

Research Article

Gamifying Senior High School Genetics: Students Experiences and Attitude

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Received: 01/Apr/2024; Accepted: 03/May/2024; Published: 31/May/2024

Abstract— This study aimed to explore gamification in senior high School genetics and its effect on students' academic performance, attitude, and experiences. The research used purposive sampling techniques, and thirty participants participated. The study revealed that students were interested in using gamification in Genetics education, appreciating its advantages, such as increased engagement, simplified understanding of topics, and motivation to learn. This indicates that incorporating gaming elements into education creates an enjoyable classroom atmosphere, encouraging students to work and reach their academic objectives. It underscores how gamification can positively impact learning across subjects.

Five emerging themes were produced in terms of experience. Students find gamified approaches to learning Genetics engaging and motivating, appreciating the interactive and immersive nature of the activities, personalized learning experiences, skill development opportunities, collaboration with peers, and long-term engagement with genetic concepts facilitated by gamification.

Keywords— genetics, science education, secondary school, gamification

1. Introduction

Gamification, without a doubt, is an effective teaching tool in 21st-century learning. It filled the gap between digital natives and immigrants. Teachers and students enjoy this creative way of learning, thus guaranteeing motivation among learners. [1], [2], [3]. The combination of teaching and technology has renovated the educational environment by presenting innovative methods to make learning more practical and engaging. Learning Management Systems (LMS) like Moodle and Canvas make it easier to generate, disperse, and trace course content, which advances educational management effectiveness. These platforms foster interactive learning via discussion forums, quizzes, and multimedia content. Furthermore, digital tools like virtual laboratories and virtual reality give students real-world, direct-on experiences that are remarkably favorable in science and engineering.

Gamification, or the incorporation of game-design elements in non-game settings, aids technological change in education. It promotes and connects students by integrating points, badges, leaderboards, and levels into the learning experience.

2. Related Work

Previous studies on the effect of gamification show that students' academic performance significantly increases when

exposed to gamified instruction. [4] in physical science courses and language subjects among learners [5] Using games in the classroom setup is an effective educational tool to increase academic performance. [6]. Pede (2017) stated that educators should implement technology wherever possible as schools move into the digital age. The leveled gamification method connects teachers with traditional and standards-based grading practices. [8]. Gamification, described by [9] In addition to using game metaphors, game features, and concepts, game methods may be applied in non-gaming contexts to increase user behavior and motivation, and it is the application of game methods. [10] that makes learning more fun.

Although the excellent influence of computer games and serious games, which were earlier technologies used in education, has been extensively addressed [11]. It remains an intriguing research topic. Gamification is a sequential technology of games and game-based techniques in education that has been studied extensively since the 1980s [12]. According to one study, the assessment results demonstrate positive benefits in students' engagement with gamified learning exercises and a significant increase in learning outcomes. [13]. It also boosts student engagement and understanding. [14]. In the K-12 program, games can increase academic achievement, motivation, and classroom dynamics. [15], [16].

In an analysis of the leaderboard in a virtual classroom [17] Eighty female undergraduate students took a math test in a virtual classroom after seeing one of three leaderboard conditions: one in which most of the top positions were held by men, one in which women held most of the top positions, or one in which there was no leaderboard.

Several researchers focus only on increasing academic performance and the effect of leaderboards on academic performance, not on students' attitudes and experiences regarding the use of gamification. This led the researcher to work on this paper and explore more students' experiences and attitudes regarding gamification.

Genetics is typically a challenging subject for high school students to master because it involves some cross-linked information concerning topics such as genes, proteins, cells, tissues, organs, and systems. [18]. Additionally, it becomes harder to make connections between and clarify ideas like gene expression at the cellular level and the impact of a gene at the organism level. The subject was chosen to be explored using gamification.

This study aimed to explore gamification in senior high School genetics and its effect on students' academic performance, attitude, and experiences. Specifically, it would like to answer the following questions:

1. Is there a difference in the respondents' scores before and after using gamification?
2. What is the attitude of students on the use of gamification?
3. What are the students' experiences in using gamification?

3. Theory

Gamification is supported by core principles that stem from psychology, game design, and educational theory. Self Determination Theory (SDT), created by [19], [20] suggests that individuals are driven by three needs: independence, proficiency, and connection. Gamification addresses these needs by offering options (independence), presenting challenges and feedback (proficiency), and nurturing a sense of community (connection) (Deci & Ryan, 2000; Deci & Ryan, 2008). Flow Theory, introduced by (Csikszentmihalyi, 1990), defines engagement as achieving a balance between challenge and skill level, resulting in a flow state. Therefore, gamified tasks should be challenging yet attainable with objectives and immediate feedback to encourage a flow state (Csikszentmihályi, 1990): behaviorism and Operant Conditioning theories put forth by B.F. Skinner focuses on molding behavior through rewards and penalties. Gamification utilizes rewards such as points and badges to reinforce desired behaviors and promote continued participation. [22]. Social Comparison Theory, developed by Leon Festinger, indicates that individuals assess themselves based on comparisons. In gamification contexts, leaderboards and social sharing capitalize on comparison to inspire users through competition. [23].

