

EFFICACY OF AFRICAN SIMULATION GAMING STRATEGY IN ELEMENTARY SCIENCE TEACHING IN NIGERIA

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Abstract

This theoretical study examined the efficacy of African simulation gaming strategies in elementary science teaching in Nigeria, anchored on David A. Kolb's (1984) Experiential Learning Theory. The study explored the concepts of simulation and educational games, highlighting their pedagogical strengths in fostering active, experiential, and learner-centered science education. Emphasis was placed on the simulation gaming strategy, including procedures for its effective use in teaching science, alongside examples of selected African simulation games and their application in conveying specific science concepts. The study also discussed the relevance of simulation to science teaching, identifying its potential to enhance students' critical thinking, problem-solving skills, engagement, and retention of scientific knowledge. Limitations and disadvantages of simulation games, such as resource intensity and potential classroom management challenges, were critically examined. Educational implications were drawn to guide curriculum planners, teachers, and policymakers in leveraging simulation gaming strategies to improve science learning outcomes. The study concluded with suggestions for integrating African simulation games into elementary science curricula to enhance instructional effectiveness and learner participation.

Keywords: Stimulation; Educational Gaming; African Simulation Gaming Strategy; Elementary Science

Introduction

Science education occupies a strategic position in the educational systems of nations because of its critical role in fostering scientific literacy, technological advancement, and sustainable socio-economic development. Through science education, learners acquire knowledge, skills, values, and attitudes necessary for understanding natural phenomena, solving real-life problems, and contributing meaningfully to national development. Consequently, the effectiveness of science teaching has remained a major concern of educators, curriculum planners, policymakers, and researchers across the globe. In Nigeria and other developing countries, science education is particularly significant as it serves as a foundation for manpower development in science, technology, engineering, and mathematics (STEM)-related fields, which are essential for innovation and industrial growth (Clark et al., 2020). Over the years, science educators have

adopted a wide range of teaching methods and instructional strategies aimed at enhancing learners' understanding of scientific concepts and processes. Classical and contemporary literature identifies methods such as lecture, demonstration, discovery learning, inquiry-based learning, project method; storytelling, dramatization, and role play as common approaches to science instruction (Adeyele, 2024; Squire & Jenkins, 2021; Wagbara, 2025). While these methods have contributed significantly to classroom practice, evidence from classroom observations and empirical studies suggests that excessive reliance on teacher-centred approaches, particularly the lecture method, often limits learners' active participation and reduces opportunities for meaningful engagement with scientific ideas. This challenge is more pronounced at the elementary and junior secondary school levels, where learners require instructional experiences that align with their developmental characteristics.

Learners at the basic education level are naturally curious, energetic, imaginative, and strongly motivated by play, exploration, competition, and social interaction. At this stage, learning is most effective when it is concrete, activity-based, and connected to learners' immediate environment and experiences. Traditional instructional approaches that emphasize rote memorization and passive reception of information may therefore fail to sustain learners' interest or promote deep conceptual understanding. In response to this concern, learning theorists and science educators have consistently emphasized the importance of learner-centred and activity-oriented instructional strategies that actively involve learners in the construction of knowledge (Kwabe et al., 2024; Uzezi & Deya, 2025). According to these theorists, meaningful learning occurs when learners relate new information to existing cognitive structures, engage in problem-solving, and apply knowledge to real-life situations rather than merely recalling facts. Within this theoretical context, contemporary science education research has increasingly focused on innovative instructional strategies capable of promoting active learning, motivation, and higher-order thinking skills. One such strategy is simulation gaming. Simulation gaming strategy represents an integration of simulation and game elements to create structured learning experiences that model real-life or hypothetical situations. In these environments, learners assume roles, make decisions, interact with peers, and experience the consequences of their actions within defined rules and objectives (Umeh, 2024). By blending the experiential nature of simulations with the motivational appeal of games, simulation gaming provides learners with opportunities to explore scientific concepts in ways that are both cognitively engaging and emotionally rewarding.

Simulation gaming strategy is grounded in constructivist learning theory, which views learning as an active, social, and contextualized process. Through guided play, collaboration, and reflection, learners using simulation games are able to develop scientific understanding, critical thinking skills, creativity, and problem-solving abilities. Empirical studies have shown that well-designed simulation and game-based learning environments can significantly enhance learners' motivation, conceptual understanding, and retention of knowledge, particularly in science-related subjects (Plass et al., 2015). These environments also encourage communication, teamwork, and shared responsibility for learning, thereby supporting both cognitive and affective learning outcomes. Recent global research further confirms the effectiveness of simulation and serious games in science education. Adams and Brown (2022) highlighted that games create powerful learning environments by integrating clear goals, immediate feedback, challenge, and identity formation, all of which are essential for deep learning. Similarly, a meta-analysis by Wouters et al. (2013) revealed that serious games have significant positive effects on learners' cognitive and motivational outcomes when compared with conventional instructional methods. In the Nigerian context, studies such as Akinsola and Animashahun (2020) have reported improved achievement and interest in basic science among learners exposed to game-based instructional strategies, underscoring the relevance of simulation gaming for local classrooms.

In the African educational context, simulation gaming holds additional promise due to the availability of rich indigenous games, cultural practices, and communal learning traditions that can be adapted for instructional purposes. Scholars have argued that culturally relevant instructional strategies rooted in learners' socio-cultural environment enhance understanding, relevance, and transfer of learning (Aina & Sofowora, 2019). Indigenous African games, when adapted as simulation games, can serve as powerful tools for contextualized science teaching by linking abstract scientific concepts to familiar experiences. Empirical evidence from South-East Nigeria indicates that game-based learning strategies significantly enhance students' engagement and participation in basic science classrooms (Okeke & Eze, 2022). Against this backdrop, this paper examined the concepts of simulation, games, and simulation

gaming strategy as instructional approaches in science education. It also discusses the procedures and conditions necessary for the effective implementation of simulation gaming strategy in science classrooms. Furthermore, the paper presents examples of selected African simulation games and illustrates their application in teaching specific science concepts at the elementary and junior secondary school levels. Through this discussion, the paper seeks to demonstrate the pedagogical relevance, cultural suitability, and practical value of simulation gaming strategy as a complementary approach to improving science teaching and learning in Nigerian schools.

