Interactive Math Explorations Using the Game-Based Application MatematiX

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Abstract: The paper proposes the application MatematiX - an application designed and developed with the main goal of helping children learn math in a simple, interactive and fun way, using the game-based approach. Today's education only emphasizes in-person interactions, with the majority of document storage taking place on online platforms. While most children spend their leisure time on the internet, only a small number of these platforms provide entertaining and educational content. It follows that the creation of the suggested learning application is required in light of these problems. MatematiX, was created specifically for this use and is a children's app that offers games and mathematical explanations that require the user to apply math. One of the numerous approaches to solving this issue is the application that is discussed in this paper.

1 INTRODUCTION

The school system is the first thing that immediately comes to mind when we discuss education. People either love it or hate it, and our willingness to work hard to learn the material that is taught in school will determine how much we learn.

The problem with this system is that not everyone is willing to spend most of their time trying to grasp a concept that was fleetingly presented to them in school, especially when we are talking about little children who have a smaller attention span than the average adult. (Asprilia et al., 2020)

Since technology permeates every aspect of our lives these days, we can't help but wonder what other fields could benefit from technological advancements. One of them might be the educational system (Liu, 2019). The technology could help enhance the less applicable and difficult to understand portions of education or just offer a more straightforward method of presenting the core ideas of any given course (Parikh et al.,).

Mathematics in particular is a science that requires previously learned concepts to understand new ones. Sometimes even the smallest problem as not remembering how two numbers are subtracted from each other can be troublesome (Papert, 2020).

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The unfortunate thing is that some children grow to despise mathematics because they are unable to fully grasp these fundamental ideas during their early school years. Furthermore, practising math is not enjoyable, which is not helpful either.

What if, however, technology could assist with that? Finding enjoyable ways to teach children fundamental mathematical concepts and engaging ways for them to practice those concepts is the main goal of this paper (Sardone and Devlin-Scherer, 2016).

In terms of the paper's organization, we have two main parts: the first part of the paper is concerned with the presentation of the current math learning context and the existing solutions and the second part of the paper is concerned with the process of developing and testing the application, MatematiX, designed for this purpose.

2 LEARNING MATHEMATICS TODAY

2.1 Mathematics Learning in Romania for 0-4 Graders

The educational system in Romania is effective, just like in any other nation, but there is an opportunity for improvement (Marius, 2018). The most persis-

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tent problem is the exclusive use of classical teaching and the lack of active teaching. Usually, the teacher talks during the lesson, and the child memorizes the teacher's words, or the methods provided to solve the tasks without really grasping the concepts (Anwar et al., 2020).

More interactive teaching strategies are needed in schools to help learners learn the material. For the child to understand the concepts and their relevance or application in everyday life, in addition to memorization, they must determine the most effective way to present them (Ariansyah and Suprianto,).

2.2 Active Learning: The Concept

Active learning is a learning method that consists of actively involving the students in the learning process (Conrad, 2018). The degree of active learning is contingent upon the extent to which students actively engage in the learning process.

This involvement can be defined as doing something more than listening to the teacher like participating in group activities, learning through play, technology-based learning, activity-based learning, group work, and project method, among others (Bonwell and Eison, 1991).

These activities share common factors encompassing key qualities and characteristics of active learning, such as thinking creatively, applying learned concepts in practice, utilizing the concepts during the learning process and explaining the concepts to others.

Active learning is the opposite of passive learning; it is learner-centered, not teacher-centered, and requires more than just listening; the active participation of each student is a necessary aspect of active learning. To develop higher-order thinking skills, students need to be actively engaged in their job while also considering why they are doing it.

In environments (Hyun et al., 2017) where active learning strategies were implemented, positive feedback was received.

2.3 Game-Based and Visualization-Based Learning

Game-based learning is an active learning method, that does not limit to creating games for students to play, it is designing learning activities that can incrementally introduce or reshape concepts. Traditional games can incorporate competition, points, incentives, and feedback loops. When designed with learning principles in mind, games can increase student motivation, engagement, and learning (Pho and Dinscore, 2016).

According to (Fridolin Sze Thou Ting and Shroff, 2016), in recent years, games have been used in traditional classroom settings to augment active learning strategies for cognitively diverse students, by providing a context for problem-solving. Game-based learning is an interactive learning methodology and instructional design strategy that integrates educational content and gaming elements, by delivering interactive, game-like formats of instruction to learners. Moreover, game-based learning integrates aspects of experiential learning and intrinsic motivation with game applications that have explicit learning goals, thereby allowing learners to engage in complex, problem-solving tasks and activities that mirror real-world, authentic situations. For example, results from a study (Snow et al., 2013), demonstrated that a computer game simulation of Newton's laws of motion was actively effective in helping non-physics students understand key concepts of force. In addition, studies have demonstrated that game-based learning may enhance student achievement in reading skills, self-efficacy and student performance (Yoon, 2014).

