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Gadimath: Gamified Discrete Mathematics

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ABSTRACT

GADIMATH: Gamified Discrete Mathematics is an interactive two-dimensional mobile-based application in discrete mathematics running on the Android platform. This application would serve as a supplementary tool to reinforce the students' learning in discrete mathematics. It would help students to follow specific rules, achieve goals, and solve problems. Upon using the application, students would experience enjoyment, interaction, and motivation while learning takes place. The problems and difficulties that the students encountered towards mastering learning competencies in mathematics are the instructions, school adjustments, and over-extended schedules. With all these problems and difficulties, the proponent develops the GADIMATH's main features, which are the user-friendliness, infotainment, reliability, interactivity, learning reinforcement, portability, and dynamic environment. Also, GADIMATH has seven functions namely, choose avatar, gameplay, backpack, shop, settings, help, and about that are combined to form an accurate and complete product.

A rapid application development model was used in the study because the development of GADIMATH was broken down into small modules and combined to provide a final product. This model was used since the progress and development of the project were measured through the various stages. These stages are the requirements planning, user description, construction, and cutover. The instrument includes 24 measures. However, only twelve measures were considered relevant to product features. Twenty-five respondents were selected to test the application, whereas 10 are teachers and 15 fifteen students. After the data were gathered, the proponent used frequency distribution

to determine if the purpose of the game has been achieved. Then the average results were generated and compute the percentile rank and its mean scores.

The game is being described as an excellent game since all of the attributes are said to be “Excellent”. These attributes are the operability, training, communicativeness, completeness, consistency, accuracy, simplicity, conciseness, modularity, hardware independence, generality, and expandability.

The development of GADIMATH to school institutions helps students to supplement their knowledge in learning discrete mathematics in the form of gamification. Also, it provides an additional learning tool for teachers who are teaching discrete mathematics. The development of the game help students to develop their mind-setting goals as they answer all the questions for each level of the game while enjoying the whole experience. As GADIMATH follows the scaffolding of activities based on the curriculum given by the Commission on Higher Education (CHED), it greatly helps students to understand the topic because the game itself follows the sequence of the topics given the CHED. The implementation of the features and functionalities of the game makes it useful and usable to school institutions who are offering discrete mathematics and to the students who are currently taking or have finished the said course.

Implementing a gamified application in teaching helps educators find the balance between achieving their objectives and catering to evolving student needs. Using gamified applications can greatly help students to learn by doing, which ultimately improves their processes and outcomes.

INTRODUCTION

Gamification of education is a developing strategy to boost students' motivation and engagement by consolidating the elements of game design in educational settings (CD, 2017). Elshiekh and Butgerit (2017) proved that gamification is useful in education, as it increases students' determination and commitment to learning. Moreover, it was found out that students enjoyed themselves while learning. This result is further supported by Khalid, Zainuddin, and Nuwairi (2018), proving that gamification can be used as a tool to inspire students and to increase their commitment.

According to Kasurinen and Knutas (2018), university students are more exposed to gadgets and games that most likely motivate them to learn. Also, they suggested that gamification is a practical approach to engage students in learning in the education domain.

Ganal and Guiab (2014) have determined the problems and difficulties that the students encountered towards mastering learning competencies in mathematics. Among these problems are problems with instruction, problems with school adjustment, and over-extended schedules.

Other problems that may affect the learning process include the negative attitude towards the subject, students' load of work every day, and teacher's adaptation of their method to the learner's capability (NG, 2014). However, based on the article of Edsys (2017), gamification has provided benefits in learning and instruction such as positive attitude towards learning, improved attention span, improve student thought process, and better communication skills.

With this, the proponent had developed GADIMATH: Gamified Discrete Mathematics, an interactive two dimensional (2D) mobile-based application. This application would help students increase their motivation and interest in learning discrete mathematics. Moreover, this application would develop the students' critical and analytical thinking skills and strengthen their knowledge about the course.

1.1 Purpose

GADIMATH is a mobile-based application in discrete mathematics running on the Android platform. This application would serve as a supplementary tool to reinforce the students' learning in discrete mathematics. It would help students to follow specific rules, achieve goals, and solve problems. Upon using the application, students would experience enjoyment, interaction, and motivation while learning takes place.

The application would cover functions, relations and sets, basic logic, proof techniques, basics of counting, and introduction to digital logic and digital systems (CMO 53, S.2006).

1.1.1 Reinforce Student Knowledge about the Fundamentals of Discrete Mathematics

This application would serve as a supplementary tool to help students understand the concept of discrete mathematics. The drill provided in the game, where the students can gain XP, coins, and potions, was designed to improve the engagement and interest of the students. Also, GADIMATH would increase students' understanding of the concepts of the course and, at the same time, are expected to enjoy the learning process while using the application.

1.1.2 Design an Interactive Environment that Promotes Learning

GADIMATH is a supplementary application designed with a dynamic environment. This provision is useful to get the interest of the students in learning discrete mathematics. It provides students with a pool of dynamic activities that would further develop their knowledge and understanding of the course. Also, the use of appropriate music background, volume, typeface, colors, and game plan are included to establish an interactive environment.

1.1.3 Implement Scaffolding in the Different Activities of the Designed Game

Edglosarry (2015) describes scaffolding as a type of instructional techniques used to drive students progressively toward greater understanding and, ultimately, greater self-sufficiency in the learning process. The level of the game increases once the previous level has been completed. Upon completing the level of each dungeon, the students are expected to understand and comprehend the lesson well. This would give students the drive to complete the stage while at the same time, enjoy and have fun.

1.1.4 Provide Additional Learning Tool to Discrete Mathematics Teachers

GADIMATH aims to enhance teaching and improve educational outcomes. According to Johns Hopkins University (2014), implementing a gamified application in teaching helps educators find the balance between achieving their objectives and catering to evolving student needs. Moreover, based on the research of Brull and Finlayson (2016), using gamified applications can help students to learn by doing, which ultimately improves processes and outcomes. GADIMATH would serve as a supplementary tool for discrete mathematics teachers.

1.2 Technical Review of Related Systems

This portion discusses the comparison of the developed application with three existing applications to provide a better understanding of the advantages and similarities of the applications.

Space Math Hero. According to inFocusMedia (2019), this is an exciting math game with mental calculations and spaceship as the weapon. It is a survival of the planet game where evil math monsters attempting to destroy the Universe, charging the lasers by answering the questions quickly and correct. It has a planetary map to view the progress of the players, and the mission is to save the Earth and the other planets in the Universe. It has three different difficulty levels with more than 6000 problems to solve.

Based on inFocusmedia (2016), this application does an excellent job of reexamining math data and operating on agility and memorization while having fun. It is excellent for practicing speed and reviewing. Also, based on the review of Bridging Apps (2016), they trialed Space Math Hero with students with Attention-Deficit/Hyperactivity Disorder (ADHD) and other learning disabilities. This application boosts critical thinking math skills, in which students are required to obtain a more challenging level in math and real-world functionality. The reality that this application does not need internet connectivity and could accommodate unlimited users for free makes Space Math Hero a great supplement to any math classroom. While according to Geeks and Juniors (2016), Space Math Hero is a prominent math drill application that supports interactive activities for five years old and older. It incorporates four operations of arithmetic. The application sustains unlimited user profiles, which means it is fitting for classrooms.

This application above developed by inFocusMedia is the basis of one feature of the study, which is to develop more creative and interactive mental calculations. Space Math Hero is a survival game wherein the player's goal is to save the Earth and other planets in the Universe by the evil math monsters. On the other hand, GADIMATH is a combat and survival game that involves computer-liked creatures called the deadbots that would hinder the players from proceeding to the next level until they defeat it. There are five levels for each dungeon, and each level has three different enemies. Space Math Hero does not provide a progression in the game. The level of difficulty is the same based on the grade level of the student alone. On GADIMATH, however, all levels are incrementing from easy to difficult depending on the level of the game.

Math Combat Challenge. According to Titan Deep Space Company (2017), Math Combat Challenge is a survival math game, with some first-person and starship areas. The passkey of the game is problem-solving while working to survive. The complexity of the math problems are random and can be configured, from manageable additions to equations. There are 41 achievements integrated into the game. The stadium, Asteroid, Titan are three arenas in the game. Four advancing levels of difficulty and enemies will try to stop the players from solving the math problems. They need to solve math problems while engaging the enemy. The mystery of solving math and fight is what they need to accomplish to triumph. Numerous errors and they will lose.

The application mentioned above, developed by Titan Deep Space Company, points to the feature of the study, which is to entertain the players and with the aid of mathematics. Both applications are a survival game. However, there is a big difference when it comes to integrating the new environment and the type of communication as well.

Math Combat Challenges is a stressful online and offline game. Players must answer specific tasks while combating countless hordes of enemies trying to stop their calculations. It aims to make the players suffer enough to have fun.

On the other hand, GADIMATH is an offline mobile-based application that provides students an interactive and dynamic environment. This application is a survival game to defeat the deadbots to unlock the next level. XP, coins, potions, music volume, dungeons, and levels are provided to make the gameplay more exciting and enjoyable for the students and other players.

Zeus vs. Monsters. According to Peaksel (2016), Zeus vs. Monsters is a math game for kids incorporated with the four mathematical operations. With 50 levels and ten bosses to conquer, this is an extremely math experience. The game is played by players of all ages with loads of positive motivation, informative and educative facts, and appealing music. Greek Gods, Zeus, and Athena are some of the game characters, including the mythical creatures or monsters such as Titans, Giants, Minotaur, Cerberus, Medusa, Typhon, Chimera, Centaur, Satyr, and Hades. Zeus vs. Monsters empowers players to prepare and establish their arithmetic skills at their level while giving advancing levels of difficulty. The game has multiple goals- encourage the kids to hone their ability to stay focused for more lengthened periods, shift their understanding of math, and see it like an entertaining way to spend time, and not a bothersome and difficult thing to do. Also, kids will become familiar with some of the famous Greek symbols and mythology characters and tales. Zeus vs. Monsters gives fun in math for all ages because math problems go moderately from very easy to notably hard. Besides, based on the reviews of an education game developer Aleksandra Ivic (WWW08), Zeus vs. Monsters is a game that lets kids practice math in a

fun and entertaining spaces. And not only that, the game incorporates information for all the characters that are in the game, and the kids will familiarize Greek Mythology too. The unique part of it is the "For educators" part, where they can monitor specifically what the kids missed and what to teach after. Of course, in the "Settings" part, they can choose from the different modes of difficulty, and they can always set limits and their preferred operations that they want to appear. Pleasant graphics and thrilling music make this game a fun and enjoyable experience, but still with high educational value.

The application, as mentioned by Peaksel, is relevant to the developed study because it also has levels and bosses similar to GADIMATH. Each level has a maximum of three enemies to defeat in each dungeon. While the level increments, the more robust the monsters are to be defeated. Moreover, in Zeus vs. Monsters, parents, tutors, or teachers can track correct and wrong answers for each math operation and number range. At the same time, GADIMATH can provide mathematical and logic problems that will develop and enhance the critical and analytical thinking skills of the students. Also, GADIMATH provides a gamified environment wherein students may gain experience, coins, and points. Both applications have a goal, and the only difference is that Zeus vs. Monsters' goal is to defeat all the creatures using math operations while GADIMATH's goal is to defeat the deadbots to proceed to the next level while trying to answer discrete mathematics related questions. Zeus vs. Monsters uses Greek and mythical mythology, while GADIMATH has its creatures only made exclusive for the game.

Criteria on a game should identify how to compare the proposed application and see how it differs from other existing applications. Table 1 shows the differences between the four games.

GADIMATH is also equated with the three different existing games in the market. These show the difference of the GADIMATH among the related systems in which it provides new functionalities.

Name of Game / Concept	Space Math Hero	Math Combat Challenge	Zeus vs. Monsters	GADIMATH
Avatar	Single	Single	Multiple	Multiple
Game Opponents	Evil Math Monsters	No specific name is given for the enemy	Mythical Monsters/Creatures	Programmed Computer Creatures called Deadbots
Storyline	One storyline throughout the game.	One storyline throughout the game.	The storyline in stages of the game	The storyline in dungeons and level of the game
Challenges/Task	Basic Arithmetic Operations for Whole Numbers	Combat Survival Game in Basic Math	Mixed Mathematical Operations	Combat and Survival game with Discrete Mathematics concepts
Reward Structure	None	Experience Points	None	Coins, Potions, Experience Points
Target Audience	Kids ages 5 to 15 years old	Kids with Basic Mathematics course	Kids ages 4 to 10 years old	Discrete Mathematics Learners
Word/Question Generation	Practice and Quizzes evaluation	Mathematical Exercises that are randomly and Highly configurable	Basic algebra operations and functions	Questions that are related to discrete mathematics integrated per level of each dungeon

Table 1. Comparison of Related Applications.

1.2.1 Avatar

The Avatar is a feature of GADIMATH that represents the characters in the game. Each character of the game and its opponents represent the Avatar. GADIMATH provides two main characters: Male and Female. The player needs to select one character that they can use to play the game. Also, the level of the game has three enemies to defeat. These enemies are integrated into all the levels of the dungeon, and the type of enemy changes once the level progresses.

