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GAME-BASED LEARNING IN MATHEMATICS FOR PUPILS AND TEACHERS

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Abstract: **Computer games are utilized as teaching aids in a method known as "game-based learning." Enhancing teaching abilities, evaluating learners, tracking progress, and offering learning support are among the learning objectives. The Self-Determination Theory is employed in the study to evaluate the uptake of web apps. 41 fifth-grade pupils who were enrolled in the study completed a 5-point Likert scale questionnaire. These participants used a game-based learning platform. The results show that most participants embraced and adjusted to the game-based learning methodology. The outcomes show that fifth-grade pupils benefit and are positively impacted by this method.**

Keywords: **game-based learning, learning management system, self-determination theory**

I. INTRODUCTION

A learning strategy known as "game-based learning" makes use of educational computer games for learning objectives such teacher improvement, learner assessment, and evaluation. Furthermore, the increasing acceptance and utilization of digital games is a result of their expanding popularity. Additionally, research on digital game-based learning has growing interest in light of technological advancements in recent years (Chen et al., 2021). Furthermore, a web program called game-based learning seeks to improve cognitive ability while acting as a substitute for traditional teaching methods.

Pupils' mathematical performance is one of the main issues in mathematics education (Rameli et al., 2016).

onetheless, many students think that one of the most difficult core disciplines to master is mathematics. This pessimistic notion could be caused by a number of factors that make it difficult for them to study arithmetic. Also, the quick changes in education have a big impact on students. system and mode of distribution. Students must learn more efficiently and independently in this circumstance (Winters et al., 2008). Furthermore, not doing so will affect students' motivation to learn and may eventually cause them to lose interest in learning. In addition, students struggle with mathematics because they are not engaged in the subject matter. Furthermore, actions that are connected to academic inspiration such as the drive to complete challenging assignments and persevere through trying circumstances will determine students' capacity to handle the difficulties of regular school life (Masaali, 2007).

Nonetheless, to address the issue on the preceding statements, a game-based learning application is a web application that help pupil learn in an innovative way, and also to enhance their cognitive skills in mathematics. Furthermore, according to Haase and Hanel (2022) games in digital settings can enhance pupils' creative performances. To address the issue of having a hard time of learning mathematics. The application itself has a playable game that let pupils have fun in answering the question and also claim real life rewards base on the what the teachers add on reward menu. Moreover, it has been proposed that games can promote more effective learning by fostering a more enjoyable, captivating, and learner-centered environment (Prensky, 2001).

Game-based learning application uses gaming dynamics to promote learning and interest students. Furthermore, there isn't an SMS notification feature in the present game-based learning program. Additionally, when used properly, technology assisted learning techniques can have a big influence (Ferdig et al. 2020). Moreover, one method for enhancing and augmenting 18 education is game-based learning. The elements of digital education that are most commonly used are challenges, leaderboards, levels, badges, points, and feedback (Khaldi et al., 2023). Additionally, this study presents a novel approach to motivate students to finish assignments, enhance their cognitive skills, and provide them with a reminder via SMS. Additionally, the educator will employ the game-based learning tool as a creative exercise.

Figure 1 below shows the application for game-based learning has three entities that are directly linked to the system: the teacher, pupil, and administrator.

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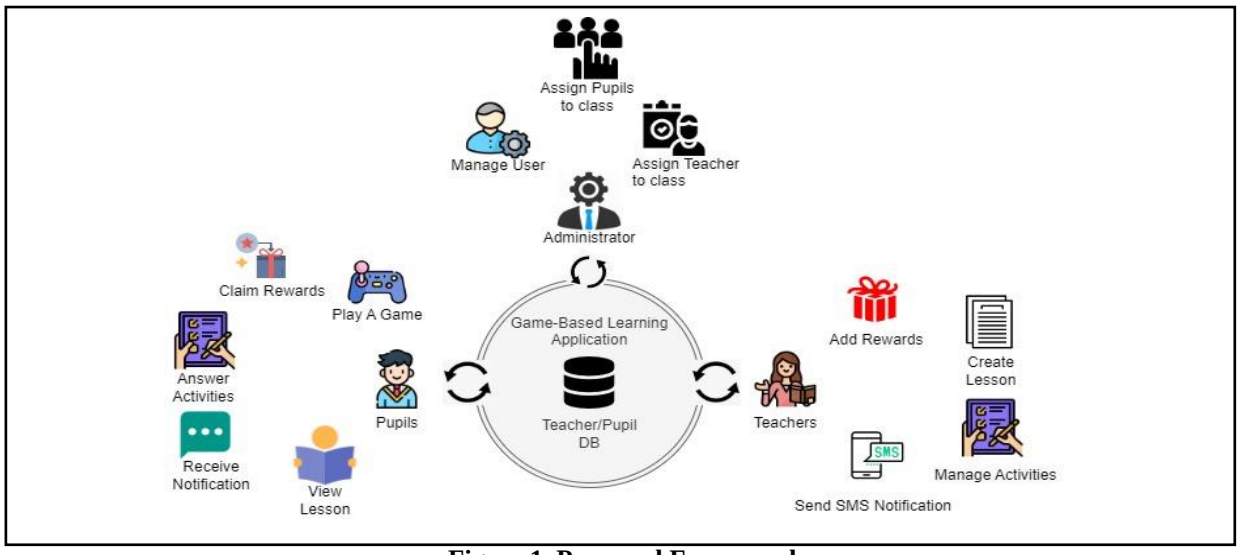

Figure 1. Proposed Framework

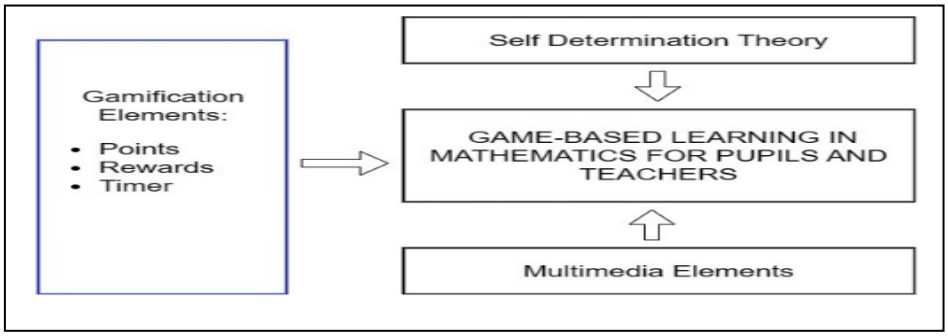

Figure 2. Game-based Learning in Mathematics Diagram

Figure 2 illustrates how this design was made to direct the creation of game-based mathematics education for both teachers and pupils. Furthermore, the use of gamification, multimedia, and self-determination theory components aims to enhance the efficacy of instruction for grade 5 pupils. Challenge, timing, prizes, and points are the remaining four gamification elements. According to Uysal and Yildirim (2016), the theory identifies three basic psychological requirements that must be met in order for wellbeing and makes a distinction between intrinsic and extrinsic motivation. Additionally, the researchers employed competence and autonomy, which are two of the three essential psychological requirements for overall health.

