

A gamified online learning environment with comprehensive assessments and software integration

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ABSTRACT

The National Achievement Survey (NAS), conducted by the Ministry of Education, India, highlighted a concerning decline in mathematics proficiency among students in Maharashtra as they advance through grades. This trend is further aggravated by the limited availability of online resources in Marathi, hindering their learning progress. To address this, a pilot study was proposed to develop a specialized online platform tailored for Marathi medium students, integrating gamification and artificial intelligence (AI)-driven feedback to enhance engagement and comprehension. The pilot project, conducted at a Marathi medium school with approval from the principal, focused on polynomial division tests for 8th-grade students over four days. Results revealed that despite the easy level test's higher difficulty, students scored higher on the medium level test, possibly due to an adjustment period to the online platform. Notably, some students performed better on the hard-level test, indicating the platform's potential to improve performance. While promising, the study's limitations, including a small sample size, highlight the need for further research with a larger cohort and the integration of automatic suggestions for concept-specific games and assessments in future iterations to optimize the platform's effectiveness.

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1. INTRODUCTION

In light of recent findings from the National Achievement Survey (NAS) conducted by the Ministry of Education, Government of India in 2021, concerning mathematics proficiency among students in Maharashtra state board schools, a pressing issue has emerged. The survey reveals a concerning trend: as students progress through grade levels, their performance in mathematics declines significantly. For example, only 45% of 5th-standard students, 34% of 8th-standard students, and a mere 29% of 10th-standard students demonstrate proficiency in mathematics. This decline underscores a critical challenge facing the educational landscape, demanding immediate attention and innovative solutions. The current educational landscape in Maharashtra is marked by a stark reality: despite over 9 lakh students enrolled in Marathi medium schools from 1st to 8th standard, there exists a notable deficiency in accessible, creative online educational resources tailored to the specific needs of these students, particularly in mathematics and in their native language, Marathi. This dearth of resources exacerbates existing challenges in cognitive development and contributes to

the observed decline in academic performance among students. Recognizing the urgency of this educational crisis, a specialized online learning platform is proposed, expressly designed to support Marathi medium school students in mastering mathematics concepts effectively. While previous studies investigated the impact of virtual learning, they did not explicitly address the effect of gamification in online learning with its influence on the learning of students in Maharashtra in Marathi medium schools.

By integrating gamification elements, the objective is to enhance engagement and comprehension of mathematical concepts across various educational levels. Moreover, leveraging data science and artificial intelligence (AI), personalized feedback and improvement suggestions are offered, tailored to individual student needs. This approach not only fosters a deeper understanding of weak areas but also enhances analytical skills and cognition through targeted practice. Research into general mathematics achievement highlights the importance of building a strong mathematical foundation for students. Various studies suggest that the paths to mastering higher-order mathematics skills are similar across different performance areas. This is particularly relevant for word problem-solving and pre-algebra, where there are notable connections and similarities. However, a closer look reveals a key difference, especially between fourth-grade pre-algebraic and word-problem performance, where language comprehension plays a more significant role in later word-problem solving. This underscores the need to tailor teaching methods to accommodate students' cognitive resources, emphasizing individualized approaches for word problems and pre-algebra [1]. In the realm of Indian mathematics education, there's a contrast between traditional methods and innovative approaches like bilingual education, mobile learning, and gamification. While traditional methods have been longstanding, their effectiveness is decreasing, leading to a shift towards innovative techniques such as flipped classrooms and personalized learning, which ultimately improve student outcomes [2]. Exploring methods for addressing learning disabilities, including dyscalculia, the research investigates the impact of technology-based interventions like computer-assisted instruction (CAI) and programmed instruction (PI) in remedial efforts. Results highlight the effectiveness of CAI compared to traditional methods, suggesting its potential to help students with mathematical learning difficulties. Gender does not significantly affect the effectiveness of interventions, with both PI and CAI showing promise as effective techniques [3]. Investigating modern teaching methods in mathematics education, the research delves into the shift from procedural to conceptual learning. It highlights the move towards experiential learning, as outlined in National Education Policy (NEP) 2020, stressing the importance of using technology to engage students while addressing challenges like overloaded curricula. The study advocates for teacher training to empower educators in creating dynamic classroom environments [4]. In examining how teaching methods affect learning outcomes in primary mathematics education, the research compares traditional and experiential approaches. It finds that experiential learning significantly improves comprehension and retention compared to traditional methods. Actively involving students and providing hands-on experiences deepen understanding, underscoring the value of integrating experiential teaching into mathematics instruction for better outcomes [5].

