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Original Article

Innovative Learning Tools for Young Children: Enhancing Basic Math and Reading Skills through Interactive Software

Lida Asencios-Trujillo[1], Lucia Asencios-Trujillo[2], Carlos La-Rosa-Longobardi[3], Djamila Gallegos-Espinoza[4]

[1, 2,3,4]*Postgraduate School, Enrique Guzmán y Valle National University of Education, Lima, Peru.*

[1]*Corresponding Author : lascncios@uneedu.te*

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Abstract *- Current educational methods frequently struggle to fully engage students, especially in subjects such as mathematics and reading comprehension. This study introduces the use of educational software designed for children aged 9 to 11, aiming to enhance their performance in these essential areas. By incorporating interactive educational games and didactic exercises, the software aims to inspire students and support their learning process. The development of the software followed the agile Scrum methodology, involving both educators and students. Data was gathered through surveys and standardized tests to evaluate the software's impact on students' academic achievements. Preliminary findings suggest a notable improvement in the performance of students who utilized the educational software compared to those who adhered to traditional teaching methods. Additionally, there was an observed increase in motivation and class participation. The use of educational technologies has proven to be an effective strategy for enhancing learning. However, it is crucial to tailor the content and methodologies to meet the unique needs of each student. This study underscores the importance of ongoing research and development of innovative educational tools. The developed software has demonstrated its value in enhancing mathematical and reading comprehension skills in children aged 9 to 11. Future research should concentrate on personalizing content and integrating emerging technologies.*

Keywords *- Curriculum design, Educational technology, Teaching methods, Primary education.*

1. Introduction

In Peru, a standardized evaluation was conducted to measure the learning achievements of students from both state and private schools. This assessment categorized student performance into three levels: beginning, in process, and satisfactory. For second-grade primary school students, the results in Mathematics revealed that 51.1% were at the beginning level, 31.9% were in progress, and only 17% reached the satisfactory level, reflecting an approximate 2% improvement across all levels compared to previous years. Despite this, over half of the students remained at the beginning level, indicating a failure to meet expected learning outcomes [1]. Conversely, the Reading results indicated that 3.8% of students were at the beginning level, 58.6% were in progress, and 37.6% achieved a satisfactory level. This suggests that second-grade students performed better in Reading than in Mathematics, although more than half did not reach a satisfactory level in this evaluation [2]. The COVID-19 pandemic significantly disrupted education, requiring millions of teachers and students to adapt to new digital learning methods. This shift revealed substantial challenges, as many struggled with digital literacy and access to technology. In 2020, 230,000 students from primary and secondary schools in Peru exited the educational system, and 200,000 enrolled secondary students struggled to effectively access online education [3]. Surveys conducted from April to July 2020, involving over 10,000 families across Peru, evaluated the "Aprendo en Casa" program. The findings showed that two-thirds of parents were pleased with the program's content, and a teacher or tutor had contacted most. However, significant connectivity issues hindered the program's effectiveness in many households [4]. The pandemic underscored the importance of Information and Communication Technologies (ICT) in education. By the fourth quarter of 2021, 95.3% of Peruvian households had at least one form of ICT, with 94.2% having a mobile phone. Internet access was available in 75.1% of households in Metropolitan Lima, 58.7% in other urban areas, and only 18.5% in rural areas. Additionally, 80.1% of children aged 6 to 11 were able to use the internet [5]. Young children, particularly those between the ages of 5 and 7, often face challenges with reading due to a lack of interest,

concentration, confidence, or parental illiteracy. Traditional teaching methods frequently fail to engage them. Integrating audiovisual technology into classrooms can address this issue by making learning more engaging and interactive [6]. Primary school students construct their understanding of arithmetic operations through various teaching strategies. They compare different methods to determine the most effective or simplest approach, often preferring mental calculations over using pen and paper or calculators. These processes, initially used without explicit naming or definition, gradually become "objects of study," helping students discern when to use specific methods [7]. Teachers understand that mastering arithmetic operations and their properties is fundamental to schoolwork. Emphasizing various forms of calculation, such as approximation, mental math, and the use of calculators or algorithms, helps build students' self-assurance and reinforce their learning. Group activities and mathematical games are especially effective in enhancing understanding and enjoyment of mathematics [8]. Mathematics is often seen as challenging, especially for young children encountering it for the first time. Effective teaching methods are crucial to making the subject enjoyable and fostering mathematical reasoning rather than rote memorization. Interactive problem-solving and group work can enhance communication and engagement between students and teachers [9].

Educational software has been shown to significantly improve learning outcomes in specific mathematical areas. For instance, a study on geometry learning software created in Adobe Flash C23 demonstrated that interactive exercises could stimulate and motivate children, enhancing their understanding through diverse resources [10]. The GeoGebra application is another example of innovative teaching tools that make mathematics classes more interactive and enjoyable. Effective implementation by teachers can help students overcome their fear of mathematics and see its practical applications in daily life [11]. A software program named "We Are All Different and Valuable" was created to tackle diversity and inclusion issues. Initial surveys evaluated attitudes towards diversity, followed by the use of the software, which included reading materials and interactive activities.

Post-software questionnaires showed a positive change in attitudes, highlighting the software's effectiveness [12]. Similarly, the Berni software, created to improve reading comprehension, was designed for autonomous student work. Available in both portable and online versions, it allows students to work without constant supervision, facilitating understanding and engagement[13-16]. Given the latest national assessments and the impact of the COVID-19 pandemic, it is evident that Peruvian children aged 6 to 8 are not meeting expected learning outcomes in mathematics and reading comprehension. Traditional teaching methods often fail to engage young children, who need interactive and entertaining content to retain information effectively. The proposed software aims to address disinterest and distraction by starting with a questionnaire to assess each child's knowledge level and providing tailored content.

By incorporating interactive and enjoyable learning methods, the software helps children retain information while having fun. The software development utilizes Visual Studio Code for coding, HTML5 for structure, CSS3 for layout, JavaScript for animation and functionality, and SQL Server for database management, creating a robust educational platform to enhance children's understanding of mathematics and reading.

