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Math Adventures with Tuffy: A 2D Game to Aid in Learning Mathematics

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Abstract: ***Games have always played a significant role in a student's life. With the fast paced technological development and the virtualization of learning environments, the need for bridging the gap between learning and gaming has never been higher. Studies have shown that integrating games into academics have shown significant improvement in the students' engagement and are motivated to perform well.***
The aim of this study is to develop a 2D platform game to support learning of mathematics at elementary level. Various academic aspects are integrated into in order to set a learning environment using game mechanics. Building on the pre-existing ideologies on games for learning while basing it on Educational requirements and enhancing the gaming experience.
This makes the learning experience engaging and fun all the while focusing on the learning experience, and when education is related with fun the positive aspects of gaming would be reflected on academics as well. The study focuses on game development and how various concepts for gamification are implemented and integrated to it. Understanding the relationship between education and gaming leads to compelling Academic solutions. This could revolutionize the field of Education and how it is imparted.
Keywords: Gamification, learning environment, educational tool, development, math game.

I. INTRODUCTION

In this era of rapid digitization and growth, there is a rising need for new and innovative methods of teaching and learning. Advancements in the educational field have been rapidly rising with new technologies, teaching approaches and learning aspects. In this epoch of learning, educational games and gamification has received quite a lot of attention and has started to get accepted as a positive way of engaging learners from various backgrounds.

A. What is Game?

A game is an activity that has an objective or a goal, various obstacles or challenges and rules that guide the achievement of that goal. It also contains interaction with other players or the game environment and feedback mechanism to represent the progress and performance resulting in quantifiable outcomes generating emotional reactions from the player. (Boller & Kapp, 2017) Games are an integral part of a kid's life and it has always been related to fun and entertainment, but gaming in education is not a completely new concept. Even if the concepts involved in games are not used profoundly, game principles are subtly implemented in various fields.

B. The concept of gamification

Gamification is a process where game design elements and various game principles are applied to a non-gaming environment. Gamification has been implemented in almost all the fields and it has shown positive results. Various businesses use game design elements like leader boards and performance graphs to update and analyze their employees and have proper reward systems for the same. These things have shown to motivate the employees to perform well. Gamification shifts the focus of any environment from a ground level and tries to connect performance of individuals and their behaviour with game elements and principles. This shift in perspective gives the individual an opportunity to do the same action with a much differ and positive approach leading to new outcomes and results. This also means gamification can also be applied to the smallest task, like a daily routine or even a to-do list. Gamification of something reduces the stress in the process of performance and enables the individual to indulge in the process instead.

C. Games and Learning

Games and learning is a field of educational research and study which focuses on the advantages and positives individuals gain through playing games/ video games as well as how the game design principles and techniques could be implemented to create new and innovative learning environments.

Games allow people to experience customizable simulations of real life scenarios, this gives the people opportunities to think, analyze and act in new ways. It helps to integrate social aspects, Thought process and technology simultaneously.

D. Games in education

Games in education could turn out to be quite interesting. From a psychological perspective games are viewed as fun and positive. Integrating gaming into education and learning environments can also bring forth the positive psychological aspects of gaming into every classroom learning experience in a student's life. Games have shown to improve various cognitive and intellectual skills in kids and have also motivated them to perform well.

Several studies have indicated that gamification of the educational environment has had higher performance than the traditional non game based classroom environment.

Games which are specially meant for educational purposes are known as learning games (also known as serious games). Learning games generally have an objective which is connected with an academic outcome.

A good example of this are the games meant for kids, which helps them to count and differentiate between various colours.

In this study the aim to develop a 2D platform game which will help Kids to learn primary level mathematics in the form of a game. There are various such games on Play store and other platforms but most of them enhance the play objective rather than the learn objectives.

E. Why do we need games in education?

Gamification and games for learning is not all about the learner's enjoyment, it's important or to understand that gamification is an effective instructional approach on student learning. There are a lot of advantages to integrating games with education

1) It increases student's motivation
2) Enhance their ability to recall and retain the information they have learnt
3) Encourage healthy competition
4) Improve peer to peer communication
5) Immediate feedback on performance

In order to further emphasize the positive aspects of games for learning this study intends to develop a game by applying the various gaming principles and elements concurrent with the academic requirements.

II. LITERATURE REVIEW

Educational games have been booming from the mid-80s and have seen significant growth, development and acceptance as a pedagogical tool over the years. Quite a lot of researchers and authors have divulged into this field of study and have come with a lot of valuable scientific discoveries and theories, which has led to an improved understanding of human behaviourism and growth of cognitive skills.

