



Effectiveness Of Hybrid Gamification On Achievement In Mathematics Among Secondary School Students

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ABSTRACT

This paper investigates the impact of a Hybrid Gamification strategy on secondary school students' Mathematics achievement. An experimental study was conducted on students studying in Standard IX of Holly Cross Higher Secondary School Cherpunkal in Kottayam District, Kerala. The investigator used instructional material prepared based on the Hybrid Gamification Technique using different software like Wordwall, Blookit, Gimkit, etc., and game elements like Scoring cards, Badges, and Points for the Experimental group and the Existing Activity-Oriented Method for the Control group. The results showed a significant difference between the Experimental group's and the Control group's scores on the Achievement test, and the Hybrid Gamification strategy is effective for teaching Mathematics and attaining significant performance in Achievement in Mathematics. There is no significant difference in the post-test scores of males and females in the Mathematics Achievement.

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Keywords: Hybrid Gamification, Game Elements, Secondary School students, Mathematics Achievement, digital games

INTRODUCTION

Education is not just meant to focus on academic disciplines, but it uses the latest technologies, such as video, audio, and digital games and software, to educate learners and make the learning process more engaging and interesting ("Modern Education," 2022). Providing universal access to quality education is the key to India's continued ascent and leadership on the global stage. Universal high-quality education is the best way to develop and maximize our country's rich talents and resources for the good of the individual, society, country, and world (NPE, 2020). In the curriculum, the Mathematics discipline holds an important and unique place among other disciplines (Park & Brombacher, 2008). Mathematics is fundamental to human thought and logic and integral to understanding the world and ourselves. Mathematics provides an effective way of building mental discipline and encourages logical reasoning and mental rigour. Collaboration of technology in the traditional classroom is a hybrid learning environment, and it increases positive attitude towards learning (*The Importance of Technology in Mathematics Report Example*, 2023). Games show a natural way to spark passionate engagement with learning. New technologies and strategies provide new ways to deliver and develop learning experiences (Hammer, 2008).

Mathematics is one of the important subjects which we need to be taught effectively. Historically learning Mathematics and teaching has been motivated by the belief that the study of Mathematics helps the individual learn, reason, and apply. As far as Mathematical instruction is concerned, the major goal is the involvement of the students in the process of discovering Mathematical ideas and formulating processes. But many students complain that learning mathematics is not at all interesting and attractive to them. To activate and make interest in Mathematics, Gamification is an Innovative Technique to be applied. Gamification is using game mechanics and dynamics to drive game-like engagement in a non-game context (Micheal, 2011). A hybrid gamification is an approach that combines both digital and non-digital game elements to create a more engaging and interactive experience. It uses game-like features such as points, badges, leaderboards, challenges, and rewards to motivate and encourage participation in real-world activities. In mathematics education, hybrid gamification can be used to make learning more fun and engaging, especially for students who may find mathematics challenging or uninteresting (Dichev & Dicheva, 2017).

A Gamification

Gamification is the process of introducing game concepts to a non-game context to motivate users to become more invested in it. The term Gamification refers to the practice of incorporating game design features and the ideas and principles that govern gameplay into non-gaming settings. Problems are resolved with the use of gamification. Workplace training, sales team effectiveness, and knowledge retention are just a few areas where gamification has proven effective (Virtanen, 2021).

Gamification in education refers to integrating game design elements into a learning environment. In general, the purpose is to enhance student engagement with learning. Even if the outcome is not strictly a game, the instruction has been gamified when educators incorporate specific features. Some features, like badges and scoring, are frequently used. However, instructors should also be aware of less structured elements like setting up the classroom for a lesson or giving students a variety of projects. While sustaining the same learning objectives, gamified instruction makes learning more enjoyable. Using gamification in the classroom can increase motivation and interest while diminishing student-driven problems (Blankman, 2022).

B Steps for Gamification

A few steps are included during gamification to efficiently integrate game elements into non-game contexts. The fundamental stages in the gamification process:

Define your objectives: Defining your objectives is the first stage in gamification. This involves identifying the desired behaviour or outcome to encourage or accomplish with gamification.

Understanding your target audience: This involves identifying the demographics, interests, motivations, and objectives of the intended audience. By gaining audience comprehension, tailor gamification strategy to their needs and preferences.

Choose Game Elements: This comprises selecting the game mechanics, design elements, and rewards used to motivate and engage users. Points, badges, leaderboards, and challenges are all popular elements of a game.