A significant amount of research in game-based learning has focused on examining student performance and how game-based learning is applied, in order to make the learning process more interactive and engaging for learners. For the specific subject of mathematics, game-based learning assists students to visualize graphical representations of complex mathematical concepts in a particularly engaging way (Chang et al., 2012). However, reviews of the effects of game-based learning research on student performance are typically limited to secondary school students in North America and Europe. For example, a research study (Kebritchi et al., 2010), demonstrated that 3-D games help eighth graders learn algebra more effectively, thus attaining higher scores on their tests. Moreover, various additional research studies have investigated the relationship between game-based learning and mathematics achievement and motivation.

The exploration of visualizations and animations in learning systems primarily revolves around the use of techniques that involve visual elements in educational systems. This is done to enhance and support the learning process in various ways. An animation is a dynamic visual medium produced from static drawings, models, or objects posed in a series of incremental movements that are then rapidly sequenced to give the illusion of lifelike motion.

3 INTRODUCING ACTIVE LEARNING STRATEGIES

In Romania, the teaching process is currently based mainly on face-to-face teaching, and, the online environment is mostly used as an alternative platform for storing the courses or for submitting and grading school assignments.

Although most of the teaching during the pandemic took place online, via platforms such as Microsoft Teams, Zoom, or Google Classroom, these online platforms were not used to their full potential. In the majority of schools, especially during online courses, professors typically delivered lessons by dictating and verbally explaining concepts to students. In the most favorable situations, teachers used an online whiteboard to better explain the concepts. This process was very stressful, especially for the younger children who found it difficult to follow the explanations. (Edelhauser and Lupu-Dima, 2021)

Unfortunately, the system of face-to-face learning is not so different from the one that was used during online learning. Usually, teachers have too much material and too little time to teach it, so some concepts are not as well understood or as much explained as they should be. Furthermore, sometimes the amount of homework that the children get is overwhelming even for parents.

The pandemic has taught us that dictating the explanations online is not the best kind of learning, but that does not mean that there are no ways to create a context where online learning would help the pupils and ease the learning process for both the parents and the children. (Șuteu et al., 2021)

Studies (Newton, 2011) have shown that children may not always grasp all the concepts taught in class, often requiring a method to recall and reinforce the explanations provided. Online platforms can serve as a means for revisiting these explanations in a more interactive and comprehensible manner. This approach allows students to have accessible, user-friendly access to class explanations, making the learning process more enjoyable and less challenging for them.

The best idea would be for each school to have access to a platform that is continuously developing according to the needs of the children in that school, for example, if the pupils in the third grade seem to struggle with retaining the process of subtracting larger numbers (those with more than two digits), the school would request the platform's developers an explanation or a game that would make the subtraction process easier to understand. The developers would consult with the mathematics teachers in this case and come up with the best idea to implement the required features for the platform.

The problem with this idea would be with the acceptance of the platform. Usually, parents consider online education through games or animations a myth, but fortunately, most teachers can see the beneficial use of technology in learning processes (Diana Oblinger et al., 2005). The truth is that the learning process cannot be done just through online fun, but online platforms can be of significant help.

The solution for such online platforms to have success would be for the teachers and the schools to encourage their usage and emphasize how beneficial they can be. This way the parents would be more prone to accept the usage of these platforms.

It is important to understand that online learning cannot substitute the presence of a teacher, especially when we talk about younger children, this platform would be intended to help the children review and practice concepts that they have learned in class.

4 EXISTING SOLUTIONS

This section presents solutions (applications) from other countries (2), but also solutions from Romania (3).

4.1 Solutions from Other Countries

4.1.1 Math Games by Teach Me

Math Games (see Figure 1) is a website that features educational games designed to enhance mathematical skills, accompanied by video explanations provided by teachers. The resources are for children from preschool to eighth grade. The platform offers a diverse range of well designed games for each subject. Also, there are some visual exercises that are available for some of the subjects and exercises where the children must provide the correct answer to a question. If their answer is wrong, you will receive the correct answer and a link to the video explanation of that subject, performed with images on a digital board.

Furthermore, the website offers diverse features for teachers, including access to the curriculum, worksheets, and the option to create a classroom-specific game with customized questions and answers. This feature also includes a live view of the results.

The site supplies a series of curricula from different countries and all the resources are in English.