2. Methodology

2.1. Scrum Methodology

To ensure the effective completion of the project, we will implement the Scrum agile methodology. This approach provides several key benefits:

- Client Involvement: Scrum includes the client in the work process, ensuring that their needs and feedback are continuously incorporated.
- Clear Team Structure: It defines clear roles and responsibilities for each team member, facilitating easy adaptation to the methodology.
- The team can monitor progress and ensure that expected results are being achieved through regular activities like daily meetings, sprint reviews, and retrospectives.
- Flexibility: Scrum allows for adjustments to the product's characteristics as needed, promoting a willingness to change.

Additionally, this methodology fosters synergy among team members, helping achieve the desired outcomes in any phase of the project [17-19].

2.2. Principles of Teaching Mathematics

Effective mathematics instruction involves several key principles that foster both understanding and engagement in students. These principles ensure that learners grasp mathematical concepts and appreciate their practical applications.

2.2.1. Third-Order Heading

Focus on helping students understand the principles behind mathematical operations rather than just memorizing procedures. This foundational comprehension is crucial for deeper learning.

2.2.2. Active Learning

Promote active involvement through problem-solving activities, group discussions, and collaborative projects. Engaging students in this way develops their critical thinking and problem-solving abilities.

2.2.3. Real-World Applications

Relate mathematical concepts to real-world situations. Making connections to everyday life enhances relevance and interest, showing students the practical value of mathematics [9].

2.2.4. Differentiated Instruction

Adjust teaching strategies to meet the diverse needs of students. Varied instructional methods ensure that all learners can access and understand the material effectively.

2.2.5. Continuous Assessment and Feedback

Use continuous assessments to track student progress and provide feedback. This approach helps identify areas needing improvement and reinforces learning.

2.2.6. Use of Technology

Utilize technology to enrich the learning experience. Tools such as GeoGebra and other educational software can help make abstract concepts more concrete and engaging [11].

2.2.7. Mathematical Reasoning

Develop a culture of logical reasoning and critical thinking. Encourage students to articulate their thought processes and consider multiple ways to solve problems.

2.2.8. Interactive and Enjoyable Lessons

Interactive and Enjoyable Lessons: Design interactive and enjoyable lessons to capture student interest. Incorporating games, puzzles, and hands-on activities can make mathematics learning enjoyable and stimulating [8]. Applying these principles enables educators to foster an effective learning environment that enhances a comprehensive understanding of mathematics and prepares students for future academic endeavors.

2.3. Crafting User Stories

Table 1 displays the user stories, offering a clear visualization of the features that users wish to see implemented in the software. These user stories aid in understanding the specific needs and expectations of the users who will access the application.

2.4. Flowchart

Outlined below are the specific steps involved in each process:

2.4.1. Do you have an Account?

Existing Account: If you already have a registered account, you will be directed to the main panel of the web system without any additional steps. New Account: For users without an account, registration is required. This involves providing personal information, details about the educational center, and information regarding the teacher. After registering, users will complete entrance tests to evaluate their skills before beginning the course.

2.4.2. Enter the Main Page

Upon completing the registration or login process, the main page of the personalized educational web system will be displayed. This page features active courses, pending tasks, and topics to unlock. New users will only see the personalized course viewing section without general data on the screen.

2.4.3. Viewing the Personalized Course

This section displays the topics that are automatically generated based on the results of the entrance tests completed during registration.

2.4.4. Course Completion

Upon completing the course, the student will be presented with four final activities.

- Provide feedback on ways to enhance the visual section of the page.
- Didactic Suggestions: Submit suggestions for new didactic methods to be implemented in the web system.
- Review of Suggested Didactics: Review and vote on didactics suggested by other students to decide if they should be included in the courses.

Table 1. User stories and desired features

ID	Description	Priority	Criteria
US01	As a student, I want to have interactive math games so that I can learn mathematics in a fun and engaging way.	High	The game should include various math challenges and levels
US02	As a parent, I want to track my child's progress in reading comprehension to see their improvement over time.	Medium	A progress tracking dashboard should be available with detailed reports.
US03	As a teacher, I want to assign personalized exercises to my students based on their skill levels to cater to their individual learning needs.	High	The software should allow custom assignment creation and distribution.
US04	As an administrator, I want to manage user accounts and permissions to ensure secure and organized access to the application.	High	The admin panel should include user management functionalities.
US05	As a student, I want to receive immediate feedback on my answers to understand my mistakes and learn correctly.	High	The software should provide instant feedback with explanations for incorrect answers.