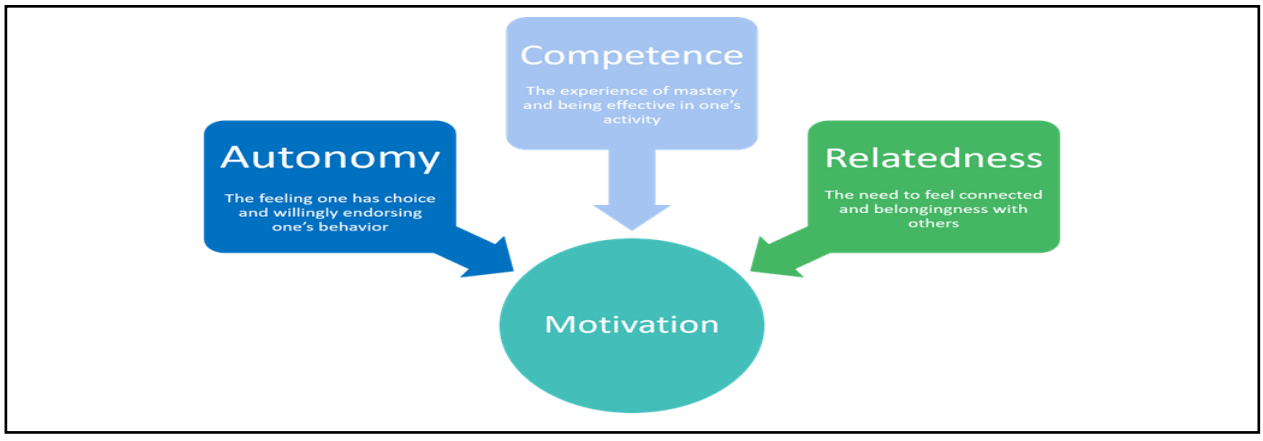

Figure 3. Self Determination Theory Diagram

A web application called "Game-based Learning in Mathematics for Pupils and Teachers" attempts to improve students' cognitive math skills while they play games. The games will also provide us with an alternative to worksheets and assignments. As a result, the self-determination theory (SDT) will serve as our theoretical foundation for understanding students' motivation. Comprising a number of mini-theories, the self-determination theory (SDT) aims to explain motivation-based occurrences. According to Ryan and Deci (2002), it consists of three primary components: relatedness, competence, and autonomy. These aspects foster an environment that encourages individuals to follow their passions and take on new challenges. Since Digital Game Based Learning (DGBL) can meet each of these fundamental demands, this idea guides the research (Ryan et al., 2006).

II. LITERATURE REVIEW

The studies and literature in this chapter provided background and theory relevant to the proposed study. One educational innovation that has garnered a lot of attention is game-based learning. Research indicates that students who employ game-based learning yield superior learning results, and games can improve students' attitudes, engagement, and comprehension of rational numbers. Haase and Hanel (2022) assert that playing games in a digital environment can improve students' creative output. Additionally, gaming can develop a creative and problem-solving attitude that is attentive, adaptable, and broad-associative. Nonetheless, challenging arithmetic issues sometimes hinder subsequent creative performance. Consequently, engaging in quick games with others—during brief breaks, for example—might be a helpful tactic to enhance creative performance. When creating digital learning environments, these interactions need to be taken into account.

The Android-based learning tool KOKA is an online math game that emphasizes congruence and similarity (Oohar et al., 2021). Furthermore, the most significant discovery of this research is how youngsters who utilize learning games based on Android smartphones develop a passion for mathematics. After engaging with the games and gaining knowledge of the subject, children who had previously considered mathematics to be a terrifying subject have changed their thoughts.

In the study of Murray (2001), online mathematics games are only useful when they are used to stimulate learners' thought processes and assist them in drawing connections between concrete examples and abstract mathematical concepts. Therefore, online math games must successfully navigate the challenging terrain of piquing learners' early interest without becoming addictive or impairing academic achievement (Paraskeva et al.,2010). On the other side, by playing games where they learn things without realizing it, kids can increase their cognitive abilities through playing online math games. However, the problem can be solved by including components that restrict playtime and require pupils to work cooperatively on an outside educational assignment before returning to play (Marange and Adernoff, 2021). As an alternative, a creative and engaging homework activities might be built upon the online math game itself.

2.2 Gamification

These days, gamification is becoming more and more common and is being applied in many other sectors, such as business, healthcare, and education. Furthermore, the main factor propelling the implementation of gamification has been the reward component. Furthermore, gamification has been utilized, particularly in the educational sector, to inspire and encourage 1 33 pupils participation. However, the idea of using game aspects to engage and motivate students to study is known as gamification. In other words, students' lives now regularly involve games. In this case, it has been suggested that games can encourage a more pleasurable, fascinating, and learner-centered atmosphere, which can lead to more effective learning (Prensky, 2001). According to Isaías and Rebelo (2020) gamification and engagement aspects are present on the majority of the chosen e-learning websites. The experts felt that the more widely used tools were the mose successful. However, it also showed that increasing gamification and engagement features has a favorable effect on involvement advancement, which may enhance the efficacy of e-learning. In designing gamified E-learning, designers should focus on what game features should be used in lower grades. This should be determined when designing gamification. In digital higher education, the most frequently utilized components include 18 points, badges, leader-boards, levels, feedback, and challenges (khaldi et al.,2023). However, this only applies to a higher level since grade 1 tends to have different views on what they want, so adding a lot of game elements in grade 1 is not good since they are ignored. It is a wise decision to use no more than six game elements to entice kids to learn and participate in online activities. In general, the gamification of online education has the potential to completely transform how students approach their studies. Through gamification and math games, they will enjoy and enhance their interaction throughout online learning.

2.3 Self-Determination Theory

Self-determination theory, according to Ryan et al. (1997), is an approach to human motivation and personality that blends conventional empirical techniques with an organismic meta theory emphasizing the significance of individuals' inherent internal resources for behavioral growth and regulation. The self-determination theory is referred to as meta theory since it incorporates other theories and offers a thorough comprehension of human motivation and behavior (Legault, 2017). Furthermore, self-

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determination theory highlights the relationship between intrinsic and specific extrinsic incentives and situational reactions in a range of contexts, such as personality, social and cognitive development, and situational reactions (Legault, 2017).

III. MATERIALS AND METHODS/METHODOLOGY

The researcher used the following methods and procedures to support the design and construction of the proposed system.

3.1 Research Design

In this part, the software development life cycle paradigm used by the researcher will be the Agile Model. This approach aligns with the researcher's objective of developing an application that uses games to teach mathematics. The Agile model is a deliberate, incremental software development process that prioritizes client feedback, flexibility, and teamwork. These prototypes underwent iterative testing, development, and improvement until the ultimate, fully working version was achieved. Throughout the development cycle, the researcher can effectively and adaptably modify their needs analysis and collecting thanks to this repeated process.

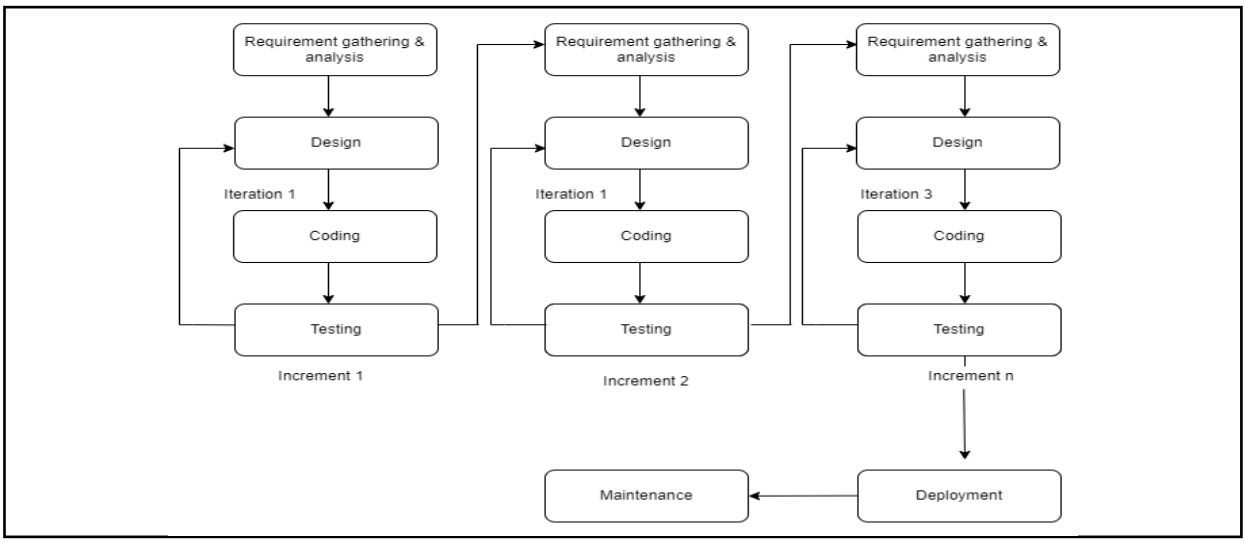

Figure 4. Agile Model

In this part, the software development life cycle paradigm used by the researcher will be the Agile Model. This approach aligns with the researcher's objective of developing an application that uses games to teach mathematics. The Agile model is a deliberate, incremental software development process that prioritizes client feedback, flexibility, and teamwork. These prototypes underwent iterative testing, development, and improvement until the ultimate, fully working version was achieved. Throughout the development cycle, the researcher can effectively and adaptably modify their needs analysis and collecting thanks to this repeated process.