Incorporate game elements into the context: This encompasses identifying the touchpoints where game mechanics and design elements can be incorporated to make the experience more engaging and motivating. In a fitness programme, for instance, game elements could be incorporated into workout tracking, progress reporting, and social sharing features.

Test and iterate: It entails getting user feedback and analyzing their behaviour to determine the effectiveness of the gamification strategy. Based on this feedback, modify, and enhance the gamification strategy to make it more effective.

Evaluating and refining: This includes analyzing the influence of gamification on user behaviour and outcomes and optimizing strategy correspondingly. Continuously refining the gamification strategy, provide users with a more effective and engaging experience.

C Theories Related to Gamification

Gamification draws on theories from psychology and game design to understand how to motivate and engage users effectively.

Self-determination theory: Self-determination theory (Ryan & Deci, 2000) suggest that one of the main factors influencing motivated behaviour is the fulfilment of fundamental human requirements for autonomy, competence, and relatedness. It defines a path along which broad motivations may be pursued, from intrinsic motivation at one end to extrinsic motivation at the other. Extrinsically driven tasks are undertaken because of outside circumstances, although intrinsically motivated tasks are perceived as autonomous and self-determined. The second type of extrinsic motivation is referred to be introjected regulation, in which

individuals pursue goals as they have integrated and have learned to administer their own benefits and drawbacks associated with the goal. The internalized extrinsic incentive is known as identified regulation, but the most thorough internalization of an extrinsic aim is known as integrated regulation (Wright, 2001).

Flow Theory (Mihaly Csikszentmihalyi, 1970): Flow theory suggests that people are most engaged and motivated when they are in a state of flow characterized by a deep sense of focus and immersion in an activity. Individuals in these intense activities have their attention fully absorbed. Flow is a state of mind that combines cognitive, physiological, and affective aspects. Gamification can facilitate flow by providing users with clear goals and feedback, opportunities for challenge and growth, and a sense of control over the activity.

Game design principles: Gamification draws heavily on game design principles such as points, badges, and leaderboards to motivate and engage users. These elements tap into users' desire for achievement, recognition, and competition, and can effectively drive user behaviour.

Cognitive load theory: Cognitive load theory suggests that people have a limited capacity for processing information and can become overwhelmed if presented with too much information or complexity. Gamification can address cognitive load by breaking tasks down into smaller, more manageable steps and providing clear and concise instructions and feedback.

NEED AND SIGNIFICANCE

Gamification has gained substantial attention in education due to its potential to enhance student engagement, motivation, and learning outcomes. In recent years, the traditional educational landscape has evolved, and educators are continually seeking innovative approaches to improve student achievement. Mathematics, a fundamental subject with a reputation for challenging students, provides an ideal context to explore the effectiveness of hybrid gamification, combining digital and non-digital game elements, in enhancing learning outcomes among secondary school students.

Secondary school students often need more support and motivation towards mathematics, leading to suboptimal learning outcomes. The integration of gamification elements has shown promise in capturing students' attention and sustaining their interest in complex subjects like mathematics. Hybrid gamification can simulate real-world problem-solving scenarios, allowing students to apply mathematical concepts in practical contexts. This can foster a deeper understanding of the subject and its relevance in everyday life.

The study aims to determine if hybrid gamification positively influences math achievement. This research will offer insights into innovative teaching methods for educators, allowing diverse techniques to engage and motivate students. Hybrid gamification prioritises student experiences, aligning with modern education ideals of personalised learning. This study could lay the groundwork for future research on gamification's effectiveness across various subjects, age groups, and cultural backgrounds. By addressing the need for innovative teaching, the study could transform traditional classrooms into dynamic learning spaces, enhancing academic performance and nurturing a positive attitude toward math among secondary school students.

REVIEW OF RELATED LITERATURE

Recent research has shown that Hybrid Gamification influences Achievement in students' learning process. (Cavicchini and Mariani, 2019) Studied the impact and possibilities of Hybrid Board game. The study found that the hybridization of the analogue medium with the digital are in a tabletop, allowing a new level of interaction between player and game system. (Bitrián et al., 2021) investigate how gamification foster the user engagement and positive marketing outcomes. The results show that, gamification increases user management through satisfaction of the needs for competence, autonomy, and relatedness. (Appiah, 2016) conducted a study on effects of the gamification framework and hybrid learning to improve Elementary Mathematics through engagement in hybrid learning in the classroom. The study revealed that the Gamified activities made students interested with their teachers, peers, and the instructional materials. (Hasnat, 2020) conducted a study to gain a deeper understanding of Gamification and its different elements by focusing on using Gamification as a digital marketing tool to enhance customer loyalty and retention in retail store settings.