Space Math Hero and Math Combat Challenge have only one Avatar, which is used throughout the application. Zeus vs. Monsters has multiple avatars because enemies are changing once the player answers the correct mathematical questions. GADIMATH, on the other hand, has multiple avatars because the Deadbots in the application are changing once the player completed each level.

1.2.2 Game Opponent

A game is not as exciting as what we have expected without the so-called opponents. GADIMATH is composed of opponents found in the world of the computer. These programmable computer-like creatures called Deadbots would serve as the opponents of the players. Each level in dungeons comprises a maximum of three enemies; two minions and one boss.

Space Math Hero has a programmable evil math monster that attacks the player every time they got an incorrect answer. Math Combat Challenge also has an enemy who attacks the player for their incorrect answers. No specific name for the enemy was given. Peaksel enumerated the mythical monsters/creatures in Zeus vs. Monsters: Titans, Giants, Minotaur, Cerberus, Medusa, Typhon, Chimera, Centaur, Satyr, and Hades (WWW18).

1.2.3 Storyline

Stories are an essential part of games. In games, there are heroes and villains (WWW16). GADIMATH is a survival playing game with seven different dungeons and comprises of three levels. Each level has a maximum of three enemies to defeat. Player needs to defeat all programmed computer-like creatures

by answering the questions assigned for each level of the dungeon to unlock the next levels and would have a higher chance to survive.

Space Math Hero and Math Combat Challenge have only one story throughout the game, which is to defeat the evil monsters or enemies by answering the mathematical problems correctly. The time limit is provided for each question. Zeus vs. Monsters, on the other hand, also has one story throughout the game, which is to defeat the mythical creatures. Three stars are given, which signifies the life of the player.

1.2.4 Challenge/Task

Challenges in GADIMATH refer to the activities that need to be done or completed to attain its goal, and that is to unlock the levels for a higher chance of survival. The application provides multiple-choice questions with a time limit depending on the degree of difficulty of the questions. This is to ensure that the players have enough time to think and use the appropriate potions to counter the attack of the Deadbots. The questions are purely multiple-choice questions but will provide students the knowledge that they deserve and, at the same time, enjoy the whole experience while learning takes place.

Space Math Hero focuses on the challenges in the basics of arithmetic operations for whole numbers. Math Combat Challenge is a survival game in basic mathematics. Zeus vs. Monsters has intermediate challenges because it focuses on mixed mathematical operations, while GADIMATH is a combat and survival game where all questions focus on discrete mathematics concepts.

1.2.5 Reward Structure

A reward is a game element that satisfies the user and motivates them to achieve more (SH, 2013). GADIMATH would integrate a reward system to catch the attention of the players and avoid getting bored once the level has been completed. Experience points (XP), coins, and potions are provided to add excitement in the game. The higher the level, the more coins would be acquired. XP is leveling up once a particular level has been reached.

Space Math Hero and Zeus vs. Monsters have no reward system because the only goal is to finish the game and answer the questions correctly. Math Combat Challenge provides XP, while GADIMATH provides coins and XP that is used to add-up items such as the potions, which are used to attack the enemies.

1.2.6 Target Audience

The target audiences of GADIMATH are the students who have discrete mathematics subjects. This would be used to supplement teachers after class discussion. This would give students the privilege to answer questions based on their understanding while enjoying the game. GADIMATH would not just supplement students with learning but also help them develop their critical thinking skills.

Space Math Hero focuses on kids ages five to fifteen years old. Math Combat Challenge focuses on kids with basic mathematics courses. No specific age range has been provided. Zeus vs. Monsters is only played with kids ages four to ten years old.

1.2.7 Word/Question Generation

The creation of questions in a game is essential because it adds thrill and excitement, not just for the game but also to the players. GADIMATH incorporates discrete mathematics multiple-choice questions. These questions are assigned to each level of the game. The questions that are integrated into the game are arranged randomly in each level of the game, which is based on the sequence of the topic of Discrete Mathematics. These questions are divided into three main divisions, namely: Easy, Average, and Difficult. This is to ensure that players would surely think for the answers correctly to defeat the enemy in much lesser time.

Space Math Hero provided practice and quizzes evaluation to players while Math Combat Challenge has mathematical exercises that are randomly and highly configurable. Zeus vs. Monster's content of the game is more on the basic algebra and functions.

1.3 Project Scope

The study focuses on the development of GADIMATH, a gamified application to reinforce students' knowledge of discrete mathematics. This is an offline application that runs on any Android devices, preferably the tablet. The study covers selected topics such as functions, relations and sets, basic logic, proof techniques, basics of counting, and introduction to digital logic and digital systems. It is a multiple-choice type of application wherein all questions are arranged from easy to difficult at each level. The application would not replace the traditional approach of teaching discrete mathematics. However, it would help students develop their skills and ability to perform discrete mathematics with

ease. The application is available for all students taking discrete mathematics courses and even those who want to use the application for fun while learning.

1.3.1 Gameplay

This section covers four sub functionalities: Game Mechanics, Tutorial, Fight, and the Book of Knowledge. The Game Mechanics comprise of rules and procedures on how to achieve and get the potions, coins, and XP. The Tutorial section teaches the players how to control the game. The questions that are integrated into the application are arranged in scaffolding from easy to difficult. The players can only collect six potions in the entire gameplay, which would then be stored in the backpack for future use. The Book of Knowledge only covers the information of the dungeon and the levels of the game.

1.3.2 Development Platform and Software

The application is developed using the C# programming language. It also uses the Unity cross-platform as a tool in implementing the game.

1.3.3 Interface Design

The application is designed in complete simplicity and user-friendliness. It provides an interface that is easy to understand so that an average user can immediately interact with it. Mechanics and tutorials are provided for the user to follow right away quickly. The correct usage of human-computer interaction methods is applied in this application to make it more balanced and pleasing to the eye. The placement of menus and functionalities are arranged in an organized manner, convenient and easy to use.

PRODUCT DESCRIPTION

The ever continuous development of competitive software is surfacing from time to time. Modern technological marvels of today will be in its state of obsolescence a few months later. Innovations and purpose are always significant criteria for introducing a new product. People consider factors like usefulness and benefits to potential users. The success of these tests would determine how the product would be accepted and be embraced by the users.

GADIMATH is a supplementary tool that is designed and developed to reinforce the student's learning and understanding of discrete mathematics. GADIMATH would provide players the better interaction in the game where all functions and features are easy to understand. This ensures that GADIMATH would be at its best performance, thus, making the players feel entertained and fulfilled once they have completed all the levels. The content of the questions for each level is arranged based on the sequence of the topic of the discrete mathematics course (CMO 53, S.2006).

Such kind of technology is somewhat available in the market today, but each has its unique functions and features. Since innovations are always asked on the developed application, such novelties are added and implemented.

This chapter discusses the features of GADIMATH: Gamified Discrete Mathematics. It elaborates further on the primary functions of the application, as depicted in the decomposition chart. The functional requirements are provided to describe how each part of the application activities works altogether.

2.1 Product Perspective and General Features

GADIMATH is a supplementary tool used to reinforce students' learning about their understanding of discrete mathematics. It would help them develop their mind-setting goals as they answer all the questions for each level of the game while enjoying the whole experience. Figure 1 shows the general features and components of GADIMATH.

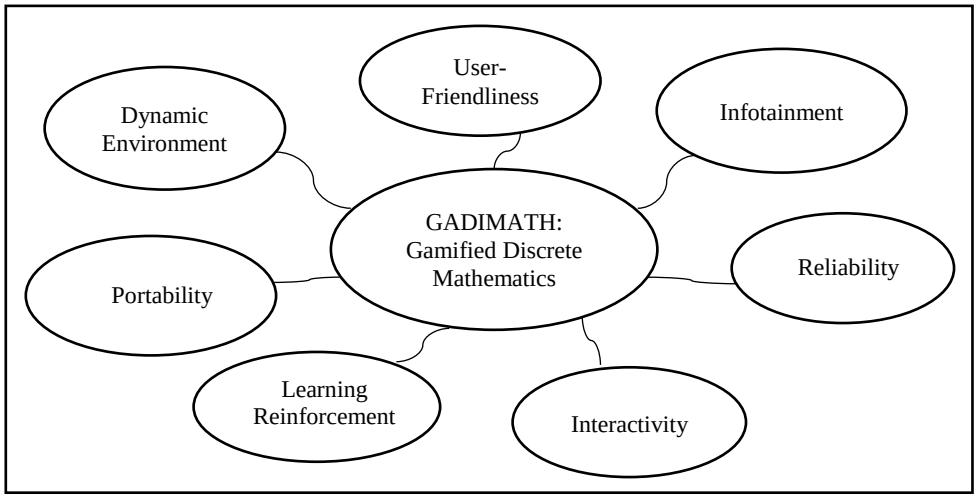


Figure 1. General Features and Components.

2.1.1 Dynamic Environment

The Idea Group Incorporation explains that the game environment is the collaboration of game rules, objectives, and subjects together as a whole to provide an interactive flow of activity (WWW14). GADIMATH provides a dynamic environment that changes over time once a particular level is completed. Also, the dungeon of the game changes its environment when all of the levels have already been completed. This would provide enjoyment to the players and would motivate them to complete the game while learning.

2.1.2 User-Friendliness

User-friendliness is a system that is easy to learn and use (WWW17). GADIMATH is designed to give players the ease of use while playing the game. It would have a compact design where everything needed is placed in one setting, and there is no need to search for it. The game's functionalities are properly arranged in such a way that the players can easily find and click wherever they want.

2.1.3 Infotainment

Instant access to information is essential in such a fast-changing world. Therefore, high-performance apparel, like interaction technologies, is needed (RR2018). GADIMATH is a mobile application that combines information and entertainment to provide an entertaining and fun experience while playing the game. The topics integrated into the application are based on the curriculum of the discrete mathematics course (see Appendix B). Also, the students would be able to engage in the game because they need to answer the questions correctly in order to proceed. Since the game focuses on discrete mathematics, all the information and knowledge they want regarding the topics are observed since the topics are arranged based on the sequence of the discrete mathematics curriculum.

2.1.4 Reliability

Reliability estimates how much random error might be in the scores around the true score (WWW10). In addition, it is the degree of how consistent the application when it comes to giving its purpose and the manner of displaying its output to the players. GADIMATH provides reliable content because the three jurors thoroughly verified all the questions that have been integrated into the game. They agreed that the questions are suitable for a particular topic. Also, the game underwent a series of a test run to ensure that it would produce an accurate result.

2.1.5 Interactivity

The interaction of the game begins when the players start to use the application and choose their avatar. GADIMATH allows the player to choose what they want to do with the game. As they click or tap any of the buttons within the game, interaction takes place. GADIMATH is a mobile application designed to give a better interaction with the players. The manner of collecting the potions, choosing the desired avatar, maneuver sounds, and music volume, answering the questions, and the selection for the best answer is what makes the game interactive.

2.1.6 Learning Reinforcement

Learning reinforcement allows users to achieve a goal in an uncertain, potentially complex environment (WWW05). GADIMATH aims to reinforce the student's knowledge about the fundamentals of discrete mathematics. This would also strengthen their ability to understand and comprehend the questions assigned to each level of the game. When

answering the questions, students need to think well to come up with the correct answer and develop their critical and analytical thinking skills, which helps them comprehend and select the best answer.

2.1.7 Portability

Portability is a feature of the application where users have the convenience to access the system anytime. With this feature, students would be able to use the application in an offline mode, provided, they must install the application on their respective Android devices. GADIMATH can be transferred from one tablet to another, provided that it meets the specification required to run the application.

2.2 Operating Environment

Every game has a different working environment. It is based on the requirements stated in the deployment stage. It is composed of different hardware platforms, software needed, and operating systems. These requirements aid the development and the release of GADIMATH.

Figure 2 shows the player interaction with GADIMATH and the functionalities of the application. The process starts with the player choosing an avatar. This is an offline application and shareable to any Android devices, preferably the tablet. Another function of GADIMATH is the gameplay, where players can see the book of knowledge, fight, game mechanics, and tutorials. The fight functionality is the game proper where players need to answer all questions correctly within the level of each dungeon to survive. Each level has Deadbots that would hinder the

players from surviving from the game. Every wrong answer is an attack from the enemy. The damage or change in the questions would depend on the potions used.

Another function is the shop where players can buy a potion that they can use in the fight. The reward system is in the form of XP, coins, and potions. XP was used to increase the level of the character and would have the opportunity to gain more coins and potions. Coins would increment depending on the level of the game a player has played. They can use it to buy potions that they can use to attack the enemy, defense, and change the questions. Lastly, the settings will give players the prerogative to adjust the background music and volume control of the game.