In the realm of educational technology, researchers have explored various gamified learning applications aimed at enhancing mathematical education. These applications incorporate gamification elements such as points, badges, leaderboards, avatars, and virtual currency to engage students. They also offer adaptive learning features, where the difficulty of exercises adjusts based on student performance, and promote collaborative learning by enabling students to work together on tasks and challenges. These tools cover a range of basic mathematics concepts and are built using open-source technologies like hypertext preprocessor (PHP), structured query language (SQL), and JavaScript [6]. Researchers have developed gamified mobile applications tailored to specific grade levels, resulting in improved mathematics scores among students. These applications also provide features for teachers to monitor student progress, create quizzes, and access additional resources. Studies have assessed the impact of these applications on students' learning styles and the integration of technology into education [7]. Furthermore, researchers have created learning aid applications that blend traditional school knowledge with interactive gamified experiences. These applications leverage various technologies to accommodate diverse learning styles and offer unique avenues for students to grasp mathematical concepts in engaging ways [8]. Some studies have focused on evaluating the positive and negative aspects of using gamification tools in mathematics subjects, gathering feedback from students through questionnaires. Others have conducted controlled experiments to compare the effectiveness of gamified learning environments with traditional methods, assessing improvements in mathematical learning [9]. Additionally, research has explored game-based learning in computer science education, comparing traditional teaching methods with teacher-authored educational games. Assessments have been made on student engagement, motivation, perceived difficulty, and enjoyment of learning methods [10]. In a meta-analytical study, researchers conducted a comprehensive bibliometric survey of gamification research in education, providing insights into its growth, key areas of focus, and potential future directions across various databases [11]. A study conducted in the area of error correction in language learning reveals that students generally appreciate correction and display moderate to high motivation levels, especially when

they have positive attitudes towards feedback [12]. There exists a need to bridge the gap between perception and practice by shifting towards learning-centered assessment approaches through comprehensive training and institutional support. This highlights the importance of implementing effective alternative assessment methods [13]. Discovering effective methods for teaching programming to high school students has become a focal point in recent years. In an experimental study, significant learning improvements were noted without gender disparities among the participants [14]. Research conducted to explore the effectiveness of a game-based mathematics test found that the game-based test correlated well with traditional methods. Notably, the game-based approach lowered test anxiety and increased engagement, with no bias based on prior gaming experience or gender [15]. Few studies have focused on combining mobile technology for algebra instruction with a prompt-based learning approach. One such study describes the development of Metafora, a web-based integrated portal that offers both tools and pedagogical support [16]. This platform not only enhances the learning experience in the subject but also helps develop critical skills for collaborative learning in science and mathematics education. Another study [17] explores the use of directorial and network conditions to support innovative teaching and learning processes. It emphasizes the importance of aligning research on pedagogy, assessment, and school improvement. Additionally, the authors of [18] present an exploratory learning environment (ELE) where diagnostics are provided during the task to aid in the learning process. Problem-solving is a central focus in gamified learning research. The study in [19] explores the strategic identification of mathematical simplifications within pedagogically-driven setups. Additionally, research on gameplay interactions [20] highlights the importance of hypothesis testing in strategic play, particularly in narrative-driven learning environments, demonstrating its connection to learning outcomes and problem-solving skills. A visual prompt-based mobile learning strategy (VPML) aimed at enhancing the understanding of basic algebra concepts is designed in [21]. The study in [22] investigates the comparative effects of two different problem-solving methods. It examines the mathematical word problem-solving performance of students with learning disabilities using two approaches: schema-based instruction (SBI) and general strategy instruction (GSI). One more web-based intelligent tutoring system for mathematics designed to assess students' performance is introduced in [23]. The importance of motivation for engagement in learning is reviewed and presented in the literature [24]. E-learning for English in online mode along with gamification experience was found to improve student participation significantly [25]. User personal information and its management forms the central point of study to improve engagement and learning [26]. Movement skills improvement in physical education was analysed. As part of gamification, students were given choices of tools, teammates and were involved as a part of interesting stories like 'princesses and knights' and 'transformers' for students' enhanced participation [27].

Numerous research gaps exist in gamified learning applications, notably in customization options for teacher assessments, limited question banks hindering diverse learning experiences, and a lack of focus on critical thinking skills evaluation. The concentration on specific mathematics topics overlooks holistic coverage, potentially limiting the educational scope. Challenges arise from platform coherence issues, accessibility concerns for certain demographics, and limited sample sizes impacting the finding's robustness. The absence of intervention duration details complicates assessing long-term sustainability, and the exclusive focus on single mathematics concepts calls for broader investigations. Many concepts experimented in earlier research focus on offline methods of improvising quality education which are sustainable but would only be limited to school hours or classroom hours. Thus channeling a complete requirement of a full-proof system that would be incorporated seamlessly anywhere and at any time. More focus has been applied to the techniques to enhance the quality of education but comparatively is less shown on the reasons for lack of understanding and interpreting the problems. Identifying these gaps provides opportunities for future research to advance gamified learning applications in mathematics education.