The world has seen digital growth like no other in the past few decades and the increasing need for more innovative approach towards pedagogy led to the slow but steady acceptance of games as an effective pedagogical tool. A study was conducted to analyse how games can affect the learning process and teaching of history. In this study, the authors used various theories like social activism theory and cognitive processing theory to understand how games, can be integrated with the curriculum. Concepts of gaming such as problem solving, simulation, puzzles and tutorials used to give students an opportunity to interact with the curriculum in a different way [45]. Oblinger [32] in her paper discusses how, games such, as football or even video games can be immersive and a very good environment for learning. The paper also discusses how games for learning, can be integrated in educational curricula. It has concluded that not all games are viable learning environments.

Egenfeldt-Nielsen [15] gives us an overview of all the significant research conducted so far in educational use of video games. In the paper, he goes through concepts of behaviourism, cognitivism and constructionism. He evaluates the major key tensions that arise due to these concepts. He states that all the previous studies focus on one or two major characteristics in learning games rather than having an inclusive and much broader understanding of learning perspectives and learning from video games.

In his article, Gee [17] focuses on how game developers design a game in such a way to keep the audience engaged and motivated to learn the complexities of the game even if it is not very easy. The problem in many games is that the user finds the games difficult and gives up before learning how to play the game properly. Learning how to clear new challenges is another technique used by game developers to engage the users and give them a sense of accomplishment. Using such techniques has made the gaming industry skyrocket. Papastergiou [36] assessed the effectiveness of computer games in learning computer memory concepts for Greek high school students by integrating their computer science curriculum in an application. This ended up having positive results and motivational appeal and concluded that computer games could be an effective pedagogical tool.

In his book, Squire [41] acknowledges the ability of a game to influence the social, cultural and intellectual growth of the user. It has immense potential to influence and contribute to the educational growth of the user as well. He gives many examples of how games have influenced the actual life of many of its users in a very productive way. Thought inducing games that trigger the cognitive and reasoning part of your brain greatly increases your intellectual ability to solve problems in real life. Authors like those that Mitchell and Savill-Smith [29] talk about how video games influence young people and how games can be used for learning. The article shows how different individuals play games for different reasons, for learning or leisure. The article [29] discusses the benefits of games such as enhanced learning, new skills, critical thought etc. The article also mentions how math related games have helped children develop math skills at a young age. Ormsby et al [33] in their paper go through the potential of video games and simulations in student engagement with science, math and technology. With the rising need for people in the field of science, Math and technology, also, people who have to be critical thinkers and have analytical skills the authors see challenges and limitations classroom learning can pose and how games for learning could break these barriers. Divjak and Tomic [12] review in the pre-existing literature in the field of games for learning. It is important to understand how well various elements of game mechanics, applied to pre-existing educational games. In most cases, educational games do not have properly integrated educational content and the focus will be on game media. This is what Buckley [5] analyses in his paper and aims to create a genre hybrid Educational video game in which introductory programming curriculum is integrated. Buckley [5] uses machine architecture visualization to have a grasp of core concepts, resulting in a cross-platform educational game for teaching programming.

When discussing gamification of education, it is also necessary to understand gamification of assessments, as they play a significant role in keeping track of students' performance. Attali and Arieli-Attali [1] discuss the same. In their paper [1], they have analysed whether 'points', one of the most basic elements of gamification contributes to the performance of students in computerized assessments.

Author Corti [9] states in their article, game based learning as a serious business application. Game based learning is very important and has very high potential both commercially as well as educationally. It is not vital but can give a huge advantage to a student who utilizes it well enough.

The first ever-educational game created was a game called LOGO. It is a programming language game blended with mathematics; Seymour Papert and Wally Fuerzeig developed it in 1970. Another prominent game released in 1971 OREGON TRAIL, which was developed by MECC, this kind set up the path for future potential educational applications and games.

Fellnhofer [16] in her evaluation study evaluates how educational games, using specific frameworks and gaming features can improve mathematical skills and knowledge. Her evaluation included exploratory factor analysis, linear regression analysis, t-test, ANOVA and Kruskal-Wallis test to cover multiple factors involved such as age and gender. Her evaluation had positive results highlighting the chances for educational games to be an effective pedagogical tool to improve math skills. Authors Drigas and Pappas [13] go through various studies, which evaluated the effects of video games, and the various tools in mathematics education. The purpose of this paper [13] was to examine the various studies, which assessed the contribution of video game based learning in mathematics and concluded that game based learning had quite the positive impact on student's mathematical skills as well as their motivation. Kembritchi, Hirumi and Bai [26] examine the various effects of computer mathematics games on students' achievements and their knowledge in mathematics, their computer skills and English language skills prior to playing the game. Also in another research, the author Kembritchi [24] discusses how mathematics computer games have a positive impact on students in public high school settings. An Experimental study conducted by author Kembritchi [24] states how mathematical computer games play a vital role in increasing class motivation by using various analysis methods such as analysis of covariance.

