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Creation and Development of a Digital Game for Use of Gamification as a Teaching-Learning Approach in Mathematics: A Secondary Level Research

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Abstract: Content gamification is a relatively recent method for increasing learner motivation and engagement. Individual online learning can also benefit from gamification strategies. The researchers created Fire-Alarm, a digital game to help x number of standard students better understand the concept of the chapter "Height and Distance." The design and development of the game are discussed in detail in this article. The many gamification theories examined before its creation are also mentioned. Finally, an achievement test was administered as a pilot project to determine the effectiveness of the gamified module.

Keywords: Digital game; gamification; mathematics; content gamification.

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Introduction

The principles and strategies employed by teachers to facilitate student learning are referred to as a teaching method. These tactics are influenced by the subject matter being taught and the characteristics of the students. Learners have a better comprehension of any subject by using teaching-learning tools in the classroom. The computer is a great instrument in today's world for accomplishing any subject's goals. Mathematics is an abstract subject that serves as the foundation for all sciences. It is important to learn Mathematics because it provides the foundation for physics and engineering; hence contributing to national growth.

Due to a lack of educational resources and methods, students' interest in mathematics is waning. Based on these findings, the researcher developed a gamification framework to help secondary students learn and teachers teach mathematics. By involving students in active, participatory, and collaborative learning, gamification and blended learning were introduced into the classroom. This intervention aids in the transformation of classroom dynamics and the development of novel teaching and learning methods. The introduction of this gamification paradigm also increased pupil-teacher engagement, transforming students into motivated, active learners.

Gamification is a supplement to standard teaching methods used in secondary school mathematics classes to boost pupil engagement, motivation, and involvement in class and make mathematics teaching and learning more pleasant. It has gained popularity as a way to motivate and engage today's digital generation by encouraging and influencing specific behaviors. It is now used in many educational programs, despite its prominent use in marketing methods. It assists instructors in striking a balance between meeting their goals and the changing requirements of students (Huang & Soman, 2013). Gamification encourages students to study by providing positive feedback; they are motivated, exhibit interest, and are stimulated to learn as a result of the positive feedback they receive.

The study's goal is to encourage more efficient and interesting learning among secondary mathematics students using gamification in education. Gamification, according to Yu-kai Chou (2015), is the process of taking all the enjoyable and addictive qualities in games and applying them to real-world or productive activities. Wang (2011) defines gamification as a set of design concepts, techniques, and systems used to influence, engage, and inspire individuals, groups, and communities to desired behavior and outcomes. Gamification, according to Kapp (2012), is the use of game mechanics, aesthetics, and game thinking to engage people, encourage action, promote learning, and solve issues.

The word gamification was coined in 2008, although it was not extensively embraced until later, in 2010, and it is sometimes confused with terms like "game layer," "applied gaming," "productivity games," and "behavioural games" (Deterding et al., 2011). The idea is that a designer combines the human impulse to communicate and share accomplishments with goal-setting to guide learners' attention and drive their goals (Landers & Callan, 2011). When students face challenges, they may become despondent, devastated, disheartened, or cynical; however, these emotions are absent in the gaming environment. They can also prefer immediate gratification to stay involved and driven. Gamification can help with this. According to Muntean (2011), gamification is an effective tool for motivating pupils to study or read more.

Review of the Literature

A gamified learning environment is a relatively recent teaching strategy, intrinsically engaging, that can push pupils to learn. The teacher is tasked with creating a gamified atmosphere that engages and entertains the learner while simultaneously teaching through role play and other strategies that tap into the learner's natural motivation.

Boredom or lack of engagement, a pattern of escalating absenteeism in which each absence makes the person less willing to return to school, and, most importantly, being distracted by technology, such as smartphones and the Internet, according to Richtel (2010), are all reasons for dropouts or poor performance in education.

J. N. da Silva et al. (2020) designed an interactive game-based application —Interactions 500— aimed to help students review concepts

related to intermolecular forces in a collaborative environment. The authors compared the knowledge of a group of 44 students who played the game regarding another group (N = 40) who were not exposed to it and studied alone at home.

