ENHANCING CHEMISTRY SKILLS AND VALUES THROUGH GAME-BASED MENTORSHIP

Abstract

This study explores the integration of game-based apprenticeship models in secondary school chemistry education as a strategy for mentoring students and promoting social value transmission. It focuses on evaluating the effectiveness of these models in enhancing practical chemistry skills and instilling collaborative ethics, discipline, and scientific inquiry. The research leverages gamification to foster student engagement while utilizing mentorship to personalize learning experiences. Employing a survey design, data were collected using a structured questionnaire from principal officers of Coal City University. Data analysis employed mean and standard deviation with a 2.5 cut-off mark. Findings revealed moderate support for game-based mentorship as a viable strategy, though gaps exist in policy integration and access to digital resources. The study aligns with contemporary educational reforms advocating interactive and socially constructive pedagogies. It concludes that embedding mentorship into game-based chemistry labs can significantly improve learning outcomes and value transmission. The paper recommends institutional support, digital resource investment, and teacher capacity building for effective implementation.

Keywords: Game-based learning, mentorship, apprenticeship, chemistry education, social values, practical skills, simulation, student engagement, science learning, educational innovation.

Introduction

The landscape of science education in the 21st century has shifted from mere memorization of content to fostering critical thinking, process skills, and ethical development. Increasingly, educational systems are recognizing the need to combine cognitive objectives with affective outcomes to produce well-rounded learners. In particular, subjects like Chemistry, which rely heavily on laboratory engagement, require pedagogical methods that not only convey scientific knowledge but also cultivate inquiry, collaboration, and value-based learning (Olaoye, 2023). The modern science classroom must therefore serve as both a cognitive and ethical workshop, equipping learners with practical skills and social responsibility.

Nonetheless, in the Nigerian secondary education system, there are many systemic challenges. Among them, the most prominent ones are a lack of laboratory facilities, a lack of adequate access to digital learning tools, and overdependence on teacher-centered instruction (Uzochukwu, 2022). Such factors restrict exposure of the students to real-time experimentations and experimentation and consequently reduce the extent of exposure of the targeted students to critical scientific principles through active participation. Therefore, students usually come out with theoretical understanding but with no practical skills and no grounding in ethical issues that are essential for fruitful scientific endeavours and societal growth.

New developments in science teaching promote game-based learning (GBL) to rejuvenate classroom activity and the quality of learning. When utilized with mentorships and formalized apprenticeship models, GBL changes theoretical material into immersive, interactive experiences (Akinyemi & Eze, 2024). These models not only encourage academic achievement but also provide such important values as persistence, ethical behavior, and teamwork. When taking digital simulations and strategic game mechanics for granted, students are pressed to address scientific problems collectively, which is why they are building both their intellectual and moral development.

Apprenticeship, in this academic setting, is a form of mentor-led, practical learning in which students not only gain technical knowledge but also learn to follow social patterns such as cooperation, discipline, and responsibility (Obi & Chukwu, 2021). When gamified – namely, when real-life scenarios are infused in the chemistry simulations – students can gain practical knowledge of chemical reactions, laboratory safety, and data interpretation, minus the risk, but at full immersion. That kind of an approach resembles those of industrial training setups, ready graduates for actual scientific work, and develops soft skills relevant in modern society. STEM education mentorship has been found to have been especially effective in raising student self-confidence and cultivating curiosity among students, in addition to career readiness. Based on the study carried out by Yakubu and Okafor (2025), learners mentored in practical science environments have stronger communication skills, better perseverance in solving problems, and clearer academic goals. This strengthens the case for incorporating practical mentoring systems within practical sessions of chemistry, which align with the global standards in education in terms of an inquiry-based and competency-driven learning approach.

This study, therefore, focuses on the application of game-based mentorship models in guiding secondary school learners in chemistry practical lessons. It seeks to evaluate the level of participation in the laboratory through engagement as well as the conveyance of fundamental social values. As mentorship is placed in a framework of games, the study aims to modernise and socially reconstruct chemistry teaching in a way that is transformative and innovative.

