



Gamification in Environmental Education: Enhancing Engagement and Learning Outcomes through Game-Based Learning

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Abstract: Environmental education is pivotal in fostering sustainable practices and eco-conscious behaviour among learners. In many cases, however, the traditional method of teaching does not help to engage students or their interest. The study investigates gamification in the field of EE as a new pedagogical method. The use of game mechanics in learning activities, including challenges, rewards, and interaction with storytelling, will make learning in the environment more immersive and interesting because educators can make complex environmental topics more understandable. The study examines the literature and analyzes case studies of successful implementations as well as the different results of the influence of gamification on the environmental knowledge, attitudes and behaviors of students. The primary goals of the study are to examine the feasibility of gamification to increase the engagement in EE and to assess the effects of gamified learning, on the EE learning outcomes of students, knowledge, attitudes and behaviours. The study is of descriptive and analytical type. The primary data is collected from a well-structured questionnaire, and other published works are used to collect secondary data. Both primary and secondary data are used for the study. The hypothesis is tested using statistical tools such as Chi-square test, simple average and percentage. The results of this research point to the possibility of gamified learning to positively influence critical thinking, collaborative, and problem solving abilities, and to foster environmental stewardship.

Keywords: Environmental Education, Gamification, Behaviour and Game-Based Learning

1. Introduction

The gamification model in education has its roots in early theories of psychology, notably those of B.F. Skinner. His studies on reinforcement and the effect of reward on human behavior were the basis for the use of motivational structures that would impact on educational applications of gamified systems later on (McLeod). With the development of technology in the late 1960s and 1970s, the educational software available at the time in the 1970s and 1980s started integrating some of the components of a game. Games such as The Oregon Trail, Carmen Sandiego and Math Blaster were entertaining and educational and set the standard for what is now known as game-based learning. The language was not used then, but these tools had the potential to evoke the possibi-

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ties that gamified education could provide. The real word was coined by British programmer Nick Pelling around the year 2000 and has been utilized by many companies around 2010, including Foursquare and Nike+ with their badges and point systems (Pelling). Concurrently, researchers started providing more formal definitions and models of gamification, and started to focus on how gamification can impact engagement and behavior in other settings, such as education. Since 2010, the application of game design elements, such as progression, badges and competition, became more popular in classrooms and universities. The use of these strategies was popularised in classrooms through platforms like Duolingo, Kahoot! and Classcraft, and theorists like Werbach, Hunter and Deterding explained theoretical models that help understand how gamification can impact learning outcomes, motivation, and student engagement. The success of gamification methods in promoting SRL and knowledge retention led to a shift towards the application of gamification within specific disciplines, such as EE. The shift became more pronounced in the mid-2010s when climate change and sustainable living became more visible and a priority. Gamified tools started to be viewed by educators not only as teaching tools but as tools that could inspire real-world change in behaviour. The first games introduced in this area were energy-related, such as EnerCities, and eco-apps, including JouleBug, which enabled the user to make decisions that would have an impact on the environment, which then would be simulated and feedback, points, or rewards would be provided. These tools were used to give students an interesting and relevant means of examining issues of energy use, waste management and conservation. This momentum continued, and during the late 2010s and early 2020s, formal studies and education programmes were conducted to assess the role of game-based learning in environmental settings. The pilot projects and case studies presented evidence of higher engagement levels among the learners and a higher tendency to change behavior regarding the environment, indicating that gamification may be a useful tool for influencing environmental attitudes and behaviors in the next generation.

Gamification is based on what motivates human behaviour: a need for achievement, a need for recognition, a need for autonomy, and a need for connection. Gamification is a way to engage these psychological motivators and makes learning more active than passive. The evidence gathered in the last decade has shown how beneficial a gamification approach can be to learning outcomes and students' engagement, especially in environmental contexts. Ouariachi, Olvera-Lobo and Gutiérrez-Pérez (2020) studied various types of gamified platforms to promote environmental behaviour. This study found that there were six common factors that consistently made a platform successful: meaning, ownership, social influence, achievability, challenge and credibility. In other words, the more personal, social and meaningful the experience was, the more likely that it was to result in long-lasting engagement and behavioral change. Such programs include platform-based programs like SaveOhno and JouleBug, which connect real-world environmental problems with virtual rewards and community involvement.