Lobet et al. (2020) developed a biological treasure hunt activity for 346 first-year biology students by using QuoVidi, an open-source web-based platform. It was conceived to teach biological vocabulary and observe the surrounding natural world. Students received a list of quests that addressed botanical and zoological terms.

Pearson (2020) used crossword puzzles as a model of remote active learning for first- and second-year undergraduate pharmacy students. Chemistry-themed crossword puzzles were delivered via the eBlackboard site and used to supplement lectures and problem content.

Gamification, or the incorporation of game elements into non-game settings, has the potential to assist schools in overcoming the challenge of motivating and engaging students because it encourages students to act.

Research on Mathematics Gamification

Pam Bishop, Mike Beilby, and Adrian Bowman (1992) researched computer-based learning in mathematics and statistics. The CTI Centre for Mathematics and Statistics was set up under a UFC initiative to collect and distribute information about computer-based teaching material. It now has a substantial database of computer packages and has contacted relevant departments in all higher education institutions. The effect on teaching quality is described with a case study, and an examination is made of the present and future role of the computer, based on visits and contacts made in this sector.

Balarabe Yushau (2006) carried out a study that examines the influence of blended E-learning on students' attitudes towards mathematics and computers. A random sample of 70 students of the preparatory year program of King Fahd University of Petroleum & Minerals (KFUPM), Dhahran served as the sample of this study. Data were collected at the semester's beginning (pre-program) and the end (post-program) using Aiken Mathematics Attitude Scale and Greessen and Loyd Computer Attitude Scale. The result indicates that the subjects have a positive attitude towards Mathematics and computers.

In their study, Ortega-Tudela and Gomez-Ariza (2006) aimed to explore the extent to which computer-assisted teaching facilitates learning basic mathematical concepts and skills in children with Down Syndrome (DS). Thus, the effectiveness of a multimedia teaching method is compared with a traditional one in the teaching of counting and cardinality abilities and concepts. In this study, two groups of DS children were trained. One of them was taught using mathematical multimedia software, while the other learned through pencil-paper-based tasks on the same material as the multimedia group. The children of both groups were evaluated before and after training sessions. The multimedia group showed a higher performance than the paper-pencil-assisted teaching group on various tasks and measures, suggesting a clear relation between teaching methods and mathematical learning in DS children.

Gabriel López-Morteo and Gilberto López (2007) introduced an electronic collaborative learning environment based on Interactive Instructors of Recreation (IIRM), establishing an alternative approach for motivating students towards mathematics. The IIRM is educational software component specializing in mathematical concepts, presented through recreational mathematics, conceived as interactive, recreation-oriented learning objects integrated within the environment. The architecture of the learning environment, which integrates communication services that support the interaction processes of the learning community through instant messaging, chat rooms, and multi-player math games was presented. Students have access to several easy-touch mechanisms that allow them to customize their content, layout, and appearance through the environment's workspace interface. At the internal level, the functionality of IIRM is enhanced with features supported by the environment infrastructure. The different aspects of the learning environment in three short, motivations oriented. Math courses given to Mexican high-school students were evaluated. The results indicated that the use of the IIRM-based electronic learning environment positively affects student attitudes toward mathematics.

Reis et al. (2010) presented a case study where a set of multimedia exercises were used to possibly improve pupils' mathematical skills, one with mental retardation and another with cerebral palsy. Being part of a web-based system to support students' learning, the referred set of multimedia exercises proved to be the children's favorite, rather than

exercises in paper form, which also led the children to show a fair more positive attitude towards learning. Also, they observed that through the mentioned multimedia exercises, the children became far more autonomous, interested, persistent, happy, able to absorb the material easily and more willing to continue working.