1. This phase consists of Requirements Gathering and analysis. This phase produces a requirement specification document which includes all possible system requirements.
2. Phase 2 — Design: During this stage, the system design is created and the necessary specifications from the previous step are examined. This system design facilitates the creation of the high-level architecture for your entire system as well as the definition of hardware and software needs. .
3. Task: Coding (done according to the team's definition of Done) It sounds pretty awful: designers and programmers are already working on their projects. And it is the job of designers and programmers to deliver a working product in the shortest time possible. As a result, the application will have very little functionality since it is built incrementally.
4. Testing: In this stage, the Quality control staff tests whether or not the product works properly and searches for errors.
5. Maintenance: That's right, yet another one of the key elements for this paradigm. At this point, the project has been updated and any mistakes or errors have been corrected. and subsequent software components are created based on feedback to close the project.

3.3 Physical Environment and Resources

This section presented the Game-Based E-learning system hardware and software specifications.

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Hardware

Computers/Laptops: Systems that store and process data, typically in binary form, according to commands from a program.

- Hard Disk 2 GB: A part of a computer that controls where data is stored, reads it, and writes it. It is the main storage medium.
- RAM 2GB: Random-access memory is where the processor stores temporary data.
- Software Requirements
- PHP: An HTML-embedded open-source scripting language that is perfect for web development
- C: A popular, flexible, and machine-independent programming language used for writing various applications.
- MySQL: A database management system for data storage.
- Windows 10/11: Major releases of Microsoft's Windows NT operating system, necessary for running the software.
- Android: An operating system required to deploy the game-based learning application, enabling seamless operation with device hardware and capabilities.
- XAMPP: A lightweight Apache distribution for creating a local web server for testing and deployment.
- Visual Studio: A tool for writing both native and managed code supported by Microsoft platforms.
- Python: Used to create the mobile application interface.
- HTML/CSS: HTML structures web pages, while CSS manages their visual design.
- Laravel: A cross-platform PHP framework for building web applications.
- JavaScript: A scripting language for developing application behavior.

3.4 Tools and Techniques to be Used in the Study

This study examines numerous software diagrams, including Use Case Diagram, Data Flow Diagram, Entity-Relationship Diagram, and Context Diagram.

Use Case Diagram

A use case diagram shows the interactions between the actors and the use cases. Use cases are the tasks that the module needs to accomplish. Performers may be an external system or the system's ultimate user.

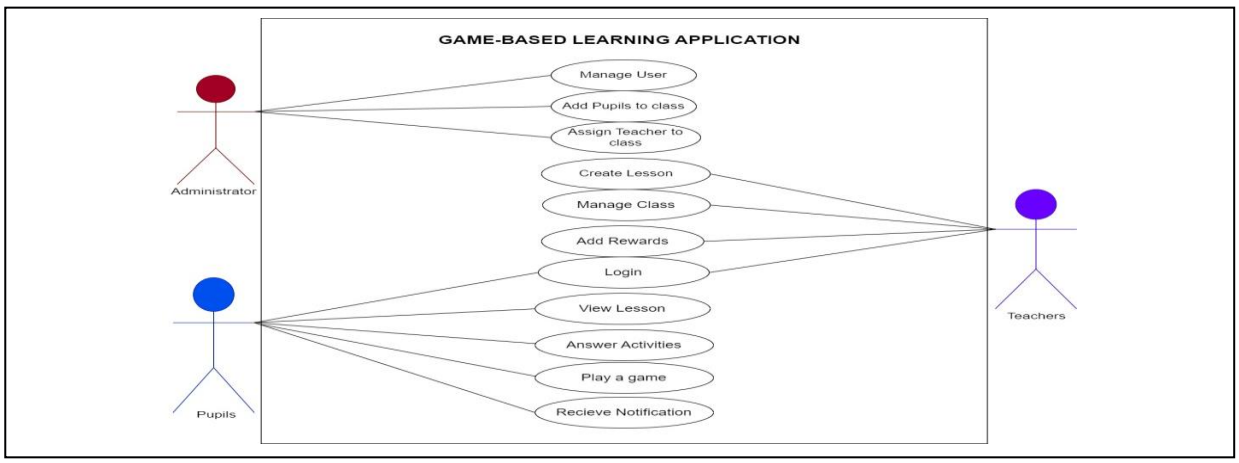

Figure 5. Use Case Diagram

The figure shows how the users view and manage the game-based application. Where admin can register users and approve teachers works. The teachers manage classes, lessons, and pupils. Additionally, can add rewards and send SMS notifications. The pupils can play the game, view lessons, claim rewards and receive notifications.

Context Diagram

The most detailed graphic representation of a system is a context diagram. It displays data as well as the system's sources and destinations for the data. Due to their distance from the system boundary, these sources and destinations are referred to as external entities. In some circumstances, the diagram may also depict a data flow between external entities, particularly if the analyst is unsure of where a system boundary line.

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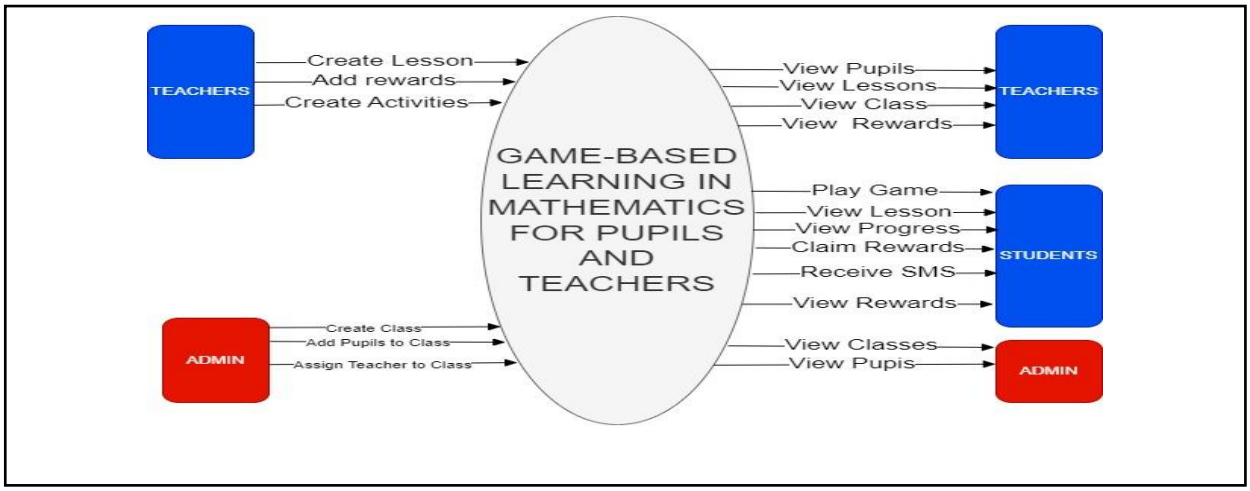

Figure 6. Context Diagram

The diagram illustrates the users process of the application. Where teachers can manage lessons, classes, and pupils. Furthermore, the teachers can add rewards and send sms notification. The pupil can play the game, view lessons, claim rewards and receive sms notifications. The admin can register a user and approve teacher works.

Data Flow Diagram

Data movement across the information system is graphically depicted in the Data Flow Diagram (DFD). It enables the user to portray information system processes from the perspective of data.