In this regard, another study by Sadeghi (2024) is interesting to mention that was conducted with the students of the Iranian maritime industry in developing marine ecology course using the gamification of e-learning systems. Students' engagement and comprehension were significantly higher in the cases of CCE than in the case of traditional

methods of instruction. These modules enabled learners to learn in an interactive manner on complex ecosystems such as coral reefs and mangrove forests, thus making the abstract concepts more tangible and memorable. Motland & Aarhus (2023) examined the effect of a gamified application named coralQuest in the K-12 education sector. They have shown that the use of gamification features (such as leaderboards and pedagogical agents) led to an increase in student enjoyment and their sense of achievement. Notably, it was found that those students who were already interested in environmental issues were even more positively affected, implying that gamification can stimulate new interest and reinforce existing curiosity.

Gamification can be used for any age and can impact the young learner as well. Hosseini et al. (2023) conducted a study to examine the impact of gamification learning on the first-grade students in Tehran. Using a quasi-experimental design, the researchers observed the effects of the intervention on environmental literacy, specifically on the actual behaviours related to a healthy environment, such as conserving electricity and water, sorting trash, and using eco-friendly habits. Environmental education is important in increasing knowledge, but environmental literacy requires a change in attitudes and behaviours. Gamification can help make this possible by providing learners with the opportunity to experience the consequences of their decisions in a simulated environment.

This broader systematic review by Girón Polo et al. (2024) also suggests that gamification fosters a positive impact on motivation, critical thinking, and self-regulated learning. These are the kinds of skills that EE should be developing. Gamification has the capacity to reach students' minds and hearts, making it easier to internalize and act upon the values for the environment. Gamification works best when it is designed well, aligned to learning goals and knowledge of the target user.

In their review, Ouariachi et al. (2020) emphasized the need for gamification platforms to be more relevant than they simply are, "fun". Representing the experience of real world environmental problems, making problems achievable and based on real world actions, achieving a sense of ownership for the students. For example, in Joule Bug, students log eco-friendly behaviors like walking to school or saving water at home, and earn points and badges that correspond to real-world actions off the classroom walls.

Teachers have a dynamic role in this process. Teachers must be trained and supported appropriately to be able to implement gamification successfully in the classroom, as mentioned by Girón Polo et al. (2024). It is not simply a matter of incorporating game elements, it is also a matter of rethinking the learning experience in the light of pedagogical objectives, requirements and students' needs. These can be the choice or adaptation of digital platforms, the development of narrative contexts and the facilitation to link students' experiences of games to the wider context of the environment. Furthermore, gamification could be used in various learning methods, from classroom learning to online learning, allowing for the adaptation of gamification for various learning environments. Gamification offers many promise and alluring aspects, but also has some drawbacks. Klock, Santana and Hamari (2023) identified various ethical issues in the context of gamification in education. These include problems of manipulation, over-

competition, drop in intrinsic motivation and risk of superficial engagement and attention to reward.

In order to solve these problems, researchers suggest to include the elements of voluntariness, transparency, and student agency in gamification approaches. Being supportive of students' decisions about games on choosing games and explaining their purpose and encouraging collaboration over competition can help offset potential problems and foster a more ethical, inclusive learning environment. Therefore, gamification is a potential way of rejuvenating EE in a promising way. It turns learning into an interactive, engaging and emotionally meaningful experience and can grab a student's attention and inspire them to act. The experiments and experiences clearly demonstrate the positive effects of well-designed gamified experiences on the acquisition of knowledge, critical thinking and creativity, and most important, pro-environmental behaviours.

The key question is not if gamification works, but how it can be done in a thoughtful and ethical way in a variety of educational contexts. The educators need to be given the freedom, tools and training to investigate gamification in a manner suitable to their objectives and students' needs. Concurrently, continued studies are required to draw in on best practices, moral issues, and the long-term results of gamified learning for environmental awareness. Reimagining the education of the next generation is not only an innovative and novel approach but one that is necessary in an age where environmental challenges demand collective and urgent action. Gamification, when used with care and creativity can prove itself to be one of the most effective tools that can inspire long-term change.