Theoretical Framework

Experiential Learning Theory by David A. Kolb in 1984 provides the theoretical foundation for this study. Kolb postulates that learning is a dynamic process in which knowledge is created through the transformation of experience. According to the theory, learners acquire understanding by actively engaging in experiences, reflecting on them, forming abstract concepts, and testing these concepts through experimentation. This cyclical model consists of four stages: concrete experience, where learners encounter a specific situation; reflective observation, in which they think critically about the experience; abstract conceptualization, where they draw general principles; and active experimentation, where they apply the principles in new contexts. The theory emphasizes that learning is most effective when it is active, participatory, and grounded in real-life contexts rather than passive absorption of information. It highlights the importance of engaging learners in meaningful activities that promote critical thinking, problem-solving, and knowledge retention. Kolb noted that when learners connect experiences to conceptual understanding, they are empowered to internalize scientific concepts deeply and apply them creatively in novel situations.

The relevance of Experiential Learning Theory to this study is particularly strong because African simulation gaming strategies naturally embody the principles of experiential learning. These strategies provide culturally familiar, interactive, and contextually rich scenarios where elementary science students can explore scientific phenomena through role-playing, decision-making, and problem-solving activities. Students are encouraged to observe the consequences of their actions, reflect on outcomes, formulate scientific principles, and test these principles within the simulation. This approach fosters not only cognitive development but also collaborative learning, creativity, and motivation. In the Nigerian elementary science classroom, where abstract scientific concepts often pose comprehension challenges, the integration of African simulation gaming guided by Kolb's experiential learning cycle ensures that learners acquire a deeper and more meaningful understanding of science content. Through active participation in simulations, students develop analytical skills, enhance their ability to transfer knowledge to real-life situations, and become more engaged in the learning process.

Concept of Simulation

Simulation is an instructional strategy that allows learners to engage with representations of real-world situations in a structured and controlled environment. Ogunbanwo et al. (2025) defined simulation as a teaching and learning strategy in which learners engage with a model or representation of a real-life situation in a controlled and interactive environment. It involves assuming roles, making decisions, and observing the outcomes of actions, allowing learners to experience complex processes, test hypotheses, and develop practical skills without the risks, costs, or constraints of real-world experimentation (Habibi et al., 2024). In education, simulations are designed to replicate key aspects of reality, promote active participation, enhance critical thinking, and provide opportunities for learners to apply theoretical knowledge in practical or problem-solving contexts (Akinsola & Oladunjoye, 2021). Through participating in simulations, students assume roles, make decisions, and experience the consequences of their actions in a way that bridges the gap between theoretical knowledge and practical application. This active engagement enables learners to explore complex phenomena, practice essential skills, and develop higher-order thinking abilities such as problem-solving, critical analysis, and decision-making, all without the risks or costs associated with real-life scenarios (Nwigboji & Nwoke, 2025). Central to the educational value of simulations is their capacity to foster experiential learning. Unlike traditional teaching methods that often rely heavily on passive information delivery; simulations immerse learners in interactive, often dynamic contexts where learning occurs through doing and reflection. According to Heinich et al. (as cited in Isyaku & Olajumoke, 2025), several characteristics distinguish educational simulations from other instructional techniques. First, simulations must be based on realistic models that accurately reflect the processes or

systems being studied. Second, learning objectives should focus on application and practical outcomes rather than rote memorization. Finally, learners must take active responsibility for their decisions, as their choices directly influence outcomes within the simulated environment. These features collectively promote learner autonomy, engagement, and intrinsic motivation.

In science education, simulations are particularly valuable due to the practical constraints of classroom experimentation. Some scientific experiments involve costly equipment, hazardous materials, or procedures that are time-consuming and difficult to replicate safely in a standard laboratory (Umeh, 2024; Akinsola & Oladunjoye, 2021). Simulation-based approaches; including computer simulations, virtual laboratories, and interactive models, offer students opportunities to visualize and manipulate complex scientific processes. For instance, virtual experiments allow learners to observe chemical reactions, manipulate variables in physics experiments, or explore biological systems at a cellular level, all without physical risk. These experiences can strengthen conceptual understanding, encourage inquiry, and enhance students' preparedness for hands-on laboratory work. Nonetheless, simulations should complement rather than replace practical laboratory experiences, as direct interaction with real materials remains critical for developing manual dexterity, observational skills, and authentic scientific reasoning (Alake & Olojo, 2020). Beyond science education, simulation has broad applications across disciplines such as engineering, medicine, business, and social sciences. Role-play simulations, case-based learning, and scenario analysis allow learners to engage with complex social, economic, or technical systems, promoting collaborative learning and reflective practice. In the African educational context, simulation strategies have been successfully employed to teach environmental science, agricultural processes, and health education, demonstrating their adaptability to local curricula and resource constraints (Akinsola & Oladunjoye, 2021). Globally, the increasing integration of digital technologies, such as augmented reality (AR) and virtual reality (VR), has expanded the potential of simulation to create highly immersive, interactive learning environments that cater to diverse learning styles and contexts (Kefalis, 2025).

Educational Strengths of Simulation

Simulation as a pedagogical strategy presents a wide range of educational strengths that extend beyond traditional instructional methods, offers immersive, interactive, and learner-centered experiences. Simulations through replicating real-world scenarios and providing structured opportunities for exploration, foster cognitive, affective, and psychomotor development in ways that conventional teaching alone cannot achieve. The following detailed discussion according to Udeani and Akhigbe (2024) highlights key educational advantages of simulation, supported by research evidence and practical considerations.