The proposed system endeavors to empower both students and educators through the creation of an interactive and personalized learning platform that seeks to revolutionize the teaching-learning paradigm. With a focus on catering to the distinct requirements of Marathi medium school students in the domain of mathematics education, the system contributes to broader global initiatives aimed at mitigating educational disparities and fostering equitable access to high-quality education for all learners. To realize this goal, the proposed system conducts a pilot study utilizing a relatively modest dataset, aiming to provide insights into the potential performance of the envisioned project across various execution scenarios and circumstances.

The proposed project is a structured website with two main sections: learning environment and testing environment. The testing section is further subdivided into exercise-wise, chapter-wise, and miscellaneous categories to cater to the needs of students from standard 5th to standard 10th. Concurrently, the learning section features a variety of games covering diverse mathematical concepts, aiming to create an engaging and interactive learning atmosphere. The system gathers extensive student data, including registration information and performance metrics from tests, such as overall scores and time allocated per question. This data collection enables the system to make informed assessments of student performance. This

article offers an overview of the system, showcasing the inclusion of tests at various difficulty levels and interactive games, alongside the functionality for accessing and analyzing student data. The outcomes of this pilot study are intended to identify any potential issues that may arise during the main study.

2. METHOD

The pilot study encompassed a cohort of 44 students of 8th standard at a Marathi medium school in the state of Maharashtra, India. Marathi is a language widely spoken in the region of Maharashtra. These students underwent testing based on recommendations and guidance provided by their class instructor. Tests were stratified into three levels of difficulty. The pilot study spanned a duration of 4 days. On the initial day, students were introduced to the web portal, followed by three subsequent days during which they were tasked with completing tests of increasing difficulty levels. Pre- and post-pilot study assessments were conducted to gauge student performance across test-inclusive chapters. Additionally, feedback from both participants and their instructors was collected to further corroborate the study's findings.

2.1. Procedure

The project employed a methodology focused on the development of an interactive online learning platform tailored specifically for Marathi medium students, emphasizing the enhancement of student engagement, comprehension of mathematical concepts, provision of comprehensive assessments, and promotion of overall cognitive development. The project's scope entailed the creation and implementation of a fully functional platform featuring gamified learning experiences and interactive games designed to reinforce understanding of mathematical concepts, in addition to a robust testing module. The platform aimed to deliver personalized learning experiences through the utilization of data science and AI analysis, while also equipping teachers with data-driven insights to support informed decision-making. The project culminated in the creation of a prototype, which included a test portal offering tailored assessments for students, alongside the integration of two interactive games aimed at making mathematics learning more engaging and accessible.

2.2. Design and development of web portal

The design and development of the web portal focused on three main components: a section for tests, a section with games based on mathematical concepts, and the integration of these components with a database for storing and retrieving student data. The test section was meticulously crafted to mirror the classroom environment while also being visually appealing and captivating. Meanwhile, the games section comprised two games with multiple levels, each presenting essential mathematical concepts in novel and engaging ways. Lastly, the database section was structured to encompass all requisite parameters for student analysis and assessment. These parameters primarily included registration details and test-related information, encompassing the status of each question, the duration taken to complete the entire test, as well as the duration taken for each individual question.

2.3. Populating portal with tests

The web portal was first presented to the class instructor responsible for the students participating in the study, aiming to gather insights for further refinement. Based on the instructor's feedback, the test portal was filled with three unique tests, each covering different levels of difficulty. These tests encompassed a curated selection of questions designed to address the conceptual challenges commonly encountered by students. This approach facilitated participants' improvement in conceptual mastery through the utilization of the web portal in a more streamlined and effective manner.

2.4. Introduction of the web portal to the participants

Before using the tests available on the web portal, participants attended an introductory orientation session. This session included a guided tour of the portal's navigation, an exploration of the test section's user interface, and an overview of the features that support math learning through games. At the primary prototype stage, the portal is introduced with two games, the first addresses the concepts of digits to enhance the understanding of place value, and the second for rules of addition operation.

2.4.1. Digital catchbox game

Figure 1 depicts an educational game called "Digit Catchbox," where digits of a number fall from the top of the screen, and the player must catch the correct digit in a movable box. This game aims to improve students' understanding of place value in numbers through an interactive and engaging experience. For instance, with the number 123.325, students may be asked to identify the digit in the tens place. To answer correctly, the student must move the box to capture the digit in the tens place, which is 2 in this

example. The box can be moved horizontally using a mouse or trackpad, allowing the player to position it accurately to catch the correct digit.