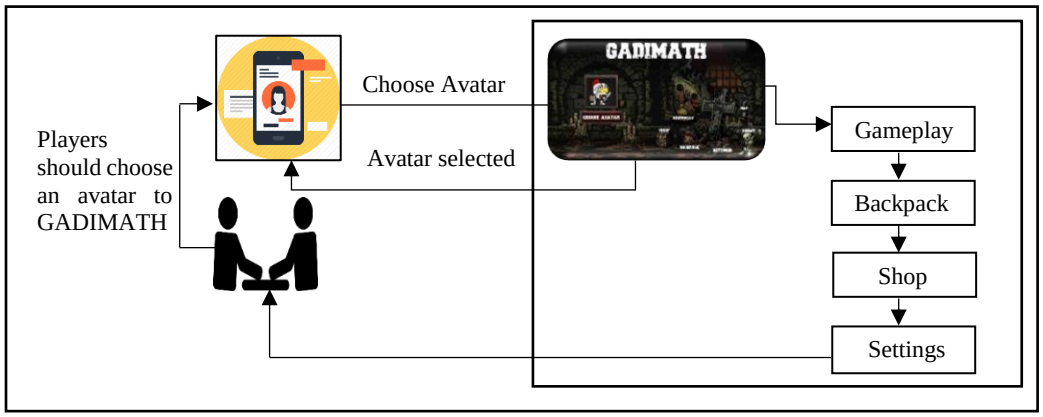


Figure 2. Operational Flow of GADIMATH.

2.2.1 Hardware Platform

Every game has different requirements which are to be met by the developers to maintain a pleasant environment. GADIMATH runs in Octa-core Processor with at least 1.2 gigahertz (GHz) or faster processor. It will have minimum storage of 1.2 gigabytes (GB) depending on the language

version. The minimum requirement for random access memory (RAM) is 512 megabytes (MB), but two GB is recommended. The internal storage must have at least 2 GB disk space for installation, and extra free space is required during installation. It has a minimum video display of 1280 by 800 pixels or higher on a 10-inch device. This application is designed to work offline.

2.2.2 Operating System

Upon the development of a particular game, every developer should know what type of operating system is compatible with the game to achieve an excellent performance. The proponent will develop GADIMATH as an offline application to be implemented in any tablet device. It runs in the Android operating system in a Jellybean version.

2.3 Design and Implementation Constraints

The following sections discuss the different design and implementation constraints in implementing the application, as the proponent is concerned about the different constraints that might hinder the development of the game. This section defines the different limitations and requirements in the hardware, operating system, and language of developing the GADIMATH.

2.3.1 Game Environment

The game is implemented using a two-dimensional (2D) space in the Unity 3D engine. The proponent decided to use the 2D space because it is effortless to manipulate during the development of GADIMATH. The application has only single-player mode functionality because of the

network connection that can cause delays during the gameplay and could affect the development process.

2.3.2 Hardware Limitations

This section discusses the hardware limitations upon the development and the implementation limitation of the target application. In the development, the proponent decided to use a tablet with a minimum specification of a 1.6 GHz Octa-core processor with 64 GB storage and two GB of RAM. These are to avoid lags and crashes during development.

In the implementation, the minimum hardware requirement for the application is 1.6 GHz Octa-core chipset with two GB of RAM. This is to provide quality in the performance of the game.

2.3.3 Language Requirements

The primary challenge of a game is only getting the code to work to produce a result that delivers appearance and functionality. For the language requirements of the game, the proponent used C# under the Unity 3D game engine that is needed for the programming of the game. The proponent chooses to use C# as the programming language because it provides a more structured language; the execution time is too quick and better object-oriented programming (OOP) features.

2.3.4 Dungeon, Topic, and Level

This section presents the dungeons, topics, and levels available in the game. GADIMATH has seven dungeons, and each dungeon has three

levels. The topics integrated into the game are based on the curriculum of discrete mathematics (see Table 2).

DUNGEON	TOPIC	LEVEL
Hero Quest	The Theory Behind Discrete Mathematics, Relations and Functions	The Trial
		Courage of the Weak
		Awakening
Labyrinth of Queen Ruby	Set and Set Theory	Cavern of Pythons
		Lake of Android Elves
		Ruins of King Pascal
Queen of the Abyss	Basic Logic (Propositional Logic, Logical Connectives, Truth Tables, Normal Forms, Validity)	Looking at the Abyss
		The Abyss Gazes into You
		Abyssal Exchange
Maze of the Ancient Keyboard	Predicate Logic, Universal and Existential Quantification, Modus Ponens and Modus Tolens, Limitation of Predicate Logic	Alterground
		Cave of Tabs
		Page of Elf Intruders
Maze of the Mythic Forest	Proof Techniques (Axiom Systems, Contradiction, Contrapositive, Direct, Indirect)	Forest of Calamity
		Forest of Illusion
		The Swamp of Despair
Spiritual Realm	Combinatorics (Arithmetic and Geometric Sequences and Series, Principle of Counting, Permutations, Combinations)	Spirit Elves
		Convergence
		The Rejection
The Cave of Judgement	Basics of Counting, Introduction to Digital Logic and Digital Systems	Den of the Snake
		Artifice
		Devine Retribution

Table 2. Dungeon, Topic, Level.

2.3.5 Level, Complexity, Character Damage, and Health Points

This section presents the complexity level of GADIMATH. Also, the projection of the damage, number of hits, and Health Points (HP) a character can produce (see Table 3) thus, according to {WWW04}, the

damage computations have a significant role in the creation of the hero health points. In GADIMATH, the health points are computed through the given damage value and the number of hits it would cause to the enemy.

LEVEL	COMPLEXITY	CHARACTER		
		No. of Hit	Damage	HP
The Trial	Easy	2	3	7
		2	3	7
		3	3	8
Courage of the Weak	Average	3	4	14
		3	4	14
		4	4	15
Awakening	Difficult	4	5	22
		4	5	22
		5	5	24
Cavern of Pythons	Easy	3	6	18
		3	6	18
		3	6	20
Lake of Android Elves	Average	4	7	27
		4	7	27
		4	7	30
Ruins of King Pascal	Difficult	5	8	39
		5	8	39
		5	8	42
Looking at the Abyss	Easy	3	9	32
		3	9	32
		4	9	36
The Abyss Gazes into You	Average	4	10	45
		4	10	45
		5	10	50
Abyssal Exchange	Difficult	5	11	60
		5	11	60
		6	11	65
Alterground	Easy	4	12	50
		4	12	55
		4	12	61
Cave of Tabs	Average	5	13	72
		5	13	72
		5	13	78
Page of Elf Intruders	Difficult	6	14	91
		6	14	91
		6	14	98
Forest of Calamity	Easy	4	15	70
		4	15	70
		5	15	77
Forest of Illusion	Average	5	16	90
		5	16	90
		6	16	98
The Swamp of Despair	Difficult	6	17	112
		6	17	112
		7	17	120

Spirit Elves	Easy	5	18	94
		5	18	94
		5	18	102
Convergence	Average	7	19	117
		7	19	117
		7	19	126
The Rejection	Difficult	8	20	143
		8	20	143
		8	20	152
Den of the Snake	Easy	9	21	170
		9	21	170
		9	21	170
Artifice	Average	10	22	200
		10	22	200
		10	22	200
Devine Retribution	Difficult	11	23	231
		11	23	253
		12	23	275

Table 3. Level, Complexity, Character Damage, and Health Points.

2.3.6 Level, Complexity, Enemy Name and Health Points

This section shows the level of the dungeons and their complexity. The name of the enemy was also provided with their corresponding health points (see Table 4). GADIMATH have three main levels. Each level corresponds to the complexity of the questions that are randomly selected. The HP that the enemy would have depends on the complexity of the questions. The HP's are accelerated from per level of the game.

LEVEL	COMPLEXITY	ENEMY	
		Name	HP
The Trial	Easy	Lady Vanas	5
		Ysiel	5
		Vereesa	6
Courage of the Weak	Average	Lakota	10
		Kylanna	10
		Kalaran	12
Awakening	Difficult	Telaron	18
		Jahubo	18
		Nezir	20
Cavern of Pythons	Easy	Rohash	12
		Vermin	12
		Windtamer	15
Lake of Android Elves	Average	Alleria	21
		Windroc	21
		Lyrea	25
Ruins of King Pascal	Difficult	Gulroc	32
		Haromm	32
		Torlok	36
Looking at the Abyss	Easy	Rayge	23
		Naraat	23
		Sophurus	27
The Abyss Gazes into You	Average	Franzhal	35
		Ptah	35
		Wilda	40
Abyssal Exchange	Difficult	Splinthoof	50
		Dani	50
		Norsala	55
Alterground	Easy	Gulgort	36
		Yevaa	36
		Torunscar	42
Cave of Tabs	Average	Yeti	52
		Jormungar	52
		Lokholar	59
Page of Elf Intruders	Difficult	Shard	70
		Tomb	70
		Scion	77
Forest of Calamity	Easy	Briatha	53
		Halfdan	53
		Kufungi	60
Forest of Illusion	Average	Lurker	72
		Nathanos	72
		Shado-Pan	80
The Swamp of Despair	Difficult	Torayon	94
		Qalina	94
		Grimtotem	102
Spirit Elves	Easy	Elderspawn	72
		Mindshackle	72
		Vonfeasel	81
Convergence	Average	Rockweed	124
		Mechaslime	124
		Sizzik	124
The Rejection	Difficult	Gloomseeker	150
		Hanako	150
		Zomera	150
Den of the Snake	Easy	Kun-Lai	179
		Skyfin	179
		Ghoul	179

Artifice	Average	Omus	209
		Zujai	209
		Ivus	209
Devine Retribution	Difficult	Adalyn	242
		Elwynn	242
		Zeppelin	265

Table 4. Level, Complexity, Enemy Name and Health Points.

2.3.7 Enemy Name, Type and Damage

This portion presents the enemy name, type, and damage. Each level of the game has three enemies to defeat, two minions and one boss (see Table 5). The attack damage by each deadbot is increasing once a specific level has been achieved.

Enemy Name	Type	Damage
Lady Vanas	Minion	2
Ysiel	Minion	2
Vereesa	Boss 1	2
Lakota	Minion	3
Kylanna	Minion	3
Kalaran	Boss 2	3
Telaron	Minion	4
Jahubo	Minion	4
Nezir	Boss 3	4
Rohash	Minion	5
Vermin	Minion	5
Windtamer	Boss 4	5
Alleria	Minion	6
Windroc	Minion	6
Lyrea	Boss 5	6
Gulroc	Minion	7
Haromm	Minion	7
Torlok	Boss 6	7
Rayge	Minion	8
Naraat	Minion	8
Sophurus	Boss 7	8
Franzhal	Minion	9
Ptah	Minion	9
Wilda	Boss 8	9
Splinthoof	Minion	10
Dani	Minion	10
Norsala	Boss 9	10
Gulgort	Minion	11
Yevaa	Minion	11

Torunscar	Boss 10	11
Yeti	Minion	12
Jormungar	Minion	12
Lokholar	Boss 11	12
Shard	Minion	13
Tomb	Minion	13
Scion	Boss 12	13
Briatha	Minion	14
Halfdan	Minion	14
Kufungi	Boss 13	14
Lurker	Minion	15
Nathanos	Minion	15
Shado-Pan	Boss 14	15
Torayon	Minion	16
Qalina	Minion	16
Grimtotem	Boss 15	16
Elderspawn	Minion	17
Mindshackle	Minion	17
Vonfeasel	Boss 16	17
Rockweed	Minion	18
Mechaslime	Minion	18
Sizzik	Boss 17	18
Gloomseeker	Minion	19
Hanako	Minion	19
Zomera	Boss 18	19
Kun-Lai	Minion	20
Skyfin	Minion	20
Ghoul	Boss 19	20
Omus	Minion	21
Zujai	Minion	21
Ivus	Boss 20	21
Adalyn	Minion	22
Elwynn	Minion	22
Zeppelin	Boss 21	22

Table 5. Enemy Name, Type and Damage.

2.3.8 Avatar

This presents the avatars used in GADIMATH. The selection of the avatar depends on the wants of the players (see Table 6). GADIMATH has two avatars to be used in the game proper. This serves as the character of the players for them to play and start the game.

AVATAR		
Category	Male	Female
Character Name	Michael	Michella

Table 6. Avatar.

2.3.9 Level, Complexity, and Drop

This portion presents the levels, complexity of the questions, and drop, which comprises XP, Coins, Potions, and the Quantity of the potions to drop (see Table 7).

LEVEL	COMPLEXITY	DROP			
		XP	Coins	Potion	Quantity
The Trial	Easy	15	25	None	None
		30	50	None	None
		45	75	All level 1	2
Courage of the Weak	Average	60	100	None	None
		75	125	None	None
		90	150	All level 1	2
Awakening	Difficult	105	175	None	None
		120	200	None	None
		135	225	All level 1	3
Cavern of Pythons	Easy	150	250	None	None
		165	275	None	None
		180	300	All level 2	4
Lake of Android Elves	Average	195	325	None	None
		210	350	None	None
		225	375	All level 2	4
Ruins of King Pascal	Difficult	240	400	None	None
		255	425	None	None
		270	450	All level 2	5
Looking at the Abyss	Easy	285	475	None	None
		300	500	None	None
		315	525	All level 3	6
The Abyss Gazes into You	Average	330	550	None	None
		345	575	None	None
		360	600	All level 3	6
Abyssal Exchange	Difficult	375	625	None	None
		390	650	None	None
		405	675	All level 3	7
Alterground	Easy	420	700	None	None

		435	725	None	None
		450	750	All level 4	8
Cave of Tabs	Average	465	775	None	None
		480	800	None	None
		495	825	All level 4	8
Page of Elf Intruders	Difficult	510	850	None	None
		525	875	None	None
		540	900	All level 4	8
Forest of Calamity	Easy	555	925	None	None
		570	950	None	None
		585	975	All level 4	8
Forest of Illusion	Average	600	1000	None	None
		615	1025	None	None
		630	1050	All level 4	8
The Swamp of Despair	Difficult	645	1075	None	None
		660	1100	None	None
		675	1125	All level 4	8
Spirit Elves	Easy	690	1150	None	None
		705	1175	None	None
		720	1200	All level 4	8
Convergence	Average	735	1225	None	None
		750	1250	None	None
		765	1275	All level 4	8
The Rejection	Difficult	780	1300	None	None
		795	1325	None	None
		810	1350	All level 4	8
Den of the Snake	Easy	825	1375	None	None
		840	1400	None	None
		855	1425	All level 4	8
Artifice	Average	870	1450	None	None
		885	1475	None	None
		900	1500	All level 4	8
Divine Retribution	Difficult	915	1525	None	None
		930	1550	None	None
		945	1575	All level 4	8

Table 7. Level, Complexity, and Drop.