Environmental Education (EE) has become a key area of focus in the global drive towards sustainable development and climate change mitigation. It includes the sharing of information on the environment, but also the cultivation of attitudes, skills, and behaviours to protect the environment (UNESCO, 2014). However, despite this necessity, EE is still struggling to be effective in engaging the learner and changing his/her behaviour, especially at the school age level. The traditional pedagogies of instruction, such as lecture and rote learning, do not create emotional and cognitive links for students with actual environmental issues (Tilbury, 1995).

Gamification is an attractive option in this changing educational environment. Gamification is the incorporation of mechanisms from computer games, like points, levels, badges, stories, and rewards, in non-game environments to increase the engagement, motivation and performance of users (Deterding et al., 2011). They are elements that can be present in educational settings and can help to give learners goals, immediate feedback and a sense of achievement, which are proven to increase intrinsic motivation (Ryan & Deci, 2000). Importantly, gamification makes people passive consumers of information into active recipients of information, in line with the constructivist and experiential learning paradigms.

In the world of EE, gamification is not simply a means of motivating; it is a journey of a mission driven one. For instance, designing a realistic ecological emergency or developing scenarios based on sustainable practices to provide students with a context for

exploring the world of the environment in an immersive, real and meaningful way (Barab et al., 2010). Even better learning can be gained if learners make virtual decisions and see the results of those decision; for instance, through games like “EcoChains,” “Climate Quest,” and “Recycle Hero” is a mobile application, where the consequences are shown, and they are able to reflect on and learn from it (Kuo et al., 2019).

Furthermore, gamification helps develop important 21st-century skills like critical thinking, collaboration, and problem-solving. These skills are not just relevant to environmental activism, they also have relevance to the world we live in which is becoming increasingly complex and interdependent (OECD, 2018). Studies indicate that students who play games in learning activities tend to behave more positively in the sense of empathy, knowledge retention, and sustainable behavior in protecting the environment (Wu & Lee, 2015; Hamari et al., 2016).

The aim of this study is to explore the extent of the gamified educational strategies to improve the environmental learning outcomes of the students in Kerala, India. It explores the link between gamification and learning engagement, learning outcomes, attitudes and learning behaviors. It thereby adds to the evidence to support innovative pedagogies that are learner-centred, and are in line with the objectives of the National Education Policy (NEP 2020) and the UN's Sustainable Development Goals (SDG 4 and SDG 13).

This study measures the effectiveness of game-based learning and offers recommendations for curriculum designers, policymakers, and educators aiming to educate future-ready, environmentally responsible citizens. The roots of gamification are in the motivation theories, including Deci and Ryan's Self-Determination Theory (SDT), which emphasizes autonomy, competence, and relatedness as the three prerequisites for intrinsic motivation (Ryan & Deci, 2000). These needs are met in a gamified environment by choice, progression, feedback, and social interaction (Domínguez et al., 2013). Deterding et al. (2011) stress the need for gamification to be effective, which does not need to be complete games but rather game-like elements being used in a meaningful way.

According to Kolb's experiential learning theory, experiential learning models are good for EE because they bring concrete learning experiences. In Taiwan, Wu and Lee (2015) developed “Climate Detectives”, a location based mobile game in which students were tasked to solve detection problems related to the climate situation. They found that students who learned through games had higher problem solving skills and environmental retention. Barab et al. (2010) created a 3D virtual world that combines science and social responsibility with environmental issues, called “Quest Atlantis.” Academic engagement and critical thinking were improved as demonstrated by results. In a similar way, Kuo et al. (2019) have determined that the students in Hong Kong that played a mobile game about recycling had measurable behavior change regarding recycling.

Bajaj and Sharma's (2018) research in Delhi schools showed that the incorporation of gamification into eco-club activities increased the ecological sensitivity and, simultaneously, the participation of the students in the classes. Similarly, Roy & Ghosh (2021) noted that board games and stories are also being used in rural schools. There are some positive outcomes, however, there are a number of challenges to be addressed, such as the lack of digital infrastructure, insufficient teacher training, and the low alignment with the curricular goals. Very little research to assess long term effects on behaviour. This study is designed to overcome this gap and provides empirical data from a sample that is statistically valid.