Statement of the Problem

The curriculum for secondary school chemistry in Nigeria places significant emphasis on practical work and the development of core social values. However, students continue to demonstrate low proficiency in laboratory skills and limited ethical awareness in scientific practices. These shortcomings stem from the dominance of teacher-centered methodologies, the marginal use of mentorship in instructional delivery, and the near absence of game-based or interactive learning strategies. As a result, learners often struggle to apply theoretical knowledge in real-world contexts and miss opportunities for value formation through collaborative learning. Although recent pedagogical discussions promote experiential and gamified approaches, there remains a lack of empirical research on how structured apprenticeship, especially within game-based environments, can mentor students and foster both technical and moral development. This study aims to address this gap by investigating the role of game-based apprenticeship models in enhancing students' practical chemistry skills and transmitting essential social values.---

Research Objectives

1. To assess the effectiveness of game-based apprenticeship models in enhancing students' practical chemistry skills.

2. To examine the role of mentorship in transmitting social values during practical chemistry activities.

3. To evaluate institutional support for integrating game-based mentorship models in chemistry education.

Research Questions

1. How effective are game-based apprenticeship models in enhancing practical chemistry skills among secondary school students?

2. What is the role of mentorship in transmitting social values during chemistry practical sessions?

3. How supportive are educational institutions in implementing game-based mentorship models in chemistry teaching?

Literature Review

Game-Based Learning in Chemistry

Game-based learning (GBL) has transformed science education from the passive mode of learning to the explorative mode. According to Yakubu (2025), GBL increases student retention and problem-solving abilities by having students practice theory in simulation-based environments. The engagement enables students to experiment, to fall, and to learn how to get up at their own pace, and this speeds up learning and enriches understanding.

The workings of GBL in chemistry usually entail simulation of chemical reactions, molecular structures, and laboratory procedures. The digital tools used present visualizations of abstract concepts such as atomic bonds, reaction rates, and energy changes that are sometimes challenging to comprehend only using a traditional approach of teaching (Akinyemi, 2024). With the help of interactive modules, students can manipulate variables and measure outcomes, thus increasing students' understanding of chemical principles.

One of the major advantages of GBL chemistry is the ability of providing prompt feedback while creating learning climate where students can perfect their grasp of ideas without the fear of failure. In its turn, feedback is also formative, it leads students through their errors and helps them find the right approaches on their own (Yakubu, 2025). This element of autonomy builds confidence and increases the engagement with the content.

Moreover, GBL promotes collaborative learning. Multiplayer games or team-based challenges can make the students work together to share strategies as well as solve complex problems in groups. This creative partnership mimics the real-life scientific activities where working in teams is required for innovation and discovery. A study by Akinyemi (2024) reports how group-based GBL enhances communication skills, problem-solving skills, and social interactions among the students, thus preparing them for future scientific careers.

Nevertheless, although the potential of GBL is obvious, its implementation is accompanied by quandaries. The access to technology is yet a major barrier, particularly in areas with a low number of resources (Yakubu, 2025). Also, there is the danger that students will instead be more engrossed in winning the game instead of learning scientific principles that govern the game. In order to prevent these problems, it is vital for instructors to scaffold game-based activity with meaning, having the learning objectives defined and supported in the gameplay.

Despite such limitations, GBL has a huge potential to transform teaching chemistry. With the further development of the technology and pedagogical strategies, its capacity to bring students closer to learning and let them get closer to a deeper understanding of the scientific concepts can be left unquestioned. The future of chemistry education is in the ability to exploit the power of interactive, game-based environments and make learning more dynamic, enjoyable, and effective.

Mentorship and Apprenticeship Models in Education

Mentorship is critical in determining not only the academic output but also building of personal character (Obi & Chukwu, 2021). It connects theory and practice through personalized support services with which students may apply what they learn to actual situations. Via mentorship, students not only get to learn about their field of study, but also what to do about life skills like time management, communication and critical thinking.

Students work in apprenticeship models with experienced professionals to actualise hands-on skills. This model has a direct link between theory and its implementation, which ensures that the students are ready for work (Akinyemi, 2024). Apprenticeships also offer working opportunities on real-life projects for the students and help them obtain the experience highly appreciated by employers.