Figure 1. Digital catchbox game

2.4.2. Interactive addition game

Figure 2 shows an interactive addition game designed to make learning mathematics fun and engaging. In this game, students are given an addition problem involving two numbers. The game features two cars, with one moving steadily toward the finish line at a fixed speed. To help the second car overtake and win the race, the student must correctly solve the addition problem. The quicker the student answers correctly, the quicker the second car accelerates, creating a competitive and enjoyable learning experience.

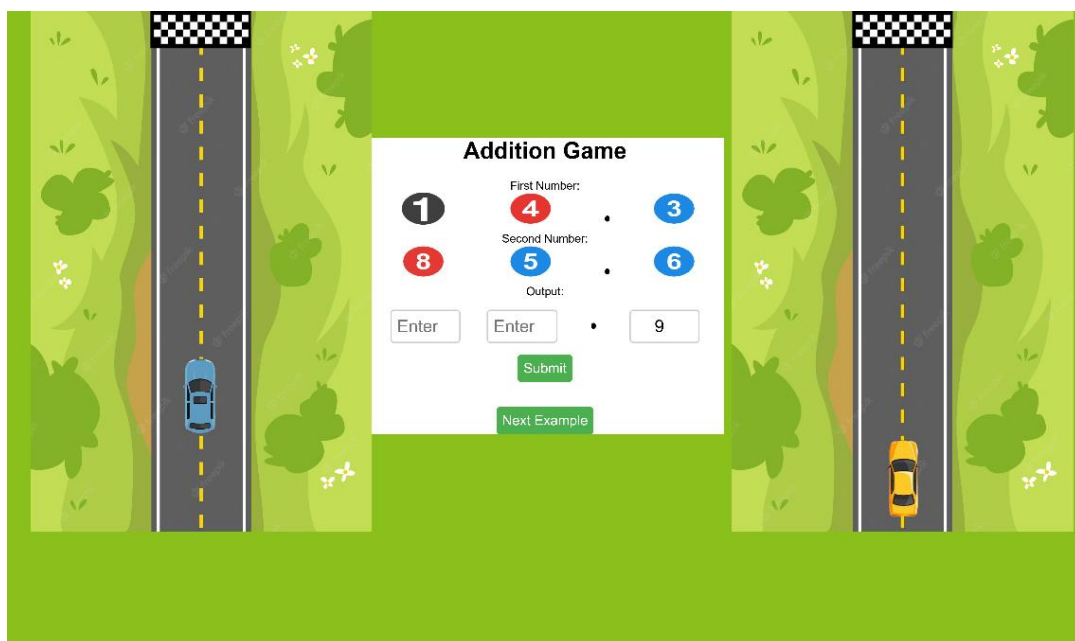


Figure 2. Car game: interactive addition game

Additionally, participants were provided with the opportunity to familiarize themselves with the platform by attempting a straightforward test. This introductory exercise was designed to ease their initial interaction. This approach helped to acquaint participants with the functionalities and layout of the platform, ensuring a smoother transition into subsequent activities. The design intuitively provides accessibility to the users irrespective of their technical competence.

2.5. Feedback and suggestions

After the tests were completed, a detailed report was generated, including a thorough performance analysis of all participants based on backend data. This report was submitted to the class instructor for validation, and feedback was gathered to guide the next steps of the main study. The feedback included recommendations for adding gamification elements, such as badges and leaderboards to visually track student progress, as well as incorporating sound effects for congratulatory messages, among other suggestions. These recommendations will be carefully reviewed and incorporated into the web portal's improvements for the main study, with the goal of enhancing the overall user experience and the platform's effectiveness.

3. EXPERIMENTAL RESULTS

The portal is designed for ease of use, with a user-friendly interface that allows both students and teachers to navigate it effortlessly. It includes features that make it simple for students to engage with, while also enabling teachers to collect relevant feedback efficiently. Its core functionality aims to streamline educational interactions.

3.1. Test portal design and user experience

Following are some of the important features: i) Thematic familiarity: the portal's design aimed to enhance user experience by incorporating a visually engaging theme. Key elements included a blackboard-style background, contributing to a sense of familiarity and approachability for student users and ii) Responsive user interface (UI): the user interface was designed with responsiveness in mind, ensuring optimal functionality across various devices and screen sizes. This includes, i) Easy question navigation: smooth and intuitive navigation between questions; ii) Readability: clear and legible question presentation with appropriate font sizes for comfortable reading; and iii) Screen size adaptability: dynamic adjustments of layout and elements based on the screen size.

3.1.1. User registration and authentication

Secure user registration and authentication are implemented to ensure that only authorized individuals can access the portal. Initial registration: prior to commencing the tests, students were required to register by providing basic information such as name, school name, standard, division, and phone number. Simplified login: subsequent logins were streamlined for convenience. Students could easily access the portal using their standard, school name, division, and roll number, eliminating the need for separate credentials. This unique identifier system facilitated user identification and streamlined the login process.