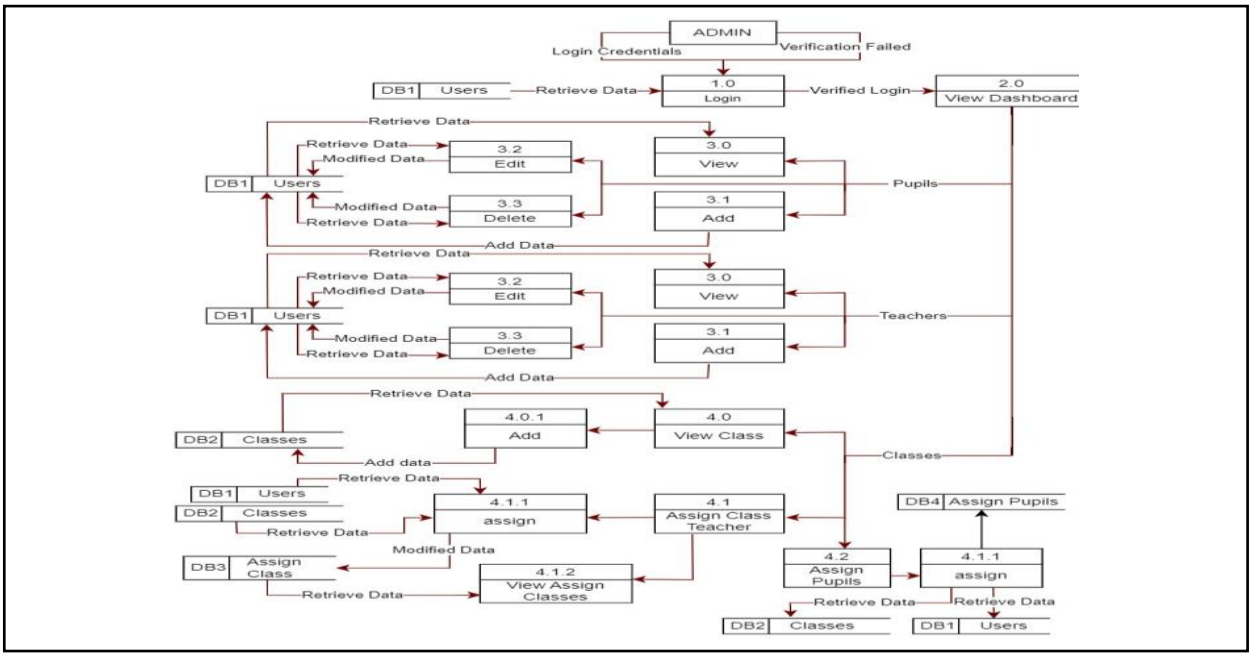

Figure 7. Admin Data Flow Diagram

The admin flow diagram is displayed in the figure. The administrator logs into the apps that are game-based. Following login the administrator may successfully log in to the application, register users, and approve the work of teachers.

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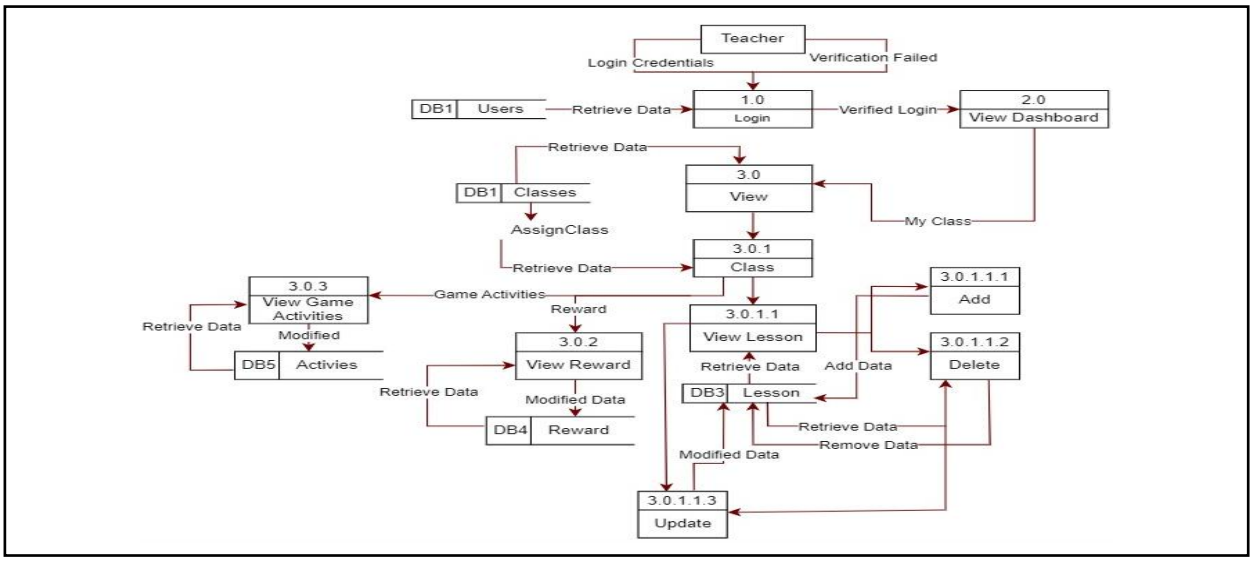

Figure 8. Teacher's Data Flow Diagram

The figure displays the teacher data flow diagram. Teachers begin by inputting their login details. Once they've logged in , teachers gain control of the app. They can then manage classes, students, lessons, and game questionnaires that act as activities for pupils. What's more, teachers have the ability to see and add rewards, check activities, and send SMS notifications.

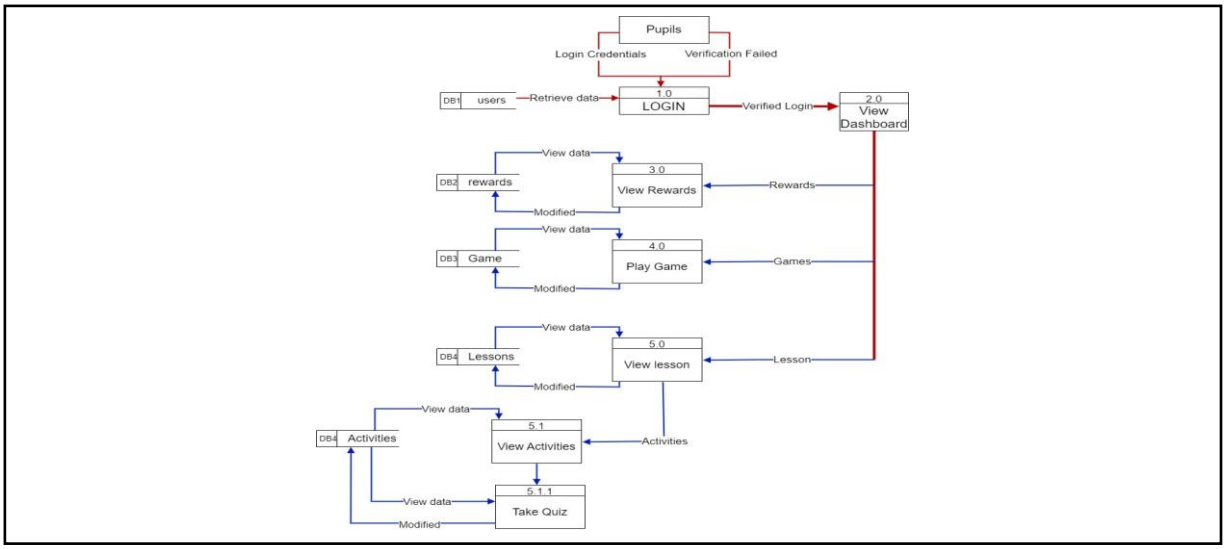

Figure 9. Pupil's Data Flow Diagram

The figure displays the data flow diagram for pupils. Students begin by entering their login details. Once they've signed in, they can use the app and see lessons, messages, and alerts. When they click on a lesson, they have the option to view activities and play games

Entity-Relationship Diagram (ERD)

One kind of data modeling technique that makes use of graphics to show the relationships between the various parts of an information system is the entity-relationship diagram (ERD). An entity relationship diagram, or ERD, is used to display the entity framework's infrastructure.