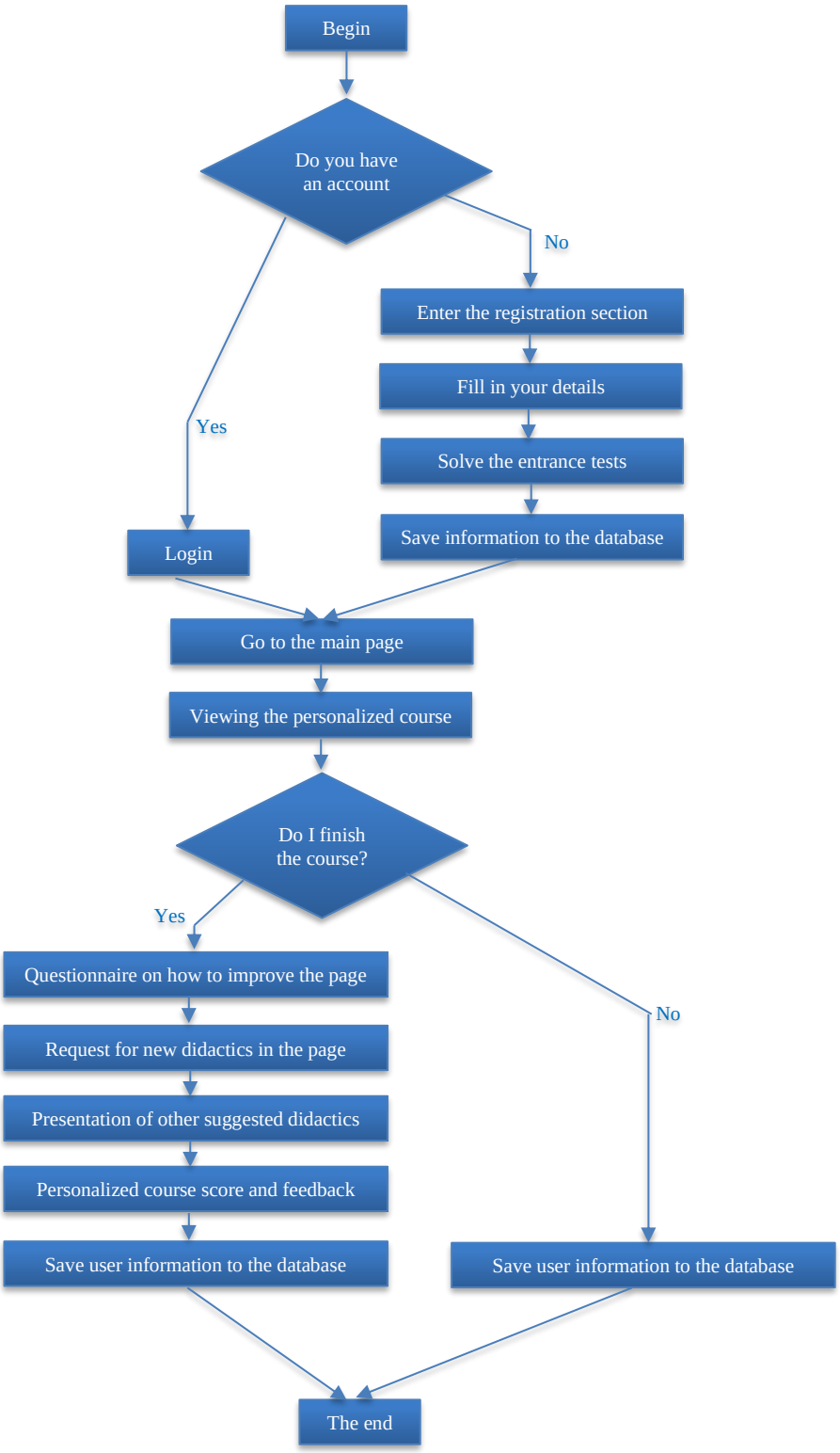

Fig. 1 Flow chart

2.5. Roles and Functions in the Development of Educational Software

As illustrated in Figure 2, developing educational software requires understanding its various functions. These include the formative function, which involves structuring information based on real-world contexts, and the instructive function, which guides student learning to facilitate educational objectives.

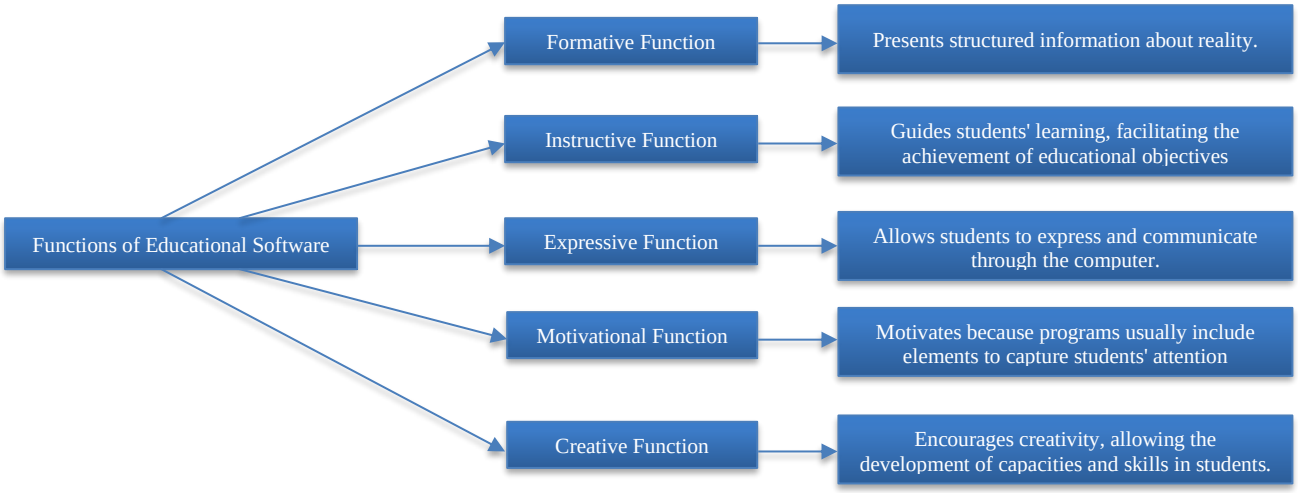

Fig. 2 Key functions in educational software development[16]

The expressive function encourages student interaction with the computer, while the innovative function ensures that the software for mathematics and reading comprehension captures children's attention through new tools for problem-solving. Lastly, the creative function enables students to develop new skills and abilities through the use of educational software.

2.6. Analysis of Students' Pre-existing Knowledge in Reading Comprehension

When analyzing and evaluating the interface design for children aged 6 to 8, we will first prioritize conducting preliminary exams before accessing the main interface. These exams will gather data on the students' phonological knowledge and verbal memory, helping us identify any difficulties they might face while using the software. Based on the results of these initial tests, we will adapt the software's content to address the specific needs and challenges identified by each student. Figure 3 illustrates the percentages of sections where reading problems are identified in relation to phonological knowledge:

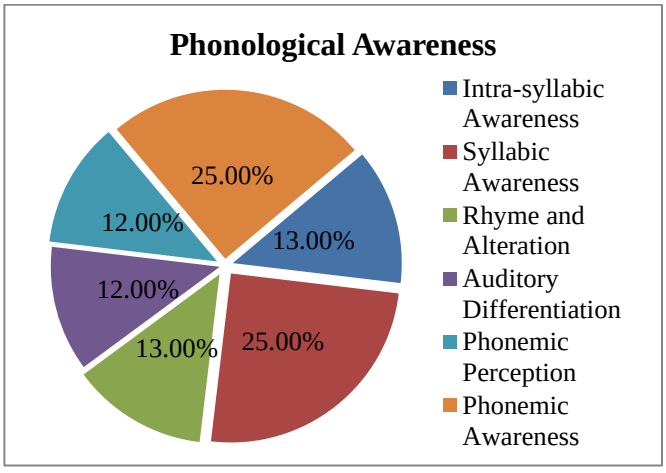

Fig. 3 Statistical data on phonological knowledge

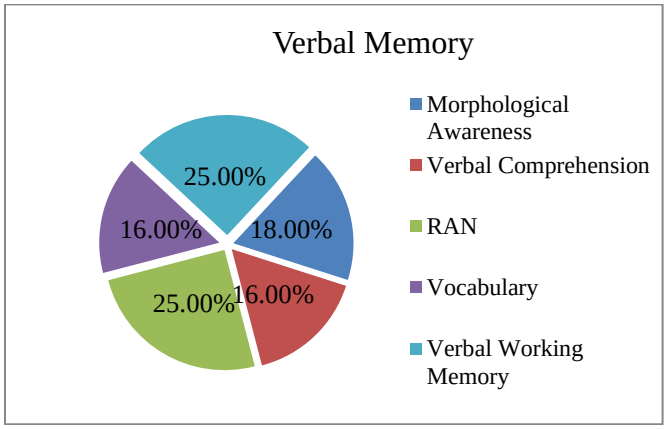

Fig. 4 Verbal memory data analysis

In phonemic perception, which involves the production and perception of language sounds, 12% of students experience difficulties. Auditory differentiation, which is the ability to distinguish between different sounds, also shows 12% of students encountering problems. Rhymes and alliterations, referring to the repetition or similarity of sounds between words, present issues for 13% of students. Syllabic awareness, which involves identifying and discarding syllables that do not fit a word, shows that 25% of students struggle in this area, with an additional 13% facing intra-syllabic challenges. Phonemic awareness, which is the ability to distinguish individual sounds, reveals that 25% of students have difficulties.

Figure 4 illustrates the percentages of sections where reading problems are identified in relation to verbal memory: Vocabulary: 16% of students have difficulties in this area, which tests the knowledge of a certain number of words. Rapid Automatized Naming (RAN): This measures the speed of data processing in individuals, with 25% of children exhibiting problems. Verbal Comprehension: 16% of students struggle with understanding the words in a text.

Morphological Awareness: Involves understanding the formation of words and manipulating their composition, with 18% of students experiencing issues. Verbal Working Memory: Pertains to reflecting, asking questions, and solving problems, where 25% of students encounter difficulties.

2.7. Importance of Learning Mathematics

Children need to start learning mathematics from the first grade, or even earlier if possible, to establish a solid foundation. Mathematics plays a significant role in many aspects of daily life, including sports, family activities, school, and everyday tasks. Early exposure to mathematical concepts helps foster collaboration, active participation, and the acquisition of new skills that children will continue to develop as they grow. For instance, a first-grade child, typically around 5 to 6 years old, should be capable of performing basic addition and subtraction, identifying geometric shapes, measuring with a ruler or tape, understanding the value of different coins, and telling time. These foundational skills are essential for their overall cognitive development and practical life applications. Figure 5 illustrates an example of teaching methods for young children. For children aged 7, the mathematics curriculum can build on the previous year's knowledge, advancing to more complex concepts. At this stage, they can work with larger numbers in addition and subtraction and begin to understand the basics of multiplication and division with smaller numbers.

Additionally, they can learn to identify angles in geometric shapes and distinguish between even and odd numbers. By the age of 8, children who have built a strong foundation in mathematics during their first two years of schooling can be further challenged. With an understanding of addition, subtraction, multiplication, and division, they will find it easier to tackle exercises involving larger numbers, typically up to 100 for multiplication and division. At this stage, students also start learning about fractions and identifying geometric shapes like rectangles. Figure 6 illustrates another teaching method suitable for 8-year-olds.