Some of the disadvantages are: To gain full access to the resources of the site, you need to be upgraded to premium. The explanations are not that interactive

Figure 1: Math Games website.

and are a lot like the explanations from class. Another downside of this site is the fact that all the resources are in English, and even if today it is a well-known language, taught in almost every school, more children would benefit from having the resources in the mother language.

For further references see Math Games website.

4.1.2 Math Playground

Math Playground (see figure 2) is a website with math games for children created by Colleen King. The site is free, kidSAFE COPPA CERTIFIED, and the ads are controlled. The site is very well-structured and provides resources for children from kindergarten to sixth Grade.

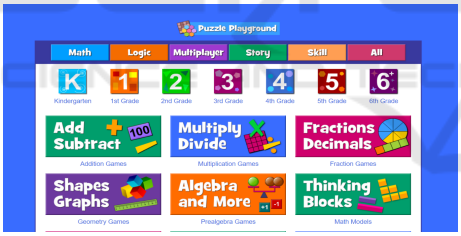

Figure 2: Math Playground website.

There are various kinds of games: games that require the solving of mathematical exercises to progress in the game, games involving logical thinking and puzzle solving that use maths indirectly through the game, and exercises like tasks. Another plus is the multiplayer games feature, which lets the children play the games in the classroom with the teacher.

Additionally, there is a related platform known as ”Puzzle Playground” (as depicted in Figure 3), which features similar games without grade-level divisions. These games, sourced from various global developers, aim to support children not only in enhancing their mathematical abilities but also in developing skills such as logic, strategy, spatial reasoning, creative thinking, pattern recognition, and problem-solving.

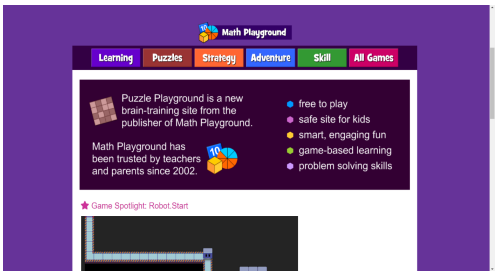

Figure 3: Math Playground website.

However, there are some drawbacks to these site, including the absence of explanations for mathematical subjects, a lack of solutions for incorrect answers in the games, and the absence of progress tracking or leader boards within the gaming interface. Also, the resources are only available in English.

For further references see Math Playground website.

4.2 Solutions Implemented in Romania

4.2.1 Mquest

mquest (see Figure 4) is a website offering virtual mathematics lessons customized for students ranging from fourth grade to eighth grade. It was developed by a series of Romanian teachers, as part of the projects of the site mindfactory. This website has the purpose of integrating new and advanced learning methods into the Romanian schooling system.

Because this site was developed by teachers, it treats all the subjects that are required in the curriculum and the video explanations are very well detailed. The videos differ from lessons taught on virtual blackboards to lessons taught on pictures from real life. Also, together with the video explanations, there is a short, written explanation of the topic along with solved problems that students can attempt and check their answers for accuracy afterward.

Figure 4: Mquest Website.

However, a drawback of the videos lies in their extended duration, they last between 5 and 15 minutes, and their limited visual appeal. Essentially, they are screen recordings of a teacher's explanation against a visual backdrop, featuring the teacher's mouse move-

ments, voice narration, and occasional visual effects such as the appearance of the numbers, or objects that are used for the explanations. In addition, there are some videos where you can only hear the teacher talking and the images of the video are just images related to the objects that the concept is explained with (i.e. if they use bottles to explain the subtraction concept, there is a video of how the bottles are created and also the teachers stops from time to time from the mathematical explanations and presents the process of producing the plastic bottles).

Some other downsides of this website: not all resources are free and besides the exercises, there are no ways of practising the learned concepts.

For further references see mquest website.

4.2.2 Websites Like Pomul or Y8

These websites contain all kinds of games, not only math or logic games. There are games developed by different authors around the world that undergo a thorough selection process before being featured on the platform.

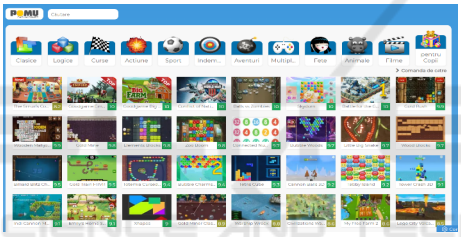

Figure 5: Pomul Website.