Learning and teaching mathematics is an incredibly diverse field, and traditional educational approaches to underlying inventiveness of the subject. The conventional method of teaching math at the college level is tedious and monotonous. Hybrid learning is an approach to education which integrates digital technologies within traditional classroom instruction. Some students can take their classes from the convenience of their own homes, while others must attend in person (Gogia, 2022). The study shows that the hybridisation of classroom activities using Gamification by card game and QR code increases the achievement score in Mathematics and have difference in the pre-test score and post-test score. Gamifying mathematics using a

hybrid card game enhances their understanding of decimal, fractions, and percentage (Yung et al., 2020). The inclusion of games into instruction, which has shown to be an effective method of fostering student engagement (Rivero, 2021). Su, (2017) investigated and effectively predicted that Gamification learning is a series of entertainment materials with meaningful teaching activities. The user behaviour of game design levels is collected and analysed, along with the level design and interactive elements. Smith, (2018) shows up to be a positive correlation between gamification and students' mathematics performance on standardised tests. The reviews on empirical studies on Gamification indicates that gamification has positive effects, but these effects are extremely context and user-specific (Hamari et al., 2014). (Saleh & Sulaiman, 2019) conducted a study and opined that teachers and students will unquestionably benefit from the use of Quizziz in teaching and learning. Teachers can evaluate the performance of their students more quickly and easily with the aid of digital displays than with paper and pencil. Zhao & Li, (2020) explored that educational activities can enhance the flow experience of students during classroom practice.

OBJECTIVES

- To find out the effect of Hybrid Gamification on Achievement in Mathematics Among Secondary School Students.
- To find out the difference between post-test score of Experimental and Control groups on Achievement in Mathematics with respect to gender.
- To compare the effect of Hybrid Gamification over the Activity Oriented Method on the post-test score of Achievement in Mathematics among Secondary School students of Standard Nine using scores on pre-test as covariate.

HYPOTHESES

- There exists no significant difference between the means of the Pretest scores on Achievement in Mathematics among the students of Standard Nine of the Experimental and Control Groups.
- There exists no significant difference between the means of Posttest scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups.
- There exists no significant difference between the means of Posttest scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups with respect to gender.
- There exists no significant effect of Hybrid Gamification over Activity Oriented Method on the posttest scores on Achievement in Mathematics controlling the effects of pretest scores.

METHODOLOGY

A. Research Design

The investigator used the Experimental method for the present study to explore the effect of Hybrid Gamification on Achievement in Mathematics. The Pretest-Posttest Non-Equivalent Design is used for the study. The investigator developed an Instructional Material based on Standard Nine of Kerala State Syllabus Mathematics Text Book. The topic selected for preparing the instructional material is 'Prism.' The investigator prepared 15 lessons using the Gamification technique, such as games designed by using the software Wordwall, Blookit, Gimkit, Quizziz and Game elements Scoring cards, Badges and points and the treatment given to the Experimental group and Existing Activity Oriented Method is used for Control group. The experiment was conducted during a two-month period. The Achievement Test in Mathematics is prepared and conducted to assess Achievement in Mathematics before and after the treatment given.

B. Population and Sample

The study population comprises Secondary School Students from Standard Nine of Holly Cross Higher Secondary School Cherpunkal in Kottayam District, Kerala, India. There is one Experimental group and Control group, and given different treatments to both groups. A random sampling technique was used for the sample selection. The study's sample size is 76 students from Standard IX.

C. Instruments

The investigator used the following tools and Instructional material for data collection in the present study.

- Instruction Material based on Hybrid Gamification prepared by the investigator.
- Instructional Material based on Existing Activity Oriented Method prepared by the investigator.
- Achievement Test in Mathematics prepared by the investigator.

D. Statistical Techniques Used

The investigator used the following Statistical techniques for the study,

- Descriptive Statistics: Arithmetic Mean, Standard Deviation
- Simple Independent Sample t test
- ANCOVA

DATA ANALYSIS

The data collected were analysed using Descriptive Statistics; significant difference is analysed using t test and find the effect of Hybrid Gamification over Activity Oriented Method by Controlling the effect of pretest scores of dependent variables.