2.3.10 Level and Time

This portion presents the estimated time to finish the game per level in a specific dungeon. Once the level progresses, the time increases (see Table 8). The given time limit is based on the complexity of the questions projected per level of the dungeon. The time given is useful in the gameplay most especially in attacking the deadbots because the faster the time in answer question means, additional attack points are given to the player's character.

LEVEL	TIME / SEC
The Trial	30
Courage of the Weak	60
Awakening	90
Cavern of Pythons	30
Lake of Android Elves	60
Ruins of King Pascal	90
Looking at the Abyss	60
The Abyss Gazes into You	90
Abyssal Exchange	120
Alterground	60
Cave of Tabs	90
Page of Elf Intruders	120
Forest of Calamity	60
Forest of Illusion	120
The Swamp of Despair	180
Spirit Elves	60
Convergence	180
The Rejection	210
Den of the Snake	60
Artifice	180
Devine Retribution	240

Table 8. Level and Time.

2.3.11 Potion Name, Description, and Effect

This portion presents the potion name, description and effects per dungeon and level of the game. Each potion corresponds to the damage of a particular character or enemy. There are potions intended for physical attack and defense but there are also potions that are intended specifically for the questions and time allocated per level of the game (see Table 9). These potions are drop in random for each level of the game. Each potion has a corresponding coin value. Players should reach the required number of coins so that they can collect many drop potions.

POTION NAME	DESCRIPTION	LEVEL			
		1	2	3	4
Wind	Change Question	5 seconds change question with 10 seconds cool down	10 seconds change question with 20 seconds cool down	15 seconds change with 30 seconds cool down	20 seconds change question with 40 seconds cool down
Water	Reflect % damage	5% reflect damage with 10 seconds cool down	10% reflect damage with 20 seconds cool down	15% reflect damage with 30 seconds cool down	20% reflect damage with 40 seconds cool down
Fire	+ % damage enemy	10% Damage to the enemy with 20 seconds cool down	15% Damage to the enemy with 30 seconds cool down	20% Damage to the enemy with 40 seconds cool down	30% Damage to the enemy with 60 seconds cool down
Earth	- % enemy (Defense)	10% Defense with 20 seconds cool down	20% Defense with 40 seconds cool down	30% Defense with 60 seconds cool down	40% Defense with 80 seconds cool down
Holy	+ Health	15% Health with 30 seconds cool down	20% Health with 40 seconds cool down	25% Health with 50 seconds cool down	30% Health with 60 seconds cool down
Rebirth	New Life	40% new life with 80 seconds cool down	50% new life with 100 seconds cool down	60% new life with 120 seconds cool down	70% new life with 140 seconds cool down
Poison	- health every time the enemy attacked	10% health during enemy attack with 20 seconds cool down	15% health during enemy attack with 30 seconds cool down	20% health during enemy attack with 40 seconds cool down	30% health during enemy attack with 60 seconds cool down
UnHoly	Life steal (% of damage done)	10% Life steal with 20 seconds cool down	15% Life steal with 30 seconds cool down	20% Life steal with 40 seconds cool down	25% Life steal with 50 seconds cool down
Fog Breathing	50:50	10 seconds omit 2 wrong answers with 20 seconds cool down	15 seconds omit 2 wrong answers with 25 seconds cool down	20 seconds omit 2 wrong answers with 30 seconds cool down	25 seconds omit 2 wrong answers with 35 seconds cool down
Freeze	Time Freeze	5 seconds time freeze with 15 seconds cool down	10 seconds time freeze with 20 seconds cool down	15 seconds time freeze with 25 seconds cool down	20 seconds time freeze with 30 seconds cool down
Magic Quest	Skip Questions	5 seconds skip question with 15 seconds cool down	10 seconds skip question with 20 seconds cool down	15 seconds skip question with 25 seconds cool down	20 seconds skip question with 30 seconds cool down

Cosmic Blend	Add time	5 seconds additional time with 15 seconds cool down	10 seconds additional time with 20 seconds cool down	15 seconds additional time with 25 seconds cool down	20 seconds additional time with 30 seconds cool down
Antidote	Disabled enemy potion effect	5 seconds disabled enemy potion effect once hit with 10 seconds cool down	10 seconds disabled enemy potion effect once hit with 20 seconds cool down	15 seconds disabled enemy potion effect once hit with 30 seconds cool down	20 seconds disabled enemy potion effect once hit with 40 seconds cool down
Blessed Sight	Reveal Answer	5 seconds reveal answer with 25 seconds cool down	10 seconds reveal answer with 30 seconds cool down	15 seconds reveal answer with 40 seconds cool down	20 seconds reveal answer with 50 seconds cool down

Table 9. Potion Name, Description and Effect.

This chapter has discussed and described the general features of the GADIMATH, the operating environment, the design and implementation constraints. The application perspective has explained how the application flows and works. The general features are enumerated with the discussion of the main attributes provided by the application. The operating environment includes the hardware platform, software development tools, and the operation where the GADIMATH is compatible and workable with. Lastly, the design and implementation constraints were presented which discusses the limitations of the application in terms of hardware, development tools, and security considerations.

SYSTEM FEATURES

A product feature is the characteristics of the product that describes its appearance, components, and capabilities (WWW01). In addition, according to eNotes in 2010, the product features are the qualities that would make the product sellable or make it stand out among its competitors. It is longer-lasting or more durable. It is cheaper to operate, and it is better built. It has a particular function that is absent from other competitors, and so forth. In short, this aims to benefit the users as one of its critical traits while ensuring that it maintains the quality and value of the product.

This study aims to develop an application that would be used specifically in schools and homes. GADIMATH would be known for its functions and features beneficial to the students and the teachers teaching discrete mathematics.

This chapter discusses the features of GADIMATH: Gamified Discrete Mathematics, including all major functions of the system, as illustrated in the decomposition chart. Also, the functional requirements are enumerated. It describes how these functionalities will determine the different activities and interactions of the system.

3.1 System Decomposition

Decomposition is the manner of breaking down a problem into smaller manageable parts (WWW02) that are easier to conceive, understand, program, and maintain (WWW20).

The decomposition chart of GADIMATH is composed of different levels. It provides the major functions at a hierarchical level, which includes subsections. With this,

the players would have a complete understanding of how the application parts and functions are organized.

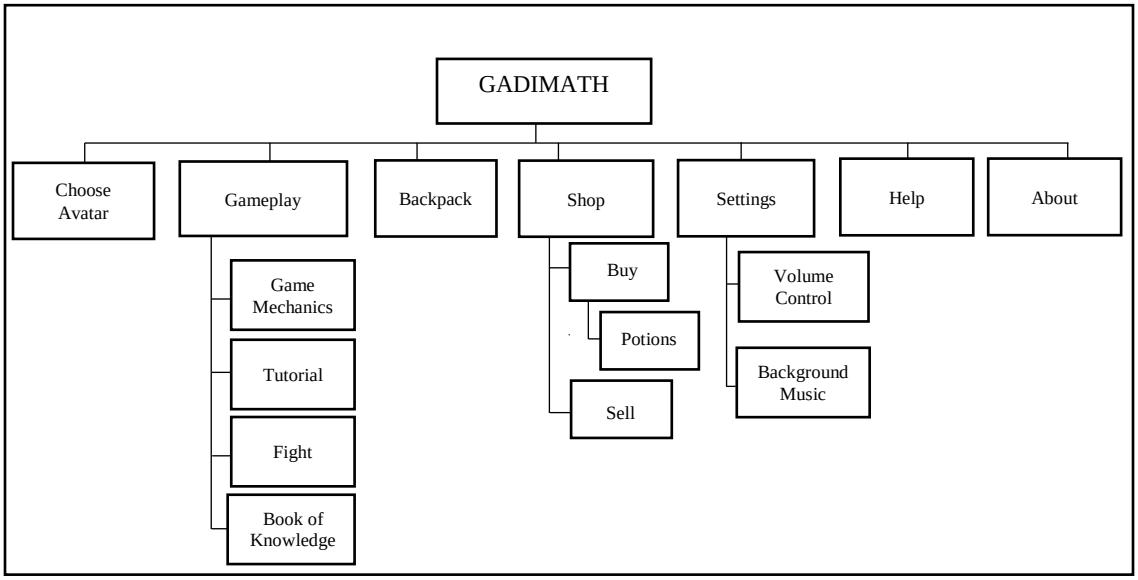


Figure 3. GADIMATH Decomposition Chart.

Figure 3 shows the decomposition chart of GADIMATH: Gamified Discrete Mathematics. This provides the blueprint of the application. The chart is composed of seven main functions that would be the main functionalities of the application. The main functions are grouped with their sub-functions.

3.2 System Functionalities

This section elaborates on the functions of the application, as indicated on the decomposition chart. Each feature would be designed, and the sequence of the activities are shown as provided in each diagram. The functional requirements of each function are also included in this section. The use case diagram of the application is shown below, and

GADIMATH has only one user. The user has the full authority to use and navigate the application.

3.2.1 Choose Avatar

As games are created, there are some requirements that the player should provide to play the game. To fully use the application, the player needs to choose his desired avatar in order to proceed.

3.2.1.1 Description and Priority

In order to proceed and play the game, a player must select his desired avatar. By choosing his avatar, a player can explore the game and experience the enjoyment while at the same time learning.

3.2.1.2 Stimulus/Response Sequences

The player performs its first task in playing the game. The first time the player runs the game, he needs to select his prescribed character to continue the game (see Table 10). There are two types of characters available in the gameplay, the male and female characters. The player has the right to choose another avatar whenever he wants, provided that he should not enter in the fight. After choosing the character, the player can now proceed to the gameplay to start playing the game or read the game mechanics and tutorials on how to play the game. Also, he can read the information of each unlocked dungeon in the book of the knowledge section under the gameplay menu.

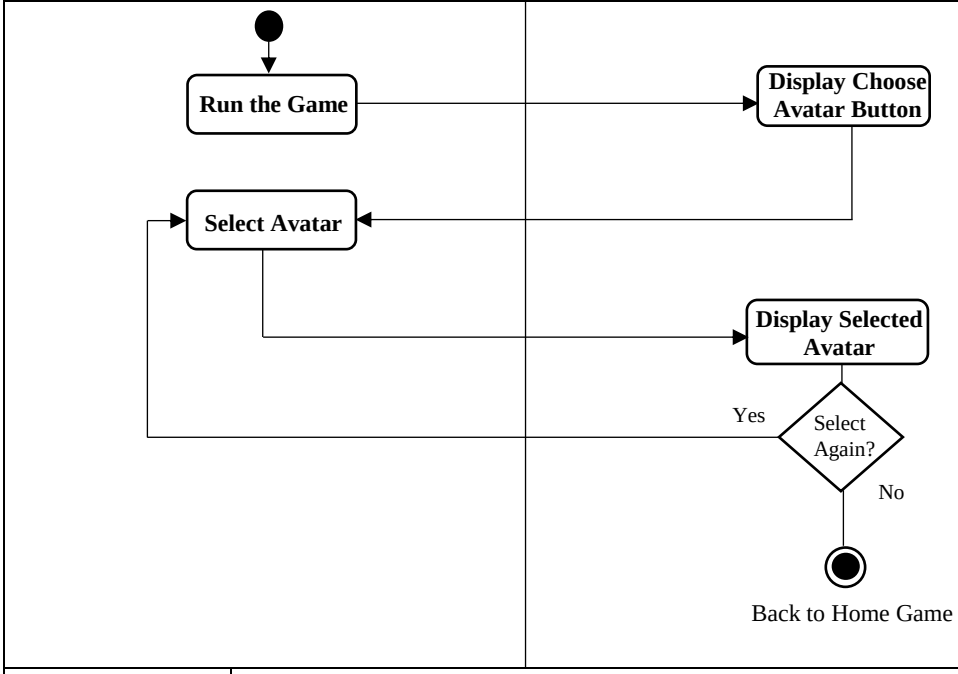
Function Name	Choose Avatar
Pre-Condition	The user must correctly perform the following task that is illustrated in the diagram.
Post-Condition	The user can enter the game home.
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can exit the game.
Exception Flow	The user cannot explore the gameplay if they cannot choose an avatar.

Table 10. Choose Avatar Activity Diagram.