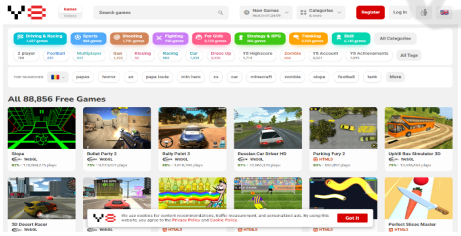

Figure 6: Y8 Website.

Unfortunately, these games do not supply correct answers for questions the child answered incorrectly within the game, nor do they provide the correct methods to solve them. Also, there are no leader-boards and the content is only available in English.

See also Y8 website and Pomul website.

4.2.3 Educational Magazines Like Edu, Terra, Media Kinder

This type of magazine includes a code that can be utilized to access resources through their app, which is available on Android or Windows platforms. The app provides interactive stories, and the child has to solve all kinds of problems using different types of knowledge in order to help the main character of the story fulfill their mission. The magazine also contains different exercises that the child can solve or various on-paper games. Some drawbacks of these magazines include the inconvenience of installing an additional app. While the games aid in developing various cognitive abilities, they may not be specifically tailored to address subject-specific needs, as they are more centered around general knowledge topics. Furthermore, these magazines are not free and not so well known.

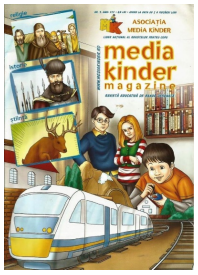

Figure 7: Media Kinder Magazine.

Figure 8: Edu Magazine.

5 TECHNOLOGIES USED FOR IMPLEMENTING THE APPLICATION

A web application would be the most suitable choice to facilitate the use of the application in schools. This approach would enable access from school computers as well as from home via PC or phone. Additionally, teachers could oversee students playing the games during class, making lessons more engaging and enjoyable.

5.1 Front-End and Back-End Technologies

The front-end part, is implemented with HTML5, Java Script and CSS, because of their compatibility

with any web browser.

HTML5 (Bengtson, 2013) is the latest version of HTML, which includes new features and improvements over the previous versions. It came with new semantic tags for better structuring of the page like canvas, section, main, footer, header, as well as increased support for multimedia and advanced graphics.

JavaScript is an interpreted high-level programming language popular for building online applications. It is a client-side scripting language, which means it runs in the user's browser rather than on the web server. Also, JavaScript is used to enhance interaction on a Web page, validate form data, create animations, and control the Document Object Model. It can also be used as a server-side language together with systems such as Node.js.

Cascading Style Sheets (CSS) (Durango and Academy, 2015) is a style sheet language that provides a wide range of styling properties that can be used for the positioning and styling of the HTML tags. The CSS styles can be applied to any element of the HTML document by declaring some properties for a unique id or to a series of elements that have the same class by declaring some properties for the class name.

For the back-end part, we chose the Microsoft C# (Capek et al., 2015a) because the C# programming language is very easy to use especially when talking about object-oriented programming. Also when it comes to tooling, there is a wide range of tools provided by the .NET framework like Entity Framework or Identity Framework. Additionally, the Microsoft framework provides a very secure and easy-to-use authorization and authentication process.

5.2 Application Architecture

The application follows the classic Server-side web application architecture (see Figure 9). It is divided into two parts: the Client-side, to which we'll refer as the front-end, and the Server-side, to which we'll refer as the back-end. The communication between the two layers is made through HTTP requests.

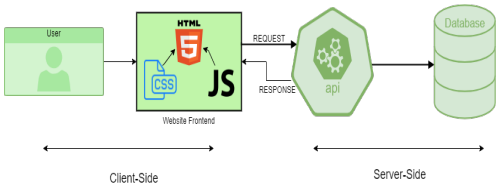

Figure 9: Application Architecture.

The Server-side consists of a RESTful API (Capek et al., 2015b), Representational State Transfer, that is implemented using C# and Swagger. It is responsible for handling business logic, communicating with the database, and processing and returning responses for the requests made by the Client-side.

6 THE DEVELOPED APPLICATION: MatematiX

This section presents the implementation of Matematix, an application for online practice and review of mathematical topics covered in class using animations and games. Since it is a web application, students from all over the country could access it and benefit from the learning environment.

Since this solution was implemented for children in Romania, as we have mentioned, the resources are only available in Romanian language.

6.1 Registration and Login

The interface of the application is designed to be interactive and child-friendly. To access the application, the user must have an account. If the user does not have an account, they can go to the registration page and register in the application. The information of the account must be filled-in the login page ((see Figure 10) to have access to the resources of the application.

Figure 10: Login Page.

6.2 The Main Page

After the login is successful, the user is redirected to the main page (see Figure 11) of the application. The menu has a few options. It can take the user to the main page or to the `My account` page. The main page presents the different games and explanations available for the children, along with a picture and a small description of each option.