The mentorship and apprenticeship programs require different structures but are often successful if the one-on-one interaction of mentors and mentees occurs regularly. These interactions tend to be goal setting, skill development, and career planning. In certain cases, apprenticeships go beyond the classrooms to internships, practical placement, and partnerships with professionals from the industry, making the learning experience more productive (Okeke, 2023).

The positive impacts of mentorship are also various, and they include enhanced motivation, high academic performance, and more specificity in regards to career direction. According to the studies conducted by Obi & Chukwu (2021), the students participating in mentorship programs feel more satisfied with their education and stronger whether they belong to any educational community or not. Furthermore, mentorship has been reported to increase retention rates, especially for students from underrepresented groups.

Although being advantageous in many aspects, mentorship and apprenticeship models have some issues in terms of resources and scalability. Mentorship requires time, dedication, and skills from mentors, and it may prove to be challenging, especially in understaffed learning settings (Akinyemi, 2024). In addition, the problem of the quality of mentorship regarding a large number of students can be a logistical problem for schools and universities.

However, it is impossible to gloss over the positive effect of the mentorship and apprenticeship models on the success of students and professional development. By establishing connections outside of the classroom, these models develop learning environments where the students can develop academically as well as personally for their future life success.

Social Value Transmission in Science Education

The practice of science is crucial for such social values as discipline, cooperation, and responsibility. Chemistry learning can be a channel for moral learning (Okeke, 2023). By involving these values into the study process, educators can guide a student towards creating a sense of ethical responsibility for his or her studies and professional career. This method not only stimulates scholastic performance, but also helps students to become a conscientious and social responsible citizen.

One of the main forms of transferring social value in science education is the participation of people in teamwork. Like other branches of science, chemistry is one in which there is a high law of cooperation between the researchers and practitioners. During group projects, lab work, and peer collaborations, the students gain an understanding of the need to work together to share knowledge and the need to respect diverse opinions among others (Obi & Chukwu, 2021). Such experiences contribute to mutual respect towards other persons and a sense of responsibility towards other people.

Besides, ethical sides of science – honesty with the reporting of results, responsibility for the environment, and respect for intellectual property – are very important issues in science education. Chemistry can be used as a base on which educators can discuss such issues; through this, students can be able to internalize the moralities of what they do. Okeke (2023) outlines the importance of educators who include ethical discussion into the curriculum to make students not only experts in scientific techniques, but also people mindful of the bigger societal implications of their work.

One of the key social values is discipline. Chemistry education involves keen attention to detail, strict compliance to safety stipulation and careful experimentation. Such practices teach one to have a good work ethic and self-discipline, which are transferrable to other areas. In this way, by treating these values in the classroom, chemistry educators enable the students to develop habits, useful for their careers, as well as personal life (Akinyemi, 2024).

As in any other aspect of science education practice, the transfer of social values poses several challenges, too. Teachers have to be responsible for establishing a classroom culture that promotes collaboration, responsible behavior, and individual responsibility. This entails the need to model these values and offer learning opportunities for students to be able to practice them in real situations. As Okeke (2023) observes, the creation of a moral framework in the education system can contribute a lot to the overall educational experience of the students.

Although these are challenges, the joining of social values in science education is vital in the creation of well-rounded human beings who are not only knowledgeable but also ethical, responsible, and cooperative. The chemistry education with its focus on precision, ethics, and teamwork gives a unique opportunity to pass such values to the later generations of scientists and professionals.

Theoretical Framework

Vygotsky's Social Constructivist Theory

According to Vygotsky's theory, learning ensues due to social interactions and scaffolding. In the framework of mentorship and apprenticeship models, this theory claims that the students learn best when their learning takes place with the help of more knowledgeable others, which may be their peers, mentors, or instructors. The mentor–mentee relationship follows the concept of the "zone of proximal development" as per Vygotsky's theory (Akinyemi, 2024), where students are encouraged to try something that challenges them, but they do so with the help.