An investigation conducted by Salam, Hossain and Rahman [39] on class VIII students using team games tournament technique on one group and traditional lecture based learning on the other for learning mathematics. After the pre and post assessments, the TGT group showed higher performance and learning outcomes compared to the control group. The TGT group also showed a positive mindset towards the learning atmosphere and the subject itself.

Authors Maloy, Edwards and Anderson [28] study how a combination of computer based activities, educational games improve students' overall performance. Maloy et al [28] describe the impacts of 4MALITY, a web-based mathematics tutoring system on students. 4MALITY proved to be quite effective, with 70% of students improving their scores from pre and post-tests.

When it comes to integrating game play into academics it is important to know the teachers' and tutors' view regarding game play in a classroom-learning environment. Demirbilek and Tamer [10] develop a framework using a grounded theory approach, based on the perceptions and views of various math teachers in turkey. Though the teachers expressed concern over management of the classroom when it involves game play they do agree that games have a positive impact on math learning. Kafai [21] goes through two perspectives of teachers, one that instructs the students to learn by embedding lessons directly in the game and ones that encourage and teach students to create their own educational games. It emphasizes how games can influence a student's social life as well as his/her educational goals. The conclusion is that creation of games by young children is still a new endeavour but the potential it has is astronomical. A research paper by Yong, Gates and Harrison [44] deals with the various perspectives on digital games in learning and mathematics. In most cases Educational, games mostly focused on the implications in a classroom environment, but the context of the educational game from home is quite blurry and not quite accounted for. Authors Derboven, Zaman, Geerts and De Grooff [11] throw light on this aspect of educational games. Derbovan et al [11] study how the game 'MONKEY TALES' are interpreted by children and how appropriate it is for their preference. This proved to be quite useful when it came to game generalizability and designing of educational games.

The research conducted by Plass et al [37] involved designing of a game that would allow students to approach math in various conditions such as individual tests, competitive game play and collaborative game space. The idea was to see which mode of play would be more effective when it comes to learning, motivation and overall performance in students. The research concluded with positive results in motivation regarding math regardless of mode, but competitive game play was a major contributor in case of scores. Collaborative space improved motivation and increased positive approach towards the subject itself.

The fast-paced digitalization has also increased the number of educational websites that claim to be interactive and approach education in a fun way. The research paper by Scanlon, Buckingham and Burn, A [40] deals with understanding how games and game mechanics are being embedded in educational websites to teach mathematics. They emphasize the importance of giving credit to the process rather than rewarding only the correct answer as mathematics is a subject of absolute truth. Papadimitriou and Virvou [35] proposed an online adventure game, which will aid in teaching arithmetic. The said educational game is an adventure game that includes multiple mini games built into it.

In their research paper Castellar, All, De Marez and Van Looy [7] go through the various possible impacts of educational games (specifically math games) on the cognitive abilities of students The paper concluded that improvement in arithmetic performance and working memory capacity of students through games differed well in comparison to paper exercises. In the given context, another important focus point would be to understand the convolution between motivation and game based learning. Authors Hoffman, Paek, Zhou and Türkay [18] in their paper emphasize the need for more comprehensive assessments to understand the domain specific or game specific motivation. They used a quasi-experimental design on elementary students and video games related mathematics over a period of two weeks. Barreto, Vasconcelos and Orey [2] also study the motivation and engagement of students while playing educational games and to understand this they conducted a qualitative case study, which involves two elementary kids playing math games in the game club penguin. They found out that participant' motivation was not stable and their engagement differed based on their interactions.

Author Ke [23] proposed to use a mixed-method approach. In his paper Ke [23] emphasizes the importance of using both online and off-computer activities to help deliver the most effective way of pedagogy. His observations aided with students' think aloud protocol, lead to understanding this need for having challenging games while having interactive off-computer sessions. Hwa [19] also highlights the positive impacts of digital games, how digital games changed and are changing the pedagogy of mathematics. The paper deals with the implications of 'DigiGEMs' which is an interactive multimedia courseware [19]. 'SCOOP!' is a movement-based game that intended to reduce anxiety towards math. Isbister, Karlesky, Frye and Rao [20] use 'power poses and its effects to shift a person's feelings towards this particular subject. This application could be one major example why motivation plays an important role in the learning process.

