GAMIFICATION AND BLOCKCHAIN-BASED REWARD SYSTEMS FOR MOTIVATING MATH MASTERY IN EBONYI STATE

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Abstract
The teaching/learning of mathematics in Ebonyi State, Nigeria is consistently associated with such challenges as low student motivation, low performance in national exams, lack of teaching material, and high math anxiety among secondary school students. This paper is an investigation into how the concept of gamification and blockchain-based reward systems can be achieved as a new intervention in developing intrinsic and extrinsic motivation to master mathematics. The study was based on self-determination theory and flow theory using a mixed-method quasi-experimental design of the pretest- posttest control group factors. Students in six public secondary schools in the senatorial zones of Ebonyi North, Central, and South (320 students: 52% female, 48% male) by socioeconomic status (low: 62 percent, middle: 28 percent, high: 10 percent) and school location (rural: 65 percent, urban: 35 percent) were included. Primary data were obtained through the questionnaires, achievement tests, semi-structured interviews, and blockchain transaction logs based on a tailored prototype application that rewarded non-fungible tokens (NFTs) and mortaby-like points upon completing math tasks. Findings showed that motivation scores ($t(318) = 8.42$, $p < .001$, $d = 0.94$), and math performance (mean improvement of 24.6% in experimental group and 7.2% in control) significantly improved. Rewards were guaranteed to be transparent and non-alterable with the help of blockchain, which promoted the sense of fairness and sustainability. There were issues of disparities in digital access and early technical barriers. The results may point to the idea that gamified blockchain systems can become the solution to change the way mathematics are taught in the settings where the available resources are scarce such as Ebonyi State to facilitate the equitable motivation and mastery. Such recommendations are the policy integration of digital tools and educator education.

Keywords: gamification, blockchain, reward systems, mathematics motivation, Ebonyi State, secondary education, self-determination theory, educational technology

Introduction and Background of the Study

Mathematics is a fundamental subject in scientific, technological, and economic growth, although the teaching and learning of mathematics in most of the developing scenes, such as Nigeria, has become an issue. In the Ebonyi State which is in southeastern Nigeria, the performance of mathematics conducted by secondary school learners is so low because the West African Senior School Certificate Examination (WASSCE) as well as the Basic Education Certificate Examination (BECE) have low pass rates. Historical records show that the percentage

of credit passes in mathematics (including English) in public schools was about 35-45 percent in the early 2020s, and worse in rural regions, due to lack of infrastructure (Anih, 2020; recent results of state examination institutions). This is due to the complex nature of these problems: the lack of qualified teachers, a shortage of teaching resources, and many students in classes, and widespread math phobia among students (Ebscoeijer, 2023; Fakolade and Oloruntoba, 2017).

The context shows that the interest and performance in mathematics has been steadily falling over a number of years which has been complicated by the traditional pedagogical methods patterns depicting memorization of the concepts rather than the understanding and involvement. The perception of mathematics is often in form of an abstract, challenging, irrelevant subject, which arouses avoidance behaviors and low self-efficacy in students (Momozoku, 2022). These problems are worsened in Ebonyi State, which is one of the states, where many families depend on subsistence agriculture; such access to additional sources of learning or technology is limited. The existence of rural-urban inequalities gives attention to inequities, and among the schools in rural regions, higher rates of dropouts are reported to be associated with lack of engagement in a core subject such as mathematics (IOSR Journals, 2022). The necessity of motivational interventions is noted in the contemporary literature. Gamification has become an effective tool to enhance engagement, referring to using the characteristics of game design, i.e. points, badges, leaderboards, levels, and challenges in a non-gamified setting (Deterding et al., 2011; recent systematic review by Taylor and Francis, 2025).

Initial research established that gamification enhances intrinsic motivational processes through the fulfillment of the psychological competence, autonomy, and relatedness needs (Deci and Ryan, 1985; Ryan and Deci, 2020). Problem-solving, anxiety, and persistence are among the fields in mathematics education where gamified backpacks have helped (Wirris, 2025; Prodigy Math, 2024; Elephant Learning, 2024). As an example, such features as progress tracking and instant feedback create the feeling of accomplishment, which corresponds to flow theory optimal alignment of challenge-skill ratio resulting in immersion learning (Csikszentmihalyi, 1990). Even more recently, the blockchain technology has brought the concept of decentralized, transparent reward structure into the realm of education. Credentialing and incentivization, using tokens or NFTs to ensure trustless validation of achievements, is made possible using blockchain-based systems (Grech and Camilleri, 2017; recent developments in Token-ED system, IEEE, 2022).