Elenchothy Davrajoo, Rohani Ahm Tarmizi, Mokhtar Nawawi, and Aminuddin Hassan (2010) investigated the effect of Algebraic Mastery Learning Module (AMaLM)[1] usage on mathematics achievement of low achievers with high anxiety in mathematics. In this quasi-experimental study, 50 low achievers from a secondary school located in a rural area were involved. Target participants were divided into two groups: an experimental group with AMaLM and a conventional instruction strategy group. The content of activities for the two groups was the same but differed in their teaching structure. The activities were conducted for about three weeks of the intervention period. The activity papers for the conventional instruction (CI) strategy group were solved using only paper and pencil and compared with the solutions presented by the teachers. The experimental group solved algebra problems using the AMaLM. The material to be learned is subdivided into small units, covering one lesson to another. The two groups completed Algebraic Comprehension Test (ACT) before and after the intervention period. The mean scores of ACT I and ACT II for the AMaLM group and CI group after the intervention were 58.32, 36.88 and 25.8, and 22.96, respectively. Results showed that the experimental group improved considerably compared with the control group. The preliminary findings of this pilot study provided evidence that the construction and mastery of algebraic concepts assist students to have a positive attitude toward mathematics learning. AMaLM as a self-guided learning tool has specifically favored the learning process in reinforcing algebraic knowledge for low achievers with anxiety towards mathematics.

Nathan, M. J. (2010) revealed that technology plays a unique role in learning and practicing mathematics. Technology support for mathematics education largely reflects the formant shifts of underlying theories

[1] AMaLM is a self-guided book to ease the learning of mathematics for low achievers with mathematics anxiety. It was developed based on constructivist learning theory and mastery learning theory.

of learning and intellectual behavior. Information processing theory and theories of cognitive skill acquisition have been and continue to be dominant influences in mathematics education. Increasingly, designs of educational technologies are influenced by emerging theories of knowledge, practice, and collaborative and discovery-based learning focused on situated and socio-cultural perspectives, constructivism, and embodied cognition. These have inspired technologies that support active learning and discovery, self-monitoring, dynamic software, anchored instruction, networked devices, participatory simulations, serious games, and construction kits for real mathematics.

Othman N. Alsawaie and Iman M. Alghazo (2010) carried out an intervention study that explored the effect of using video lesson analysis methodology (VLAM) on the ability of prospective middle- and high school mathematics teachers to analyze mathematics teaching. The study sample consisted of 26 female prospective mathematics teachers enrolled in a methods course at the United Arab Emirates University. The participants were divided equally into two groups: experimental and control. The experimental group was involved in video lesson analysis, where they analyzed ten video lessons throughout the semester. The group members interacted via discussion forums through Blackboard technology. Both groups wrote analyses of two video lessons, one before the intervention program and another at the end of it. It was found that the intervention remarkably improved the ability to analyze the mathematics teaching of the experimental group, while a slight improvement occurred in the control group.

Mengping Tsuei (2012) aimed to explore the effects of the peer tutoring system on children's mathematics learning. In the project, 88, 10-11-year-old students peer-tutored each other in mathematics in a face-to-face online environment for a year. Compared to the control group, students in the experimental group had significant gains in mathematics learning, especially in the arithmetic and application questions. This study demonstrated the positive effects of peer support via online synchronous learning on students' self-concept and attitudes toward mathematics learning. The results indicated that the longer the vulnerable pupils engaged in peer tutoring online, the more they benefited from the process. The finding suggests that students demonstrate different mathematics reasoning skills when they are paired with peers

at different levels of ability. These findings indicate that the synchronous peer tutoring system is an effective tool to enhance elementary students' learning in mathematics and promote positive self-concepts.

Bragg (2012) conducted a study on the effect of mathematical games on on-task behaviors in the primary classroom. Educators generally assume that games ignite children's on-task behaviors, but there is little systemically researched empirical data to support this claim. This paper compares students' on-task behaviors during non-digital game-playing lessons compared with non-game-playing tasks. Six randomly selected grade 5 and 6 students (9-12 year-olds) were observed during ten mathematics lessons. Two thousand one hundred observations were recorded via an observational schedule and analyzed by comparing the percentage of exhibited behaviors. The study found the children spent 93% of the class- time showing on-task engagement during the game-playing lessons compared with 72% during the non-game-playing lessons. The game-playing studies also promoted greater incidents of student talk related to the mathematical task (34%) than the non-game-playing lessons (11%). These results support the argument that games serve to increase students' time on task in mathematics lessons. Therefore, it is contended that using games explicitly addressing the mathematical content being taught in a classroom is one way to increase engagement and, in turn, the learning potential.