Comparison of Means of the Pre-test Scores on Achievement in Mathematics among the students of Standard Nine of Experimental and control Groups

To compare the means of the Pre-test Scores on Achievement in Mathematics among Standard Nine of Experimental and Control Groups. The investigator formulated the research hypothesis which states that “There exists a significant difference between the means of the Pre-test scores on Achievement in Mathematics among the students of Standard Nine of the Experimental and Control Groups.”

Table 1 Result of the Test of Significance of Difference between the Means of the Pre-test scores on Achievement in Mathematics of Experimental and Control Groups

Group	N	M	SD	t value	df	p-value
Experimental Group	38	14.78	2.17	1.46	74	.146*
Control Group	38	14.07	2.04			

*Not Significant at .05 level

From the Table, the investigator observes that the means of Pre-test scores on Achievement in Mathematics among the students of Standard nine of the Experimental and Control groups are 14.78 and 14.07, respectively. The calculated ‘t value’ is 1.46, and the p-value is greater than 0.05, and it is not significant at 0.05 level. The investigator found no significant difference between pre-test scores of Experimental and Control Groups on Achievement in Mathematics.

Comparison of Means of the Post-test Scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups

To compare the means of the Post-test scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups, the investigator formulated a research hypothesis which states that “There exists a significant difference between the means of Post-test scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups.”

Table 2 Results of the Test of the Significance of the difference between the Means of Post-test Scores on Achievement in Mathematics of Experimental and Control Groups

Group	N	M	SD	t value	df	p-value
Experimental Group	38	27.0	2.47	10.39	74	.000*
Control Group	38	20.5	2.95			

*Significant at .05 level

From the table, the investigator observes that the Means of Post-test scores on Achievement in Mathematics among the students of Standard Nine of the Experimental and Control groups are 27.0 and 20.5 and Standard Deviations are 2.47 and 2.95, respectively. The calculated ‘t value’ is 10.39 and p-value is .000 which is less than 1.96 and significant at .05 level of significance. The investigator found that the Experimental and control groups post-test scores differ significantly at .05 levels of significance.

Comparison of post-test score on Experimental and Control group on Achievement in Mathematics with respect to gender

To compare the means of the Post-test scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups with respect to gender, the investigator formulated a research hypothesis which states that “There exists a significant difference between the means of Post-test

scores on Achievement in Mathematics among the students of Standard Nine of Experimental and Control Groups with respect to gender.”

Table 3: Results of the Test of the Significance of the difference between the Means of Post-test Scores on Achievement in Mathematics of Experimental and Control Groups with respect to gender

Variable	Group	Gender	N	Mean	SD	df	t-value	p-value
Achievement	Control	Boys	24	27.20	2.50	36	.675	.504*
		Girls	14	15.07	4.131			
	Experiment	Boys	19	26.78	2.59	36	.520	.606**
		Girls	19	27.21	2.39			

*Not Significant at 0.05 level. ** Not Significant at 0.05 level.

From the table the Achievement score of Control and experimental groups students have no significant difference between boys' and girls' students. For this the null hypothesis is accepted and research hypothesis is rejected and the p value is significant at 0.05 level. The investigator found that there is no significant difference between boys' and girls' students in the Achievement Score in Experimental and control groups.

To compare the effect of Hybrid Gamification over the Existing Activity Oriented Method on Post-test scores of Achievement in mathematics among the students of Standard Nine of the Experimental and control groups using pretest scores as covariate

To test the effect of Hybrid Gamification over the Activity Oriented Method on Achievement in Mathematics in terms of total scores controlling the effect of pretest scores, the investigator formulated the null hypothesis as 'There exist no significant effect of Hybrid Gamification over Activity Oriented Method on the posttest scores on Achievement in Mathematics controlling the effects of pretest scores.'

The investigator tested the null hypothesis using statistical techniques ANCOVA.

Table 4 Results of the analysis of the Effect of Hybrid Gamification on the posttest scores on Achievement in Mathematics

Source of Variance	Sum of squares	df	Mean square	F	Sig	Partial Eta Squared
Pretest on Achievement in Mathematics	26.001	1	26.001	3.62	.061	
Between group	732.81	1	732.81	102.18*	.000	.583
Within group	523.41	73	7.171			
Corrected total	1352.25	75				

*Significant at 0.05 level

From the table, observes that the between groups variance is 732.81 and the within group variance is 523.41. The F value ($F_{(1,73)} = 102.18, P < .05$) is significant at .05 level. Therefore, Null Hypothesis is not accepted and the investigator infers that there is a significant effect of Hybrid Gamification when compared to Activity Oriented Method on Achievement in Mathematics when the effect of pretest scores on Achievement in Mathematics is controlled.