The Constructivist Learning Theory, created by Jean Piaget in 1973 and Vygotsky in 1978 (cited by Saul, 2024) , highlights that learning involves participation in constructing knowledge

through experiences. Educational tools incorporating gaming elements enrich the learning process through engaging immersive activities.

4. Method

This study's participants were chosen purposively. They comprised twenty-two students enrolled in the Science, Technology, Engineering, and Mathematics strand for the school year 2023 – 2024. The participants were given a pretest before using gamification and a posttest after the intervention. The test was a 30-item two-tier test. A two-tier test acts to identify comprehension by showing a multiple-choice question supported by a deeper investigation into student interpretation. This encourages better understanding and assists teachers in recognizing topics requiring extended teaching.

For the attitude towards the use of gamification for high school genetics, a 10-item researchers survey questionnaire will be administered with the following scale:

To acquire participants' experiences, consent was first	Options	Scale	Adjectival Rating	Interpretation
			Rating	
	5	4.2 – 5.0	Strongly Agree	Very Positive
	4	3.4 – 4.19	Moderately Agree	Positive
	3	2.6 – 3.39	Undecided	Neutral
	2	1.8 – 2.59	Moderately Agree	Negative
	1	1.0 – 1.79	Strongly Disagree	Very Negative

obtained from both the parents and participants. This was done during the orientation of the study's goal. The participants were interviewed through a focus group discussion during the actual process. Lastly, the data were analyzed for common themes and precisely denoted participants' views on using gamification.

5. Results and Discussion

The following are the study results following the sequence presented in the statement of the problem.

1. SOP number 1: Is there a difference in the respondents' scores before and after using gamification?

Table 1. T-test Results for the Pretest and Post-test

Group	Mean	SD	t-value	Sig. value	Interpretation	Decision
Pretest	20.50	4.09	-5.46	0.00	Significant	Reject
Post-test	25.91	1.88				

α 0.05

Table 1 shows the t-test results for the pretest and post-test scores using gamification. It can be gathered from the table that the posttest (\bar{x} =25.91, σ =4.09) is higher than the pretest (\bar{x} =20.50, σ =4.09) with a t-value of -5.46 and a significant value (0.00) lower than the set alpha (α 0.05). These values indicated a significant difference in the student's performance in genetics before and after using gamified instructions. Therefore, the null hypothesis of the study will be rejected.

This indicates a significant difference in the scores before and after the intervention or treatment, supporting the post-test group.

Gamification is an effective strategy within science education, impeccably linking gaming elements like challenges, incentives, and competition to develop student engagement and motivation. By infusing scientific concepts and methodologies into interactive experiences, gamified platforms captivate learners' interest and expand active participation and knowledge retention. For example, in genetics class, gamification converts traditional lectures into active learning atmospheres, where students board on quests, crack puzzles, and track their development, all while discovering complex scientific principles in a fascinating and immersive way.

Using games in the classroom setup is an effective educational tool to increase academic performance. (Iwamoto et al., 2017). Pede (2017) Testified that as schools move further into the digital age, it is appropriate for educators to implement technology in their classrooms wherever possible.

SOP number 2. What is the attitude of students on the use of gamification?

Table 2

Question	\bar{x}	Adjectival Rating	Verbal Interpretation
1. Gamification made Genetics enjoyable.	4.14	Moderately Agree	Positive
2. It makes the lesson more engaging and interactive.	4.32	Strongly Agree	Very positive
3. It made complex concepts easier to understand.	4.32	Strongly Agree	Very positive
4. The gamification motivates me to work more on the subject.	4.55	Strongly Agree	Very positive
5. I feel accomplished every time I finish a task.	4.59	Strongly Agree	Very positive
6. It develops my skills to collaborate with my classmates.	4.27	Strongly Agree	Very positive
7. I have developed more critical thinking skills because of gamification.	4.77	Strongly Agree	Very positive
8. The features of gamified genetics help me more in dealing with the subject.	4.19	Strongly Agree	Very positive
9. I am willing to have more gamified activities in the future.	4.76	Strongly Agree	Very positive
10. It challenges me to be more active in class discussions.	4.73	Strongly Agree	Very Positive

Table 2 shows the students' attitude after using gamification in Genetics. The study results support the use of gamification

in genetics education as students have a favorable view of its benefits. Students believe that gamification significantly improves engagement and interaction in the classroom, with a rating of 4.32. This suggests that integrating game elements into learning captures students' interest, encourages participation, and creates a more dynamic and enjoyable learning atmosphere. The high rating ($\bar{x}=4.32$) on the ease of understanding concepts highlights how gamification helps simplify topics, making them more understandable to students and enabling more profound learning.