Focusing on how game design actually influences the students' learning process will give ample of positive insights on how to design learning games. Moyer-Packenham et al [30] go through this in their paper, they analyse how various game design features such as tutorials, feedbacks, multiple attempts, accuracy and progressive levels promoted cognition with mathematics. The results suggested how design features that are specifically oriented to certain subjects, mathematics in this case could prove to have a positive impact on the learning curve of the kids.

With games for learning as a growing field and production of educational games on the rise, there is a need for proper design principles to guide the development of such games. Chorianopoulos and Giannakos [8] have highlighted various design principles, which will aid future developers and game designers, based on previous works and surveys. They state that students need to engage with a game narrative, have familiar game environment and game mechanics, be given an opportunity to have trial and error based game play and have a collaborative learning space. When it comes to game design, another aspect to consider is whether conceptual clarification is required. This is exactly what Vandercruysse et al [43] have gone through in their paper. They have found out that conceptual clarification as support is benefitting to the students when it is external.

Sutopo and Pamungkas [42] have developed a multimedia mobile game for learning mathematics, particularly numbers for elementary school students. They have followed Borg and Gall's 7 step research model to develop this application. Katmada, Mavridis and Tsiatsos [22] develop and implement a game called 'volcanic riddles' and how it supports learning in mathematics. After the implementation and evaluation of the games prototype the results were quite positive, the students found the tough mathematical concepts easier to understand through the game and liked the innovative approach towards the subject, leading to increase in perception and performance in that subject.

Mathematics poses difficulty for students of all ages. In their research to practice paper, Muntean, Mawas, Bradford and Pathak [31] proposed a game named 'COUNT WITH ME!' which is an immersive computer, based educational game to help undergraduate students with counting principles. Their analysis resulted in a statistical improvement in students who played the game when working out topics like addition, multiplication, permutations and factorial.

Pope and Mangram [38] aim to assess the impacts of a digital mathematics game on third grade students' number sense. They used pre and post test results to assess students who played the game 'Wuzzit Trouble' and it did result in positive findings.

Oyesiku et al [34] have worked on a 2D mathematics game created using Unity game engine for high school students in sub-Saharan Africa, to improve students' motivation and interest in mathematics, helping them to increase their performance.

III.PROBLEM FORMULATION

When it comes to development of games especially for educational purposes, there are certain aspects and problems addressed. There are many things taken into consideration and some of the key research ideologies taken into account while developing such games. Areas observed several key problems, addressed in this game.

Scanlon, Buckingham and Burn, A [40] in their article have highlighted that math games tend to use the point system as a means to reward only the correct answers. Mathematics is a subject of absolute truth, and it is very important to keep track of the progress and process leading up to the answer. Attali and Arieli-Attali [1] also throw light on how the assessments are handled in gamification of subjects. Most of the educational games tend to focus more on game play, the level of integration of the game with curriculum ends up having the subject as the final objective and not a means to forward the story. Buckley [5] highlights this in his paper by using hybrid game integration. There are many different curriculums around the world, so the universal applicability for assessment of games poses a problem. Various researchers have addressed the problem using different source materials and the games are either too specific or generic. When it comes to learning, there are a lot of different perspectives that various users, students and teachers have towards any specific subject and therefore leading to a generalised approach being applied for all the games. Egenfeldt-Nielsen [15] stresses the importance of understanding the different learning perspectives and being inclusive of them when developing these educational games. Motivation is another aspect, which affects students' approach towards learning. Many students get demotivated to play a game due it relating to a particular subject. Kembritchi [24] highlights this aspect in his paper and Plass et al [37] emphasise on this. The aim of this study is to create a 2D platform game that aids in the process of learning mathematics for elementary school students. In this study, we aim to integrate Elementary mathematics curriculum into a playable game with storytelling narrative and game play. The game will highlight the key learning elements as a means to progress the game play rather than being the objectives themselves. This gives the students a different approach towards the subject and an opportunity to interact with it in a fun way, while at the same time keeping track of their learning progress.

A. The Concept of Gamification

This study aims to create a smaller version of the game with fewer levels for the students. There is a lot of scope for further development and expansion of the game with various levels and different curriculums. The objectives of this study are:

1) To create a Playable 2D platform game.
2) To have a module that keeps track of the progress and displays the score card.
3) To integrate the curriculum with the game-play of the game and embedding milestones for tracking the overall progress.