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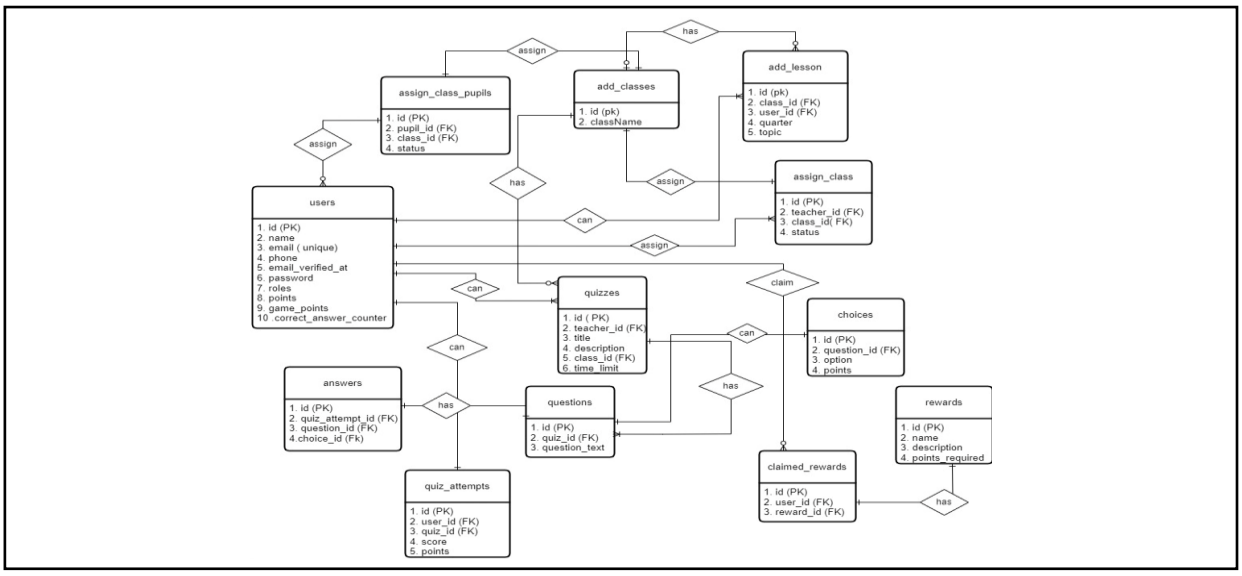

Figure 10. Entity-Relationship Diagram

The figure above shows the application entity relationship. The users serve us the entity and has the attribute of ID as the primary key, name, email is also a unique types of data in the database with email verification, passwords, roles, points, gamepoints, and correct_answer_counter. Furthermore, there are 12 entities of the application which are users, assign_class_pupils, add_classes, add_lesson, assign_class, quizzes, choices, answers, questions, rewards, quiz_attempts, and claimed_rewards.

3.5 Participants and Sampling Procedure

The reasearchers will collect data from grade 5 pupils in Tubud Elementary School, Iligan City. The pupils are the primary source of data as they have the data that is needed in our research.

IV. RESULTS AND DISCUSSION

The system layout and assessment findings were presented in this part. This covers the look, analysis, and justification of the information obtained from the surveys given to the participants. This also includes the data presented in tabular form with the corresponding interpretations.

4.1 Final Product

Objective 1: Develop a web application, which includes the following:

I. Admin Features:

A. Register a user

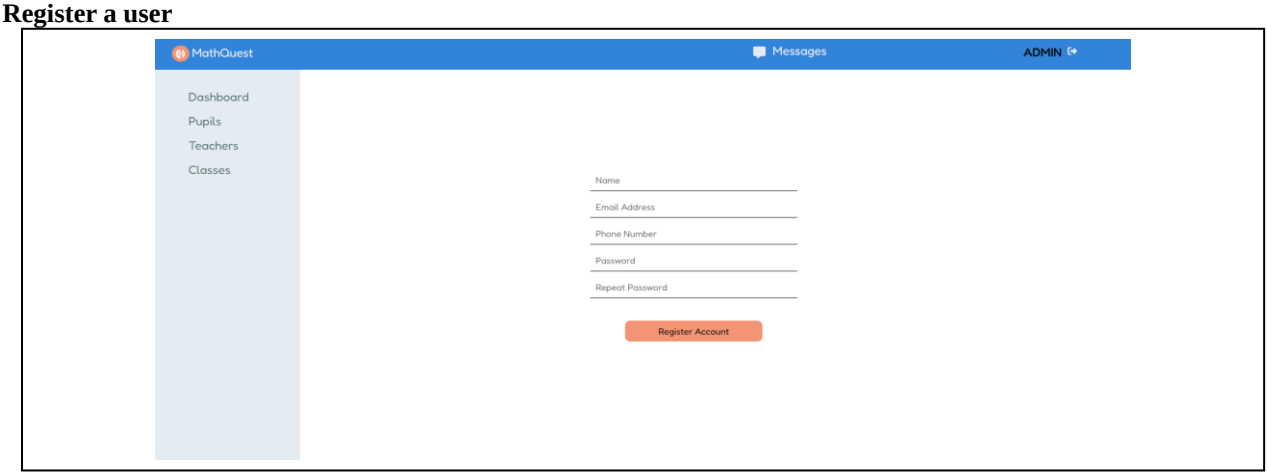

Figure 12. Register a user in admin UI

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Figure 12: Shows the register of user features. It shows how to register a user and their required data. Admin can edit, delete and add users

B. Create Class

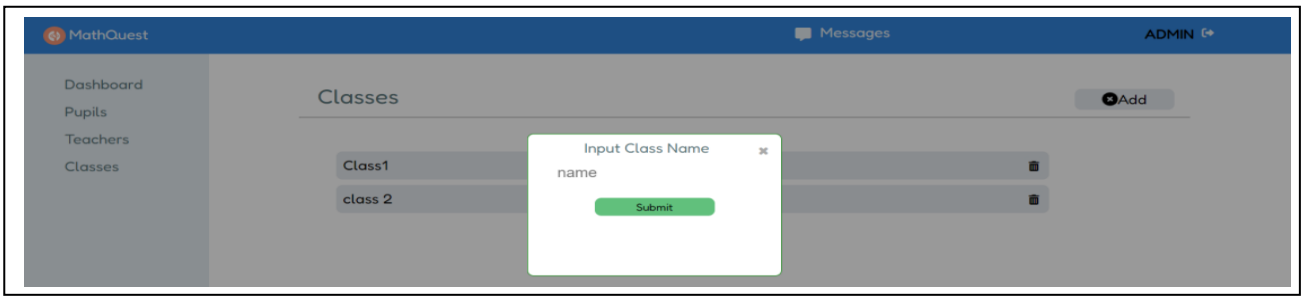

Figure 13. Create Class

Figure 13: Shows the creating of classes. The system Admin can add and delete class.