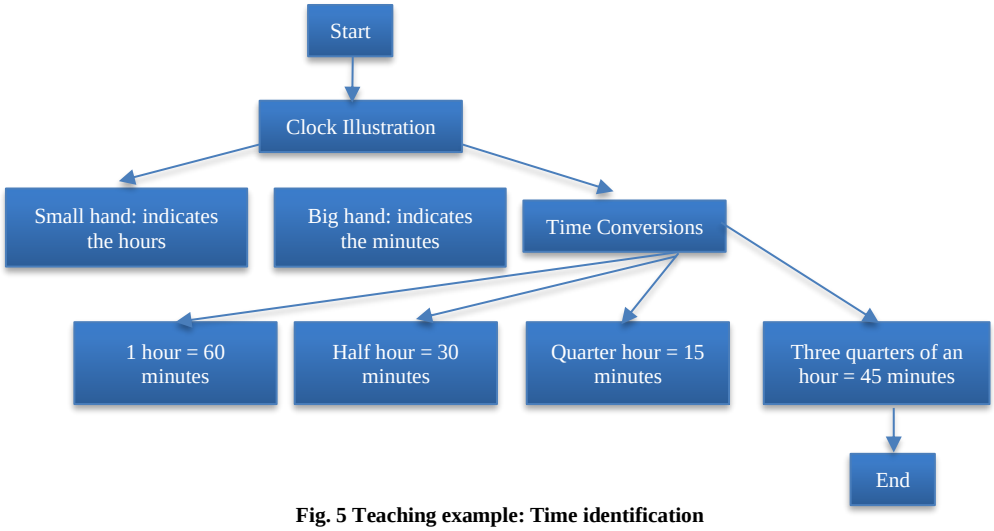

Fig. 5 Teaching example: Time identification

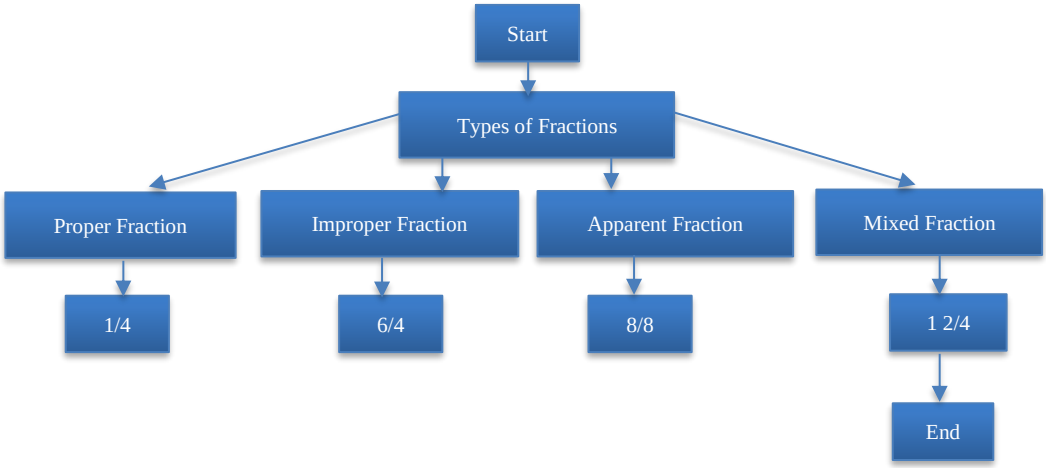

Fig. 6 Understanding fractions

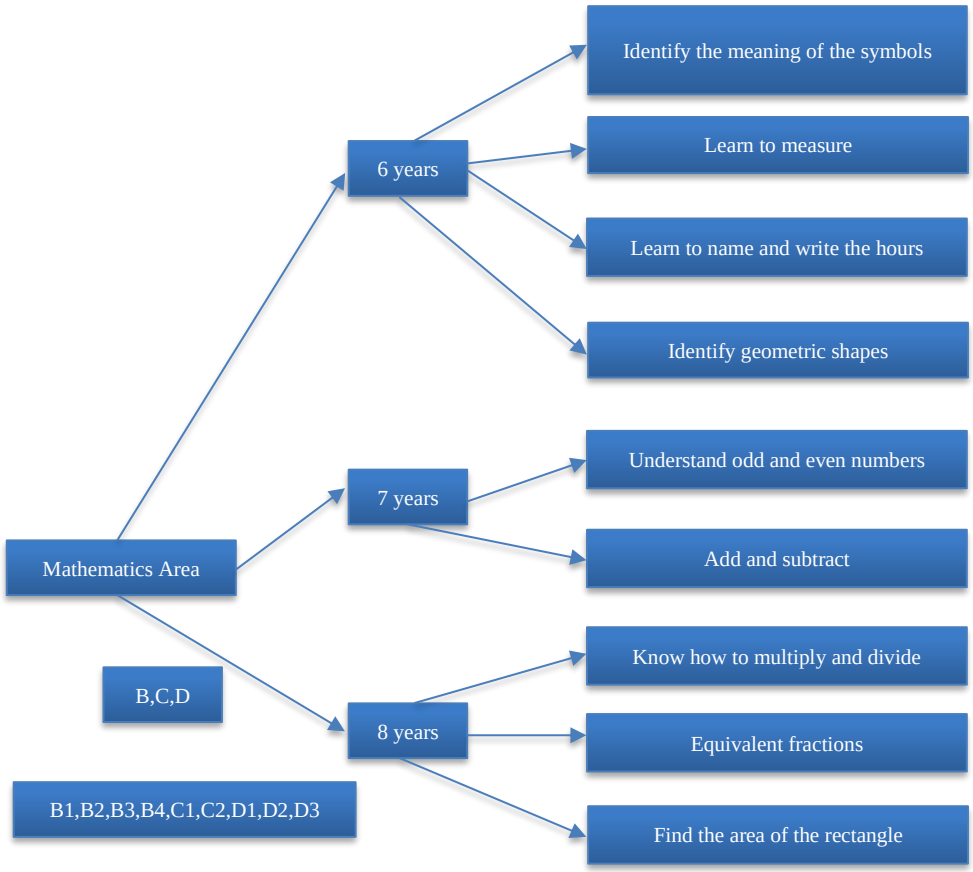

Fig. 7 Teaching framework for children aged 6 to 8 years

Finally, it is evident that at each stage of learning, strong foundational knowledge is essential for students to progress to the next level. This foundation is crucial for them to discover and develop new skills and abilities. The detailed progression through these learning levels is illustrated in Figure 7.

3. Results

3.1. Software Development

While developing the educational software, we began by creating project prototypes. These prototypes served as a guide for developing the official version, which is detailed below.

3.1.1. Login

Students will access the educational software system via a login screen where they must enter their username and password. If they do not have an account, they can register by choosing the "Create Account" option. For those who have forgotten their password, the "Forgot Password" option provides assistance to recover or reset the password. If incorrect information is entered, a notification will indicate the error. Upon successfully entering the correct credentials, students will be directed to their virtual classroom, where they can access their registered courses in mathematics and reading comprehension. The login section is shown in Figure 8.

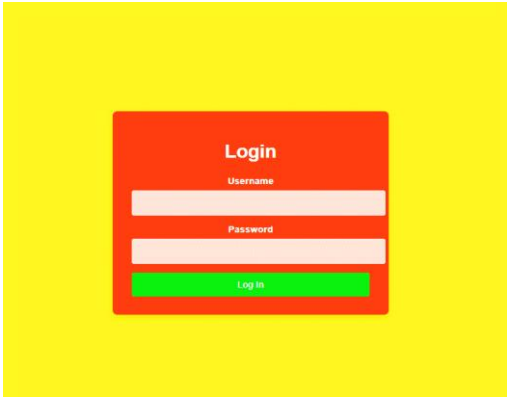

Fig. 8 Login section

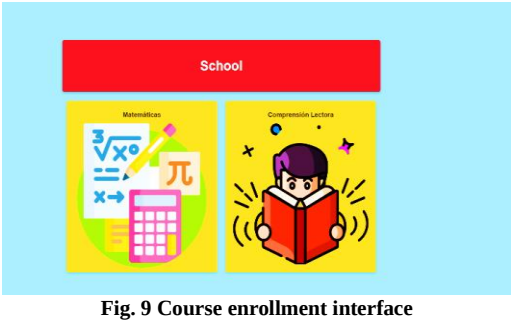

Fig. 9 Course enrollment interface

3.1.2. Courses

In this section, students access their virtual classroom by entering their login information correctly. Two icons representing the courses in which the student is enrolled will be displayed. Each course provides a variety of interactive methods and tools aimed at offering an easy and innovative learning experience. The course section is shown in Figure 9.

3.1.3. Memory Game

One of the first games implemented is a memory game called Memorama. This game allows children to identify a figure and then reveal and remember the positions of matching images. They must select pairs of identical images to discard them, continuing this process until the entire board is cleared. The game is designed to enhance children's concentration and strengthen their memory. The Memorama game can be visualized in Figure 10.

3.1.4. Sum game

In this section, we present the second educational feature of the software, which helps children learn addition. If the child answers correctly, they move on to the next problem. If the answer is incorrect, the error is marked. Additionally, if the child does not answer within the given time limit, they can restart the game using a provided button. The addition game interface is illustrated in Figure 11.