3.2.1.3 Functional Requirements

Choosing an avatar gives the player the right to explore the game. The Choose Avatar functionality includes specific rules to impose, such as:

a. The gameplay menu is activated once the player has chosen his desired avatar.

3.2.2 Game Mechanics

Game mechanics are known to be the construction of rules intended to have a game flow or gameplay. It varies depending on the style and importance of the game. Game mechanics would help the users understand the game by knowing the different mechanics and the rules of the game.

3.2.2.1 Description and Priority

Game mechanics consists of the different categories about the rules and the scoring scheme of the game. Each category holds the corresponding details and procedures on how to play the game. The category for the scoring scheme, on the other hand, contains guidelines on how to accumulate coins, potions, and experience points.

3.2.2.2 Stimulus/Response Time

The game mechanics functionality provides users the different information about the game. After the user selects the game mechanics button under the gameplay, the user is redirected to a new window and given the privilege to browse from the different categories in the game mechanics. The player needs to scroll the content of the game mechanics in order to read all the information of each category within the game. In addition, it also projects rules and instructions about the game. If the user wants to read the rules and mechanics of the game again, he can scroll the window up and down whenever he wants. The player must click the 'X' button to exit from the game mechanics window (see Table 11).

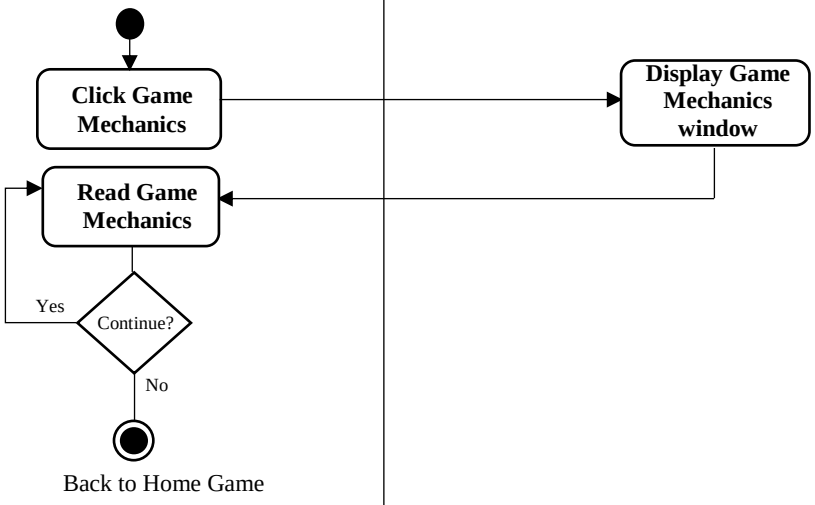
Function Name	Game Mechanics
Pre-Condition	The user must click the game mechanics menu to enter in the game mechanics window.
Post-Condition	The user can read and see the rules and mechanics of the game.
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can skip the game mechanics in the game.
Exception Flow	The user cannot modify the game mechanics menu details.

Table 11. Game Mechanics Activity Diagram.

3.2.2.3 Functional Requirements

This functionality provides the rules and mechanics on how to play the game. These includes:

a. The rules on how the game works, how to obtain the potions, coins, and experience points.

3.2.3 Tutorial

This sub-feature navigates the user across the game for the familiarity of the game environment. It applies information to the users on how to complete a particular task and game function.

3.2.3.1 Description and Priority

The tutorial sub-feature contains different instructions on how to play the game during the fight. In addition, it includes the tutorial on how to collect potions, and even how the book of knowledge works.

3.2.3.2 Stimulus/Response Sequences

The tutorial functionality gives the new users an early feel of the game. After the user selects the Tutorial button under the gameplay, the user is redirected to a new window to read and view the tutorial of the game. The user needs to scroll down the scroll bar of the window to see the other category. After hovering and clicking the scroll bar, the user has the privilege to view and read the game tutorials. After viewing and reading the tutorial, they can close the tutorial window by clicking the 'X' button to proceed to the next functionality. On the other hand, if they want to continue reading, they still scroll the window and finish all the tutorials (see Table 12).

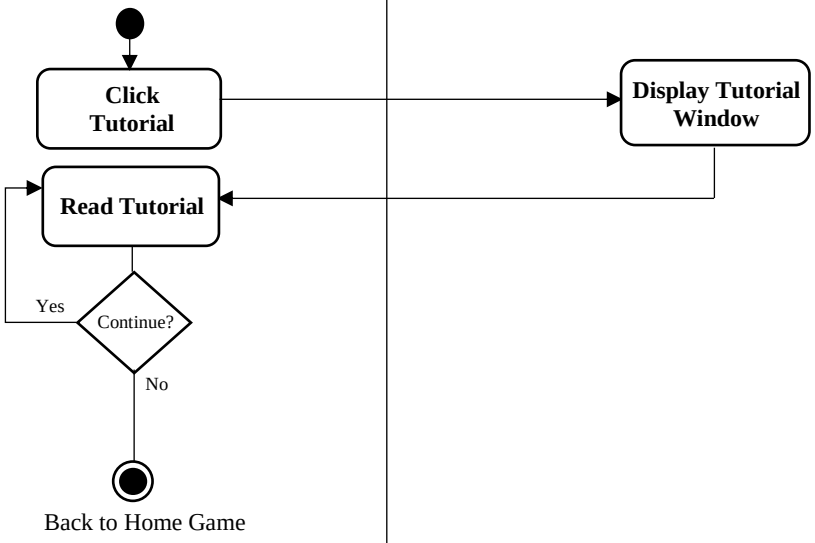
Function Name	Tutorial
Pre-Condition	The user must click the tutorial menu to enter the tutorial window.
Post-Condition	The user can read and see the rules and mechanics of the game.
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can skip the tutorial in the game.
Exception Flow	The user cannot modify the tutorial menu details.

Table 12. Tutorial Activity Diagram.

3.2.3.3 Functional Requirements

This functionality provides the familiarity of the game environment. These includes:

a. The familiarity on how the gameplay works, especially the fight sub-menu.

b. The familiarity of the GADIMATH main game controls.

3.2.4 Fight

This sub-feature represents the game proper. It allows the users to get involved with the game and familiarize themselves with the game flow. This part helps the users to understand discrete mathematics while learning and enjoyment takes place.

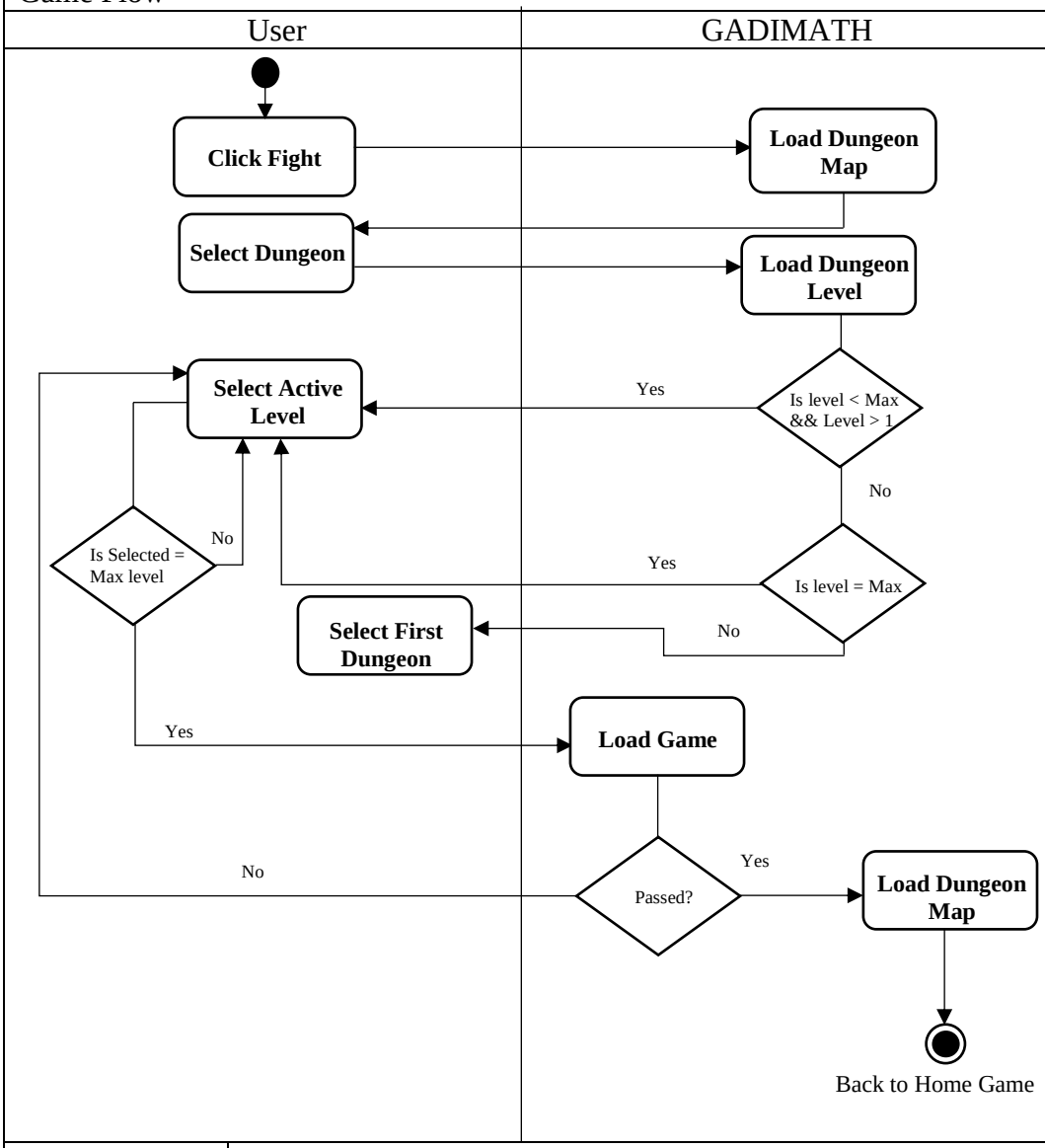
3.2.4.1 Description and Priority

The fight sub-feature is the portion of the game in which the users can maximize their time in answering the dungeon level questions. This is where the reinforcement in discrete mathematics takes place. A time limit was given to each user in answering each level of the game in order to proceed to the next dungeon.

3.2.4.2 Stimulus/Response Sequences

The fight functionality works by clicking the gameplay menu. Upon clicking the fight window, the user can see the dungeon map where they can select the activated dungeon available on the map. Each dungeon represents the topics in discrete mathematics. Upon clicking the first dungeon in the dungeon map, it will automatically load the game. The timer starts once the player taps the start button. The player needs to finish the three levels in each dungeon in order to proceed. Once the last level in the dungeon is activated, the player needs to answer the questions assigned at that level in order for them to proceed to the next level. The second dungeon in the dungeon map would be activated once the levels of the previous dungeon are finished (see Table 13).

Function Name	Fight
Pre-Condition	The user must click the fight menu to enter in the fight window.
Post-Condition	The user can explore and play in the fight of the game.
Game Flow	



Alternate Flow	The user can save and resume their finish levels in each dungeon.
Exception Flow	The user cannot modify the fight content and details.

Table 13. Fight Activity Diagram.

3.2.4.3 Functional Requirements

This functionality provides the engagement to users while playing the game. These includes:

a. The familiarization of the topics in discrete mathematics arranged per level of the game.

b. The interaction of the users to the game while answering the questions.

3.2.5 Book of Knowledge

This functionality represents the information of the dungeon. It also contains the enemy name, allocated time duration in each level, and the activated potions once the dungeon is completed.

3.2.5.1 Description and Priority

The book of knowledge contains information that is useful for the players before entering the fight. This functionality will not just give the players the knowledge about the dungeon. However, it will give them the idea of the topics covered in each dungeon, the time limit given for each level, and the additional damage once a particular potion is activated.

3.2.5.2 Stimulus/Response Sequences

The book of knowledge is activated once the game loads. The first dungeon will be activated as a default dungeon. This will give the players the information they want before playing the game. After reading the information, the players can now play the game whenever they want. The

player needs to scroll up and down the book of knowledge window to read all the content in that particular dungeon. Also, the player has the prerogative, whether they want to finish reading the information or not. Another dungeon will be activated in the book of knowledge once the dungeon one in the fight functionality has already been finished (see Table 14).