C. Assign User to class

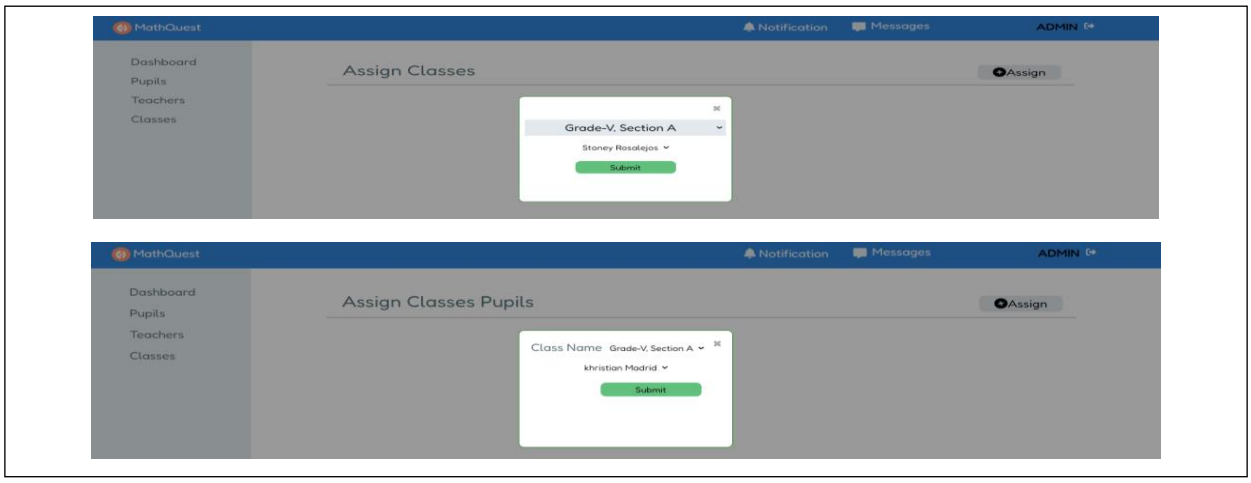

Figure 14. Assigning User to designated class

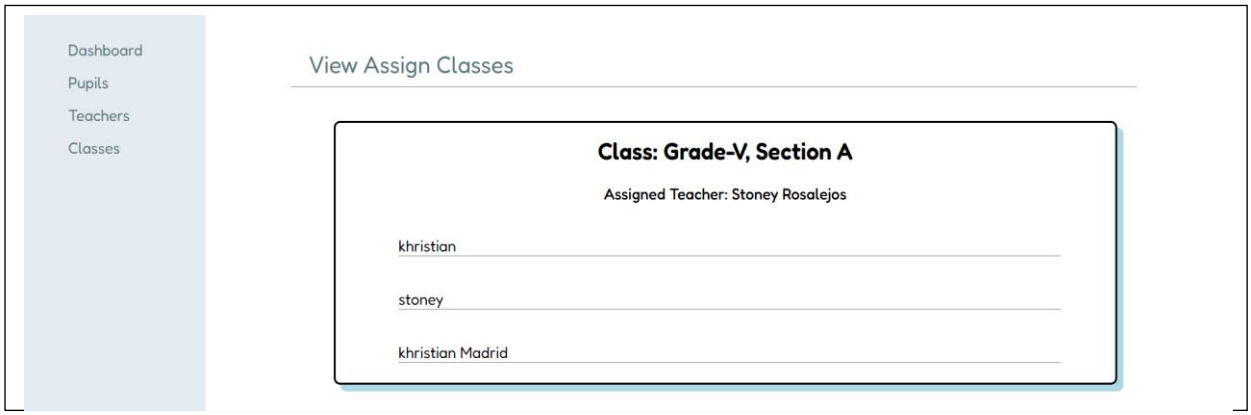

Figure 15. View of assign User to class

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Figure 14 and 15: shows the assigning the user to the designated class. Admin can delete and add users to the created class

II. Teacher Features:
A. Manage Class

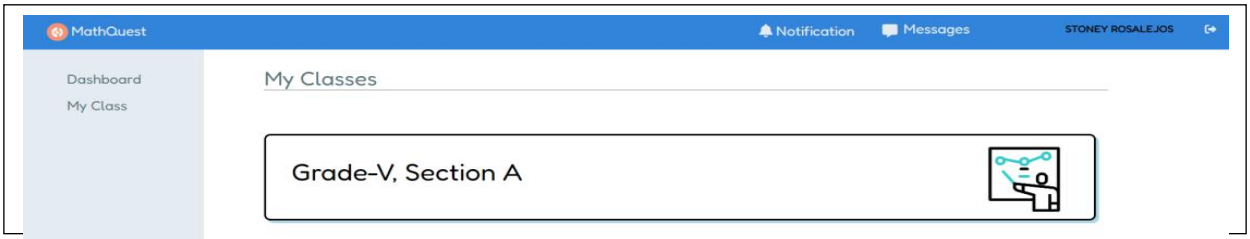

Figure 16: The assigned class to the teacher

Figure 16: shows the class that assigned by the admin. The teacher can manage the class that assigned by admin. View pupils

B. Pupils

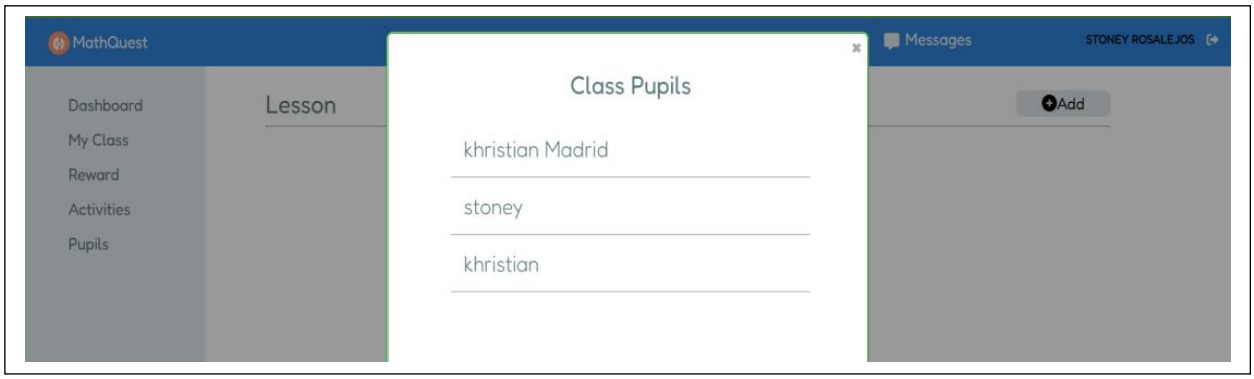

Figure 17: Pupils in Class

Figure 17: shows the student that are designated to the classes.

C. Create Lessons

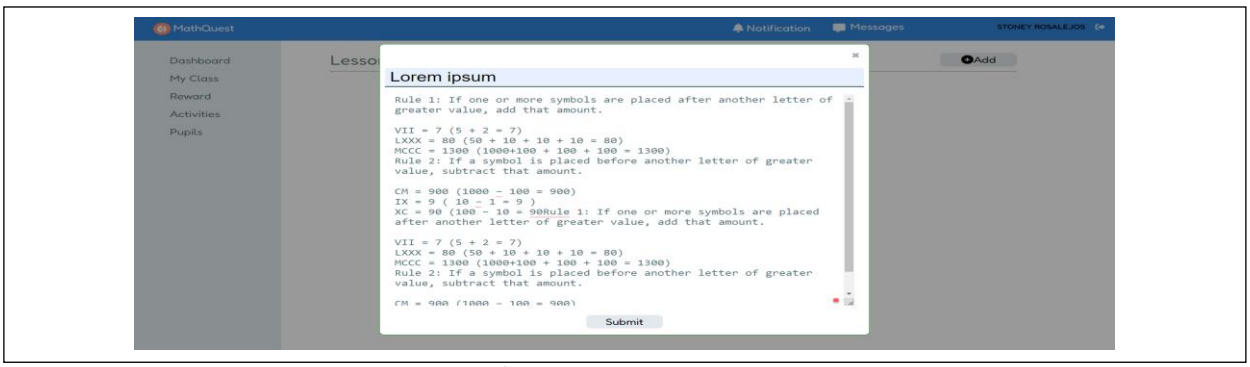

Figure 18: Creating Lesson

Figure 18: show how to create a lesson. Teacher can also update and delete the created lesson.

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D. Send SMS notification

```php
namespace App\Http\Controllers;

use Illuminate\Http\Request;
use Twilio\Rest\Client;

class SmsController extends Controller
{
    public function sendsms()
    {
        $sid = getenv("TWILIO_SID");
        $token = getenv("TWILIO_TOKEN");
        $sendernumber = getenv("TWILIO_PHONE");
        $twilio = new Client($sid, $token);

        $message = $twilio->messages
            ->create("+63 992 476 8735", // to
                [
                    "body" => "New Activiy",
                    "from" => $sendernumber
                ]
            );

        dd("message sent successfully");


    }
```

Figure 19: Send SMS Notification Code

Figure 19: Shows the code of SMS notification using twilio and it shows where the SMS attached.