- 1. Fosters Deep Emotional and Cognitive Engagement:** Simulation captures learners' attention by engaging both their emotions and intellect. By presenting realistic scenarios that mirror authentic challenges, students become emotionally invested, which research demonstrates can enhance attention, memory, and judgment. This dual engagement facilitates meaningful learning, as learners are motivated to connect theoretical content with practical situations. Emotional involvement also stimulates curiosity, persistence, and reflective thinking, which contribute to deeper understanding and long-term retention of knowledge (Alessi & Trollip, 2020). In addition, the realistic nature of simulations encourages learners to consider consequences and make decisions as they would in real-life contexts, strengthening both cognitive and affective learning domains.
- 2. Enhances Motivation and Promotes Active Learning:** The interactive and often game-like characteristics of simulations naturally attract learner interest and promote sustained engagement. Motivation in simulations is enhanced because learners actively participate, make decisions, and receive immediate feedback rather than passively absorbing information from lectures. Studies indicate that learners in simulation-based environments demonstrate higher levels of intrinsic motivation, persistence through challenges, and willingness to experiment with strategies (National Research Council, 2025). This motivational effect also supports meaningful learning, as learners are more likely to internalize knowledge and apply it to novel problems.
- 3. Develops Higher-Order Thinking Skills:** Problem Solving and Decision Making Simulations excel at cultivating higher-order cognitive skills such as critical thinking, problem solving, and decision making. By presenting complex, context-rich scenarios, learners must analyze data, evaluate alternatives, anticipate consequences, and make informed decisions. These activities encourage

reflective judgment, adaptive reasoning, and the transfer of theoretical knowledge to real-world applications (Chen & Lee, 2023). Moreover, iterative interaction with simulation environments allows learners to refine strategies and learn from mistakes, thereby strengthening analytical skills and strategic thinking.

4. **Provides a Safe and Risk-Free Learning Environment:** Simulations offer learners the opportunity to practice and experiment without real-world risks. In disciplines such as healthcare, engineering, aviation, and emergency response, practicing skills in a controlled, consequence-free environment is crucial. Learners can perform procedures repeatedly, receive corrective feedback, and build confidence before applying these skills in practical settings (Distance Learning Institute, 2021). This safe learning environment also reduces anxiety associated with complex or high-stakes tasks, enabling learners to focus on mastering content and refining skills.
5. **Supports Engagement of Less Motivated or At-Risk Learners:** Simulation-based learning can effectively capture the attention of students who may be disengaged in traditional classroom settings. Interactive, scenario-driven activities help maintain interest, reduce boredom, and create a sense of challenge and achievement. For learners who struggle with abstract or passive learning formats, simulations provide an accessible pathway to understanding and motivation, helping to bridge gaps in participation and learning outcomes (Smith, 2021).
6. **Facilitates Knowledge Acquisition, Process Improvement, and Reflection:** Simulations support not only the acquisition of content knowledge but also the development of cognitive processes and decision-making skills. Learners can experiment with different strategies, observe outcomes, and iteratively refine their approaches. This reflective cycle promotes deeper understanding, mastery of procedures, and the ability to transfer knowledge to new contexts (National Research Council, 2025). By enabling learners to evaluate the effectiveness of their actions, simulations foster both metacognition and continuous improvement.
7. **Enables Controlled Manipulation of Variables for Exploration and Analysis:** Unlike real-world contexts, where extraneous factors may interfere with learning, simulations allow educators and learners to systematically manipulate variables. This capacity enables controlled experimentation, hypothesis testing, and systematic analysis of cause-effect relationships. Learners gain insights into complex systems, understand underlying principles, and develop analytical skills that support research and evidence-based decision making (Obro, 2022). Such flexibility makes simulations particularly effective in scientific, technical, and operational domains where experimentation in real settings may be impractical or unsafe.
8. **Supports Interdisciplinary and Collaborative Learning:** Many simulation platforms are designed to be collaborative, requiring learners to work together, share insights, and negotiate decisions. This promotes communication, teamwork, and problem-solving in a social context, reflecting real-world professional environments. Research shows that collaborative simulation exercises enhance peer learning, accountability, and shared knowledge construction, which contributes to both cognitive and social development (Gredler, 2020).
9. **Encourages Transfer of Learning to Real-World Contexts:** A critical educational strength of simulation lies in its ability to bridge theory and practice. By replicating real-life scenarios and decision-making contexts, simulations encourage learners to apply conceptual knowledge in practical situations. This transferability is crucial for preparing students for professional and life situations, increasing confidence and competence in performing real-world tasks (Alessi & Trollip, 2020).

Concept of Educational Games

Educational games constitute a versatile and interactive pedagogical approach that integrates learning, engagement, and motivation with cognitive and socio-emotional development. At their core, games are structured activities in which participants pursue specific goals within a framework of rules, often requiring strategic thinking, problem-solving, and decision-making. Akpabio, (2023) defined a game as “an activity in which players strive towards the attainment of a set goal within prescribed rules,” emphasizing the inherent duality of purpose and structure. This definition underscores the deliberate nature of games, distinguishing them from mere recreational play by highlighting their instructional and developmental potential. The concept of a game is multidimensional and contextually flexible, with different disciplines

attributing varied meanings to the term. Scholars such as Gómez et al. (2022), Nelson and Hsu (2023) identified core components that are universally present in games, which include:

- 1. Player Roles:** Participants assume distinct roles that shape their responsibilities, actions, and interactions within the game, providing opportunities for perspective-taking and situational learning.
- 2. Game Rules:** Rules define permissible actions and boundaries, ensuring fairness, structure, and predictable engagement. Rules also serve as a framework within which creativity and strategy can be exercised.
- 3. Goals and Objectives:** Clearly defined goals guide participants' efforts and foster motivation, ensuring that the activity remains purposeful and outcome-oriented.
- 4. Puzzle or Storyline:** Challenges, narratives, or scenarios embedded in games provide context, maintain interest, and stimulate problem-solving and critical thinking.
- 5. Player Interactions:** Social dimensions of games, including collaboration, competition, negotiation, and teamwork, foster interpersonal skills and communal learning experiences.
- 6. Payoffs and Strategies:** Strategic planning and decision-making are central to games, requiring players to weigh options, anticipate outcomes, and optimize performance to achieve objectives.
- 7. Feedback and Outcomes:** Continuous feedback, whether immediate or delayed, informs players of their progress, reinforces learning, and encourages reflective thinking (Olagundoye & Olaniyan, 2025).

From an educational standpoint, games are defined as engaging, interactive learning environments that immerse learners in progressively challenging tasks designed to develop mastery. This perspective emphasizes that educational games not only entertain but also cultivate cognitive, social, and emotional competencies. Johnson (2024) noted that exploratory and interactive games are especially effective in disciplines such as mathematics and science, where abstract concepts may be difficult to visualize or manipulate through conventional methods. By simulating real-life scenarios in controlled, low-risk environments, games enable experiential learning, allowing students to experiment, test hypotheses, and observe outcomes without the consequences associated with real-world errors. An advanced application of educational games involves active student participation in game design or content creation. By assuming the role of co-creators, learners transition from passive recipients to active knowledge constructors. This approach fosters creativity, autonomy, and intrinsic motivation while enhancing engagement and cognitive investment in the learning process (Plass et al. 2015).

Educational Strengths of Games

Educational games are powerful pedagogical tools that extend learning beyond traditional classroom methods, offering diverse cognitive, social, and motivational benefits. They not only engage learners in enjoyable activities but also foster skills and dispositions that are crucial for academic achievement and personal development. The educational strengths of games can be elaborated as follows:

- 1. Enhancement of Attention, Focus, and Persistence:** Games are inherently interactive, goal-oriented, and often structured with progressively challenging levels. This design naturally captures learners' attention and sustains it over time. The process of navigating through increasingly complex tasks requires students to concentrate, analyze information, and persist through difficulties. This repeated engagement strengthens attention span, encourages persistence, and cultivates resilience, particularly in problem-solving contexts. The iterative nature of games allows learners to experiment, fail safely, and try again, reinforcing perseverance and a growth mindset.
- 2. Promotion of Social Interaction, Cooperation, and Communication:** Many educational games are multiplayer or involve collaborative problem-solving, which encourages social interaction and teamwork. Through negotiation, discussion, and coordination with peers, learners develop interpersonal and communication skills essential for collaborative learning. Socially oriented games also promote empathy, conflict resolution, and leadership abilities as students take on different roles within group tasks. The shared experience of working toward common goals strengthens social bonds and creates a sense of classroom community, which can improve student engagement and motivation.
- 3. Development of Advanced Cognitive Skills:** Games frequently require players to identify patterns, strategize, analyze outcomes, and make informed decisions under time or resource constraints. Engaging in these activities helps learners cultivate higher-order thinking skills such as critical reasoning, strategic planning, and principled decision-making. As Iroriteraye-Adjekpovu et al. (2025) highlighted, repeated

interaction with complex game systems fosters expertise in recognizing patterns, applying rules, and predicting consequences—skills that are transferable to academic learning and real-life problem-solving. Games also enhance memory retention, attention to detail, and cognitive flexibility by presenting multiple scenarios requiring adaptive responses.

- 4. Intellectual Engagement and Experiential Learning:** Well-designed educational games provide realistic simulations or immersive experiences that mirror real-life situations. Springer Handbook Editorial Board (2024) referred to this as “hard fun,” where learners experience the satisfaction of overcoming challenges through effortful engagement. By confronting problems in a risk-free virtual environment, students can explore complex ideas, test hypotheses, and observe outcomes without fear of real-world consequences. Such experiential learning deepens comprehension, supports reflective thinking, and allows students to internalize abstract concepts more effectively than through passive instruction.
- 5. Stimulation of Motivation, Creativity, and Curiosity:** Games provide learners with autonomy, allowing them to explore, experiment, and discover solutions in their own way. This freedom fosters intrinsic motivation, encouraging students to engage actively with the content. The trial-and-error nature of gameplay promotes creative thinking, innovation, and intellectual risk-taking. By experimenting with different strategies and solutions, students develop curiosity and a proactive attitude toward learning. Moreover, the immediate feedback inherent in games reinforces positive behavior, motivates improvement, and sustains engagement over time.
- 6. Illustration of Decision-Making and Consequence Relationships:** Educational games often simulate scenarios where decisions have direct and observable consequences. Through these simulations, learners develop a deeper understanding of cause-and-effect relationships and the impact of their choices. This fosters critical thinking, reflective judgment, and strategic planning, as students learn to anticipate potential outcomes, evaluate risks, and make informed decisions. The iterative process of making choices and observing consequences also enhances metacognition, as learners assess their thinking patterns and adapt strategies for better results.
- 7. Support for Emotional and Ethical Development:** Beyond cognitive and social benefits, games also engage the emotional domain. Learners experience a range of emotions such as excitement, frustration, satisfaction, and empathy during gameplay. Managing these emotions in a structured setting helps students develop emotional regulation, patience, and resilience. Furthermore, games that involve ethical dilemmas or cooperative tasks encourage learners to consider moral implications, fairness, and responsibility, contributing to character development alongside academic growth.
- 8. Integration with Classroom Instruction:** Games are most effective when integrated intentionally into instructional strategies. They can complement traditional teaching by reinforcing concepts, providing experiential practice, and stimulating discussion. For example, educational games can serve as formative assessment tools, enabling teachers to monitor understanding and provide targeted feedback. When thoughtfully aligned with curriculum objectives, games enhance learning outcomes by providing interactive, student-centered experiences that cater to diverse learning styles and abilities.