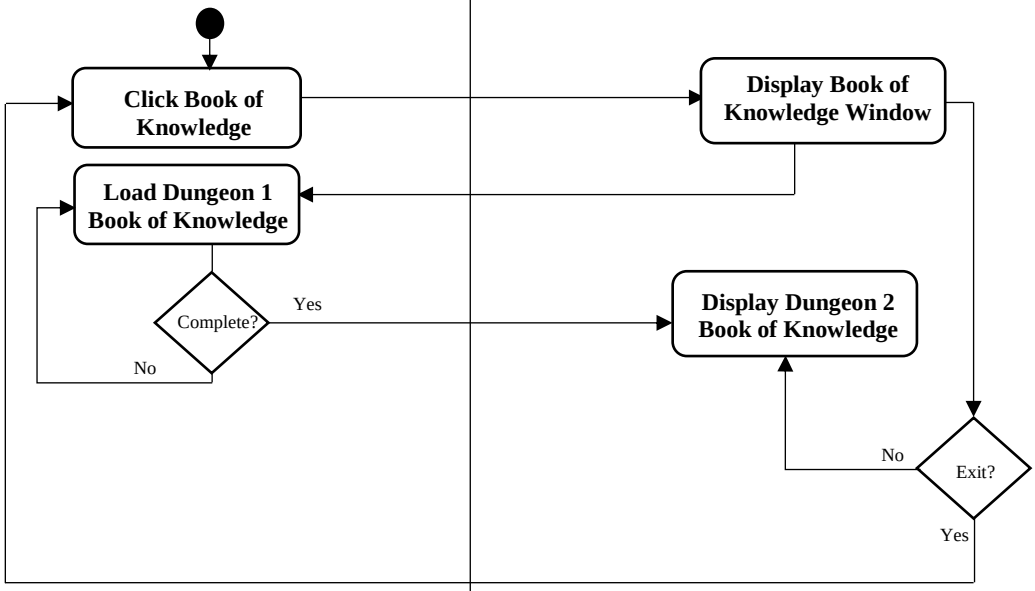
Function Name	Book of Knowledge
Pre-Condition	The user must click the book of knowledge menu to enter the book of knowledge window.
Post-Condition	The user can read and see the information of the dungeon in the book of knowledge of the game.
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can skip the book of knowledge in the game.
Exception Flow	The user cannot modify the book of knowledge menu details.

Table 14. Book of Knowledge Activity Diagram.

3.2.5.3 Functional Requirements

This functionality provides information about the dungeons within the game. These includes:

a. The name of the levels within the dungeon and the enemy that are available for each level of the dungeons.
b. The time allotted per level of the game and the activated potion in each dungeon.

3.2.6 Settings

This feature is present in every game. This can help players manipulate some settings to give the users a comfortable game. This feature allows the user to adjust the volume control and background music.

3.2.6.1 Description and Priority

This feature helps the players customize different game settings, such as volume control and background music. It gives the player the privilege to tweak some settings on the game. This is where the player sets the volume frequency base on his preference.

3.2.6.2 Stimulus/Response Time

The player must click the settings button to open the settings interface. The player then has the privilege to adjust the settings for the volume control and background music (see Table 15).

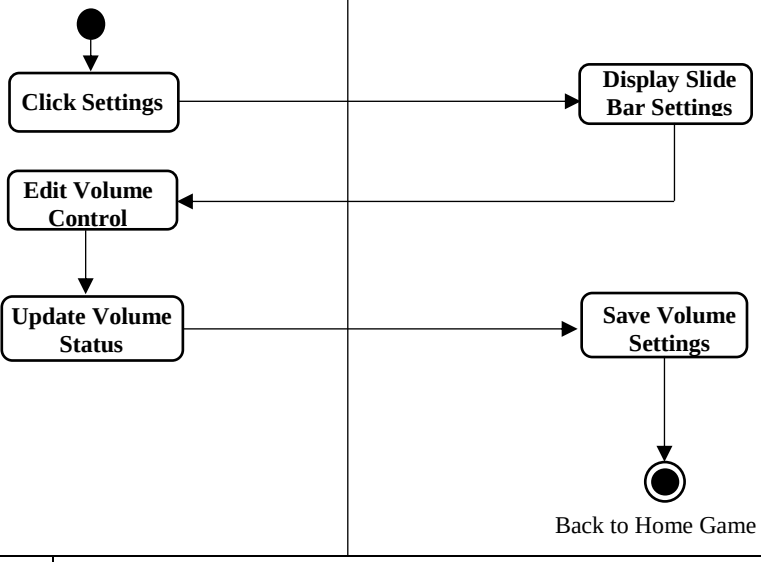
Function Name	Settings
Pre-Condition	The user must click the settings menu to enter in the settings window.
Post-Condition	The user can change their desired settings in the game
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can skip the settings in the game.
Exception Flow	The user cannot modify the settings menu details.

Table 15. Settings Activity Diagram.

3.2.6.3 Functional Requirements

This functionality can give the user access to settings in the gameplay. The player can use some functions in settings such as volume control and background music. The following are some essential sections to specify the benefits that the user can extract with the product.

a. The volume control functionality must provide the exact frequency of the volume if the user manipulates it.

b. The game must update the volume frequency if the user applied changes.

3.2.7 Backpack

This functionality collects the potions that the players have gained or bought. The potions that are already used in the fight would not be available in the backpack.

3.2.7.1 Description and Priority

The backpack is one of the functionalities of GADIMATH, where players can store their collected potions. A maximum of six potions allowed to store in the backpack.

3.2.7.2 Stimulus/Response Time

This serves as the bag in which all the potion items are stored. The players have the prerogative of whether to store particular potions or not. The maximum capacity of the backpack is six potions. The stored potions may be upgraded depending on the decision of the players. Once the player has bought some potions in the shop, it will automatically reflect in the backpack and be used during the fight (see Table 16).

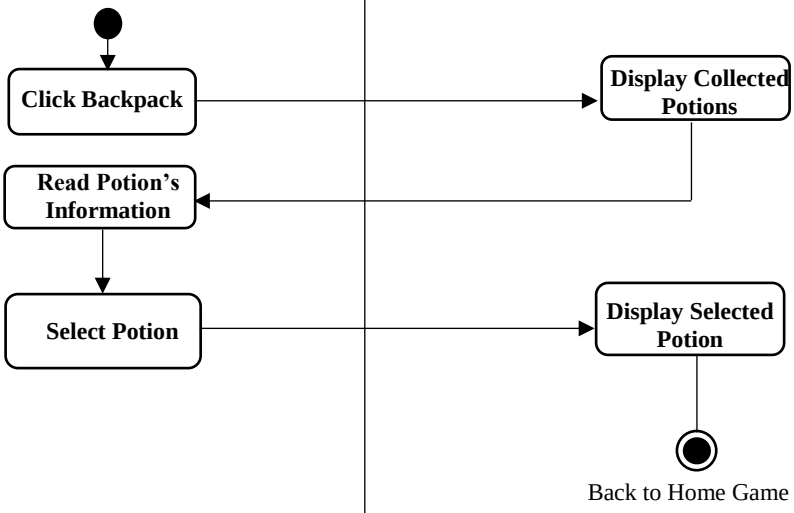
Function Name	Backpack
Pre-Condition	The user must play the fight functionality or buy potions in the shop.
Post-Condition	The user can store the potions in the backpack
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can ignore the backpack menu if they have no potions to store.
Exception Flow	The user cannot add additional potions if the backpack has reached the maximum number of potions.

Table 16. Backpack Activity Diagram.

3.2.8.3 Functional Requirements

This feature allows the user to store their collected potions during the gameplay. In addition, the potions bought in the shop are stored here. Below are the requirements to avail of potions and stores in the backpack.

a. The player must play the fight in order to gain potions.

b. The player must collect all the potions to use it for the following level and upgrades, if necessary.

3.2.8 Help

This functionality presents the most frequently asked questions regarding the game itself. It gives the users the possible ways on how to solve certain problems or questions that they may encounter during their within the game.

3.2.8.1 Description and Priority

The functionality of GADIMATH that focuses on giving the players some helpful information with the game.

3.2.8.2 Stimulus/Response Sequences

The user must click or tap the help button to open the help interface. The application displays the most frequently asked questions that the player needs to know. After this, the player has the prerogative to continue reading or exit from the help interface (see Table 17).

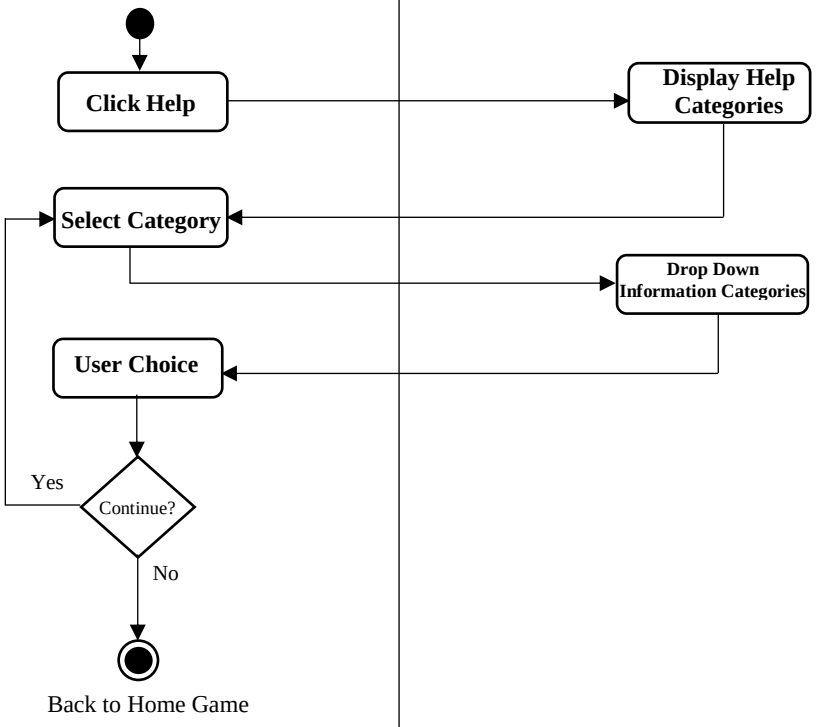
Function Name	Help
Pre-Condition	The user must click the help button to enter in the help window.
Post-Condition	The user can view and read the help information they want.
Game Flow	
User	GADIMATH
	
Alternate Flow	The user can skip the help option in the game.
Exception Flow	The user cannot change to modify the help information in the game.

Table 17. Help Activity Diagram.

3.2.8.3 Functional Requirements

This functionality provides the user the idea regarding the most frequently asked questions within the game. The help information provides:

a. A piece of static information; thus, data cannot be tampered or changed.

3.2.9 About

This refers to the information of the developer of the game and the kind of environment and language he used to accomplish the development

3.2.9.1 Description and Priority

This functionality is provided to know the developer of GADIMATH. This can be seen once the application is loaded.

3.2.9.2 Stimulus/Response Sequences

The About functionality works by clicking the About button in the landing form of the game. The user can now see the information of the developer of the game (see Table 18).

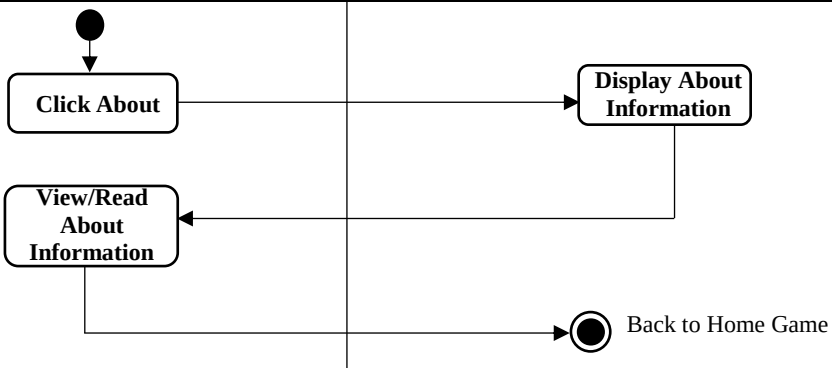
Function Name	About
Pre-Condition	The user must click the About button to enter in the About window.
Post-Condition	The user can view and read the information about the developer.
Game Flow	
User / GADIMATH	
Alternate Flow	The user can skip the About option in the game.
Exception Flow	The user cannot change or modify the About information in the game.

Table 18. About Activity Diagram.

3.2.10.3 Functional Requirements

This functionality provides the user with short information on the game itself, along with the developer. About information provides:

a. Short information about the developer and the type of language and environment used to develop the application.

This chapter has thoroughly discussed and described the application features and capabilities of the GADIMATH: Gamified Discrete Mathematics. It comprehensively narrates the descriptions and priorities of each feature, the stimulus and response sequences once it is used and the functional requirements to execute a certain program flow.

EXTERNAL INTERFACE REQUIREMENTS

Product prototypes are commonly associated with product design. It is used to present a concept of future products. For game design, the visual interface is needed in product development because it is the intended design and can stimulate the appearance of the colors and textures of the product to be developed.

GADIMATH has a visual interface that can help define the needs of the product. Provide the users with quality designs as the users navigate along with the game interface. The succeeding sections discuss product mechanics and user interfaces.

4.1 Product Mechanics

Product mechanics are part of a game which varies depending on the type of game being produced. It is also one of the reasons why users keep on using a product. It also provides an experience on the part of the user since the instructions of the game are stated in this section. In line with this, the following sub-sections are provided to highlight the different game mechanics that the player needs to understand and the goals they need to accomplish.

4.1.1 Victory Points

The users can gain coins, experience points (XP), and drop potions upon playing the game. The coins may vary depending on the duration of the length of the gameplay. The XP may also vary once a particular level has been completed. This XP is accelerated at every level of the dungeon in the game. The lesser the

amount of time consumes in answering the questions has the higher chances to continue and complete the game.

4.1.2 Catch Up

The player needs to defeat all the deadbots to finish the game. However, to do this, a player must answer the questions correctly and counter the potions that have been integrated into the deadbots to survive. The potions in the shop would help the player cope with the deadbot attributes, which would enable the player to last long in the game. Aside from the drop potions, the player must buy potions in the shop to acquire additional attack points or damage to the deadbots. The user must have enough coins to buy potions to purchase it.