B. Scope

1) The game will only be focusing on CBSE's grade 3 Syllabus and curriculum.
2) This is not a web game, and is downloadable.
3) The game is downloadable on PC and android devices.
4) The Game is not available for IOS.

C. Hardware Requirement

1) Personal Computer / Laptop 8GB RAM (Recommended)
2) 1TB Hard Drive. SSD 256 GB (recommended).
3) Processor CORE i3 8th Gen (Min); 2.40 GHz (Min). i5 9th Gen(recommended)
4) External Hard-Drive 32GB (For Backup)
5) GPU: Graphics card with DX10 (shader model 4.0) capabilities.
6) GPU: Nvidia GeForce GTX1650 (recommended)

D. Software Requirement

1) OS: Windows 7 SP1+, 8, 10, 64-bit versions only; Mac OS X 10.12+; Ubuntu 16.04, 18.04, and CentOS 7.
2) Unity 2020.1.9
3) Visual Studio 2019

IV. PROPOSED METHODOLOGY

The development of this game is based on two of the most prevalent Gamification theories in the field of learning and education. It is important to understand the impacts and outcomes of the game. Based on these outcomes it may change student's perspectives on educational games, while approaching a subject like mathematics.

A. Achievement Goal Theory

The Achievement goal theory proposed by Dweck and Leggett [14] suggested that, individuals, when have a goal to achieve they would be motivated by it to finish tasks and achieve the goals and objectives.

In the achievement goal theory, the goals are further broken down and fall under two categories namely Mastery goals and Performance goals. Mastery goals drive individuals in order to understand a concept or require mastering quite some abilities in order to achieve the goal. Individuals who are self-motivated and self-regulated tend to prefer mastery goals. They focus on self-Improvement. On the other hand, Performance goals drive individuals who perform higher and better on a social setting and tend to compare themselves with others.

B. Feedback

Feedback is one of the most common tool that is to convey results of performance appraisal in several fields. Feedback is either verbal or non- verbal mode of communication, which guide students based on their performance and help them understand their mistakes and strengths in any subjects. When it comes to education, considered one of the most efficient tools in facilitation of learning states Brookhart, S [4]. For a subject like mathematics where motivation and emotion towards the subject itself seems pretty negative or downsized, constant positive feedback in the beginning levels can improve the students perspective on the subject and after sometime help them to improve their performances drastically.

C. Gamification Framework

There are several gamification frameworks, commonly used and implemented in various fields like customer service and education. In this game, Bunchball [6] framework is followed for gamification. This framework has a much simpler approach toward gamification and has two major elements. Fig 1 explain the gamification framework.

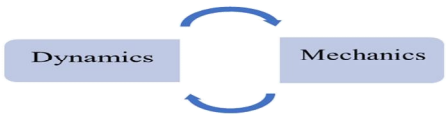

Fig. 1 BUNCHBALL [6] gamification framework

D. Dynamics

Dynamics is the experience that an individual gains from playing nor interacting with a game Bunchball [6]. The experience, mental processes and motivation, all psychological impacts that an individual gets through the game, known as game's dynamics. This includes rewards, status, self-expression, competition, achievement etc.

In this game, achievements, status and countdowns are used as active dynamics during gameplay. The achievements drive the students to proceed further with each level to forward the story's progress. The status of the avatar directly connected with their grasp of the concept. The more the students practice the higher the status of their avatars.

E. Mechanics

The gamification elements, which are required in order to make the individual who is playing the game with experience. This includes points, levels, challenges, leader boards etc. In this game, use of points, various levels and challenges used to give the students a different experience in gameplay when it comes to educational games. Thee various levels in the game incorporate various concepts learnt by the students. With the completion of each level, the student learns a new concept. Every level has points to collect after solving it. Some of the levels have mini quests to engage the kids to the gameplay and keep up their engagement levels stable. There are optional challenges that if the students choose to complete, may earn more points and rewards.

F. Proposed System model

The game is going to be built using Unity game engine for creating the 2D game environment while integrating C# scripts for various game mechanics. The C #scripts are attached to various game objects, provide instructions for various functions, and modify the game elements. C# is quite versatile when it comes to modification and scripting of game objects.

In this game, the major focus is going to be on Mastery goals, but having scorecards might encourage students to perform better. In any case, goals are dynamic and tend to change quite a lot depending on the gameplay and the game itself [14].

In this game, there would be scorecard after every level that would provide feedback on the performance of the student. The students can go back and play the same levels again to improve themselves and correct their shortcomings.