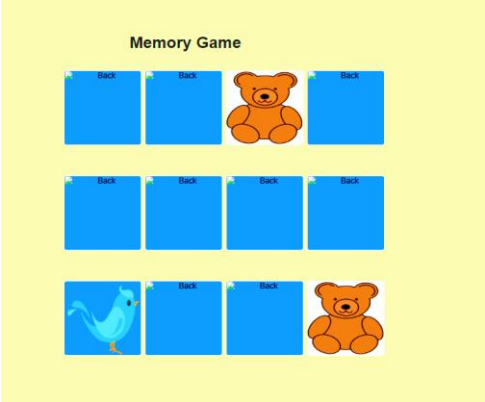

Fig. 10 Memory game interface

Fig. 11 Addition game interface

3.2. Survey

To gauge the reception of our project and gather feedback for improvement, we created a survey form. This form included various questions regarding users' opinions on the initial games, the interface, and other aspects of our project. The feedback received will help us understand user perspectives and identify areas for enhancement.

The questions from the submitted form are presented below. Figure 13 presents the first question of our questionnaire. The results show that 59.1% of respondents are male and 40.9% are female. This indicates a higher participation rate among males compared to females in the development of the questionnaire.

Figure 14 illustrates the second question of our questionnaire. The results reveal that the mother is the primary helper for the child, with 36.4% of responses indicating this. Siblings are the second most common helpers at 27.3%, followed by aunts and friends, each at 13.6%. Lastly, 9.1% of children are helped by other responsible individuals. These findings suggest that children have a greater affinity with their mothers and siblings.

This insight allows us to plan sections of the software that facilitate interaction between parents and children or develop activities that involve family members, promoting a dynamic and collaborative learning environment.

Figure 15 presents the third question of our questionnaire, which inquired about the age of the children using our software.

The results indicate that children aged 5 to 6 and 7 years old are the most interested, each accounting for 36.4% of the responses. Meanwhile, 22.7% of the users are children aged 8 and 9 years. This suggests that the age range most interested in our project is between 5 and 7 years old.