3.1.2. Test structure and phases

The test is organized into 3 distinct phases, each with a specific structure and time allocation. Phased testing: the testing process was divided into three distinct phases, each corresponding to a different difficulty level which are easy, medium, and hard. Progressive difficulty: students progressed through the phases sequentially, starting with the easiest level and gradually advancing to more challenging questions. This phased approach allowed for the collection of performance data across varying difficulty levels for each student.

3.1.3. Test completion and feedback

The performance feedback improves student learning and participation. Immediate feedback: upon completion of each test phase, students received immediate feedback on their performance, including their score and accuracy. This timely feedback mechanism provided valuable insights into their performance and areas for improvement.

3.1.4. Key considerations

These key considerations highlight commitment to user satisfaction, robust data acquisition, and efficient system access. User-centric design: the portal's design prioritized user experience, focusing on factors such as ease of use, visual appeal, and accessibility. Data collection: the phased testing approach enabled the collection of comprehensive data on student performance across different difficulty levels.

Streamlined authentication: the simplified login process enhanced user convenience and facilitated efficient user management. The registration page and login page of the portal are depicted in Figure 3.

Registration Portal

Name (नाव):

Roll Number (हजेरी क्र.):

Gender (लिंग):
Male ▼

Phone Number (फोन नंबर):

Enter a 10-digit phone number

School Name (शाळेचे नाव):
विद्या विकास विद्यालय ▼

Class (इयत्ता):
8 ▼

Division (तुकडी):
अ ▼

Select Test (परीक्षा निवडा):
बहुपदीचा भागाकार - सोपी उदाहरणे ▼

Access Key (प्रवेश की):

[Register](#)

Already a member? [Login](#)

Login Portal

Roll Number (हजेरी क्र.):

School Name (शाळेचे नाव):
विद्या विकास विद्यालय ▼

Class (इयत्ता):
8 ▼

Division (तुकडी):
अ ▼

Select Test (परीक्षा निवडा):
बहुपदीचा भागाकार - सोपी उदाहरणे ▼

Access Key (प्रवेश की):

[Login](#)

Not a member? [Register](#)

Figure 3. Registration and login portal

3.2. Pilot study, test implementation, and result analysis

On 24th February 2024, the pilot project was initially launched at Vidya Vikas Vidyalaya School with the support of the Mathematics Faculty and the honorable principal of the school. A series of comprehensive discussions was held with the Mathematics Faculty and school authorities, to decide the project objectives. It was decided to focus on the development of assessment tasks related to the chapter of Polynomial Division, tailored for 8th standard Marathi medium students. The goal was to test students' understanding and skills in this foundational area of mathematics. To ensure holistic evaluation it was decided to set three levels of assessments, viz level 1-easy, level 2-moderate or medium, and level 3-challenging or difficult. The aim of this approach is to accommodate various levels of learning and provide insights into student comprehension across the broader spectrum. The tests were carefully designed not only to challenge students but also to motivate, to create interest in mathematics, and to encourage analytical thinking, critical thinking, and problem-solving skills. The finalized tests were administered in the school's computer laboratory over a span of four days-March 6, 13, 14, and 19, 2024. A total of 44 students participated in the pilot project. This setting allowed for a structured environment where students could engage with the material using technology, further enhancing their learning experience. The administration of the tests was closely monitored to ensure consistency and fairness in evaluation. Figure 4 shows the sample of questions that were used to collect the data for the pilot study.



Figure 4. Sample questionnaires for the pilot study

The results of these assessments will provide valuable data to refine the project further and contribute to ongoing efforts to improve mathematics education in the school. Feedback from students and faculty will also play a crucial role in shaping future iterations of the project, ensuring it meets the needs of learners effectively. The following sections discuss the analysis of the test which was conducted at Vidya Vikas Vidyalaya School.

3.2.1. Analysis for test-1 (level 1-easy level)

The questions for test-1 were designed at level 1, which corresponds to an easy difficulty level. A total of 44 students participated in this test. The result of the test is depicted in Figure 5. The data visualization through a histogram depicting the performance distribution of all 44 students who participated in the easy test. The histogram indicates that 2 students attained marks within the range of 0-5, 15 students scored between 6-10 marks, 5 students achieved marks within the range of 11-15, 7 students obtained marks within the range of 16-20, and 15 students secured marks within the range of 21-25. The mean and median values for the easy test are 15.068 and 15.5 respectively. Analysis of the mean and median data reveals that the average marks obtained in easy tests are 15. Approximately 22 students fall below the average mark, while 22 students surpass the average mark. These findings suggest a balanced representation of students across various performance categories, including weak, mediocre, and bright, within the cohort that undertook the first test. Notably, the histogram chart for the first test demonstrates two prominent spikes within the ranges of 6-10 and 20-25 marks. This distribution pattern indicates a higher presence of students classified as weak to mediocre and bright performers, compared to those categorized as mediocre performers.