In order to understand the design of the game and how the system is going to function, various tools have been used to represent the various design structures of the game. Figure 2 explains the flow chart of Gameplay. It explains how the key functionalities of the game work in a graphical manner, in order to give glimpse at the inner functioning and key algorithms of the game element.

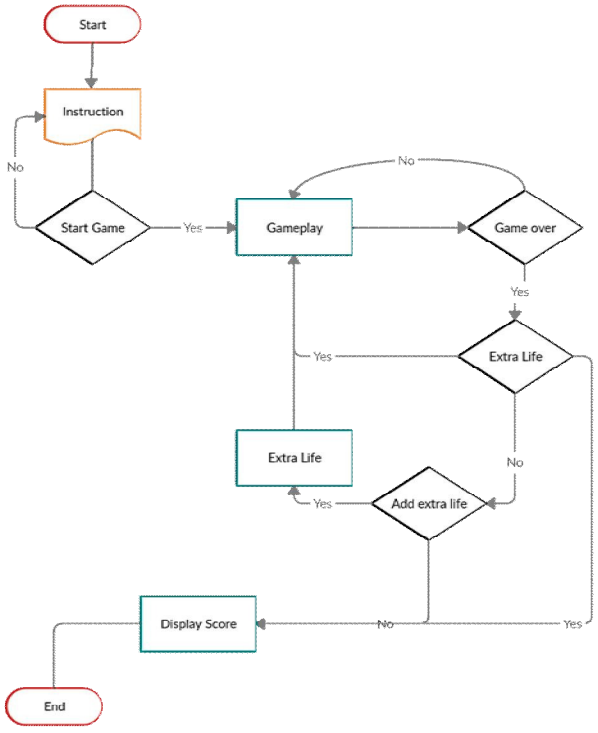

Fig. 2 Flow chart of Gameplay

V. RESULT ANALYSIS

The game developed consists of three playable levels, with basic feedback mechanism i.e., scorecard and has vast potential to be further developed and extended to accommodate various topics into much more playable levels. All the various modules and functions in the game were tested. Various game functions, their inputs, their outputs and performance were tested. Various game scenarios were accounted for performance. Table I explains the same. Fig. 3 to Fig. 10 represents the game play and various game scenarios.

Table I Test Cases

Sr. No	Test Case	Expected Output	Actual Output	Result	Test Comments
1.	Launch game	Game is launched with no errors or crash.	Game launch successful.	Pass.	No issues.
2.	Audio toggle button	Press to turn audio off.	Audio is turned off.	Pass.	No issues.
3.	Title screen animation	Proper display.	Displayed properly.	Pass.	The main camera had to be adjusted to accommodate cut portion of animation before fix.
4.	Level selector	Each level select button is working.	All buttons are functioning.	Pass.	No issues.
5.	Movement keys (WASD)	WASD keys are bound to movement and functioning.	Binds successful. Character movements accurate.	Pass.	No issues.
6.	Jump control (Space-bar)	Character jumps on command.	Jump button properly functioning.	Pass.	No issues.
7.	In-game display of game assets.	Hearts, coins and question points displayed accurately.	Accurate display.	Pass.	Problem with coin asset animation rendering. Fixed.
8.	Accuracy of point count.	Points should be counted accurate to nearest integer.	Point count accurate.	Pass.	No issues.
9.	Hearts	Character to lose 1 heart on injury or question incorrectness.	Character loses hearts accurately.	Pass.	No issues.
10.	Death of character	Character dies after losing 3 hearts.	Character dies on loss of 3 hearts.	Pass.	Int for heart index was initialized to 0. Character was still alive after losing 3 hearts. Index changed to 1. Fixed.
11.	Main Camera	Camera displays obstacles and platform before character movement.	Camera movement is stable and in accordance with character.	Pass.	Character was placed in middle of screen which led to frequent obstacle deaths due to lack of sight. Camera moved to the left. Fixed.
13.	Interaction with obstacles (Spikes, fire etc.)	Should give desired outcome.	Each outcome accurate.	Pass.	Spikes would sometimes not give damage. Hit-box of spikes were increased. Fixed.
14.	Question boxes	Question boxes provided accurate data and bound answers.	Questions and bound answers were grammatically correct and accurate.	Pass.	Grammatical corrections. Fixed.