6.3 The "Subtraction" Page[1]

This page is an animated version of the subtraction process (see Figure 12). When the user arrives on the page, he is given a set of instructions. To start the

[1] scăderea

Figure 11: Main Page.

animation, the user must select from the drop-down menu the number of digits the minuend should have; it can have between 1 and 4 digits.

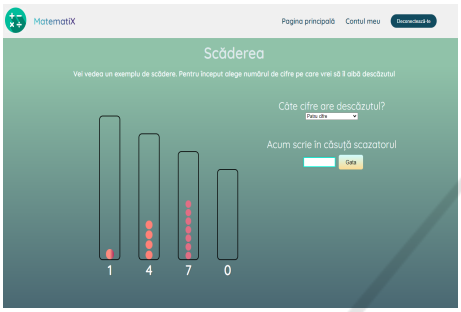

Figure 12: The page before the animation starts.

After the minuend is selected, a number appears on the screen with the number of digits in the minuend, and a bottle appears above each digit of the minuend, containing as many globes as the digit below the bottle. Also, a new input field is made visible for the user to enter the subtrahend he wants to be used for the animation (see Figure 13).

The user must write a number in the field and press the ”Gata[2]” button. If the subtrahend specified by the user is not less than the minuend, the user is informed by a warning, and the subtrahend input field is cleared. If the subtrahend is appropriate, a new button with the text ”Află rezultatul[3]” will be provided to the user, and the subtrahend’s digits are also added under the corresponding bottles. When the user clicks on this button, the animation starts.

The animation consists of the movement of the numbers and the globes for each digit of the minuend. The globes move from one bottle to another when a carry is required, and the numbers under the bottles change according to the carry. At each step, the number resulting from the subtraction of the digits slides up under the bottle, and a series of globes from the bottle corresponding to the digits of the subtrahend light up in an interactive manner. At the end of the animation, the number under the bottles is the result of the subtraction

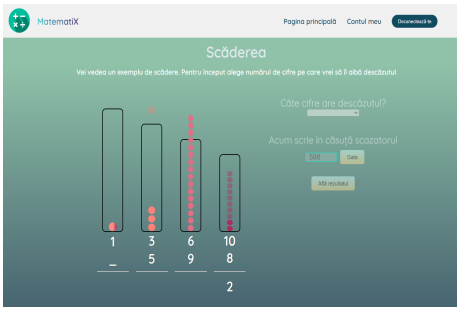

Figure 13: ”The page during the animation.

While the animation is running, the drop-down box for the minuend, the input for the subtrahend, and all buttons are unavailable to the user. After the animation is finished, the user is able to select a new number of digits for the minuend and the process can start again.

6.4 The ”Speedtest” Page

The first game that the application offers is called SpeedTest (see Figure 14). This game is designed to help the user practice basic mathematical operations, taking into consideration the order of operations and develop the ability to solve equations faster. When the

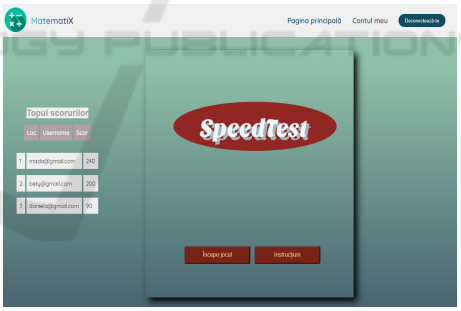

Figure 14: SpeedTest game cover.

user accesses the page, the game’s cover image is displayed along with a panel showing the game’s highest scores. To start the game, the user must click on the ”Începe jocul[4]” button. The user can also see the instructions for the game through the ”Instrucțiuni[5]” button. After the game’s play button is pressed, the game board appears on the screen (see Figure 15). At the top of the game board is a mathematical equation; on the right side of the equation is an equals sign, and after the equals sign is the score, which increases depending on the player’s moves. There are 3 figures

[2] done
[3] find the result
[4] start the game
[5] instructions

on the game board: one player and two monsters. The player must collect as many coins as the result of the equation indicates, avoiding the monsters. When he thinks he has collected all the necessary coins, he must press the ”Gata[6]” button.

If the player bumps into one of the monsters, the game ends and the message ”Ai pierdut[7] :(” is displayed on the screen. If the player collects too many or too few coins, the message ”Rezultat greșit[8]” appears. If the player collects the right number of coins, the message ”Ai câștigat[9]!” is shown on the screen.