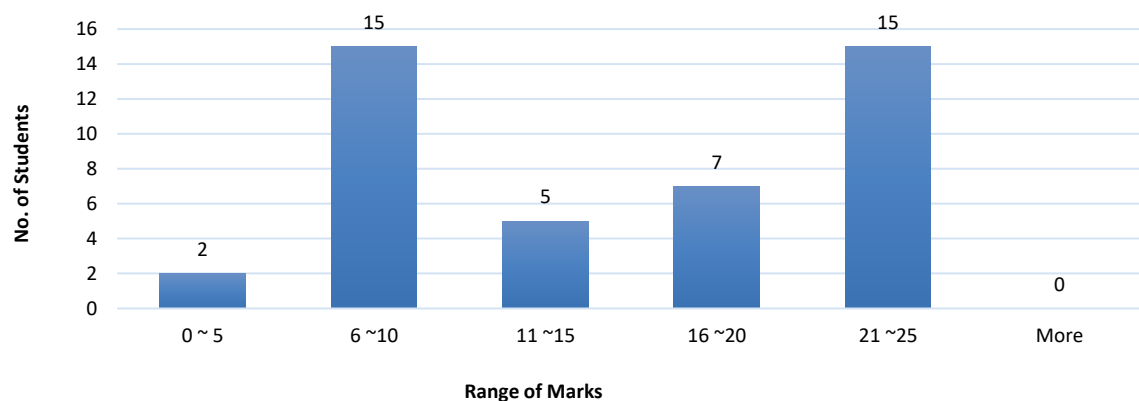


Figure 5. Representation of participants' performance for easy-level test in accordance with different ranges of marks

3.2.2. Analysis for test-2 (level 2-moderate/medium level)

The questionnaires for test-2 were designed at a moderate level. Figure 6 illustrates that 6 students achieved marks within the range of 0-5, 7 students scored between 6-10 marks, 11 students obtained marks within the range of 11-15, 10 students secured marks within the range of 16-20, and 10 students attained marks within the range of 21-25. Analysis of the mean and median data reveals that the average marks obtained in the medium test are 14.205 and 14 respectively. About 24 students were under the average score, while 20 students exceeded the average score. A more evenly distributed spectrum is evident across each performance category in the histogram chart for the medium test. This suggests that students performing the medium-level tests have achieved average performance. Additionally, a notable advantage of the medium-level test over the easy-level is the more uniform distribution of marks, indicating that students have demonstrated a more balanced performance closer to the average marks. This is evidenced by the fact that students scoring between 0-10 marks on the easy-level test are 17 and students scoring between 0-10 marks on the medium-level test are 13. This indicates that despite the medium-level test's higher difficulty, students have managed to achieve marks exceeding 10, although the class's average marks are slightly lower.

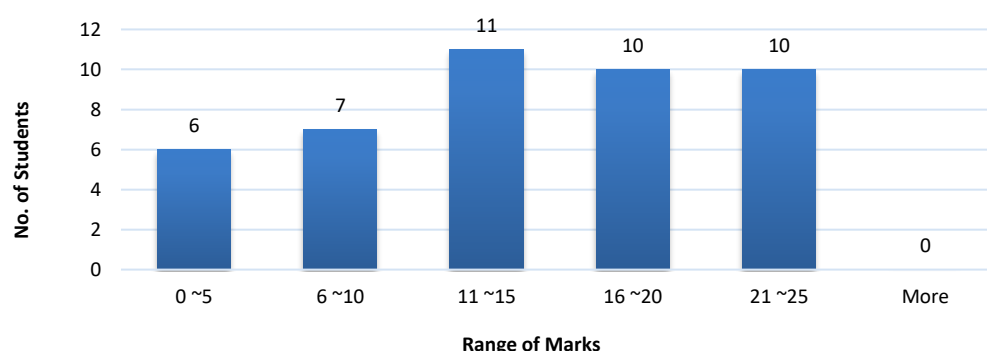


Figure 6. Representation of participants' performance for medium-level test in accordance with different ranges of marks

3.2.3. Analysis for test-3 (level 3-challenging/difficult level)

The level of question set of test-3 was difficult or challenging. Figure 7 presents the performance distribution of all 44 students who participated in hard tests. The assessment shows that 12 students attained marks within the range of 0-5, 25 students scored between 6-10 marks, 7 students obtained marks within the range of 11-15, and there were no students who scored within the range of 16-20 or 21-25. The mean and median values for the hard test are 7.76 and 7.5 respectively. The statistical analysis is carried out as given in Table 1.