E. Add Reward

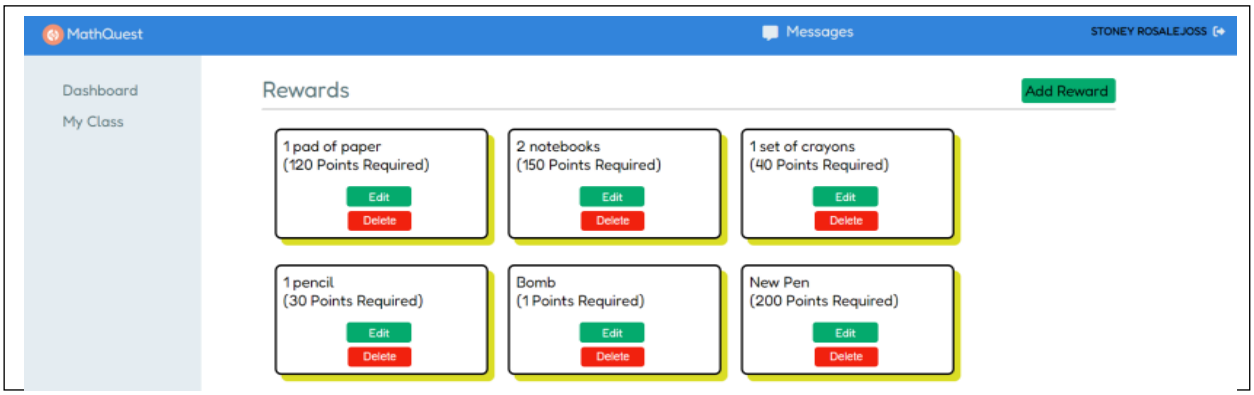

Figure 20: Add Reward Page

Figure 20: shows the added reward. Teachers can update, delete the reward

F. Manage activities

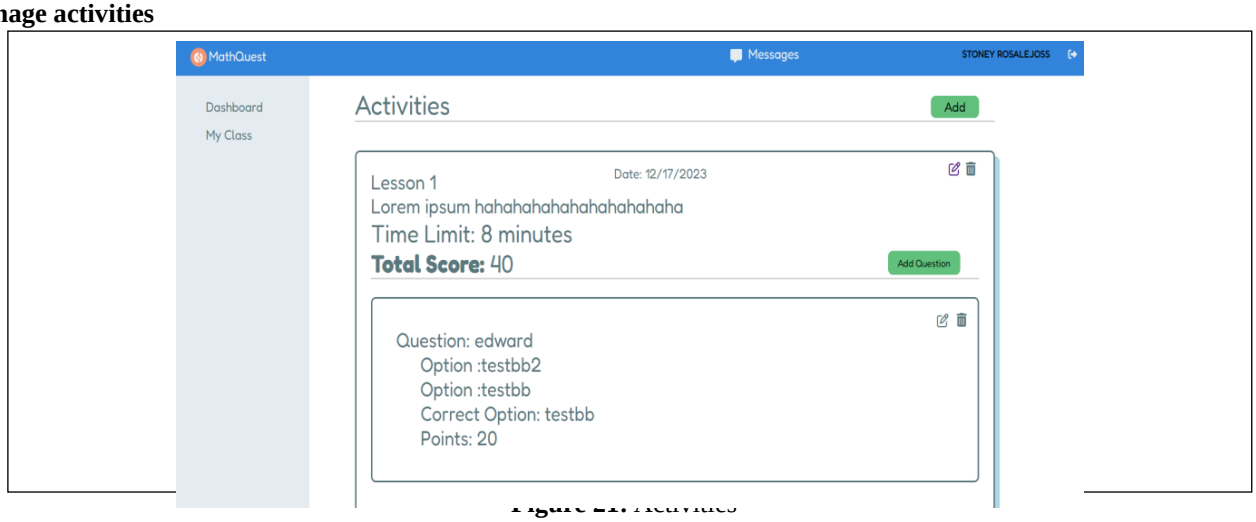

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Figure 21: show the of activity and questions. The activity is controlled by the teachers.

III. Pupils Features:

A. View Lesson

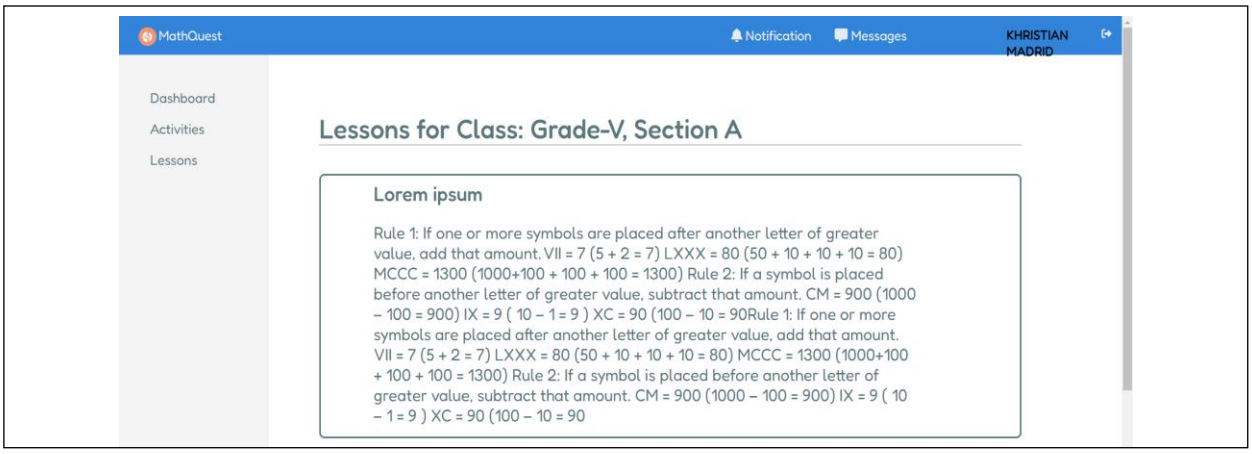

Figure 22: View Lessons in Pupil's Dashboard

Figure 22: it shows the lesson that the teachers add in the corresponding class. The pupils that are enrolled in this class can view the lesson on their dashboard.

B. Answer Activities

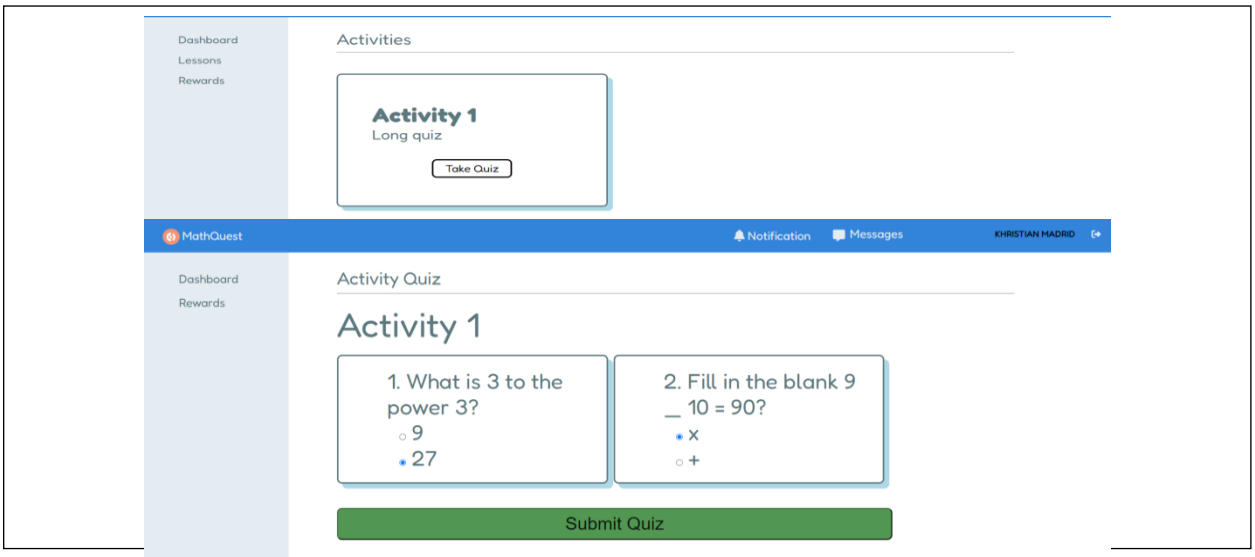

Figure 23: Activities on Pupil's dashboard

Figure 23: It shows how to take navigate through the activities and answer the quiz.