4.1.3 Resource Management

The player can use the acquired potions in the gameplay. The player is given the privilege to use these potions throughout the gameplay. The player can have six potions which they can use in the game. They can get it by defeating the boss deadbots or buying in the store and storing it in the backpack for future use. The player has the prerogative to sell and change the potions anytime they want. Also, they have the right whether to collect or not the potions that have been dropped by the defeated boss deadbots in each level of the game.

4.2 User Interfaces

User Interfaces are a medium of interaction between a user and a product. It may vary depending on the type of product being produced. It is also one of the factors to be considered as part of the strategies in delivering a good product. The following prototypes

highlight the purpose of the product. This is to let users identify the different interfaces of the game. It provides users with a visual representation of the product interfaces.

4.2.1 Choose Avatar

Choosing an avatar gives the user the prerogative to explore the game and familiarized all the functionalities integrated into the application (refer to Figure 4). In choosing an avatar, the player needs to select whether a male or female hero character to proceed.

Figure 4. Choose Avatar Interface.

4.2.2 Game Home

The design set-up through different panels provides the users with a user-friendly environment that helps the users navigate the game easily. The game home contains the following panels: the navigation panel and the gameplay panel (refer to Figure 5).

The game home of GADIMATH provides easy-to-navigate buttons like the backpack, shop, help, about, and settings. The backpack would serve as the storage for the collected potions by the players. The shop is an area in the application wherein players can buy potions. The settings give the users the chance to adjust the volume and music background of the game. The help menu displays the most frequently asked questions in the game, and the settings allow players to adjust the volume of the music. The gameplay panel allows the user to explore each dungeon and levels in the fight. Also, the tutorial teaches the players the rules and controls of the game. The book of knowledge gives the player the information of each dungeon and the topics that have been included in each level of the application. The game mechanics are often set up by rules and guidelines on how to play the game.

Figure 5. GADIMATH's Game Home Interface.

4.2.3 Dungeon Map Selection

GADIMATH has seven main dungeons. Each has three levels. GADIMATH provides a dungeon map that the player can select to proceed in the gameplay (refer to Figure 6). Each dungeon symbolizes the topic in discrete mathematics. For the players to unlock the next dungeon, they must first finish the previous dungeon. It unlocks once the deadbot in the last level of the selected dungeon was defeated.

Figure 6. Dungeon Map Interface.

4.2.4 Dungeon Level

The selection of the levels starts after selecting the dungeons (refer to Figure 7). GADIMATH has three levels that have 50 random questions per complexity level. Each level has three deadbots to defeat. Other levels would unlock right after finishing the previous levels. The same rules are followed in the next succeeding

levels. If the player have already selected the level, it redirects to the fight functionality window where players need to answer the randomized questions for them to proceed to the next levels. They cannot proceed the two remaining levels within the dungeon if they could not complete the previous level. The back button allows the player to go back to the main page of the game.

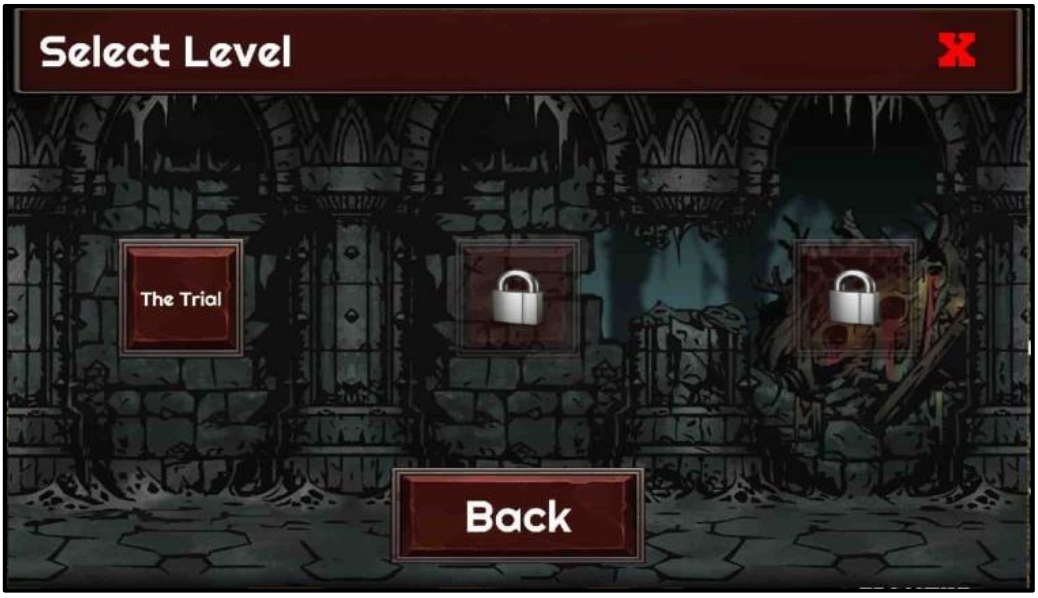


Figure 7. Dungeon Level Interface.

4.2.5 Gameplay

The gameplay screen allows the player to view the fight, tutorials, game mechanics, and book of knowledge. These are the sub-functionalities of the gameplay. This would allow players to read the information regarding the rules and mechanics on how to play the game, the information of each dungeon and levels, and the fight where players would select the correct answer to the questions

assigned for each level (refer to Figure 8). Each topic questions are arranged in scaffolding. The complexity of the game is based on the level of the game itself.

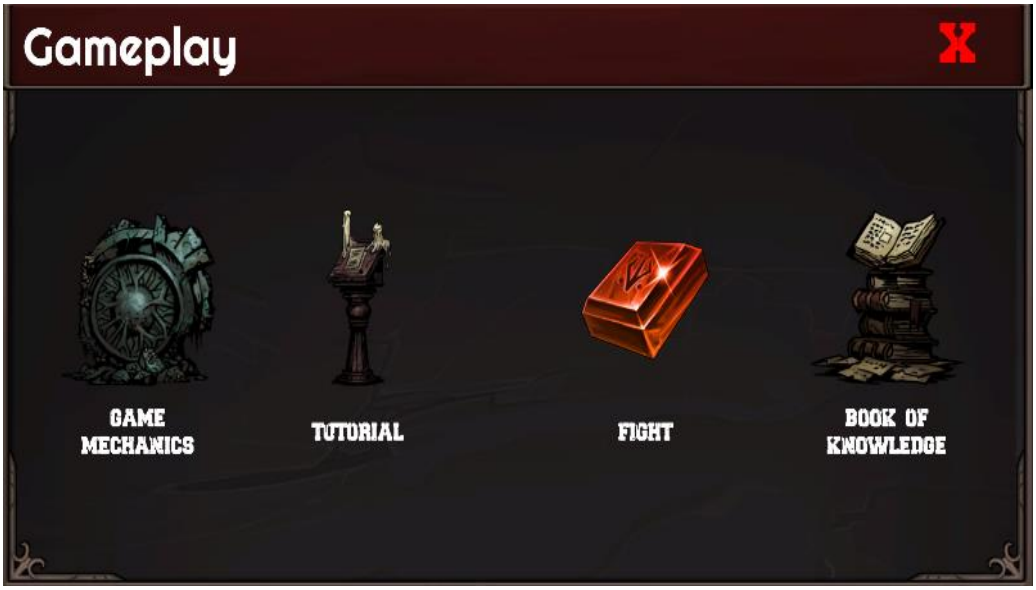


Figure 8. Gameplay Interface.

4.2.6 Fight

The fight is the gameplay proper where players need to finish to proceed to the next level (refer to Figure 9). In the fight window, players can see dungeon's name and the level that the players are currently playing. Also, it includes the time given to each question of the game at a particular level, the health points (HP), coins, and XP. The HP display the remaining life points of a particular player. Moreover, the coins refer to the value of a number accumulated once the level is incrementing. The players can use these coins to buy potions to help them survive the level. Lastly, XP determines the strength of the character. This can be useful when the level of the game is incrementing because the deadbots are attacking in

much greater damage. The higher the XP means, the bigger the damage the player can return to the deadbots. All used potions during the gameplay cannot be seen in the next succeeding levels. The players can convert their XP to coins if ever they wanted to but new potions that needs an additional coin value. The potions that have been dropped in the gameplay are also randomized. This is to ensure that the player can really use their strategy as to when they will use the potions. In addition, the deadbots have their randomized potions to trigger the attack of the player. Lastly, the questions and the choices projected in the game are also randomized to prevent players not to memorize the questions and the choices itself.

Figure 9. Fight Interface.

4.2.7 Book of Knowledge

The book of knowledge contains information about the dungeons and level of the game (refer to Figure 10). These include the enemies available at each level

of the dungeon, the topics covered, estimated time to finish each question in each level of the game, and drop potions available at the given level. The Hero Quest dungeon is the default dungeon that is open in the gameplay. In this functionality, players would have the glance on what to expect in a particular dungeon. These includes the name of the deadbots available in thee dungeon, type of potions to collect, the expected time to answer each level of the game and topics covered for within the level of the game.

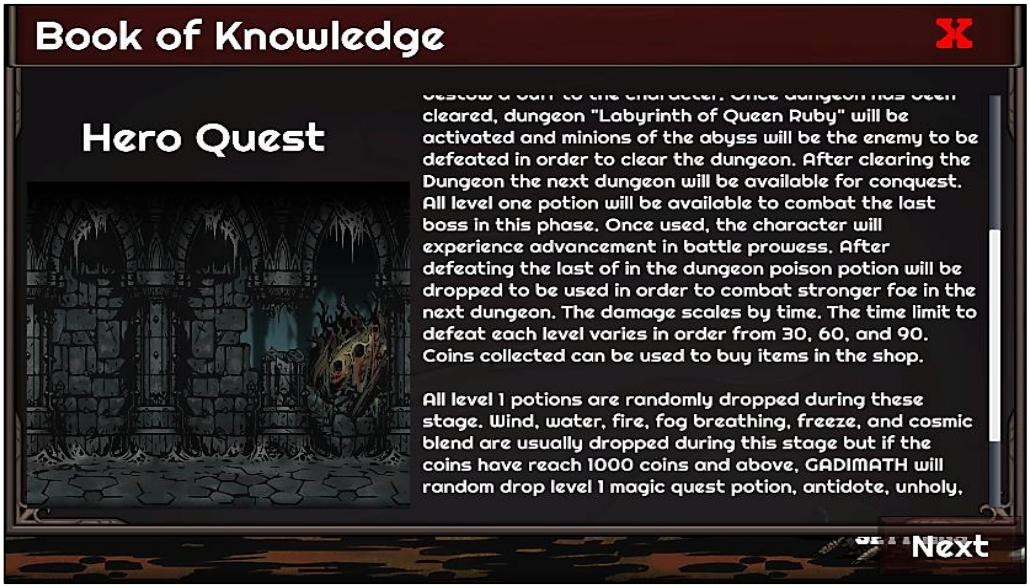


Figure 10. Book of Knowledge Interface.

4.2.8 Backpack

The backpack contains the stored potions of the players. They can get it during the gameplay proper or buy in the shop (refer to Figure 11). The players can store six potions in the entire gameplay. They can change the potions in their backpack by selling it. The sold potions are added to the total gain coins, and they

can use it to buy new potions. The potions may vary depending on the level of the game. The higher the level, the higher the attack and defense potions the player can have. All used potions during the gameplay will automatically omitted in the backpack. This is to give players the chance to add additional potions whenever they want. Players have the right to use multiple potions at a time but once it is used, they cannot activate it unless they buy it again in the shop. These potions upgrade per level of the game. The higher the dungeon level that the players have reached the more chances that the potions will upgrade faster. Once you have not seen any potions in the backpack that means that the players have not yet defeated the third deadbot in a that particular level or they have not yet buy potions in the shop since they need enough coins to do it.

Figure 11. Backpack Interface.

4.2.9 Game Mechanics

This window provides the different categories for the game mechanics of the game. It gives information on the different sets of rules that the player should know in the game (refer to Figure 12). In addition, it would help the players to analyze the game and would know that if they did not complete the levels of the game they cannot proceed to the remaining levels of a particular dungeon. In this portion also, players would know that each questions displayed in the game has a corresponding time limit to answer.