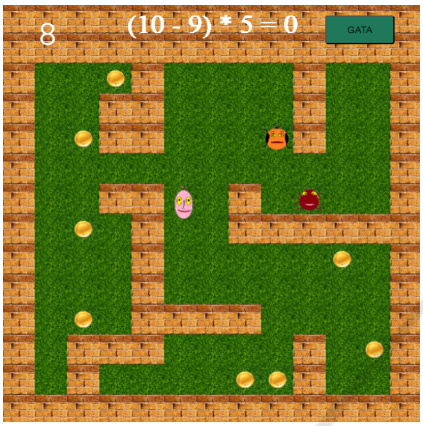

Figure 15: Game playing.

Figure 16: Wrong answer.

When the user provides the wrong answer for the equation, the correct method for solving the equation is displayed on the screen. After the end of the game, the user can click the restart button and start the game again (see Figure 16).

6.5 The “Division” Page[10]

This page has the purpose of explaining the division process for the better understanding of the children. When the user first accesses the page, there is a brief description of what will happen. The user must select how many digits the dividend and divisor have. The interface does not allow the user to select more digits for the divisor than for the dividend.

Figure 17: Digits choosing.

After successfully selecting the number of digits of the dividend and the divisor (see Figure 17), another button appears with the text ”Vezi calculul[11]”. When the user clicks on this button, the screen displays the “shell” of a division operation with 2 numbers, the dividend and the divisor in the classical positions.

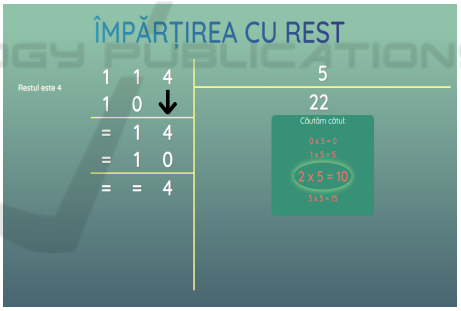

Figure 18: Final division result.

The division begins, and the screen displays the process of finding the quotient and the memory, with several animations of the numbers and text boxes on the side explaining the thought process behind the operations performed.

When the division process is complete the user can see the quotient and the reminder that resulted from the division process (see Figure 18).

[6] done
[7] you lost
[8] wrong answer
[9] you won

[10] împărțirea Cu Rest
[11] see the computatioms

6.6 The Compare the Numbers“” Page[12]

The game on this page is designed to help children improve their comparison skills. The goal of the game is to score as many points as possible by comparing numbers correctly. The game concept is based on the Whack A Mole game.

On the left side of the page, same as for the SpeedTest game, the user can see a table with the high scores for this game. There are two buttons available for the user: the “Instrucțiuni[13]” button and the ”Start” button. If the user clicks on the first button, the instructions for the game are displayed . To start the game, the user must click on the ”Start” button.

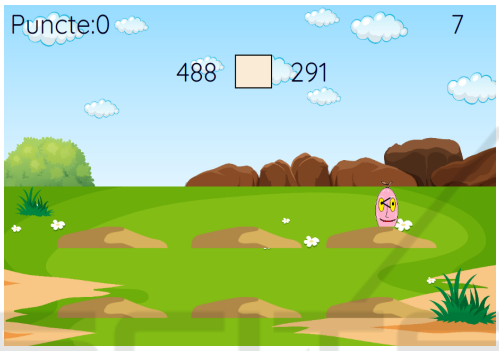

Figure 19: Game playing.

The game consists of two numbers with an empty box between them and several number comparison signs (see Figure 19). After clicking the Play button, the player must correctly click the character with the sign that defines the relationship between the two numbers on the screen. After a character is clicked, another equation is displayed, and so on until the counter ends.

There are two possible outcomes: if the user had all the answers correct, the score is doubled(see Figure 20). If there were some mistakes, the wrong comparisons are displayed on the screen along with the right relational sign between them (see Figure 21).

At the end of the game, a ”Restart” button is also displayed on the screen so that the user can play again.

7 RESULTS VALIDATION

After the application was finished we thought about the best method to test and validate our application, we needed a sample of possible “clients” for our application and a method to see the impact that the application would have in the educational domain, more specifically, in the mathematics domain.

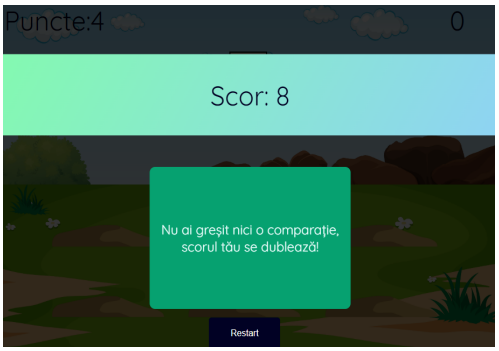

Figure 20: No errors.