15.	Re-spawn	Character re-spawns at the start on death.	Character re-spawns.	Pass.	No issues.
16.	Character animations	Character displays correct animation on death, jumps and movement.	Accurate animations.	Pass.	No issues.
17.	Level complete	Correct score is displayed, next level triggered.	Correct score, sent to next level.	Pass.	No issues.
18.	Interaction with platforms.	Platforms should be stable and in accordance with character movements.	Platforms were functioning accurately.	Pass.	The flying platforms were not adhering to the character body friction. Character had to keep moving to stay on the platform. Friction values were adjusted. Fixed.
19.	Check for clipping	Check if background is cut.	Not cut.	Pass.	Few adjustments. Fixed.
20.	Fonts	Check font colour and size.	Correct.	Pass.	No issues.
21.	Performance	Check loading times, game flow should be fast.	Low loading times, game is fluid.	Pass.	No issues.
22.	Multitasking	Check if switching between the game and other apps hinder functionality.	Functions properly even after multiple switches and idling.	Pass.	No issues.
23.	OS	Game should function on all windows platforms.	Game is functioning on multiple platforms.	Pass.	No issues.

Fig. 3 Game Title Page

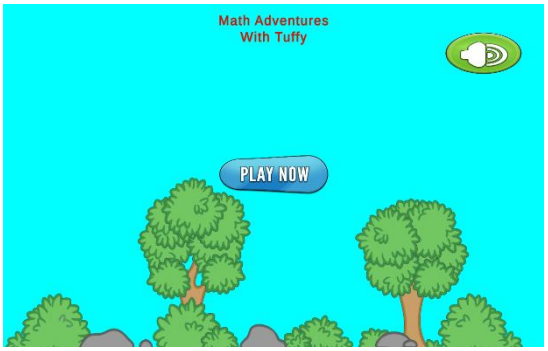

Fig. 4 Game Start Page

Fig. 5 Game: Level Selection Page

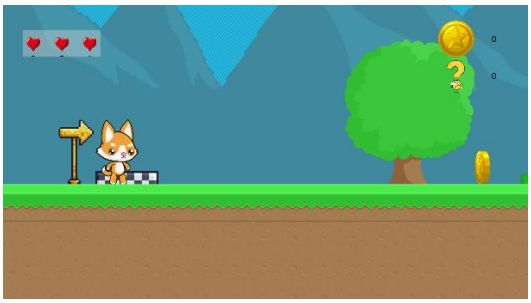

Fig. 6 Game: Level Beginning

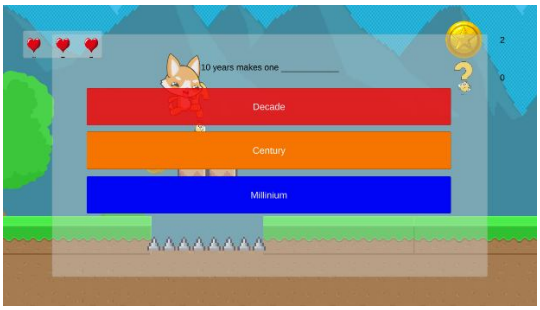

Fig. 7 Game: Question Obstacle Page1

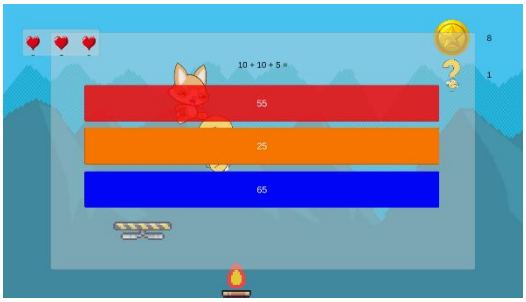

Fig. 8 Game: Question Obstacle Page1

Fig. 9 Game: End of Level

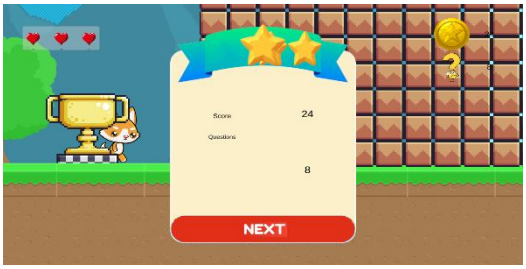

Fig. 10 Game: Scorecard

VI. DISCUSSION

Games for learning is fast developing field and there are numerous researches conducted each day to understand the essence of gamification in the field of education and learning. The aim of this study was a 2D platform game, which aids students in learning mathematics.

After understanding the important aspects of learning, psychological factors at play and the major shortcomings observed in the pre-existing studies and works, there were some key patterns observed. These shortcomings are addressed while designing the game keeping in mind the cross-dependent concepts of education and motivation.

The game is designed in such a way it runs on both desktop and android devices smoothly, compatible with all the versions of windows OS and Android versions. The game's controls and user interaction is to be smooth at all times. The UI is designed to be simpler and engaging for the students while also being true to the story and gameplay.