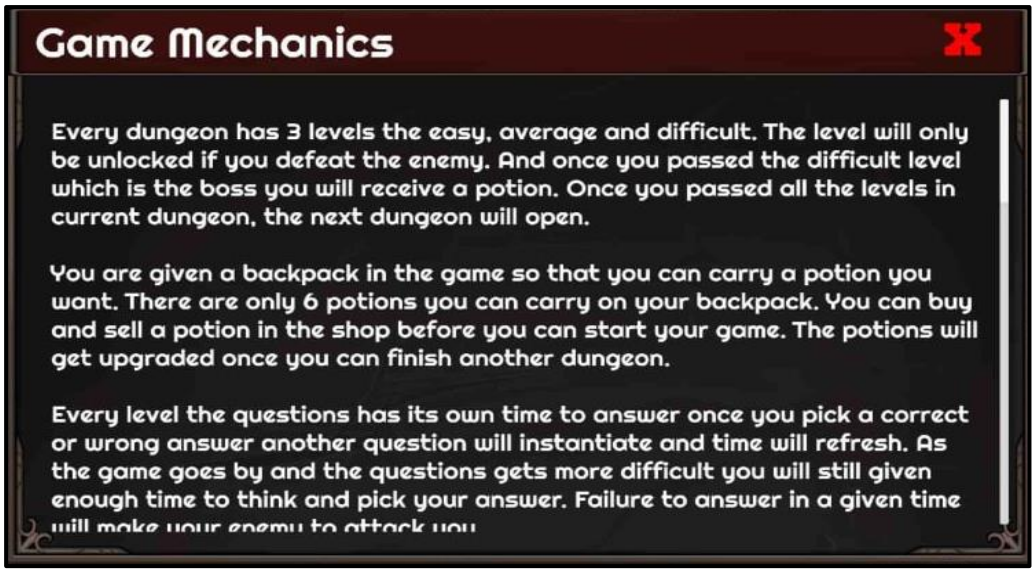


Figure 12. Game Mechanics Interface.

4.2.10 Tutorial

This window provides the player the information on how the game works and how to navigate the game (refer to Figure 13). This portion of the game would benefited the players well because it will guide them on how to navigate the game.

This is a user-friendly tutorial where player needs to scroll down and read all the steps on how to play the game for them to play the game without hesitation.

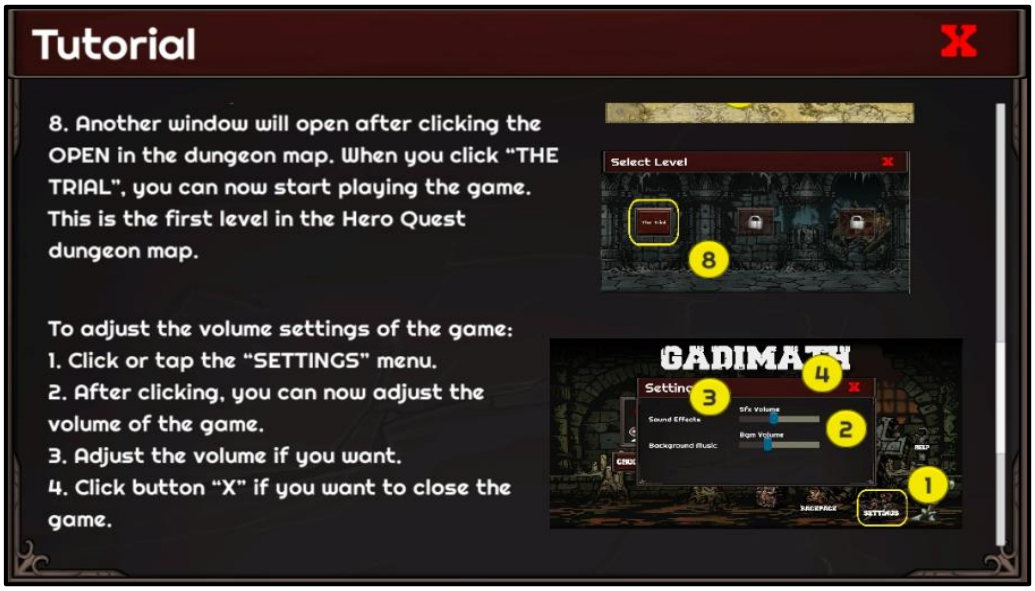


Figure 13. Tutorial Interface.

4.2.11 Shop

A shop window is a place where the players can buy potions to use in the entire gameplay (refer to Figure 14). The players can see the descriptions of each potion and how to gain it upon exploring the shop window. All potions in the shop upgrades once the dungeon accelerated. The more potions bought and stored in the backpack, the higher the chances of defeating the deadbots. In addition, the players can sell potions in the shop whenever they want (refer to Figure 15). The players can also convert their XP to coins to add up to their existing amount of coins.

4.2.11.1 Buy Potion

The buy potion interface allows the user to buy potions whenever they want as long they have enough coins to do so. These bought potions can be seen in the backpack for future use.

Figure 14. Buying of Potion Interface.

4.2.11.2 Sell Potion

The sell potion interface allows the user to sell potions that are not in use. The players can sell all his potions if they think it does not suit for the dungeon and but another. In addition, these sell potions would be automatically omitted from the backpack. Players can sell all their potions available in the backpack and change it to another. Once they sell their potion, it would add up to their existing coins which is useful as they go along with the dungeons with moderate to difficult topics to answer. These

potions would protect them from gaining more damaged or even change questions and stop time.

Figure 15. Selling of Potion Interface.

4.2.12 Settings

The settings panel allows the user to adjust the volume of the game. It has two main functions the sound volume and background music volume. The sound volume allows the player to adjust the volume of their Android devices while the game music volume allows the player to adjust the volume of the game itself (refer to Figure 15). If the user does not want to use the sound and background music during the gameplay, he has the prerogative to make the application in silent mode by adjusting the volume game. These effects integrated in the game adds excitement to the players for them not feel bored during the gameplay. The sound and background music changes as they move forward to the next level. These effects

correspond on the description of the dungeon itself. Take note that “Sfx” stands for sound effects and “Bgm” stands for background music. These two are working together to make GADIMATH entertaining while learning takes place. Sound effects takes place while clicking any buttons in the game while background music are the built-in music exclusive for each dungeon of the game.

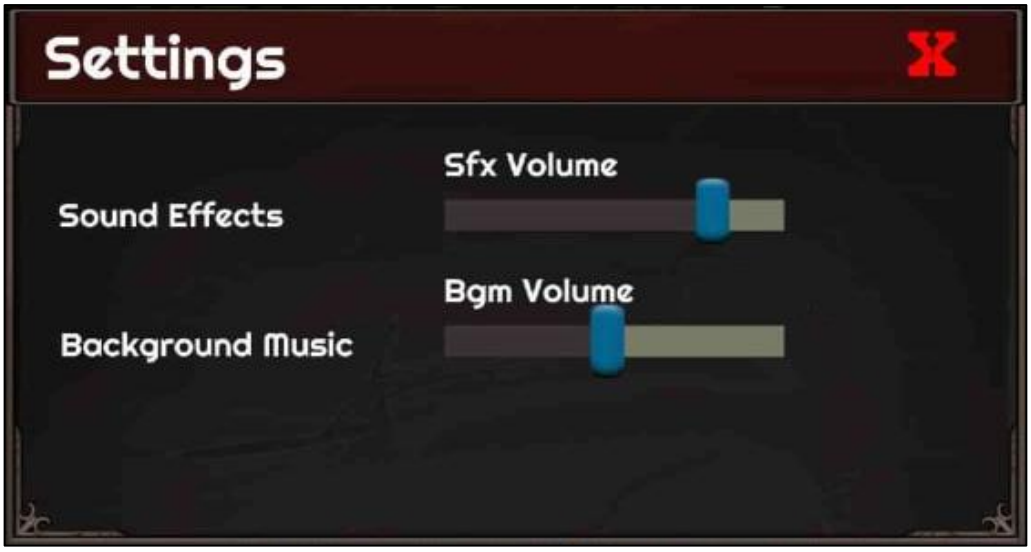


Figure 15. Settings Interface.

4.2.13 About

About window allows the user to view the information of the developer (refer to Figure 16). Once clicked, the user can see the developer’s information and the short description of the application. Here in the about functionality, players would know what is GADIMATH means and who are the people behind the success of the game application. In addition, they would know the type of engine used in

the development of the game and the available programming language that is suited in the game and the engine.

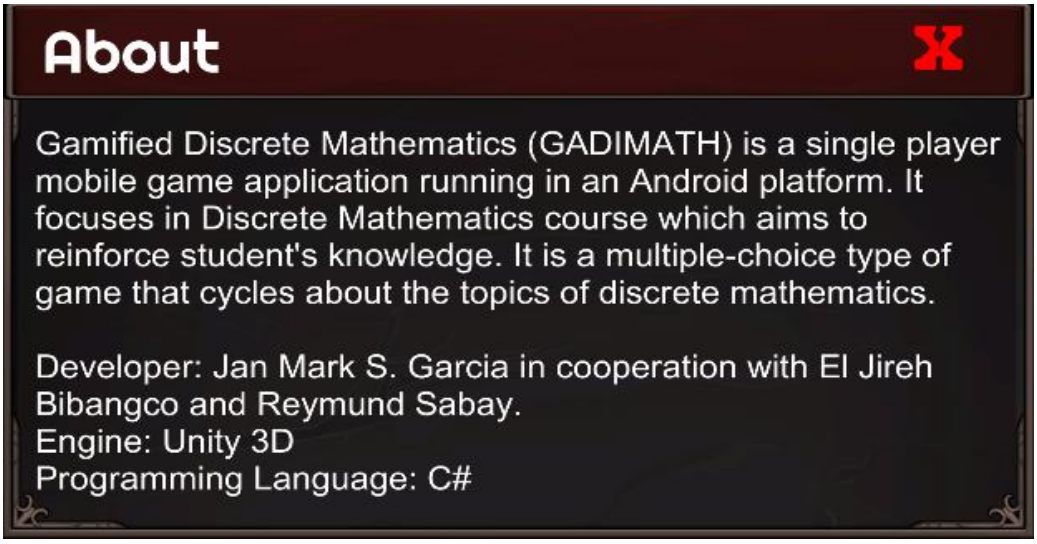


Figure 16. About Interface.

4.2.14 Help

The Help window provides the user the chance to read the most frequently asked questions in the game. By clicking the Help icon, it would redirect to the possible questions that the user may encounter while playing the game (refer to Figure 17). In the help section, players can see and read all the frequently asked questions in relation to GADIMATH itself with its corresponding answers. Examples of the frequently asked questions are they type of questions used, type of player, and the expected allotted time in answering the questions during the gameplay. This section is useful for players who are new to discrete mathematics

game. They will equipped with knowledge of what to expect in the game and how it works.

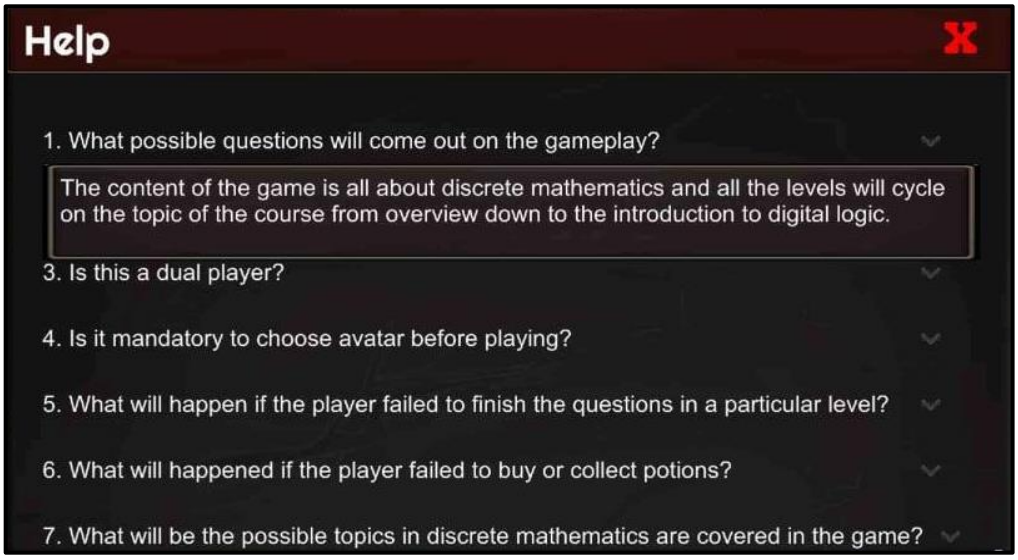


Figure 17. Help Interface.

This chapter has provided the details on how the GADIMATH: Gamified Discrete Mathematics work by showing its different functionalities and features. It gives the users the idea on how to use and navigate the application by showing the different parts of it. By giving the detailed information about the application, users would have the complete understanding of the application on how to use and operate it.

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Sacred Heart Seminary Bacolod, Bacolod City

CONFERENCE/SEMINARS PRESENTATION AND PARTICIPATION

Year	Seminars Attended
2019	1st – 5th Thesis and Dissertation Writer's Assembly
2019	Seminar-Workshop on Statistical Analysis in Research
2019	Working Together, Works: Community Organizing (COMMORG1)
2019	Introduction to Rice Post Production Technologies (MECHANIZATION2)
2019	Digital Network Systems
2019	Organic Fertilizer for Sustainable Agriculture (ORGANIC1.3)
2018	Basic Urban Gardening (URBAN1)
2018	Mastering the ABCs of Pig Production (PIG2)
2018	26TH PSITS-R6 Regional IT Congress
2018	Rubrics Item Analysis and Table of Specification
2017	Institutional Sustainability Assessment (ISA) Orientation and Outcomes-Based Education (OBE) Seminar-Workshop NICP-EC Council Visayas Teachers
2017	Training and Certification for Certified Secure Computer User (CSCU)
2016	Code of Professional Ethics for Teachers
2015	OBE Program Assessment and Evaluation Echo Seminar Workshop
2015	Faculty Training on Information Storage and Management

CHARACTER REFERENCE

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