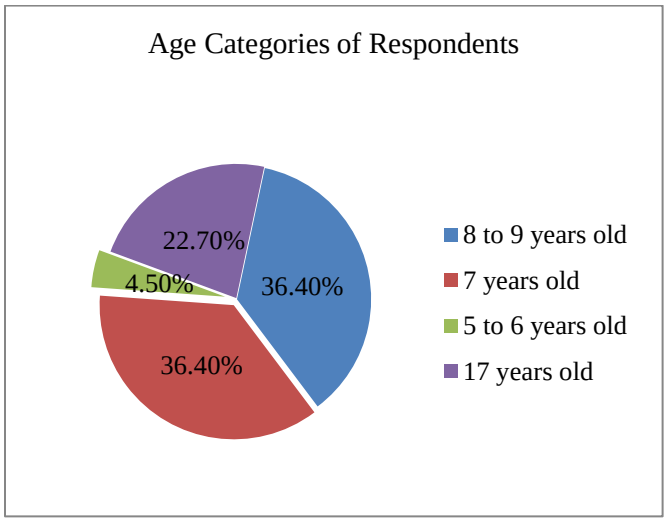

Fig. 12 Age range

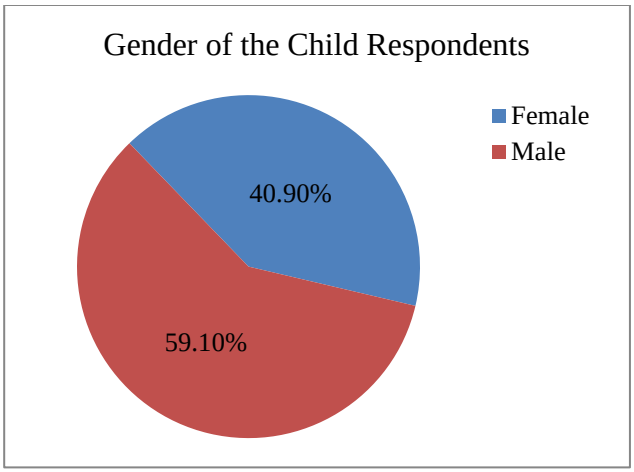

Fig. 13 Sex of the child

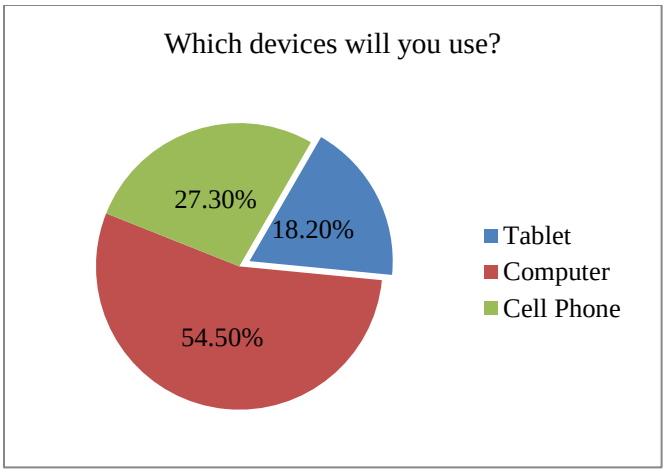

Fig. 16 Devices to be used

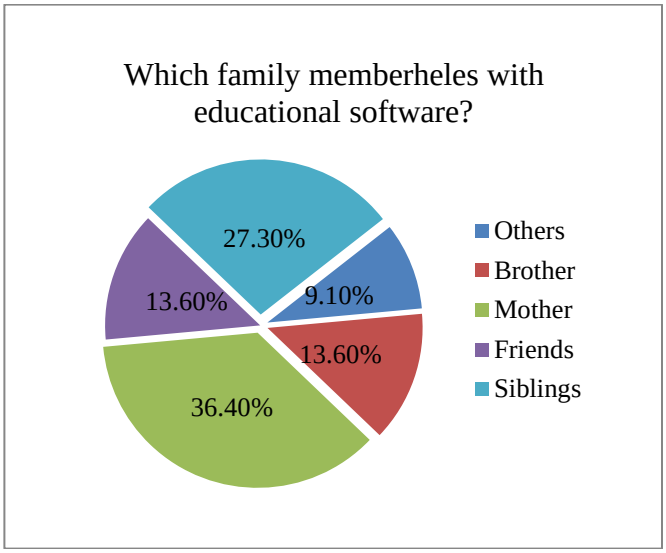

Fig. 14 Family member at the child's disposal

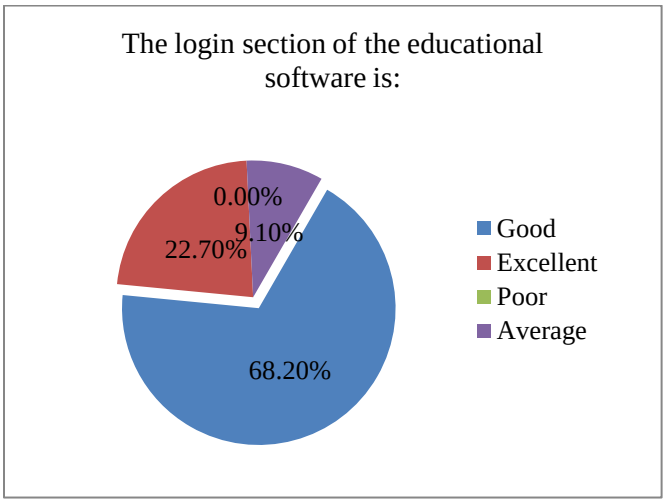

Fig. 17 User feedback on the login section of educational software

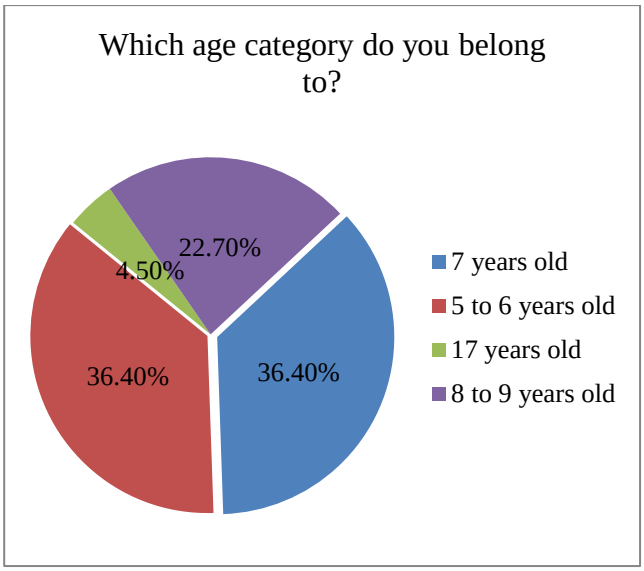

Fig. 15 Most interested age

Figure 16 presents the fourth question of our questionnaire, which identified the devices most frequently used by the children. The results show that the computer is the most commonly used device, with 54.5% of responses. The cell phone is the second most used device at 27.3%, followed by the tablet at 18.2%. This information is valuable as it helps us understand how to adapt our games and educational materials to the most frequently used devices, ensuring they function smoothly and are user-friendly across different formats. Figure 17 presents the fifth question of our questionnaire, which evaluated the users' opinions on the login section of the educational software. The results show that 68.2% of respondents thought the login section was good, 22.7% rated it as excellent, and 9.1% considered the design to be regular. These findings indicate that the design of the login section is generally well-received by children. However, the feedback from the small percentage who found the design regular should not be overlooked, and their comments should be solicited for suggestions on how to improve it to better meet their preferences.

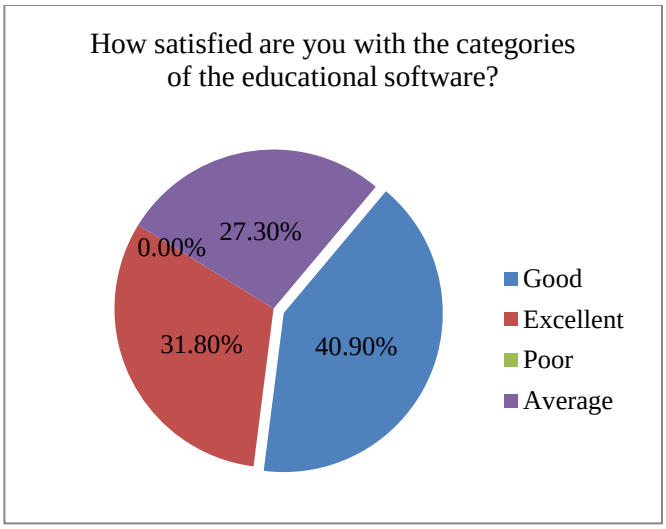

Fig. 18 User opinions on software categories

Figure 18 presents the sixth question of our questionnaire, which assessed users' opinions on the design of the software categories. The results indicate that 40.9% of respondents liked the design, 31.8% found it excellent, and 27.3% rated it as regular. These findings suggest that the current categories are satisfactory for the majority of respondents. However, the percentage that rated it as regular indicates a desire for more variety in the software categories.

This feedback highlights the need to explore and implement additional categories to enhance the software's appeal and functionality. Figure 19 presents the seventh question of our questionnaire, which reveals that 50% of respondents rated the first game of the software as very good, 40.9% thought it was excellent, and 9.1% found it to be fair. This data indicates that the majority of children enjoyed the first game implemented in the software, which is designed to help exercise their brains and improve memory. The positive feedback suggests that the game effectively engages and benefits the children.