2. Statement of the problem

EE has a pivotal role in solving global ecological problems as well as in creating sustainable development. Despite the campaigns and curriculum, however, many students don't become engaged, and do not take the knowledge they gain about the environment into meaningful action. Traditional teaching method emphasizes mainly on passive learning, theory explanation, which is not very successful in promoting environmental responsibility and behavior change. The problem is that students are more and more in an interactive digital environment, and it is important to examine novel pedagogical approaches that are more suitable with their cognitive and motivational frameworks.

Gamification, when game mechanics are applied to non-game contexts, is a new and promising approach in the field of education. The potential use of gamification has proven in other disciplines, but its impact in EE especially in the Indian school context is not well-researched. There are few existing studies that are practical or based in a Western context with differing educational dynamics. It can be inferred that there is a huge research gap in understanding the effects of gamification on the environmental learning outcomes and particularly on knowledge retention, attitude changes, and environmentally friendly behaviors among students in India. This study aims to address this gap by examining the effects of gamification on the engagement, environmental understanding and behavior of students. The results aim to give practical implications for teaching and learning EE using gamification for teachers and policy makers interested in gamification for teaching EE.

Whilst progress has been made, there are some issues to overcome such as lack of digital infrastructure, teacher training and issues around alignment to learning outcomes. Very few longitudinal studies to measure long-term impacts on behaviour. In this study, an attempt will be made to fill the gap by using an empirical data with the help of a sample which is statistically validated.

3. Significance of the Study

This study is of both academic and practical value. Academically it contributes to the existing literature on gamification, but in the area of environmental learning, which is an under explored area of gamification in education particularly in the Indian context. The research provides empirical evidence of the effectiveness of the game approach in the enhancement of students' motivation, knowledge and behaviour in environmental issues. The study provides some important insights for school administrators, curriculum developers, and educational policy makers. It was revealed that gamification can enhance environmental learning, which could be incorporated into the national education systems like NEP 2020 which promotes experiential and tech-based learning. The

research also enables determining the most effective gamification elements that can encourage sustainability among students and allow teachers to make decisions when designing and implementing teaching based on scientific data.

4. Research Questions

1. How effective is gamification to improve student participation in EE?
2. What are the impacts of gamified learning on students' learning of environmental concepts?
3. How does gamification affect students' attitude to environmental sustainability?
4. Is the observed change in behaviour of the students as a result of exposure to EE through the gamification model eco-friendly?
5. Is there a difference in the effectiveness of gamification by age, gender, or urban vs. rural?

5. Objectives of the Study

- To investigate the potential of using gamification in EE as a pedagogical tool.
- Evaluate the effects of gamified learning on students' environmental knowledge, attitudes and behaviours.
- To assess the impact of game-based approaches to promote pro-ecological behaviours.

6. Hypotheses

- **H₀ (Null Hypothesis):** There is no significant effect of gamification on students' environmental knowledge, attitudes and behaviours.
- **H₁ (Alternative Hypothesis):** There is a significant relationship between gamification and the students' environmental knowledge, attitudes and behaviours.

7. Research Methodology

The study is of mixed method (Descriptive & Analytical) to comprehensively examine the impact of gamification in EE. The descriptive component is aimed at the identification of the trends in the experience of the students and the demographic data that emerged from the responses they provided, whereas the analytical component is based on the relationships established between the use of gamified learning and the different educational outcomes assessed (engagement, knowledge retention and behavioural change). The study sample comprises of 200 students (aged 10-17) from urban and rural schools in Kerala. The sample was carefully stratified to ensure good representation and minimisation of bias, including by grade level and sex.

Both primary and secondary sources were used to gather data. A structured questionnaire was used to collect primary data which included quantitative and qualitative data. This questionnaire consisted of closed and open questions to measure the depth of students' engagement, their cognitive knowledge of environmental concepts, and whether there was any change in their environmentally responsible behaviour after the gamified interventions. The secondary data were derived from relevant literature in the form of peer-reviewed journals, academic books and the case studies from all over the world that gave a sound theoretical and contextual background to the study.