Bai et al.'s (2012) assessed the effectiveness of a three-dimensional mathematics game, Dimension M, through a pretest-posttest control group quasi-experimental design. Participants consisted of 437 eighth graders. The classrooms were randomly assigned either to the treatment group that utilized Dimension M to supplement regular classroom instructions or to the control group that received normal class instructions without any computer activities. The analysis results on the pretest-posttest data revealed that the Dimension M game increased mathematical knowledge acquisition in algebra and maintained student motivation to learn. The findings suggest that the implementation of Dimension M in mathematics education can significantly benefit middle school students learning algebra.

Chen et al. (2012) studied elementary efl teachers' computer phobia and computer self-efficacy in Taiwan. The advent and application of computer and information technology have increased the overall success of EFL teaching. However, such success is hard to assess, and teachers prone to

computer avoidance face negative consequences. Two major obstacles are high computer phobia and low computer self-efficacy. Nevertheless, little research has been done in this area, especially from instructors.

Benjamin Edward William, A. (2007) compared the effectiveness of interactive multimedia CD-based learning with the conventional teaching method with Science group students. The study sample consisted of 48 learners in the XI standard of Blessed Mother Teresa Model Higher Secondary School, Pondicherry. Using a pre-test and post-test, it was observed that the experimental group's performance was far superior to the control group. The study revealed that the interactive multimedia CD-based learning prepared by the teacher could show an immense impact on physics learning. Further, the experimental group has expressed a more favorable attitude towards the interactive multimedia CD-based learning courseware.

Gamification on Other Subjects

Language Studies

Francisco Figueroa Flores elaborates on the need for gamification in second language studies. In his opinion, one major competence for learners in the twenty-first century is acquiring a second language (L2). Based on this, L2 instruction has integrated new concepts to motivate learners in achieving fluency. An idea that is adaptable to digital natives and digital immigrants that are learning an L2 is Gamification. Gamification is new as a pedagogical strategy, but it has been used successfully in the business world. Gamification uses game elements and game design techniques in non-game contexts (Werbach & Hunter, 2012) and empowers and engages the learner with motivational skills toward a learning approach and sustaining a relaxed atmosphere. As Young (1994) addresses, this personality factor is fundamental in the teaching and learning of L2. This article covers language, second language learning methodology and approaches, an overview of the integration of technology towards L2 instruction, gamification as a concept, motivational theory, and educational implications for effectively integrating the strategy and current applications. It also calls for the necessity of empirical evidence and research regarding the system.

Social Science

Gamification: The next evolution of education by Vibha Chetan, Suman Devadula, Rohan Sridhar and Ganesh Sadashiv of PES University, Bangalore, India and MIT World Peace University (MIT-WPU), Pune paper published in Proceeding of the International Conference on Future of Education, (2018) stated that education is as effective as learning. Research has shown that understanding when experienced is better. Experiencing Learning through games can be better. This article inquires whether gamification of content improves learning. A game is designed to take the learning content from a geography course in school students' curriculum for administering this inquiry. Using this, findings from a preliminary experimental study conducted across 8-9-year-old students of the school in question show that learning, in terms of being able to recall the topics understood, is better for the group that learned through gamified content. Analysis of data through measures of central tendency across groups is indicative of this improvement. We present our game-based learning environment and findings in this context.

Psychology learning

B. Hazan et al. (2018) established the benefits of gamification for psychology learning experimentally. Teaching undergraduate psychology statistics poses challenges to instructors and students due to the perceived complexity of the material and lack of student motivation. To boost student competency and engagement in statistics, the study introduced a gamified learning environment into the laboratory portion of the undergraduate psychology statistics course in which the gamified learning group was compared to the traditional group. Changes in intrinsic motivation, perceived competence, and objective pre-and post-test course content were assessed. Objective post-test scores were positively associated with perceived competence in statistics for the gamified learning group. Perceived competence is a strong predictor of achievement and a foundational prerequisite of intrinsic motivation, suggesting that in contrast with the traditional group, students in the gamified group were further on the path towards developing inherent motivation and improved academic achievement.