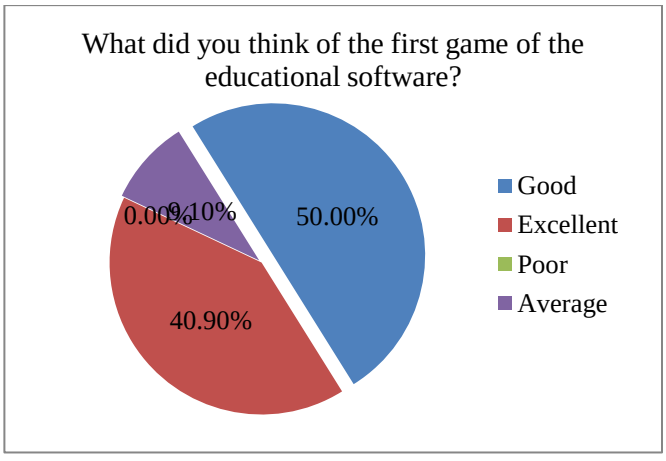

Fig. 19 User Feedback on the Memorama Game in Educational Software

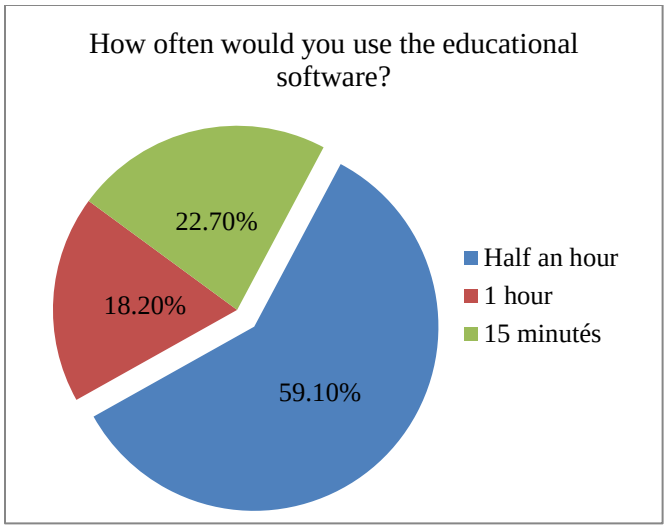

Fig. 20 Frequency of software usage

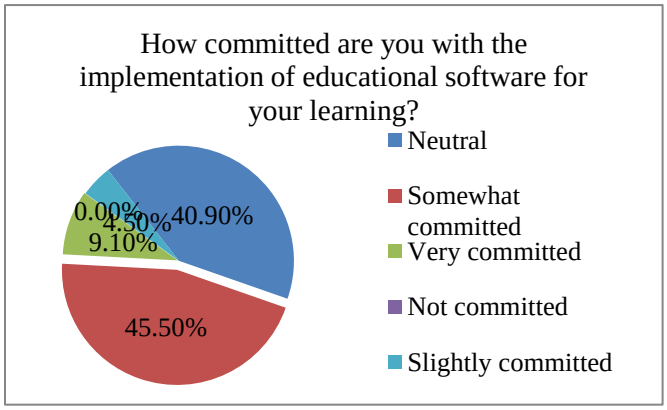

Fig. 21 Commitment to software

Figure 20 presents the eighth question, which evaluates children's interest in using educational software. The results show that 18.2% of respondents would find it engaging and use it for an hour, 22.7% would use it for around 15 minutes, and 59.1% would use it for approximately half an hour.

These findings indicate that most students are engaged with the educational software, with a significant portion willing to interact with it for at least half an hour. This suggests that the software effectively captures children's attention and provides a compelling learning experience.

Figure 21 presents the ninth question, which evaluates the children's commitment to using educational software for their learning. The results show that 45.5% of respondents feel somewhat committed, 40.9% are neutral, and 9.1% are very committed. These data indicate that over 50% of respondents have a positive interest in the software.

However, the percentage of those who are neutral or less committed suggests that there are areas of the software that may not be fully engaging. To address this, it is essential to

analyze which aspects of the software are lacking appeal and make improvements to better capture and maintain the interest of all users.

As shown in Figure 22, the tenth question reveals that 54.5% of respondents found the program easy to use, while 45.5% experienced difficulties. These results suggest potential issues with how information is distributed within the interface, the clarity of game instructions, or the comprehensibility of the learning topics.

Given that a significant percentage of respondents encountered challenges, it is essential to examine and address these areas to improve the user experience, ensuring that the software is easy to navigate and understand for all users.

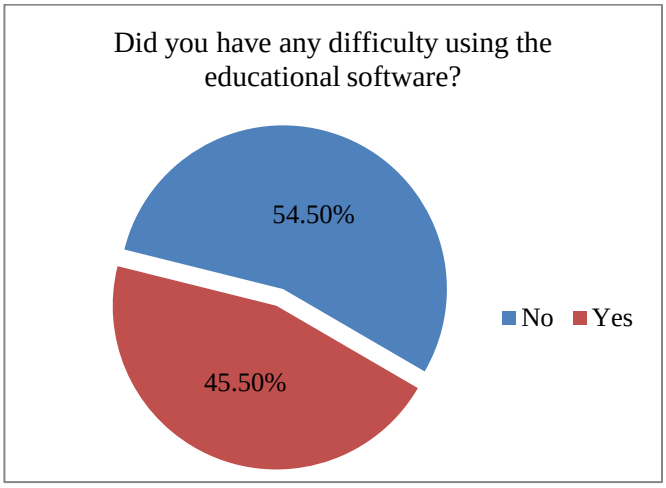

Fig. 22 Difficulty encounter

4. Discussions

During the development of this project, various observations were made by team members, which are detailed below: Initially, we recognized that, although our project has a strong foundation, it does not yet match the works of the authors we are referencing. Many planned features were excluded because they did not align with our current structure, resulting in their removal. Secondly, our present strategy is less ambitious than anticipated, as it currently targets only children aged 6 to 8 years. We plan to expand this age range to achieve a wider reach and greater engagement. Thirdly, our proposal for inclusive learning methods has not yet been implemented.

This section would be an important addition to our system, as we believe that learning should be accessible to everyone with the help of modern technologies, particularly the internet. Finally, in terms of engaging children in learning, we have begun developing prototypes of educational and captivating mini-games. However, these prototypes have not been fully integrated yet. Our educational initiative aims to draw children into learning through innovative techniques that establish a strong foundation in subjects such as mathematics and reading comprehension.

5. Conclusion

The present work successfully achieved its main objective, which was to capture the attention of young learners and motivate them to learn in diverse ways. This was accomplished through interactive games as well as traditional question-and-answer formats. By using our mini-games as a learning method, students can effectively solve problems in conventional formats.Our project was designed with the idea of providing neutral teaching for children in the early years of primary school, recognizing these years as crucial for their initial interaction with general subjects. We aimed to create a new educational method that leverages the internet to reach a broad audience. This approach is intended to build a strong foundation in essential subjects such as mathematics and reading comprehension, ensuring that children not only understand and retain knowledge but also enhance their cognitive abilities.

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