The data and trends from the general responses were analyzed and presented in percentage and average. The hypothesis about the effectiveness of the gamification was tested by using a Chi-square test to find out if there were any statistically significant relationships between gamified learning and student outcomes. Microsoft Excel and SPSS were used in the analytical process; this provided the data collected, an accurate and reliable statistic. This solid research methodology helped validate the study in terms of credibility, relevance, and applicability, both in the academic and practical aspects.

8. Data Analysis and Interpretation

The study was carried out on the 200 students of various urban and rural schools of Kerala and a structured questionnaire was used. It was intended to evaluate the effectiveness of game-based EE in terms of the engagement, knowledge retention, attitude and eco-friendly behaviours of students. The quantitative results are presented and described in thematic sections that are related to the research objectives. There was a fairly equal split of the respondents in terms of their gender with 52% being male and 48% female, and in terms of their location with 60% from urban schools and 40% from rural schools. Furthermore 65% of the students had experienced at least one environmental awareness programme or campaign in the past, providing the students with a background level of environmental issues.

One thing that came from students responses was the most compelling insight and it was about engagement. Around 78% of students said that they were more interested and enjoyed gamified lessons more than lectures. The use of games, quizzes, storytelling and challenges have been reported by many students to have improved their attention span and made learning less of a chore. The findings are consistent with other studies examining gamified education around the world (Hamari et al., 2016), which found a positive association between gamified education and motivation and attention. Furthermore, 73% of students expressed preference for gamified learning over traditional learning, suggesting a strong learner preference for interactive and participatory learning approaches.

When it comes to knowledge retention, 84% of respondents confirmed that they could better understand and remember the concepts about the environment when they were presented in a gamified format. Issues such as climate change, deforestation, pollution and biodiversity were felt to be easier to understand and relate to when taught through interactive games or simulations. As such, this indicates that not only is gamification effective in engaging users, but it also improves cognitive processing and recall. The one item of analysis of particular interest was behavioural outcomes. 68% of students stated they implemented at least one new eco-friendly behaviour after being exposed to gamified environmental lessons. These behaviours were related to practices such as segregating waste, using less plastic, planting trees, and conserving water. Besides, 74% of the students were seen to be more positive towards sustainability, thereby improving interest in engaging in sustainability awareness drives and school eco-clubs.

This study clearly shows that gamification is an effective EE pedagogy. It attracts the students' attention, assists to recall complicated subjects, and leaves an impression of responsibility to protect the environment. The results highlight the importance of using

gamification tools in mainstream education, as part of the education–sustainability nexus.

9. Chi-Square Test and Hypothesis Testing

9.1 Variables

- Dependent variable(s): Outcomes of gamified learning.
- Independent variables: Knowledge, skills, and confidence.

Table 1. Observed vs. Expected Frequencies

Outcome	Observed (O)	Expected (E)	(O - E) ² /E
High Knowledge Retention	168	130	11.08
Behavioural Change	136	100	12.96

“Chi-Square Formula: $\chi^2 = \sum((O-E)^2 / E)$ ”

“Chi-square Value: $\chi^2= 11.08 + 12.96 = 24$ ”

“Degrees of Freedom (df): $df = (rows - 1) * (columns - 1) = 1$ ”

“Critical Value at $\alpha = 0.05$ and $df = 1$, is 3.841”

“Since $24.04 > 3.841$, the null hypothesis is rejected.”

Students' environmental knowledge and behaviour is significantly related to gamified learning. Hence, the alternative hypothesis (H_1) is accepted.

A chi-square test was used to statistically confirm these results with regard to two variables: knowledge retention and behavioural change, by analyzing the relationship between the gamified learning exposure and the variables. The calculated chi-square value was 24.04, which is much higher than the critical chi-square value at 0.05 significance level and 1 degree of freedom. This means that the relationship between interventions developed with a gamification approach and improved environmental learning outcomes is statistically significant. The result of the test showed that the null hypothesis was rejected, thus it could be concluded that the implementation of gamification was able to increase a student's knowledge and behavior.