Simulation Gaming Strategy

Despite sustained scholarly efforts to draw conceptual boundaries between games and simulations, contemporary educational literature increasingly recognizes that the two instructional approaches are deeply interconnected and mutually reinforcing. Both strategies are rooted in experiential learning principles and emphasize active learner engagement, problem-solving, critical thinking, and decision-making within structured environments. While games are often associated with competition, rules, and entertainment, and simulations with realism and representation of real-world systems, these distinctions frequently blur in educational contexts where learning outcomes are prioritized over rigid categorization. As a result, many instructional designs now deliberately integrate elements of both approaches to maximize pedagogical effectiveness. In recognition of this convergence, Gómez et al. (2022) introduced the concept of simulation gaming as a unified instructional strategy that combines the realism and analytical depth of simulations with the motivational and interactive features of games. According to Aldrich, simulation gaming represents a powerful synthesis of authenticity and play; thus, allowing learners to engage with complex systems in ways that are both intellectually demanding and intrinsically motivating. He further predicted that simulation

gaming will play a transformative role in future educational practices, particularly as advances in digital technology continue to expand the scope, fidelity, and accessibility of learning environments.

Simulation gaming may be defined as an instructional strategy that seeks to replicate real-life activities, systems, or processes within a structured, game-like framework for the purposes of teaching, training, analysis, or prediction. This strategy places learners in dynamic environments where they assume specific roles, make informed decisions, and observe the consequences of their actions over time. By embedding authentic scenarios into gameplay, simulation games enable learners to explore abstract and complex concepts, test hypotheses, analyze cause-and-effect relationships, and refine their understanding through iterative experimentation. Importantly, these experiences occur in a risk-free environment, allowing learners to learn from errors without the real-world consequences that might otherwise limit exploration. Simulation games may be implemented in both digital and non-digital formats. Digital simulation games often employ sophisticated graphics, algorithms, and interactive interfaces to model real-world phenomena such as economic systems, ecological interactions, or scientific processes. Non-digital or real-life simulation games, on the other hand, may involve role-playing, physical materials, or social interactions that simulate human behavior, organizational dynamics, or environmental relationships. For instance, a classroom-based simulation game may model an ecosystem, enabling learners to investigate food chains, population dynamics, environmental changes, and sustainability challenges through active participation and collaborative decision-making. Within the context of this study, Gómez et al. (2022) conceptualization of simulation gaming is adopted as the guiding framework. A simulation game is therefore understood as a teaching strategy that represents real-life scientific activities and phenomena in the form of a structured game, with the explicit purpose of enhancing learners' understanding of scientific concepts. This approach places learners at the center of the instructional process and emphasizes learning by doing, reflection on experience, and the construction of knowledge through interaction with both the environment and peers. Through this learner-centered orientation; simulation gaming supports deeper conceptual understanding, long-term retention of knowledge, and the development of higher-order cognitive skills.

Empirical studies and practical applications further demonstrate the versatility and educational value of simulation games across diverse learning contexts. Widely recognized examples include SimCity, a simulation game that has been extensively used to model urban planning, governance, resource allocation, and social behavior. Through engagement with such games, learners gain insights into the complexity of decision-making in real-world systems and develop an appreciation for the interconnectedness of social, economic, and environmental factors. Similarly, simulation games such as SimLife and SimEarth have been employed to introduce learners to foundational concepts in genetics, evolutionary biology, ecological systems, and global environmental interactions (Akinsola & Animashahun, 2020). These applications illustrate how simulation gaming can transform abstract scientific principles into meaningful, interactive, and contextually grounded learning experiences. Over time, simulation games have retained their popularity and relevance, with their educational potential significantly enhanced by advancements in visual design, interactivity, and computational power within the video game industry. Improved realism, adaptive feedback systems, and immersive interfaces have made simulation games increasingly effective as instructional tools. Broadly, simulation games may be categorized into competitive and non-competitive types. Competitive simulation games incorporate scoring systems, rankings, or performance comparisons that motivate learners through challenge and achievement. Non-competitive simulation games, in contrast, emphasize exploration, collaboration, experimentation, and mastery of concepts without explicit scoring mechanisms. Both forms can be pedagogically valuable when appropriately aligned with instructional objectives and learner characteristics.

Regardless of type, simulation games share several core structural features. They typically assign learners specific roles, define clear goals and objectives, and require participation in activities governed by established rules and constraints. These elements provide structure and direction while still allowing flexibility, creativity, and learner autonomy. The balance between structure and freedom is particularly important in science education, where learners must adhere to scientific principles while engaging in inquiry and experimentation. Nelson and Hsu (2023) identified several defining characteristics of simulation gaming as an instructional strategy. These include the presence of clearly articulated goals and purposeful activities that guide learner engagement; opportunities for both competition and cooperation among participants; explicit rules and codes of conduct that regulate roles, actions, rewards, and outcomes; and visual or

observable results that reflect the consequences of learners' decisions. In addition, outcomes in simulation games may be influenced by chance, strategic decision-making, or a combination of both, thereby mirroring the uncertainty and complexity of real-life situations. A recreational dimension is also integral to simulation gaming, as enjoyment and playfulness contribute to sustained motivation, emotional engagement, and positive learning attitudes. Collectively, these characteristics position simulation gaming as a highly engaging and effective instructional strategy that integrates realism, structure, and enjoyment. By immersing learners in meaningful contexts and requiring active participation, simulation gaming promotes experiential learning, critical thinking, and problem-solving skills that are essential for scientific understanding and real-world application.

