thinking, and even enabling more effective completion of daily activities.</p> <p>Furthermore, individuals with low interest in calculation and infrequent practice will encounter difficulties in quick calculation, resulting in potential issues or constraints in decision-making and creative thinking, as well as limitations in accomplishing daily activities related to calculations. Increasing interest in calculation and regular practice can help improve decision-making, creative thinking, and the effectiveness of daily activities that require calculations.</p> <p>Therefore, by focusing on enhancing interest in calculation and practicing it regularly, individuals can improve their ability in fast calculation.</p>
Idea	Introduce math
Key question	How to make calculations easier and faster?
Problem	improving quick calculation skills through practice

Domain investigation involves further exploration of related topics, concepts, theories, methods, and best practices within a specific knowledge domain. This stage gathers more in-depth information, analyzes existing data, and investigates various relevant resources and references. Domain investigation helps develop a more specific understanding of how knowledge and concepts within that domain can be applied in the context relevant to their challenges. The information discovered during this stage will be used to inform the proposed solutions and further action plans in CBLD. The obtained results are as follows.

Table 2. Domain Investigation Phase

Domain Investigation Findings	<p>Fast counting still remains a challenging task for young children, especially students in grades 1-3 of elementary school. Based on a source, it is found that this difficulty arises due to several factors, such as having a mindset that mathematics is difficult and hard to learn, still using traditional calculation methods due to limited methods provided by teachers, lack of practice, and low interest in counting leading to discontinuation of learning. However, if young children have the ability of fast counting, it will have a tremendous impact on their daily lives. Mental arithmetic can be used to optimize the brain function of a child, enabling them to calculate quickly using only their mental faculties. Therefore, fun and easily understandable exercises in fast counting, such as having</p>
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	mental arithmetic skills, are needed because they offer numerous benefits, including facilitating mathematics exams, developing right brain abilities, enhancing creative thinking, and even improving the efficiency of everyday activities. Research results indicate that a 2-week mental arithmetic training to overcome mathematics phobia in elementary school students, with 4 sessions lasting 2 hours each, showed an increase in scores from 50.95 to 76.90. Furthermore, 89% of participants responded positively to the enjoyable nature of the taught materials, 85% felt assisted and given equal opportunities to try the training materials, and 86% expressed their desire to participate in similar training activities in the future. Additionally, children with low interest in counting, infrequent practice, and lack of parental involvement in counting learning face difficulties in fast counting, which hampers their ability to count and think creatively and affects their completion of daily activities involving calculations. Therefore, it is crucial for young children to have mental arithmetic skills to improve their ability in fast counting and foster creative thinking.
Idea	Introduce math
Key question	How to make calculations easier and faster?
Problem	Improving quick calculation skills through practice
Resolution	Based on our investigation, we found that first-grade students have difficulties in performing quick calculations and visualizing mathematical problems due to their reliance on traditional methods, lack of practice, and low interest in arithmetic. What if we help create a product in the form of a simple game that can train them to develop mental arithmetic skills, thereby enhancing their ability to perform quick calculations and fostering creative thinkin

3.3. Act

Act phase involves the process of applying the knowledge and skills acquired during the domain investigation phase to develop solutions or approaches that can be implemented in addressing the identified challenges or problems. In this phase, practical exploration, experimentation, and prototyping are carried out. Astro Arithmetic presents itself as an application that fosters the advancement of mental arithmetic proficiency in primary school students. Utilizing the Swift UI framework, this app offers an interactive and captivating learning journey. Its primary objective is to elevate students' mathematical aptitude, bolster their self-assurance in tackling math-related subjects, and furnish them with an enjoyable platform for mathematical exploration.

Within this game, users encounter various puzzle challenges, each solvable through the utilization of drag-and-drop mechanisms. By actively engaging with the interactive elements, learners can cultivate their arithmetic skills in an entertaining manner, free from the constraints of conventional learning settings. The following presents the outcomes of the development of the Astro Arithmetic application undertaken by the researcher.

1. Play Screen

The play screen is the first page that appears when users open this application. It is designed with an astronomy concept, making it appealing to children, especially first-grade elementary students, and accompanied by captivating animations. Here, users can start the game by tapping the start button, which is represented by an illustrative image.



Fig. 1. Play Screen

2. Guide Screen

The Astro Arithmetic application provides a gameplay tutorial or guide that facilitates users in using and playing the game. The target users, who are first-grade elementary students, will greatly benefit from the presence of this show guide feature.



Fig. 2. Guide Screen

3. Main Screen

The main screen is the primary page of the Astro Arithmetic application. This page is divided into two sections: the question and the answer. The questions and answers are presented in the form of simple puzzles, where users need to solve the puzzle by answering the questions. To answer and complete the puzzle, users can hold and drag the puzzle answer pieces to the puzzle question pieces. If the user answers correctly, the puzzle pieces containing the questions will gradually be revealed one by one.



Fig. 3. Main Screen

4. Result Screen

The Astro Arithmetic application will display a result or win screen when users successfully complete the questions within the puzzle. It will showcase a unique image obtained by users upon completing the provided puzzle.



Fig. 4. Result Screen

4. CONCLUSION

Astro Arithmetic is a game application designed to enhance the development of mental arithmetic skills among first-grade elementary students. This application is built using the SwiftUI framework, providing an interactive and engaging learning experience. It aims to improve students' mathematical abilities, boost their confidence in learning mathematics, and provide a platform for enjoyable math learning.

The game features puzzle challenges that can be solved by answering questions presented through drag and drop mechanics. By actively engaging with the interactive features, users can learn and practice arithmetic skills while having fun, without feeling like they are in a traditional learning environment.

Astro Arithmetic represents an innovative solution in the field of educational games, targeting first-grade students and their mental arithmetic development. Through its interactive gameplay and immersive experience, it aims to inspire a love for mathematics and enhance students' mathematical abilities in an enjoyable and engaging way.

Acknowledgments

I would like to express my utmost gratitude to the esteemed Apple Developer Academy @Infinite Learning for the invaluable opportunity, knowledge, ideas, and unwavering support extended to me throughout the entire process of conducting this research. Furthermore, I am deeply appreciative of the esteemed Computer Science Department at Universitas Mataram for graciously facilitating and enabling the successful completion of this research endeavor.

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