10. Theoretical Framework

The study on gamification in EE is based on two widely accepted theories in education psychology, namely, Self-Determination Theory (SDT) and Experiential Learning Theory (ELT), which are theories related to the motivation, engagement, and change of learner behaviour.

10.1 Self-Determination Theory (SDT)

Self-Determination Theory (SDT), introduced by Deci and Ryan (1985), is a theory that suggests that human motivation is driven by the satisfaction of three psychological needs: autonomy, competence and relatedness. If these needs are met, the people will be intrinsically motivated, that is, they will do activities that they find of interest and value to them, rather than for external rewards.

10.1.1 Application to the Study

In this study, gamification is adopted as a tool to engage students intrinsic motivation in the context of EE. Choice-based decision making (autonomy) and systems of progressive challenges and feedback (competence) and collaborative tasks or leader boards (relatedness) are directly tied to the three pillars of SDT.

Digital rewards and challenges met the students' need for competence and led to higher satisfaction and self-efficacy. The sense of relatedness and a group identity was developed through cooperative games and team missions. Students were given a sense of autonomy in learning by being given opportunities to take decisions in game narratives, such as controlling virtual pollution levels or designing a sustainable city. Therefore, the students' attitude in acting eco-friendly outside the classroom were considered, and students' behaviours were found to be more motivated with the theory's emphasis on motivation-driven actions.

10.2. Experiential Learning Theory (ELT)

According to David Kolb (1984) who developed the theory of Experiential Learning, learning is a four phase process: Concrete Experience, Reflective Observation, Abstract Conceptualization and Active Experimentation. The theory is based on a learner centred approach, that learning is achieved by doing and reflecting on experience.

10.2.1 Application to the Study: Gamification naturally embodies the ELT cycle:

- **Concrete Experience:** Students take part in environmental simulation, challenges and scenarios in platforms where the experience is gamified (e.g. managing waste in a virtual city).
- **Reflective Observation:** After the activity, discussions or feedback mechanisms engage learners in critical thinking about their in-game decisions and/or results.
- **Abstract Conceptualization:** To connect their experience related to game to real world concepts of sustainability, conservation, pollution control.
- **Active Experimentation:** Students are able to apply the concepts learnt in real life through taking up eco-friendly habits such as water conservation or recycling, validated by survey with 68% of students indicating that they have changed their behaviour as a result of the learning.

Gamified lessons change the way students learn to be a process of active discovery, where the students are able to observe the cause and effect of environmental actions in a simulated environment before putting them into practice in real life. This represents Kolb's model and emphasizes the notion that experiential approaches result in more meaningful and enduring learning.

11. Proposed Gamification Model

11.1 E3G Model: Engage, Educate, Empower, Gamify

This model combines four points, Engage, Educate, Empower and Gamify, in a strategic and scalable way of implementing gamification in EE in schools (Figure 1, E3G Gamification Model).

11.1.1 Engage: Building Readiness and Interest

Engagement is the first phase in the E3G Model; it involves creating a spark of curiosity and feeling of involvement in environmental issues with students. This means incorporating content that is both interactive and engaging, like storytelling, animated videos and gamified quizzes, which can engage topics such as pollution, wildlife conservation and climate change, in a fun and relatable way. Schools can arrange orientation sessions or “game days” that focus on eco-themes and introduce students to the concepts of the environment using a simple board or digital game.

11.1.2 Educate: Curriculum Integration

When the students are engaged, the next step is to educate them by matching the activities that are gamified with school's curriculum. This will ensure that learning is structured, measurable and goal-oriented. The learning objectives prescribed in the textbooks can be presented in form of level-based games, simulations and missions related to environmental issues such as climate change, biodiversity, waste management, etc.

11.1.3 Empower: Encourage Real-World Action

Empower explores how the learning benefits of the game lead to impact in the real world in the third part. Pupils are encouraged for their learning to be used in their daily life. In-game new features can be matched with schools' real-life environment projects, such as tree planting, plastic reduction or energy audit at home. Teachers can identify and record 'Green Champions' in each class to help others in the class to be responsible for these as well.