Procedure for Using the Simulation Gaming Strategy in Teaching Science

The application of the simulation gaming strategy in teaching elementary science follows a systematic four-stage process aimed at fostering active learner participation, enhancing conceptual understanding, and promoting reflective and meaningful learning. Each stage plays a critical role in ensuring that learners are cognitively, socially, and emotionally engaged throughout the instructional process. Using simulation gaming strategy in teaching elementary science should involve these four stages according to Udeani and Akhigbe (2024).

Stage One: Sensitization (Orientation Stage)

At the sensitization stage, the teacher prepares learners mentally and cognitively for the simulation gaming activity. This stage is essential for creating awareness, arousing interest, and establishing a clear learning focus. The teacher begins by explaining the meaning and purpose of simulation games, highlighting their relevance and importance in the teaching and learning of science concepts. Learners are encouraged to recall and mention simulation or educational games they are familiar with and to share the lessons, skills, or experiences gained from playing such games. This discussion helps to activate prior knowledge and build connections between learners' experiences and the intended instructional activity. Thereafter, the teacher introduces and describes the specific simulation game to be used, clearly stating its objectives and expected learning outcomes. The rules and procedures guiding the game are carefully explained and, where possible, displayed boldly on charts or cardboards for easy reference during the activity. To promote orderly participation and effective role performance, the teacher assigns specific roles to learners in accordance with the requirements of the simulation game.

Stage Two: Simulation Game Activity (Implementation Stage)

This stage involves the actual execution of the simulation game. Learners actively participate by performing their assigned roles within the simulated environment. Learning takes place through interaction, experimentation, decision-making, and problem-solving as learners respond to situations presented in the game. During this stage, the teacher assumes the role of a facilitator, referee, or coach rather than a direct instructor. The teacher closely observes the learners, ensures compliance with the established rules, and provides minimal guidance where necessary without interrupting the natural flow of the game. This learner-centered approach allows students to construct knowledge through experience and collaborative engagement.

Stage Three: Post-Simulation Activity (Reflection and Discussion Stage)

After the completion of the simulation game, the teacher organizes learners into small discussion groups. Within these groups, students reflect on the learning objectives of the simulation game and share their experiences during the activity. They are guided to analyze the decisions made, challenges encountered, and outcomes observed during the simulation. Learners also discuss how the simulation mirrors real-life situations and examine its relevance to the science concept or topic under study. Each group selects a leader or spokesperson who presents a brief summary—typically lasting about five minutes—of the group's discussion to the entire class. This stage encourages critical thinking, communication skills, and collective meaning-making.

Stage Four: Fine-Tuning and Consolidation Stage

At the consolidation stage, the teacher synthesizes and refines the ideas presented by the various groups. Misconceptions are identified and corrected, while accurate scientific concepts are reinforced. The teacher explicitly links the experiences from the simulation game to the lesson objectives and the specific science topic to ensure conceptual clarity and meaningful understanding. To conclude the lesson, learners are encouraged to express their feelings, impressions, and opinions about the simulation gaming activity. This feedback process promotes self-evaluation, reflective learning, and deeper internalization of scientific concepts, while also providing the teacher with valuable insights for improving future instructional practices.

Some African Simulation Games and Their Application in Teaching Selected Science Concepts

Simulation games embedded in African cultural practices and classroom traditions constitute powerful instructional tools for science education. These games are deeply rooted in learners' immediate environment and social experiences, making them highly relevant, meaningful, and engaging. From a pedagogical standpoint, African simulation games promote experiential learning, where learners actively participate in observing, predicting, classifying, identifying, and interpreting phenomena—core skills associated with scientific inquiry. Unlike abstract or teacher-dominated instructional approaches, simulation games place learners at the centre of the learning process. They allow learners to simulate the activities of scientists by engaging in hands-on, minds-on experiences that mirror real scientific practices. When properly planned, structured, and guided by the teacher, such games enhance conceptual understanding, long-term retention, psychomotor development, social interaction, and positive attitudes toward science learning at the primary and junior secondary school levels.

1. **Observation Simulation Game:** The Observation Simulation Game is a simple but highly effective classroom activity designed to develop learners' observational acuity, attention to detail, and inferential reasoning. The teacher begins by selecting a learner to act as the leader. The leader silently chooses an object within the classroom environment—such as a desk, door, duster, chart, or dustbin; without revealing it to other learners. The leader then provides a clue related to the object, for example: "I have seen something in the classroom that begins with the letter 'D'," or "I have seen something that is used for cleaning." Other learners take turns guessing the object based on the clue given. As guesses are made, learners refine their thinking, eliminate incorrect options, and rely on careful observation of their environment. Once the correct object is identified, the learner who guessed correctly becomes the next leader, and the game continues in a rotational manner. This ensures active participation and sustained engagement among learners.

Application in Teaching Science Concepts

The Observation Simulation Game is particularly suitable for Basic Science at the Junior Secondary School One (JSS 1) level, especially under the topic "Learning About Science." Through this game, learners simulate the fundamental role of observation in scientific investigation. They come to understand that science begins with careful and systematic observation of objects and events in the environment. The game also introduces learners to prediction and inference as scientific processes. Learners make educated guesses based on limited information, mirroring how scientists formulate hypotheses when investigating natural phenomena. Furthermore, the activity reinforces the idea that observation is not merely looking but involves purposeful and attentive examination guided by prior knowledge. At the primary school level, the game helps pupils appreciate the use of the sense of sight in identifying objects and features. It also develops language skills, critical thinking, and curiosity, which are essential foundations for scientific learning.