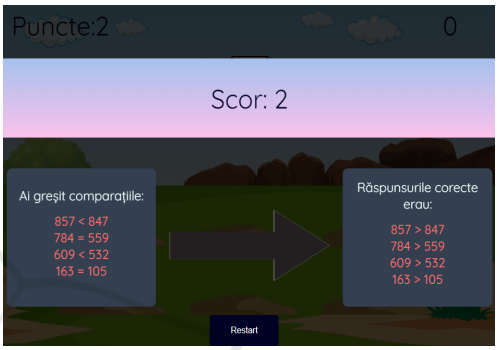

Figure 21: Computation errors.

Because we needed to see how first to forth grade children would interact with the application we thought that the best idea would be to test our application inside of a school, given the fact that the application is meant to be used at school, or, at home, in order to practice the concepts learned in school.

We talked with a school from Alba Iulia, a city located in the centre of Romania, the school is named “Ion Agârbiceanu”. In this school we went to 4 different classes, a second grade, a fourth grade and two third grade classes. In total around 80 children tested the application.

8 THE PROCESS OF TESTING THE APPLICATION WITH THE PUPILS

For each of the four classes that took part in the experiment, we divided the process in three phases. In the first phase, we would project the application on the class projector and show the explanations to the children while letting them provide the required input. We would repeat this process a few times.

[12] compară Numerele
[13] instuctions

In the second phase of the experiment, we used two laptops. The children would go one at a time to either laptop and test the games and the navigation process from one page to another. We would supervise the children and help them if they got stuck in the application.

In the last phase, the children had to answer five questions about the application to describe their experience. The questions were asked by a human resources student to ensure that the developer of the application did not influence this process. We wanted the children to understand our questions and provide honest feedback, that's why we decided it was best to discuss with them, not just give them a questionnaire to fill out.

The questions that we used are the following:

- How much did you like the application (how it looked, what activities could you do with it)
- Did you navigate easy from one web page to another?
- What did you learn?
- What would you change/add to the application?
- What mathematical operation do you think is the hardest? (this question was designed to get their opinion on the current operations implemented in the application and also to provide some future insights, on other operations that could be approached)

During these three phases, we asked the teachers to supervise the children and give their opinion on how well the application treated the mathematical subjects and what they thought about the children's interaction with the application.

8.1 Processing the Results and Drawing Conclusions

At the end of the experiment, all the answers received were introduced in an Excel document, and processed further. The processing consisted of generalizing the responses for instance if the answer was "I liked it a lot" or "I found it very interesting" we classified them as "I liked the application very much". Or if there were two answers "I learn how to compute faster" and "I learned how to compute easier" we generalized them to "I learn how to compute better",

All the computations for the number of answers of a certain kind, or, the percentage in which one kind of answer was found in the responses, were done using Excel formulas and graphs.

The answers to the first question "How much did you like the application" were classified in one of the four categories for each grade: Very much, Much, Not much, Not interested. After this, we generated a diagram based on the answers (see Figure 22).

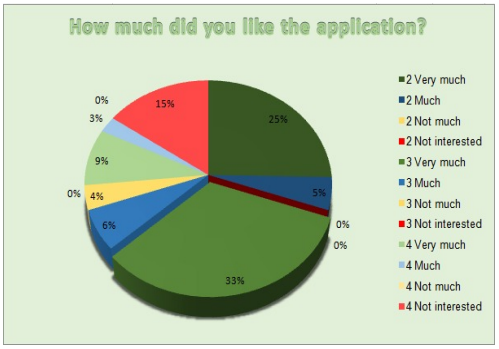

Figure 22: Diagram for the first question.

For the first 2 grades (second and third) almost all the answers were in the "Very much" category. Some of the fourth graders (15 %) were not interested in the application but the rest of them said they liked it.

The answers to the second question, "Did you navigate easy from one web page to another?" were mostly positive (see Figure 23), 86% of the children said that they did manage to navigate easily. These answers did not need any processing because they were only answers of: Yes, No, Kind of.

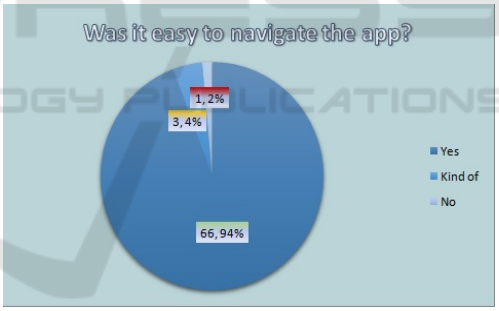

Figure 23: Diagram for the second question.