C. Claim Rewards

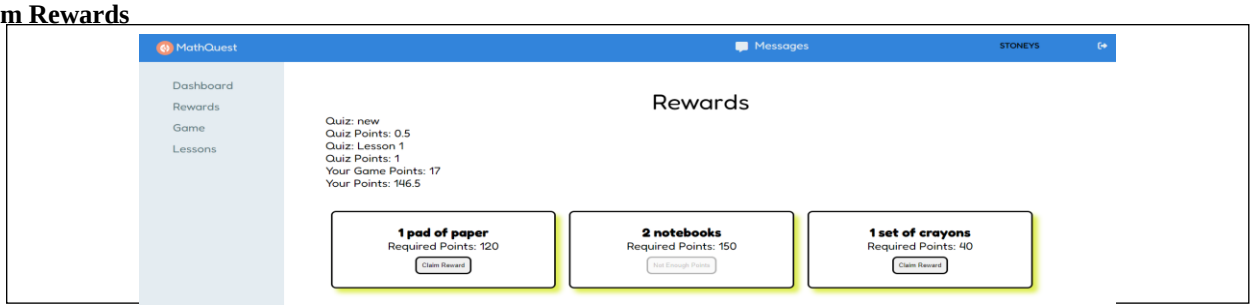

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Figure 24: It shows the reward. The pupils can claim if they have enough points and the button claim reward will become clear.

D. Play A game

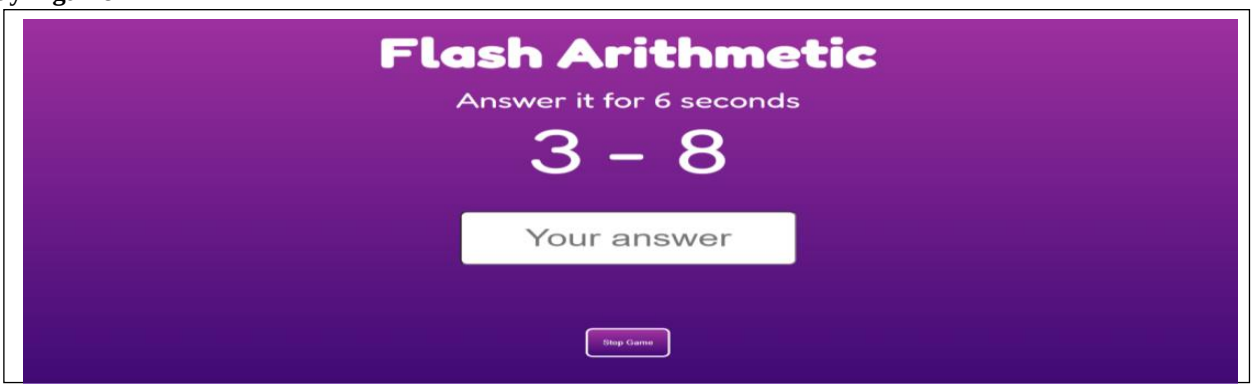

Figure 25: Game

Figure 25: Shows the game, and the web application has only one game that tests the arithmetic skills of the pupils. The pupils can earn the reward by answering it faster; within 6 seconds, the game question will change.

E. Receive SMS Notification

Figure 26: SMS Notification

Figure 26: displays the SMS alert on a mobile device. When a teacher adds an activity or lesson, the students can be notified. A notification can be sent to the teacher when a prize is claimed.

Objective 2: To evaluate the Game-based Learning In Mathematics web application Adaption.

Gender

The quantity of grade 5 respondents is displayed in the table below. The gender-specific number of responders is displayed in the "Frequency" column. The entire percentage of the population that took part in activities linked to frequency is displayed in the "Percentage" column. The table shows the data that students submitted in order to evaluate how well the web application adapted game-based learning for math students and teachers. Of those surveyed, 56.1% were men and 43.9% were women. Every participant is a fifth-grader, and 48.8% of them are 11 years old on average.

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Table 3. Gender of the Grade V Pupils

Gender	Frequency	Percent
Male	23	86.1
Female	18	43.9
Total	41	100.00

Age

The table below shows the number of Respondents of different ages. In the "Frequency" Column, the total number of responders for each age group was displayed. The "Percentage" section shows the age computation of the participants. Specifically, 20 respondents in total—48.8% of all responses—were 11-year-old students. Thirty-nine percent of the participants, or sixteen, are 10 years old. Lastly, 5. answers, or 12.2% of the total, belong to the 12-year-old age group.

Table 4. Age of the respondents

Age	Frequency	Percent
10	16	39.0
11	20	48.8
12	5	12.2
Total	41	100.00

Self-Regulatory / Autonomy

The autonomy of the pupils' degree of adaptation is shown in the table below. The "Mean," or average score supplied by respondents, in this table illustrates how simple it is to make changes to the system. The information indicates that the participants are open to modifying the framework. "Verbal Description" provides a spoken explanation of the mean scores, ranging from "Very True" to "Not at all True."

Table 5. Adaption Level of the Pupil's using the Self-Determination Theory

Item	Frequency	Interpretation
Other people want me to use MathQuest application.	**3.44**	**True**
I expected that the MathQuest Application will be interesting to use.	3.71	True
I believe MathQuest Application could improve my study.	4.17	True
MathQuest Application will help me do something important to me.	4.10	True
I want others to know I use MathQuest Application.	3.63	True
I will feel bad about myself if I didn't try MathQuest Application.	3.49	True
I think MathQuest Application would be enjoyable.	4.24	True
MathQuest Application is going to be of value to me in my study.		

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	4.17	True
MathQuest Application is going to be fun to use.		
I feel pressured to useMathQuest Application.	4.07	True
MathQuest Application will look good to others if I use it.	4.12	Very True
	3.98	Very True
Over-all Mean:	**3.92**	**True**

Legend:

Scale	Interval	Description	Interpretation
5	4.20-5.00	Highly Positive	Very True
4	3.40-4.19	Positive	True
3	2.60-3.39	Neutral	Somewhat True
2	1.80-.259	Negative	Not True
1	1.00-1.79	Highly Negative	Not At all True

Perceived Competence

The competency of the respondent in using the system to improve their arithmetic knowledge and speed of problem solving in mathematics is displayed in the table below. The belief that the system will assist the students in strengthening their adjust to the degree of mathematical difficulty.

Table 6. Perceived Competence

Item	Frequency	Interpretation
I feel confident that I'll be able to use the MathQuest Application effectively.	3.68	True
The MathQuest Application will be easy for me to use.	4.07	True
Over-all Mean:	3.875	True

Legend:

Scale	Interval	Description	Interpretation
5	4.20-5.00	Highly Positive	Very True
4	3.40-4.19	Positive	True
3	2.60-3.39	Neutral	Somewhat True
2	1.80-.259	Negative	Not True
1	1.00-1.79	Highly Negative	Not true at all

V. CONCLUSION

Based on its findings, the study comes to the following conclusions. Following the evaluation, the majority of participants are in favor of using game-based learning in mathematics to instruct students and teachers. The results indicate that the likelihood of respondents adopting game-based learning in mathematics is influenced by their beliefs about its worth for both teachers and pupils. This demonstrates that when students are exposed to game-based mathematics instruction, they become more driven to learn for both competency and autonomy. The study comes to the conclusion that game-based learning in mathematics benefits both teachers and pupils.

Ethical Approval
The Office of Research and the Dean of Computer Studies gave the researchers their approval in December 2023. Furthermore, they were given permission to survey students from the College of Computer Studies by the president of St. Peter's College in Iligan City. With their written consent, each study participant agreed that their information would be shared while maintaining data privacy.

Data Availability
Underlying data

Figshare: Game-Based E-Learning in Mathematic for Pupils and Teachers
https://doi.org/10.6084/m9.figshare.26197685
This project contains the raw data for evaluating the desktop application by the students.
- Raw-data.xls

Extended data
Figshare: Game-Based E-Learning in Mathematic for Pupils and Teachers
https://doi.org/10.6084/m9.figshare.26197685
The project contains extended data.
- Questionnaire.docx

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