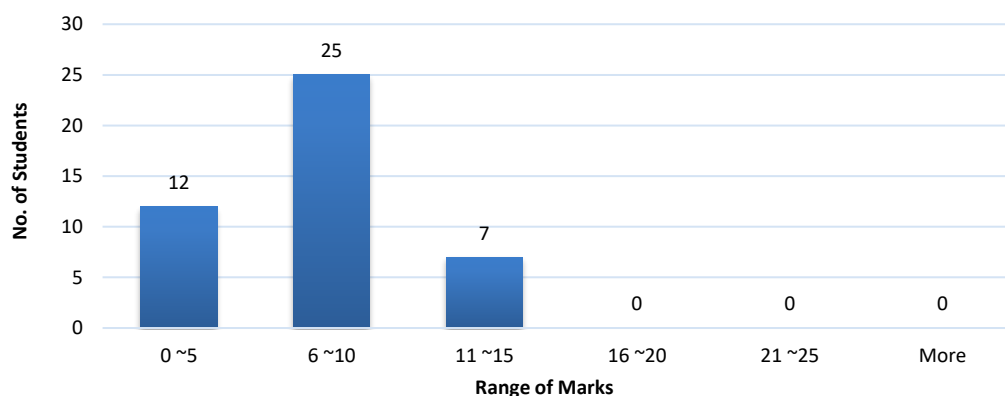


Figure 7. Representation of participants' performance for hard-level test in accordance with different range of marks

Table 1. Mean and median scores of the tests

Test difficulty level	Mean score	Median score
Easy	15.07	15.5
Medium	14.20	14
Hard	7.76	7.5

About 20 students are under the average score, while 24 students surpass the average mark. Given the test's high level of difficulty, it is noteworthy that no students achieved marks within the range of 16-25, suggesting a rigorous assessment. Additionally, the histogram distribution indicates that a majority of students scored marks between 6 to 10, with fewer students scoring within the ranges of 0-5 and 11-15. This suggests a relatively uniform performance among students as the complexity of problems increases, indicating a similar level of proficiency across the class. Consequently, addressing their individual challenges and concepts may be more manageable.

3.3. Combined overall analysis

Figure 8 represents the combined analysis for the 3 tests conducted. The blue plot corresponds to test-1 (easy test), the orange plot represents test-2 (medium test), and the grey plot denotes test-3 (challenging test). The minimum marks obtained in easy test, medium test, and hard test are 1, 2, and 3, respectively, as evidenced by the lowest points on each plot. The maximum marks achieved in the easy test, medium test, and hard test are 25, 24, and 15, respectively, depicted by the highest points on each plot. The mean and median marks for each test are positioned centrally within their respective plots. In the first test, 11 students attained marks ranging between 3 and 9, while another 11 students scored marks between 22 and 25. Consequently, students within the 25th percentile achieved marks under 9, whereas those above the 75th percentile secured marks surpassing 22. For the second test, 11 students received marks ranging between 2 and 8.25, with an additional 11 students scoring marks between 19 and 25. Thus, students within the 25th percentile achieved marks under 8.25, while those above the 75th percentile obtained marks exceeding 19. In the third test, 11 students garnered marks within the range of 3 to 5, and another 11 students achieved marks between 10 and 15. Consequently, students within the 25th percentile achieved marks under 5, while those above the 75th percentile scored marks exceeding 10.

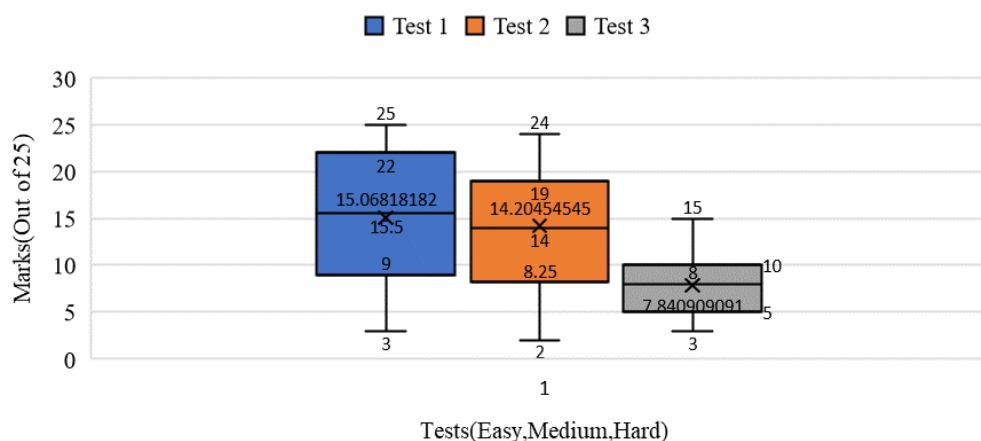


Figure 8. A boxplot representing a combined analysis of all the 3 tests conducted