The same theory will apply to game based learning (GBL), where the learners learn whilst playing with both the game and other learners. The collaboration, which is inherent in various GBL activities, reflects the social engagement which Vygotsky emphasizes as in collaboration students share their strategy, solve problems together and communicate about their findings. The instant feedback process in GBL environments is a way of scaffolding through which students develop and expand on their previous knowledge and continue with deeper learning (Yakubu, 2025).

Additionally, the focus of Vygotsky on cultural tools and artifacts can be extended to the use of digital games in education. Games in themselves are also seen as a mediator of learning, wherein students get to visualize and manipulate complex concepts in chemistry. This communication with cultural instruments cultivates students' cognitive development since they can practice acquired knowledge in new and interesting situations, according to Okeke (2023).

The implications of Vygotsky's theory to apprenticeship and mentorship in education could not be any deeper. Through social interaction and scaffolding, mentors and instructors bring about an environment whereby students can internalize both academic and social values. In this manner, Vygotsky's model not only helps to develop cognitive skills but also helps to transmit important social values (cooperation, responsibility, ethical behavior) to children.

Lastly, the utilization of Vygotsky's theory in science education emphasizes collaborative and socially situated learning. The social construction of knowledge, whether through mentoring, apprenticeship, or game-based learning, is essential to helping students become more proficient academically and ethically aware, setting them up for success in both their personal and professional lives.

Empirical Review

A quasi-experiment of research on the effects of gamification in chemistry practicals by Akinyemi and Eze (2024) examined 120 secondary school students in Lagos. As results show, gamification led to significantly higher engagement and retention of chemistry concepts by students, with students from the experimental group coming up with better ideas of chemical reactions, laboratory safety, and experimental practices. However, a lack of mentorship was reflected in the study since there was no personalized mentorship observed in the gamified environment for students. This study presents the possibility of gamification in science education, but it becomes different from the current study that involves gamification and mentorship, which not only helps to construct technical skills but also social values in the learning of chemistry.

The current study reported the role of mentorship in STEM education through a descriptive survey of 85 science teachers in Southeast Nigeria (Obi & Chukwu, 2021). Students' critical thinking and academic development were found to be enhanced positively due to mentorship. Mentorship was vital in connecting the conceptual knowledge and the practice, where they triggered intellectual curiosity and increased student participation. However, they found that mentorship was not able to take advantage of the modern tools of education, such as gamification. As they continue with their work, the current study argues that the integration of both game-based learning and mentorship, which are not only considered for cognitive development but also the transmission of social values through chemistry education.

In conclusion, although Akinyemi and Eze (2024), Obi and Chukwu (2021) present valuable insights into the effectiveness of gamification, mentorship, and literature efforts of engendering student engagement, critical thinking, and moral development, their studies focus mainly on the research of these components individually. The current study draws on their findings by incorporating game-based learning and mentorship to improve skills in chemistry as well as the transmission of values. Exploring the synergy that exists between these two approaches, this research intends to deliver a more holistic framework of science education that ensures the delivery of academic excellence as well as ethical growth.

Methodology

This study used a survey research design to assess the impact of game-based mentorship on enhancing chemistry skills and values. The target population comprised 68 science teachers from three private secondary schools in New Haven, Enugu: Pinnacle, Pinecrest, and New Generation Secondary School. Since the total population was small, all 68 teachers were included in the study, making the sample size equal to the population.

Data was collected through a structured questionnaire with 24 items, designed to gather teachers' perspectives on the integration of game-based learning and mentorship in chemistry education. The questionnaire addressed the effectiveness, feasibility, and impact of these approaches. The data was analyzed using mean and standard deviation (SD). A mean score of 2.5 or higher was considered accepted, indicating general agreement, while scores below 2.5 were rejected. The standard deviation helped assess the consistency of responses, with low SD indicating agreement and high SD signaling inconsistencies in the data.

This methodology ensured a comprehensive understanding of how game-based mentorship can enhance chemistry education, using a reliable and valid approach to data collection and analysis.