Chemistry Learning

Da Silva et al. (2020) designed an interactive game-based application (Interactions 500) to help students review concepts related to intermolecular forces in a collaborative environment. Forty- four pharmacy undergraduate students (11 groups) played the game remotely. A student got the role of a leader in charge of coordinating the game, motivating their mates, discussing answers, and clarifying doubts. In the game, there was a competition among students who had to answer different quiz questions. The students rated the game positively through a Likert-type survey regarding its design, content, gameplay, and usefulness as an educational tool. The authors compared the knowledge of a group of 44 students who played the game concerning another group (N = 40) who were not exposed to it and studied alone at home. Both groups showed similar marks in the pre-test and the post-test and the same level of learning. Therefore, the authors concluded that the game resulted in identical learning outcomes to traditional problem-solving classes. However, only the game created a pleasant learning environment, so all the students who played it reported that they preferred regular problem-solving classes.

Fontana (2020) developed a gamified activity based on ChemDraw (software designed for drawing molecules) to make students get practice using this tool. Thus, students had to compete in a tournament. The idea was that it would maintain the classroom community, improve students' wellness, and develop their organic chemistry skills. Videoconferencing software (Zoom) was used to enable real-time classroom participation. Nine students participated in the molecule speed-drawing tournament (Molecule Madness). A molecule's chemical structure was posted to the class learning platform, and for each match, two students had to share their screens with the class and compete to draw its structure first in ChemDraw correctly. Non-participating students followed the tournament as active observers (social spectators), socially engaging with fellow observers, and learning from contenders. Students competed to correctly draw molecular chemical structures, whereas advanced rounds presented more challenging molecules to remove. By playing ChemDraw, students reported wellness experiences comparable to playing traditional videogames: enjoyed practicing, felt expectancy for the coming class activity, and connected with their classmates. They also described Molecule Madness as a fun way to

learn organic chemistry, practice ChemDraw, and promote high levels of excitement and engagement. Pearson (2020) used crossword puzzles as a model of remote active learning for first- and second-year undergraduate pharmacy students. Chemistry-themed crossword puzzles were delivered *via* the eBlackboard site and used to supplement lectures and problem content. When analyzing students' exam performance with and without crossword aids, no significant differences were observed in the mean and median cohort exam grades (compared with a cohort from the previous academic year). However, more students responded to the question (from a choice of four) taught alongside online crossword exercises. The author suggested that the crossword activity instilled greater confidence to answer a question when included in the crossword exercises.

Goal of the study

The researcher will be able to:

1. Adopt and modify an appropriate content development framework for secondary mathematics gamification.
2. To evaluate the effect of gamification in terms of achievement of students after its introduction in the study of Mathematics at the secondary level.

Gamification Theories: Before planning and developing gamified material, it's important to keep these three theories in mind.

Conditioning Theory: The traditional psychological theories of learning are classical and operant conditioning. They continue to explain a large deal of behavior, especially in youngsters, despite being typically replaced and augmented with many other theories throughout the years. Even cognitive behavioral therapy is mostly based on operant conditioning concepts. Conditioning is straightforward at its core: the instructor's purpose is to establish a positive association with a useful exercise like problem solving in gamification.

Goal-Setting Theory: One of the well-supported theories of motivation in psychology, goal-setting theory can also be used to explain the gamification methodology of teaching and learning for specific,

measurable, attainable, realistic, and time-bound (SMART) goals that drive people. Researchers will have a lot better chance of getting pupils to achieve what they want to do if the researcher uses SMART goals in gamification.

Self-Determination Theory: Self-determination theory asserts that all humans are driven by a desire to self-determine —to chart their course through life. This is accomplished by satisfying three needs: feeling competent in the tasks attempted, feeling like you completed those tasks without the help of others, and feeling connected to those around you. SDT also distinguishes between two types of motivation: intrinsic and extrinsic. Intrinsic motivation is defined as self-determined motivation that is met by satisfying those three demands. Extrinsic motivation is frequently associated with monetary rewards, such as gold stars, grades, and public acclaim. Recent research in SDT has demonstrated that intrinsic and extrinsic motivations function in tandem, with intrinsic motivation occurring after activities have been internalized and extrinsic motivators being more effective in getting people to try new tasks. For example, a child who is forced to play the piano by her parents may despise it at first but continue to do so to please her parents; nevertheless, as she gains proficiency and autonomy, the piano becomes enjoyable on its own. Gamification can be used in the same way to introduce someone to something they don't know much about or know they are good at so they can generate intrinsic motivation later.