To determine whether the effect is to improve or to hinder Achievement in Mathematics, the investigator compared the means of posttest scores on Achievement in Mathematics of both Experimental and Control group adjusted for the scores on pretest scores on Achievement in Mathematics. The table shows the comparison of adjusted means of posttest scores on Achievement in Mathematics of Hybrid Gamification and Activity Oriented Method groups.

Table 5 The Estimated Marginal Means of the Posttest Scores on Achievement in Mathematics of the Hybrid Gamification and that of Activity Oriented Method group.

Experimental Condition	M	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lowerlimit	Upperlimit
Experimental	26.90	6.3	.438	.000	6.30	6.30
Control	20.60					

The table shows the estimated marginal means of the posttest scores on Achievement in Mathematics of Hybrid Gamification and control groups. The adjusted mean or estimated marginal mean of the posttest

scores on Achievement of the Hybrid Gamification group is 26.90 and that of Activity Oriented Method group is 20.60. Therefore, Hybrid Gamification group is superior to the control group in terms of posttest score on Achievement in Mathematics. The investigator infers that the instruction through Hybrid Gamification is effective in improving the Achievement in Mathematics when compared with Existing Activity Oriented Method.

RESULTS

The results of the study indicates that the Hybrid Gamification have a significant effect on Achievement in Mathematics among Secondary School Students. The Score obtained from the Achievement test in Mathematics shows that there is significant difference in the post-test scores of Experimental and Control groups. The investigator also found that there is no significant difference in the achievement scores of boys' and girls' students of the Experimental and control groups.

FINDINGS OF THE STUDY

1. There exists no significant difference between the pre-test scores of Achievement in Mathematics among Secondary School Students of Standard Nine of Experimental and Control groups.
2. There is significant difference between post-test scores of Achievements in Mathematics among Secondary School Students of Standard Nine of Experimental and Control group.
3. There is no significant difference between Male and Female students in the Achievement Score in the Experimental and control groups.
4. The study reveals that there is significant effect of Hybrid Gamification on Achievement in Mathematics among Secondary School Students of Standard Nine Students.

DISCUSSION

The present study revealed that Hybrid Gamification has a significant effect on Achievement in Mathematics among Secondary School Students of Standard Nine. Yung et al. (2020) investigated that the hybridisation of classroom activities using Gamification by card game and QR code increases the achievement score in Mathematics and have difference in the pre-test score and post-test score and the inclusion of games into instruction, which has shown to be an effective method of fostering student engagement (Rivero, 2021). Su (2017) notes that Gamification is a series of entertainment materials with meaningful teaching activities (Smith, 2018) and a positive correlation between gamification and students' mathematics performance (Hamari et al., 2014). Saleh & Sulaiman, (2019) revealed that teachers and students benefit from the use of Quizizz in teaching and learning, and teachers can evaluate the performance of their students more quickly and easily with the aid of digital displays than with paper and pencil. Zhao & Li, (2020) opinioned that a certain extent, educational activities can enhance the flow experience of students during classroom practice.

RECOMMENDATIONS

The study on the effect of hybrid gamification on achievement in mathematics among secondary school students has provided valuable insights into the potential benefits of integrating gamification strategies into the education system. Building upon the existing literature and findings, the following recommendations are suggested for further study in this area: Conduct longitudinal studies to assess the long-term impact of hybrid gamification on students' mathematics achievement. Expand the study to include a more diverse range of secondary school students. Consider factors such as socio-economic status, cultural background, and learning abilities to determine if the effects of Hybrid gamification vary across different student groups. Study whether skills and problem-solving strategies developed through gamified mathematics activities can be successfully transferred to real-world applications. By delving into these recommended areas, researchers can contribute to a more comprehensive understanding of the nuances of gamification's impact on learning outcomes, ultimately informing educational practices and policies to support students' academic success better.

CONCLUSION

The study aimed to investigate the Effectiveness of Hybrid Gamification on Achievement in Mathematics among Secondary School Students of Standard Nine. The results of the study confirm that there is a

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significant effect of Hybrid Gamification on Achievement in Mathematics. And, it is found that there is no significant difference between boys' and girls' students in Achievement in Mathematics among the Experimental and control groups. Thus, Hybrid Gamification is an effective technique to improve Academic performance in Mathematics among Secondary School Students. The software and game elements used in the study significantly affect the teaching and learning process.

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