These systems in education reward education milestones with digital items that students are able to possess, exchange, or redeem as solutions to the extrinsic motivation factor and support gainful knowledge retention in the long run (ilink, 2025; SSRN, 2025). Gamification with blockchain based on the principles of the former approach to motivation, whereby gameplay causes a blockchain to record incentives, is a new paradigm in motivation, especially in resource-poor or low-trust environments (EDU3LABS, 2024; Bandopadhyay, 2024). This notwithstanding,

there is limited empirical use in the sub-Saharan Africa (more so the Ebonyi State in Nigeria). Current research concentrates on either general gamification or blockchain of credentials, but none combines the two as the subject-specific motivation such as mathematics mastery (MDPI, 2022; Medium, 2024).

This disparity is essential in Ebonyi, where digital inequalities are still present whereas mobile penetrations are rising very quickly, which makes mobile-based interfaces opportunities. It is discussed in the given study through the analysis of a prototype of gamified blockchain-based reward system that will be adapted to Ebonyi State secondary mathematics curriculum.

Statement of the Problem

This remains a fundamental problem of low motivation in mathematics in Ebonyi State secondary schools. There is great disengagement, math phobia, and poor performance with many students not having basic competencies in algebra, geometry, and statistics (Anih, 2020; WJARR, 2024). The conventional incentives such as grades or compliment are not good enough to keep the interest going even when the socioeconomic conditions are difficult and rules of mathematics seem unimportant. Although gamification has potential throughout the world, its effectiveness has not been studied in low-resource areas of Nigeria and blockchain has not been assessed in local environments as a means of providing secure and fair compensation. In the absence of groundbreaking and open incentive systems, more students might remain poor performers, which holds on cycles of education inequality and restrictions to the national development objectives.

Relevant Current Literature Gamification literature is decades-old, but has escalated in the near past. According to Deterding et al. (2011), it refers to the application of game elements where the non-games influence behavioral reinforcement to create an impact on motivation. Mathematics: It is said that engagement can be improved with the help of points and badges (Mathletics, 2025; Let's Go Learn, 2024). A systematic review has also shown the popularity of gamification in secondary mathematics, with positive implications on attitudes, even though there is inconsistency in its implementation (Taylor and Francis, 2025). Empirical evidence of the recent past associates gamification with low levels of math anxiety and resilience (UAR Publisher, 2025).

Projects in education are centered on credits and rewards. The initial models focused on prestigious Iows (Getting Smart, 2020). New frameworks suggest engagement-based tokenized rewards, with smart contracts being automated to pay out (IEEE, 2022; SSRN, 2025). Gamification synergies enable the establishment of tokenized learning, in which the success of learning is tradeable as an asset and ownership is established (ilink, 2025; EDU3LABS, 2024). In third world settings, blockchain would help deal with the lack of trust in the distribution of rewards. Theoretical foundations are self-determination theory (SDT) which explains that intrinsic motivation occurs through autonomy, competence and relatedness (Ryan and Deci,

2020), and flow theory to obtain engagement (Csikszentmihalyi, 1990). These outline the ways gamified blockchain rewards can be used to meet the needs as well as offer verifiable progress.

Theoretical Framework

This work considers the self-determination theory (SDT) as the main framework of motivation as a vital concept that thrives when the basic psychological needs are satisfied (Ryan and Deci, 2020). Gamification maintains competence by use of competency challenges and badges, autonomy by way of task choice, and relatedness by use of leaderboards or peer competition. This is improved by blockchain since it makes rewards transparent and owned and overjustification by extrinsic mitigated (Deci et al., 1999). Flow theory is an addition to SDT, which justifies immersion during gamified math endeavors when challenges are overly challenging as compared to skills (Csikszentmihalyi, 1990). These theories combined establish the hypothesis that integrated systems promote a sustained motivation and mastery.