VII. CONCLUSIONS

This game, '*Math adventures with Tuffy'* was designed and various game mechanics and dynamics are well integrated in the game play. The story and game play have a significant role in learning process addressing the student's motivation aspect towards mathematics. Feedback provided after every level gives helpful insights on the students' progress in that particular concept and the overall performance report gives an overview on their performance in the subject.

'*Math adventures with Tuffy'* is a fun and engaging way for students to learn mathematics. It gives the students an opportunity to approach the subject in a creative way and gives them a different perspective on the same. The learning is made simpler using instructions and several guided levels for the students to get comfortable learning the subject.

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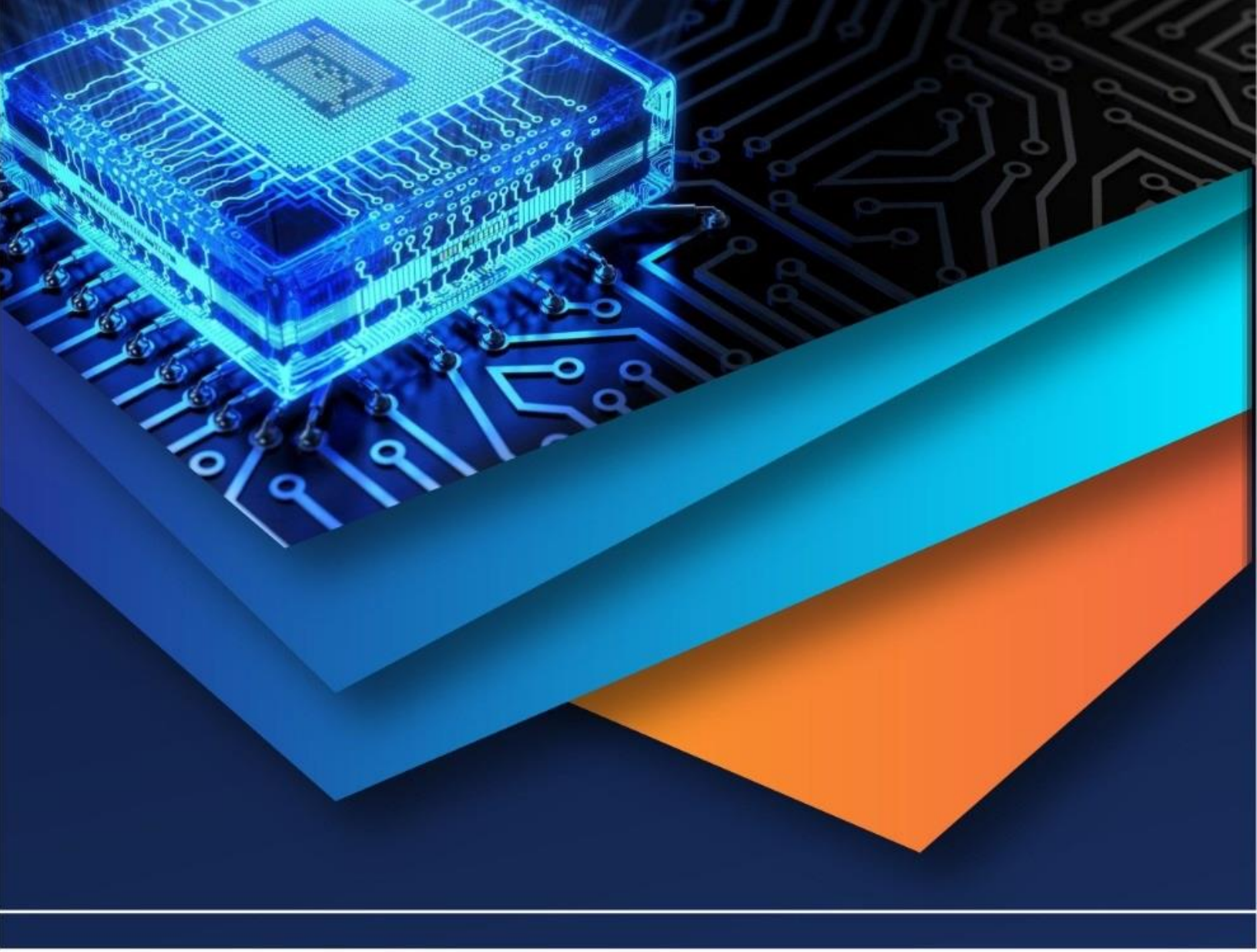

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