4. RESULTS AND DISCUSSION

A notable observation is the prevalence of students achieving higher marks in the medium-level test compared to easy-level test, despite the former being of higher difficulty. For instance, one student obtained 20 marks on an easy-level test, whereas they scored 24 marks on a medium-level test. This discrepancy may be partially attributed to students' adjustment period to the online platform during the easy-level test. Approximately 18 out of 44 students, constituting nearly 36% of the cohort, attained higher marks in the medium-level test than in the easy-level test, thereby emphasizing this trend. Furthermore, nearly 6 out of 44 students, accounting for approximately 13.5% of the cohort, achieved higher average marks in the hard-level test compared to the easy- and medium-level tests. For example, one of these students scored 9 marks in both easy and medium-level tests but managed to score 9 marks on the hard-level test. If the average of easy- and medium-level test scores is considered, it amounts to 9, which is lower than the score of the hard-level

test. This suggests that the performance of these students may not provide conclusive insights for evaluating class progress. Consequently, defining progress for these students becomes challenging, and their performance analysis based on marks remains ambiguous. Following the administration of tests, feedback was obtained from the class instructor of the participants' class. Our findings reveal that the participants exhibited superior conceptual knowledge of mathematical fundamentals compared to regular students who continued to learn mathematics in a conventional manner. Students acquiring superior knowledge of mathematics fundamentals highly correlates with the introduction of gamification in teaching as described in this work. The pilot study initially involved a small sample size, highlighting the need to expand the number of participants for the main study. Additionally, while student assessment in the pilot study was based on tests, the main study will introduce a feature that automatically suggests concept-specific games and assessments tailored to individual performance metrics, as outlined in Table 2.

Table 2. Comparative analysis between existing pilot study and proposed main study

Pilot study	Main study
	Efficacy
The effectiveness of the system was not sufficiently observable since the number of participants was too small.	To investigate whether a significant improvement has occurred after the testing, the main study will be conducted on a larger number of participants aiming at approximately 500 participants from various Marathi medium schools.
	Balancing assessment and engagement
The current web portal prioritizes the presentation of varied and engaging test content aimed at evaluating students' performance. However, this approach has led to a compromise in the level of enjoyment and interactive engagement that students could experience while accessing gaming features on the web portal.	Drawing from the collected data on participant engagement durations and interests, it is imperative to periodically rotate the test and game sections within the web portal to sustain participant engagement for extended periods. This will be realized in the main study through the implementation of a dynamic mechanism wherein test and game suggestions will continuously evolve as users navigate the web portal.
	Addressing confidence and fundamentals
Several participants encountered difficulty in solving tests categorized as easy and medium levels, leading to a reduction in their confidence levels when attempting harder-level tests. They expressed a desire for additional opportunities to attempt easy and medium-level tests to strengthen their foundational skills.	The main study will employ an algorithm capable of real-time assessment of each question solved by participants, determining whether subsequent questions should increase or decrease in difficulty, thereby enabling participants to enhance their skills at their own pace. Moreover, participants will have the autonomy to attempt specific tests repeatedly, enhancing the flexibility and usability of the web portal.

5. CONCLUSION

This paper outlines the design and implementation of an online gamified platform aimed at enhancing the teaching and learning experience. It also presents findings from a pilot study conducted to evaluate its effectiveness. Our findings indicate that higher performance in the assessments is associated with enthusiastic participation in the learning process. The proposed method benefits students as they enjoy their learning process in a competitive environment without negatively affecting their self-esteem. The results highlight significant benefits in transforming the educational landscape for Marathi-medium students in Maharashtra. However, despite the success of the pilot study, several limitations need to be addressed. We are currently conducting surveys in additional Marathi-medium schools to overcome these limitations and incorporate more interactive features. This study investigated a comprehensive approach to gamification-based learning in school setups. However, additional and in-depth research may be required to confirm its efficiency. Our research shows that balancing assessment and engagement is more resilient than appreciation or rewards. Future research may look into employing an algorithm capable of real-time assessment of each question solved by participants, determining whether subsequent questions should increase or decrease in difficulty.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : Conceptualization

M : Methodology

So : Software

Va : Validation

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O : Writing - Original Draft

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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [SS], upon reasonable request.

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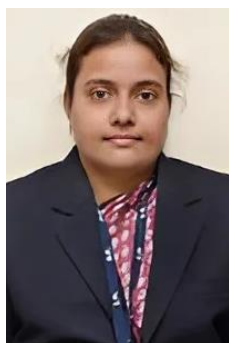
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