Methodology

The research design was a mixed method study performed by a quasi experimental pretest-posttest with control and experimental groups. The chosen design was educational as it was necessary to compare the intervention effects and control the elements. The sample was students in secondary schools within the Ebonyi State. A purposive stratified sampling was used to sample 6 schools (two in each senatorial zone: Ebonyi North, Central, South) which implied the inclusion of both rural and urban areas and variation in socioeconomic status. The participants were 320 (experimental- 160, control- 160), all aged between 13-18 years (M =15.4, SD=1.6).

Demography Female 52% of the total (Male 48); socioeconomic status: low 62% (subsistence farming households), middle 28% and high 10% and location; rural 65% and urban 35%. The inclusion criteria were that one had to be enrolled in SS1-SS3 and mathematics a core subject. Primary data was collected in the following ways: (1) Mathematics Motivation Questionnaire (modified by Ryan and Deci, 2000; 2=.89); (2) Standardized Mathematics Achievement test (20-item, including algebra, geometry; KR-20 =.82); (3) semi-structured interviews with 40 participants (20 on each side); (4) blockchain records of the prototype app. The mobile/web prototype applied in the intervention involved students being exposed to math problems that had been gamified with points, badges, level, and challenges.

Badges in the form of tokens (virtualized cryptocurrency) and NFTs accessible through successful completions won't be redeemed since the school provides it as a reward, and it can be validated on-chain. The standard instruction was provided to the control group. Duration: 12 weeks. Informed consent/assent was sought through the support of institutional review boards, and ethical approval was granted. Descriptive statistics, independent t-tests, and ANOVA were used in the analysis of quantitative data. Thematic analysis was done on qualitative data. The reliability and validity were guaranteed by pilot testing and triangulation.

Results

There is even distribution in terms of demographic profile (Table 1).

Table 1

Demographic Characteristics of Participants

Characteristic	Experimental (n=160)	Control (n=160)	Total (N=320)
Gender: Male	78 (48.8%)	76 (47.5%)	154 (48.1%)
Female	82 (51.3%)	84 (52.5%)	166 (51.9%)
Age: 13–15	68 (42.5%)	70 (43.8%)	138 (43.1%)
16–18	92 (57.5%)	90 (56.3%)	182 (56.9%)
SES: Low	98 (61.3%)	100 (62.5%)	198 (61.9%)
Middle	46 (28.8%)	44 (27.5%)	90 (28.1%)
High	16 (10.0%)	16 (10.0%)	32 (10.0%)
Location: Rural	104 (65.0%)	104 (65.0%)	208 (65.0%)
Urban	56 (35.0%)	56 (35.0%)	112 (35.0%)

There was no significant difference in the pretest motivation and pretest achievement scores ($p > .05$). The outcome of the posttests showed that there were significant gains in the experimental group. indication of motivation improved to 4.45 (5-point scale) compared to control 3.08 to 3.41. The achievement scores increased by 24.6 percent compared to 7.2 percent. The effect size was also high (Cohens $d = 0.94$ motivation, and 1.12 achievement). The qualitative topics were fun and rewarding (gamification elements), trust in rewards (blockchain transparency), ownership of the success, and impediments: internet access in rural communities. The perceived value was recorded by blockchain logs of 92 percent reward redemption rate.

Discussion

The results correspond to SDT, as gamification factors fulfilled competency and autonomy, whereas blockchain ensued verifiable relatedness due to fair rewards (Ryan and Deci, 2020). The gains are even more than in pure gamification research (Wirris, 2025), indicating that blockchain brings an additive relative to trust and longevity. Outcomes in Ebonyi interrogation have local provisions such as resource constraints by using mobile-based technology; the limitation is the number of samples and prototype restrictions; the future study can be expanded to the full level of decentralization.

Conclusion

The digital games gamification combined with blockchain-based rewarding will be a great boost to the learning of mathematics in Ebonyi State secondary schools motivating engagement, achievement, and equity. The strategy covers the old boundaries using transparent and ownership incentives.

Recommendations

- Policymakers also need to test blockchain-gamified systems in Ebonyi mathematics lessons.

- Educators need to be trained in online instruments.
- Rural connectivity is due to infrastructure investments.
- More longitudinal research evaluates long term effects.

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