For the third question, "What did you learn", the children said that the application helped them make computations faster, think faster and compare the numbers more easily. Some of them said that they managed to work better with mathematical operations that were harder for them before.

Here we also divided the answers in some categories and counted them, in order to determine what was the main subject that the application has helped the children with.

When asked what they would change or add to the application, half of the children said that they would not change anything, the majority of the remaining ones provided pretty interesting ideas that really could be implemented in the future, even ideas for new

games. Some of them wanted more games or more time for some of the games or did not like something about the interface.

For this question, we counted the answers that said that they wanted no change. After that, we analysed the rest of the answers to conclude the main issues of the application and the improvements that should be made.

Processing the answers to the last question was pretty straightforward, we divided the answers into four different categories: Division, Comparisons of numbers, Operations with parenthesis, Multiplication, Subtraction, None. After that, we counted for each grade the instances of each type of answer and the generated diagrams based on them.

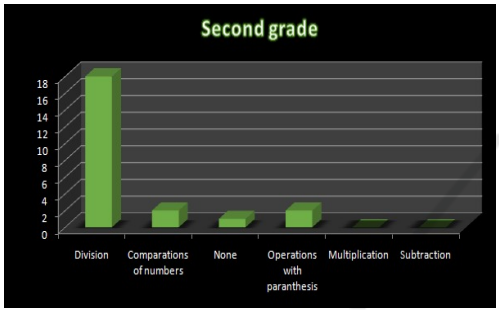

Figure 24: Hardest operation for second grade children.

The hardest operations were: Division for second (see Figure 24) and third grade (see Figure 25) and no operation for the fourth grade. This answer was as expected, we chose to implement games and explanations for the division because of the level of difficulty the children usually think this operation has. Also it is only taught in third grade so it was expected that the second and third graders will find it hard.

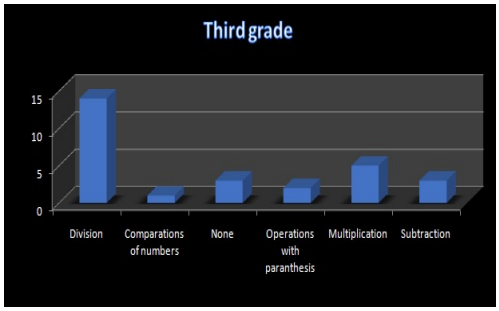

Figure 25: Hardest operation for third grade children.

9 CONCLUSIONS AND FUTURE WORK DIRECTIONS

This paper aimed to determine whether online platforms can be used as a learning environment for Mathematics and to develop o method of using the technology for the learning process's theoretical and practical aspects.

In the first part of the paper, we focused on the current learning environment, and a definition for the active learning strategy was provided. Going forward, we described how this strategy can be implemented and used with the help of technology. We also presented some existing solutions today.

The second part of the paper focused on finding the best technologies for implementing an application that would best suit our needs. Then we presented the features and the implementation of Matematix, an application with games and visual explanations designed to help elementary school children in the process of learning maths.

In the last part of this paper, we focused on testing the solution we developed and processing the obtained results.

During the testing phase, the children said they wanted more games of this kind, they were eager to play the games and wanted to play again after they tried them. This means that this kind of application could also provide an alternative to the amount of time that children spend using the internet to access other resources that are not beneficial for them.

Another aspect worth mentioning is that the teachers were also excited about the application and considered it a very good way of practising mathematics. This means that most of the parents that maybe would refuse the application at first, could be encouraged to accept it because the teachers can tell them about how it helps the children's learning process.

In conclusion, because of the mainly positive responses received while testing the application, we can say that our approach can be a very efficient method for helping children practice math and there are more unexplored resources and other useful methods of implementing active learning strategies that could be used in the academic environment.

Similar to any other product, our application can continuously undergo improvements. There are certain aspects that could be enhanced and expanded upon, such as the explanation of the division. To make the games more engaging and difficult for the children, they could have more than one level.

Also, there are a lot more mathematical subjects that could be used as a base for the implementation of other games or explanations. The application could be extended for more mature children or even for other teaching subjects like History, English, Geography, among others.

A feature that could be implemented in order to help the teachers understand what part of a particu-

lar subject is troublesome for the children, would be the reports generated based on the child's activity and game scores. If the teacher could have an overview inside the application of the progress of each child, and the mistakes they make, as well as some statistics provided by the application on the general level of knowledge of children in a class, they would understand better how they need to approach each topic, and what to insist on.

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