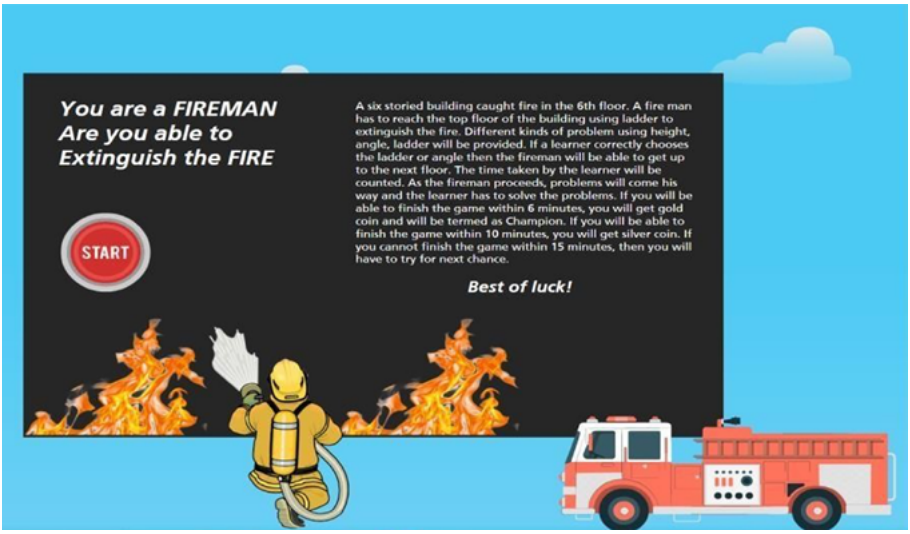
Overall, no single theory can adequately explain gamification or serve as a panacea for gamification success. However, these theories give the researcher a solid base to work with.

Designing & Creating Games

Studying Games

Before developing Fire Alarm, seven digital games were thoroughly researched (Scrabble, Pictionary, Survival, Battleship, Monopoly, Formula One, and Transformers). This study aided in the knowledge of the framework, structure, story, and rules employed in the development of these digital games and served as a foundation for building Fire Alarm.

Story behind the game



A six-storied structure caught fire in the game's backstory. Assume you're a volunteer firefighter. Your job (as a fireman) is to put out the building's fire using various sizes of ladders. The ladder's height, angle, and size have all been used to solve various problems. You will be able to get up to the next story if you choose the ladder or angle correctly as a fireman. Each problem's time will be measured. As you progress, you will encounter difficulties, which you must overcome. If you finish the game in under 10 minutes, you will be awarded a gold coin and dubbed "Champion." You will receive a silver coin if you can finish the game in less than 12 minutes. If you are unable to complete the game within 15 minutes, you must try again.

Game Description

Name of the game —Fire Alarm

- Number of players: This is a single-player offline game that may be played by several players at the same time.
- Digital offline educational game.

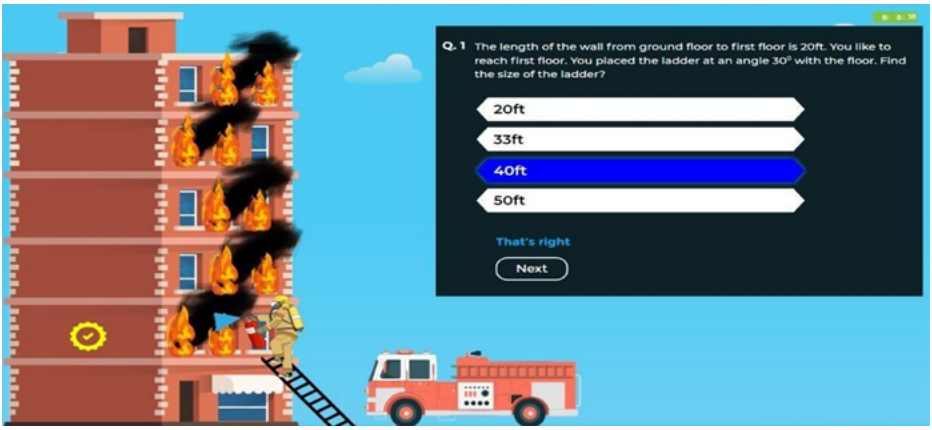
- 15- 16-year-old age group.
- Java and HTML were utilized for programming.
- The game's goal is to help you understand the relationship between height and angle.