11.1.4 Gamify: Sustain the Momentum

The last and central part of the model is Gamify, that is, the institutionalization and sustainability of gamification in EE. This requires establishing a culture of gamification in the school by designing a digital platform or portal that enables students to record eco-actions, take part in school-wide challenges and monitor their progress in real-time. It must be possible to add new game missions, inter-school games or eco-leagues so that the excitement is not lost. Importantly, gamification cannot be a one-off use of the technology but a campaign, which is embedded in the school's annual calendar.

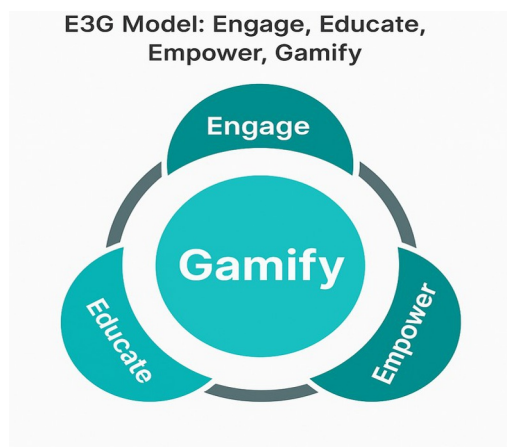


Fig. 1. E3G Gamification Model

12 Conclusion

The use of gamification in EE is a great paradigm change in education, attempting to connect learning contexts with the cognitive and emotional character of the present generations. This research has investigated the various ways that gamification affects student engagement, their environmental knowledge, attitudes and behaviors. The results from both primary and secondary research indicate that game-based learning can boost students' interest and motivation, and it can have a significant impact on behavioral changes that are related to sustainability.

The empirical findings obtained in the present study from 200 learners from different schools of Kerala clearly show that there is immense potential in the use of gamification

in augmenting deeper involvement with issues related to the environment. There was a significant increase in interest for 78% of the respondents and understanding and retention of environmental concepts was easier for 84% during gamified lessons. This is consistent with previous research that showed that playing games can lead to greater attention span and active learning (Hamari et al., 2016). Furthermore, the results of the study confirm the previous studies that include the work of Wu & Lee (2015), and Barab et al. (2010), that highlighted the cognitive and behavioural advantages of gamified educational interventions.

The behaviour of gamified learning is possibly the most important result in this study. The environmental game-based lessons have been shown to influence more than two-thirds of the students to report changing their behavior in at least one of the following ways: eco-friendly. This involved practices such as sorting waste, water saving, and non-use of plastic items, and taking part in tree planting activities. These modifications imply that gamification operates on a greater emotional and behavioral level of learning, and not just cognitive, which is important for a sustainable environment in the long term.

The results of the chi-square also support these findings as statistically indicates that there is a significant relationship between gamified learning and enhanced environmental outcomes. The result achieved (24.04) was far higher than the critical value at 0.05 significance level and the null hypothesis was strongly rejected, therefore, the influence of gamification on students' environmental learning and actions is very influential.

The findings of this research are not only academic, but also have policy implications for both teachers and curriculum developers. The focus of the reforms in India's education system as outlined in the National Education Policy 2020, is to create a holistic, joyful, experiential learning environment, and the use of gamification can be a promising educational model to help achieve this. It allows students to be heard, it gets them creative and links school learning to the world of work. Teachers can employ gamification to captivate and inspire students to learn about environmental issues and make environmentally conscious choices with the proper training and support.

However, there are some drawbacks to the study. The exposure of lessons using a gamified approach was limited and did not represent the long term impacts and scalability of these interventions. The study of the long-term impact of the use of gamification in EE in different contexts is recommended and there is a need for more research, particularly studies of a longitudinal nature and comparison across regions.

Gamification is not just a trend in the education industry, but a game-changer that changes the landscape on how EE can be taught and learned. Gamification makes learning more fun, memorable and action-oriented, enabling us to make students more informed, responsible and action oriented environmental citizen. In this world today, with a lot of ecological issues, it is essential to learn from the next generation the knowledge, motivation and behaviours for sustainable action.

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