Moreover, the results indicate that gamification motivates students, with a rating of 4.55, showing strong agreement. This implies that using methods in Genetics education encourages students to put in effort and dedication to their studies due to the intrinsic motivation these activities offer. Students also feel a sense of accomplishment ($\bar{x} = 4.59$) when they complete tasks within a learning environment, emphasizing the reinforcement and satisfaction gained from overcoming challenges and reaching goals.

These findings underscore the impact of gamification on education by enhancing student engagement, motivation, and learning outcomes in Genetics and across various subjects. Gamification led to substantial developments in students' motivation, enjoyment, and interest in the subject matter, which fostered a more positive attitude towards learning [25]. Moreover, it can establish a more dynamic and interactive learning environment, contributing to positive student attitudes [26].

SOP number 3. What are the experiences of the students who used gamification?

After using gamification in Genetics, five emerging themes describe the student's experiences.

Engagement and Motivation. Students express enhanced enthusiasm and interest in genetics when learning through gamified approaches, referring to the interactive and immersive quality of the activities. Gamification nurtures a perception of amusement and anticipation, influencing students to participate and discover genetic concepts aggressively.

"I never thought genetics could be this amusing! I love how we generate virtual organisms and investigate how traits are passed down. "

"It feels like participating in a game, but I understand so much about genetics along the way."

Personalized Learning Experiences. Students value gamification's customized learning experiences, where they can proceed at their own pace and receive tailored feedback and support. Gamified platforms adapt to individual learning patterns and preferences, meeting diverse student needs.

"I enjoy how the genetics game adapts to my level. It confronts me without being too overwhelming.

"The feedback assists me in understanding where I need to develop, which is certainly beneficial."

Skill Development. Students identify the enhancement of critical thinking, problem-solving, and data analysis skills within gamified genetics activities. By drawing in simulated experiments, virtual reality, and genetic mysteries, students improve their analytical skills and gain practical experience in genetics.

"Playing the genetics game has certainly developed my critical thinking skills."

"I must deliberate strategically to breed organisms with given traits and investigate inheritance patterns. It is like I am a geneticist!"

Collaboration and Peer Learning. Gamified genetics activities foster collaboration and peer learning as students work simultaneously to solve challenges and accomplish common goals. Students evaluate the opportunity to exchange concepts, examine genetic concepts, and learn from their peers.

"The genetics game promotes teamwork, which I certainly appreciate."

"My classmates and I collaborate to solve breeding puzzles and split tactics."

"It is good to discover from each other and see various viewpoints."

Long-Term Engagement and Retention. When acquiring knowledge through gamification, students express supported curiosity and long-term engagement with genetics models. The cooperative and excellent nature of gamified activities improves knowledge retention and encourages continued exploration of genetic principles outside the classroom.

"Even after the genetics unit was completed, I still find myself returning to the game to generate more organisms and search for unique traits."

"It is incredible how gamification has generated a genetics branch in my mind. I feel like I have truly become skilled at ideas!"

6. Conclusion

The research results emphasize that students are highly interested in incorporating gamification into Genetics education, acknowledging its advantages such as increased engagement, a better understanding of topics, and enhanced motivation to learn. By integrating game elements into the process, teachers can create an environment encouraging enthusiasm and active student participation, leading to improved learning outcomes. This indicates that gamification is a tool for educators to establish a positive and dynamic learning setting where students are motivated to participate actively and inspired to excel academically.

Identifying five themes in students' experiences with learning in Genetics offers more profound insights into the impact of using gamification. Students enjoy these methods because they are engaging and inspiring. The personalized learning experiences that come with gamification allow students to progress at their own pace, receive feedback, and cater to their individual learning preferences, enhancing their educational journey. Gamified learning offers opportunities

for developing skills like thinking, problem-solving, and data analysis as students participate in virtual experiments and genetic puzzles. Working with classmates adds value to the learning experience as students collaborate on solving challenges and achieving goals, promoting teamwork and shared accomplishments. The ongoing interaction with ideas through gamification demonstrates how effectively it maintains student interest and engagement beyond the classroom, leading to an understanding and appreciation of Genetics concepts over time.

Conflict of Interest

This research was conducted with a commitment to transparency and integrity, and the authors declare that they have no conflicts of interest.

Funding Source

This research was conducted independently and did not receive any external funding.

Authors' Contributions

The authors contributed to the progress of the paper, especially during the collection and interpretation of data.

Acknowledgments

The researcher extends sincere gratitude to their colleagues whose contributions and support were instrumental in bringing this paper to fruition. Their collaboration, encouragement, and valuable insights have enriched the research process and enhanced the quality of the study. Their assistance may have ranged from providing feedback on the research design, offering guidance on data analysis techniques, or providing moral support during challenging times. Each colleague's input has contributed to the refinement and strengthening of the research, demonstrating the power of collaboration in advancing knowledge and scholarship. This acknowledgment recognizes the collective effort involved in the research endeavor and fosters a sense of camaraderie and appreciation within the academic community.

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