The player who can solve all the problems in less than 10 minutes will receive a gold medal, while those who can solve them in less than 12 minutes will receive silver medals.

- Objective: Using trigonometric ratios and angles, study the theory and use it experimentally to find the heights and distances between two objects.
- Learning outcome: Because students are fully immersed in the game, they should be able to understand the idea more effectively.

DPE (Dynamics, Play, Experience) and MDA (Mechanics, Dynamics, Aesthetics) Frameworks

The MDA and DPE frameworks were used to create the structure of the digital game Fire Alarm. MDA framework was used to create a structure for mechanics and aesthetics. Aesthetics elicit the player's emotional response, for this game it is a quick response to cease fire, while mechanics constitute the game's foundational elements (i.e., the fundamental ideas of Trigonometry). DPE framework was used to provide a structure for dynamics, play, and experience. To satisfy the needs of serious game design for learning, the design, play, and experience (DPE) framework was designed as an augmentation of the MDA framework. To effectively create the game, the researcher first defined the experience's goals (i.e., to extinguish the fire within the stipulated time). These objectives were used to guide and designed the process as well as to assess the skill of the learner (i.e., commands over the subjects). The basic design of the game is important because it has an impact on the player's cognitive, social, and experiential background.



Playing

In Fire Alarm, the player pretends to be a fireman to begin the game. The fire started on the sixth floor of a six-story building. The learner must put out the fire in 15 minutes as a firefighter. Multiple choice questions will be presented one by one to reach the floor. The student must use the concept of height and distance to solve the problem correctly. The fireman (the learner or game player) reaches the next story and extinguishes the fire after selecting the proper ladder height. The height of each floor or the angle of the ladder is occasionally included in a multiple-choice question. By correctly answering the questions, the player will advance to the next level, allowing them to put out the fire and win the game.

Once the game has been correctly designed, the final phase is the game's try-out. As a pilot project, it was tried out on forty students. The learners appear to appreciate the game and are eager to play the second level, which appears to be more difficult than the current basic level. The scope of the research in this domain is enormous. Gamification of the content is presently used in pre-primary and primary education. Content gamification for secondary level and higher education will be the key field for future research. During this pandemic period, content gamification shows steady growth as a part of online learning. Gamified experiences radically improve skill acquisition, motivation, engagement and learner achievement tracking. The gamification market size is projected to grow from USD 9.1 billion in 2020 to USD 30.7 billion by 2025, at a Compound Annual Growth Rate (CAGR) of 27.4% during the forecast period.

Hypothesis: There is no difference in the achievement test score of students of the experimental and control groups.

Methodology of the study: The present study was experimental. The details of the methodology including the design, population, sample, tools, data collection and method of data analysis are given as follows.

1. **Design of the Study:** The present study was experimental. The Pretest-Posttest Non-Equivalent-Controlled Group design was followed in this research.
2. **Population of the Study:** All the Bengali medium-standard secondary school students of the West Bengal Board of Secondary Education constituted the population for the present study.
3. **Sample of the Study:** The sample for the present study was selected purposively with the help of convenient sampling considering the convenience criteria (i.e., availability of the schools as per the reach of the researcher and the availability of the gadgets to use for gamification). One school (i.e., Sanctoria High School of Asansol City) was selected purposively. Students of one section (i.e., section A of standard X) were considered the experimental group and the students of another section (i.e., section B of standard X) from the same school was considered the control group. Initially, there were 20 and 24 students in experimental and control groups respectively. Based on their pre-test achievement score in mathematics, the experimental and control group were made equivalent. In these equivalent groups, 22 students from each group were considered as the sample for the present study.
4. **Tools for Data Collection:** The following tool was constructed by the researcher for data collection for the present study. An achievement test was prepared by the investigator to collect data (i.e., pre-test and post-test on one chapter of the Mathematics of standard X). The achievement test was prepared on the basis of the competencies prepared by the West Bengal State Board of School Textbooks. The researcher outlined a blueprint for the construction of the achievement test in Mathematics taking into consideration the type and level of questions. The prepared achievement test was administered (i.e., pre-test and post-test on both control and experimental groups).