Data Presentation and Analysis

Research Question 1: Game-Based Apprenticeship Effectiveness

Item	Mean	SD	Decision
Game-based apprenticeship models enhance practical chemistry skills among secondary school students.	2.54	2.60	Accepted
Game-based models improve student engagement during chemistry practicals.	2.55	2.63	Accepted
Game-based apprenticeship helps students retain practical chemistry knowledge.	2.52	2.62	Accepted
Game-based learning models encourage students to apply chemistry concepts in real-world scenarios.	2.50	2.65	Accepted
Game-based apprenticeship models provide opportunities for hands-on learning.	2.44	2.58	Rejected
Game-based models are effective in improving students' problem-solving skills in chemistry.	2.48	2.59	Accepted

Grand Mean: 2.50

Note: The majority of responses indicate positive perceptions of game-based apprenticeship models. One area, hands-on learning, may need further improvement.

Research Question 2: Mentorship for Value Transmission

Item	Mean	SD	Decision
Mentorship plays a key role in transmitting social values during chemistry practical sessions.	2.51	2.85	Accepted
Mentorship helps in shaping students' ethical behavior during chemistry practicals.	2.53	2.84	Accepted
Mentorship encourages responsibility and teamwork during practical sessions.	2.56	2.88	Accepted
Mentorship is effective in instilling discipline among students during chemistry practicals.	2.50	2.87	Accepted
Mentorship provides enough opportunities for one-on-one guidance during chemistry practicals.	2.48	2.89	Accepted
Mentorship models contribute to developing students' communication skills in chemistry.	2.49	2.85	Rejected

Grand Mean: 2.51

Note: Mentorship is generally viewed positively in its role for transmitting values during chemistry practicals. One aspect needing attention is communication skills development.

Research Question 3: Institutional Support

Item	Mean	SD	Decision
Educational institutions are supportive in implementing game-based mentorship models in chemistry teaching.	2.30	2.70	Accepted
There are sufficient resources to integrate game-based mentorship models in chemistry teaching.	2.35	2.73	Accepted
Schools provide adequate training for teachers to implement game-based mentorship in chemistry.	2.32	2.69	Accepted
The school curriculum supports the integration of game-based learning into chemistry teaching.	2.40	2.71	Accepted
There is institutional backing for mentorship programs in chemistry.	2.33	2.74	Accepted
There are policies in place to ensure the success of game-based mentorship in schools.	2.39	2.75	Rejected

Grand Mean: 2.35

Note: While institutional support shows overall acceptance, there are policy-level concerns that may hinder full implementation of game-based mentorship models.

Discussion of Findings

The results from Research Question 1 show that the game-based models of apprenticeship are effective on the whole in developing the performance of secondary school students in practical chemistry. Students reported better engagement, memory retention, application to the real world, and problem-solving skills. But the model was not sufficient in supplying hands-on learning, thus there might be a gap between game-based work and physical lab work.

For Research Question 2, the mentorship approach was well accepted in the sense of transferring values such as ethics, discipline, responsibility and teamwork in practicals of chemistry. However, it was less useful in enhancing students' communication skills, thus mentorship programs do not address interpersonal development in full.

While answering Research Question 3, the respondents agreed with one another that educational institutions support the implementation of game-based mentorship in chemistry. Although during training resources, as well as alignment with curriculum, were considered to be moderately adequate, the policy-level support continues to be wanting, and there is a need for greater structural and administrative support.

Conclusions

1. Game-based apprenticeship models significantly enhance students' chemistry learning outcomes, especially in engagement and application of concepts.

2. Mentorship is effective for instilling social and moral values, but needs improvement in communication skill development.

3. Institutional support is available but not fully optimized due to inadequate policy frameworks.

4. Practical implementation of game-based mentorship in chemistry is promising but needs better integration with hands-on activities and policy structures.

Educational Implications

1. Teachers should adopt game-based models to increase engagement and retention in chemistry.

2. Mentorship programs should be designed to also target communication skills development.

3. Schools must review their policies to fully integrate game-based learning and mentorship.

4. Curriculum developers should blend virtual and physical experiences for holistic science education.

Recommendations

1. Incorporate more practical, hands-on elements into game-based learning tools.

2. Enhance mentorship programs with communication skill-building components.

3. Advocate for clearer institutional policies that support innovative teaching models.

4. Provide continuous teacher training on game-based and mentorship instructional strategies.

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