5. **Data Collection:** Considering the nature of the research questions that were being examined, the instruments used for the collection of data were teacher-made achievement tests. These instruments were used to offset the weaknesses of each other.
6. **Procedure of Data Collection:** The required data were collected with the help of the prepared achievement test in Mathematics. The researcher administered these tests personally to the control and experimental groups of students as follows.
   A pre-test was conducted with the help of an achievement test in 'Height and Distance' prepared by the researcher in both groups (i.e., the control and experimental groups before experimentation). Pre-testing was done to make the experimental and control group equivalent. Post-test was conducted with the help of the same achievement test in Mathematics after the completion of the selected one unit with four subunits of the Mathematics curriculum on both the experimental and control groups. Post-testing was done to know the effectiveness of the developed gamification package in terms of the achievement of students in Mathematics.
7. **Data Analysis:** The collected data obtained through pre-test, post-test and delayed post-test were analyzed by employing quantitative data analysis techniques. Pre-test achievement data related to Mathematics was used to make the control and experimental group equivalent. Mean, Standard Deviation, Standard Error of Mean and t-test and ANCOVA were used to analyze the quantitative data collected through pre-test and post-tests. In the post-test, we see the mean and variance of the experimental group is 80 and 6 and for the control group is 62 and 7. By using this data researcher find that t value is 9.18 which is greater than 2.16. Hence, the researcher rejected the null hypothesis at a 95% level of significance and conclude that gamified learning enhances the achievement of students.

Major Findings

Following were the major findings of the present study.

1. The developed gamified learning package was found to be significantly effective in terms of enhancing the achievement of standard X students in Mathematics in comparison to the traditional teaching method.
2. The gamified learning package to teach Mathematics to standard X students was also found to be effective in terms of the reaction and feelings of students towards the package.

Impact of Gamified Learning in Mathematics

The gamified learning activities enabled the pupils to see major concepts, big ideas and general principles in mathematics as reality. There was more interaction of pupils with their peers, the instructional materials and the gamified processes. The pupils did not only accumulate points during instructional periods but were rather engaged to perform mathematics activities. This led to the pupils being stimulated and motivated to develop positive attitudes towards the learning of mathematics. This was obvious from the way the pupils were seen working on assigned mathematics classwork and homework activities and performing self-assigned math activities. The gamified and blended activities whipped up the interest of the pupils which enabled them to develop a passion and flair for the study of mathematics. This means that the pupils would be able to practice the skills and values they acquired in solving problems in the future.

Conclusion

It was observed that teachers' preparation in advance enabled them to outline definite goals which are purposeful for the success of a particular lesson. As this study has revealed, the gamified lesson plans designed by the sampled teachers contributed immensely towards the effective teaching and learning of mathematics at the lower primary section of the sampled school. Preparing allowed them to procure beforehand all the relevant instructional materials needed for each lesson and to practice their use in the gamified mathematics lessons. This made them understand the principles and processes involved in the gamified activities that they took their pupils through in each classroom.

There was enough evidence to prove that the gamified activities made the pupils interact with their teachers, their peers, and the instructional materials. The pupils also discovered concepts and facts unaided or with minimum interference which made the learning of the topics more pleasurable and not boring, thus encouraging the pupils to learn. The intervention activities that were introduced also brought about active pupil participation which enabled them to think, feel and act creatively, resulting in the development of desirable values such as tolerance, sharing, cooperation, affection and endurance. It also enabled the pupils to develop skills such as being able to use some instructional materials for the learning of mathematics.

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