2. **Blind Man Simulation Game:** The Blind Man Simulation Game is best conducted in a safe and spacious outdoor environment such as a playground or open field. Learners form a wide circle, ensuring sufficient space between participants. One learner is selected and blindfolded, becoming the "blind man," and is positioned at the centre of the circle. Another learner, randomly chosen from the circle, calls out the blind man's name or makes a specific sound. The blindfolded learner listens attentively and attempts to trace the direction of the sound by turning and moving cautiously toward the source. The game continues until the blindfolded learner successfully identifies or reaches the speaker. The blindfold is then passed to another learner, allowing several learners to participate in the role.

Application in Teaching Science Concepts

This simulation game effectively demonstrates the use of non-visual senses, particularly hearing and touch, in understanding the environment. It is highly appropriate for Primary Science and lower basic levels, where learners are introduced to the sense organs and their functions. Through this activity, learners simulate how scientists gather information even when vision is impaired or unavailable. The game highlights the importance of sensory compensation, showing that when one sense is restricted, others become more active. Learners also engage in guessing, inference, and spatial reasoning, as they rely on sound cues to make judgments about direction and distance. In addition, the game fosters empathy and awareness of physical challenges faced by visually impaired individuals. From a scientific perspective, it reinforces the concept that scientific investigation often involves the coordinated use of multiple senses to obtain reliable information about the environment.

1. **Classification Simulation Game (Leaf Matching):** The Classification Simulation Game, commonly known as Leaf Matching, involves the teacher collecting a variety of leaves from different trees within the school or community environment. These leaves should differ in shape, size, colour, venation, texture, and margin to ensure meaningful comparison. Each learner is given one leaf and instructed to examine it carefully, paying close attention to its observable characteristics. Learners are then taken outside and asked to search for another leaf that closely matches the one given to them. Matching is based on shared features such as shape, size, colour, texture, and pattern of veins. The learner who returns first with a correctly matching leaf is declared the winner, while others are guided to compare their leaves and discuss similarities and differences. The teacher may then lead a class discussion on why certain leaves belong to the same group and others do not.

Application in Teaching Science Concepts

This simulation game is highly effective for teaching the topic “Sorting Things Out” in Junior Secondary School Basic Science. It allows learners to simulate how scientists classify organisms and materials based on observable characteristics. At the primary school level, the game introduces pupils to grouping, classification, specimen collection, and comparison; key scientific processes in biology and environmental science. Learners gain firsthand experience in systematic observation and logical grouping, which are essential skills for understanding biodiversity, plant classification, and ecological studies. The game also encourages environmental awareness, as learners interact directly with natural materials in their surroundings. It promotes inquiry, cooperation, and appreciation of nature while reinforcing the scientific principle that classification helps scientists organize and make sense of the natural world.

3. **Matching Simulation Game (Number Recognition):** The Matching Simulation Game requires carefully prepared instructional materials. These include fifteen numbered cards (1–15) and another set of fifteen cards representing the same numbers using dot patterns. Each card is attached to a string so that it can be worn around learners’ necks. The game is designed for a class of about thirty learners. Each learner wears one card, after which the class sings a song or moves freely around the classroom in a playful manner. At a signal from the teacher, such as ringing a bell or clapping—learners quickly search for their matching partner. For example, a learner wearing the number “3” searches for a learner wearing a card with three dots. Pairs that correctly match stand together, while others continue searching. The learner or pair that consistently finds the correct match within the shortest time is declared the winner.

Application in Teaching Science Concepts

This simulation game is applicable at both Primary and Junior Secondary School levels. It helps learners simulate how scientists observe, identify, recognize patterns, and classify quantities. In Primary Science, the game supports number recognition, counting skills, and basic observation. In Basic Science, it reinforces systematic identification, pattern recognition, and classification processes, which are foundational to scientific measurement and data interpretation. Beyond cognitive development, the game promotes cooperation, quick decision-making, accuracy, and social interaction. These skills are essential for scientific teamwork and problem-solving.

Thus, African simulation games, when thoughtfully integrated into science instruction, provide meaningful, engaging, and culturally relevant learning experiences. They enable learners to actively simulate scientific processes such as observation, classification, prediction, identification, inference, and sensory exploration. Adequately linking science concepts to familiar activities ensures these games bridge the gap between learners' everyday experiences and formal scientific knowledge. In addition to enhancing cognitive understanding, African simulation games promote psychomotor skills, social interaction, curiosity, creativity, and sustained interest in science. Consequently, they serve as valuable pedagogical tools for effective science teaching and learning at the primary and junior secondary school levels, contributing significantly to learner-centred and inquiry-based science education.

Relevance of Simulation Games to Science Teaching

The relevance of simulation games to science teaching is profound and multifaceted, particularly in contemporary educational settings that emphasize learner-centred, activity-based, and inquiry-driven instruction. Simulation games represent structured learning experiences that imitate real-life scientific processes, systems, or problem situations within a controlled classroom environment. By immersing learners in realistic scenarios, simulation games bridge the gap between abstract scientific concepts and practical, observable experiences. Through active participation, exploration, collaboration, and reflection, students develop not only conceptual understanding but also essential scientific skills, attitudes, and values. The relevance of simulation games to science teaching are discussed under the following major dimensions:

1. **Learning by Doing (Experiential Learning):** Simulation games strongly promote experiential learning by enabling students to learn through direct involvement rather than passive reception of information. Learners actively engage in tasks such as observing, predicting, experimenting, classifying, measuring, recording, and interpreting outcomes within simulated scientific contexts. This aligns with the principle that meaningful learning occurs when learners interact directly with materials, ideas, and situations. In simulation environments, students make decisions, test assumptions, and observe the consequences of their actions, thereby constructing knowledge through experience. Errors are treated as learning opportunities rather than failures, encouraging experimentation and risk-taking. This process reflects the natural methods of scientific inquiry, where understanding emerges from active investigation and reflection. Consequently, simulation games help learners internalize scientific concepts more deeply and retain knowledge for longer periods.
2. **Enjoyment and Increased Interest in Science Learning:** One of the most significant contributions of simulation games to science teaching is their ability to make learning enjoyable and stimulating. Science topics that may appear abstract, difficult, or intimidating when taught through conventional methods become more accessible and engaging when presented in game-like formats. The excitement of participating in activities that resemble real-life scientific situations generates curiosity and enthusiasm among learners. Simulation games provide a relatively equal platform for participation, allowing learners of varying academic abilities to contribute meaningfully. Students who may struggle with traditional textbook-based learning often thrive in interactive environments where success is not solely dependent on memorization or verbal responses. This sense of inclusion boosts learners' confidence, promotes positive self-concept, and fosters a more favorable attitude toward science as a subject.
3. **Motivation for Further Inquiry and Independent Learning:** Simulation games serve as powerful motivators for learning by sustaining students' attention and encouraging deep engagement with scientific problems. The immersive nature of simulation activities often sparks learners' desire to explore scientific concepts beyond the immediate classroom task. Students become eager to ask questions, seek explanations, and investigate related phenomena independently. This intrinsic motivation is particularly valuable in science education, where curiosity and inquiry are central goals. Simulation games stimulate learners' investigative instincts and nurture a lifelong interest in scientific exploration. By presenting science as an active and meaningful process rather than a collection of facts, simulation games inspire learners to take ownership of their learning and pursue further inquiry.
4. **Recognition of the Role of Emotions in Learning:** Simulation games explicitly acknowledge the affective dimension of learning, which is often neglected in traditional instructional approaches. By engaging emotions such as curiosity, excitement, empathy, competition, cooperation, and achievement, simulation games create emotionally rich learning experiences. Emotional involvement enhances

attention, strengthens memory, and supports deeper cognitive processing. When learners are emotionally invested in an activity, they are more likely to persist in problem-solving tasks and to develop positive attitudes toward science. Simulation games therefore contribute not only to academic achievement but also to the development of scientific attitudes such as curiosity, openness to new ideas, perseverance, and respect for evidence.

5. **Development of Communication Skills:** Simulation games provide extensive opportunities for the development of both verbal and written communication skills. During simulation activities, learners engage in discussions, debates, negotiations, explanations, and collaborative decision-making. These interactions require students to articulate ideas clearly, listen to others, justify their reasoning, and respond constructively to differing viewpoints. Unlike traditional classroom settings that may induce fear of making mistakes, simulation games create a relaxed and supportive atmosphere where communication occurs naturally and with reduced anxiety. This is particularly beneficial for shy, quiet, or slow learners, who may find it easier to express themselves within group-based and activity-oriented contexts. Over time, learners develop confidence, clarity of expression, and effective scientific communication skills.
6. **Promotion of Interaction, Collaboration, and Peer Learning:** Simulation games encourage cooperative learning and social interaction among students. Learners work together in groups, assume roles, share responsibilities, and collectively solve problems. Such collaboration promotes peer learning, where students learn from one another through shared experiences and collective reflection. In large and heterogeneous classrooms, simulation games allow learners to participate at their own levels without being constrained by uniform expectations. Each student contributes according to their ability, background knowledge, and experience. Moreover, simulation games can be repeated with the same group of learners, and each repetition often yields new insights as students apply lessons learned from previous experiences. This cumulative learning process enhances understanding and promotes continuous improvement.
7. **Encouragement of Personal Growth and Analytical Thinking:** Simulation games contribute significantly to learners' personal development and higher-order thinking skills. Through participation in simulated situations, learners develop the ability to analyze complex systems, identify patterns, recognize relationships, and draw meaningful conclusions. They learn to relate simulated experiences to real-life scientific and societal situations through analogy and extrapolation. These activities foster critical thinking, problem-solving, decision-making, and reflective thinking—skills that are central to scientific reasoning. By engaging learners in structural modelling and interpretation of events, simulation games help students develop a deeper understanding of how scientific principles operate in real-world contexts.

Disadvantages of Simulation Games

Although simulation games offer numerous educational benefits, their limitations must also be acknowledged. While these disadvantages are not particularly pronounced, largely because simulation gaming is relatively new in educational practice; the following challenges have been identified:

1. **Limited Availability of Resources:** Simulation games and their supporting materials are not always readily available in schools, particularly in resource-constrained settings. Designing, adapting, or improvising effective simulation games require time, creativity, and instructional skill. Some teachers may find these demands challenging, especially when faced with heavy workloads and limited instructional support.
2. **Inadequate Teacher Familiarity and Professional Training:** The effective implementation of simulation games requires teachers to understand the structure, rules, objectives, and instructional implications of the games. However, many teachers lack adequate training in this instructional strategy. Even when teachers are aware of simulation games, they may avoid using them due to limited confidence, time constraints, financial considerations, or insufficient professional development opportunities.
3. **Classroom Management Challenges:** Simulation games often involve increased movement, interaction, and noise compared to traditional classroom activities. Without proper planning and management strategies, such activities may become disruptive. In classrooms or school environments

with strict noise regulations, teachers may find it difficult to implement simulation games effectively unless clear rules and control measures are established.

- 4. Curriculum Integration Difficulties:** Integrating simulation games into rigid or examination-driven curricula can be challenging. When curriculum content is narrowly defined or heavily focused on coverage rather than understanding, teachers may struggle to allocate sufficient time for simulation activities. Successful integration depends largely on the teacher's creativity, flexibility, and ability to align simulation games with specific learning objectives and curriculum requirements.

Educational Implications of Simulation Games

Simulation games have far-reaching implications for science teaching and learning. They represent instructional approaches that emphasize learner autonomy, active participation, and collaborative learning within supportive and non-threatening environments. Learning through simulation games is characterized by minimal coercion and maximum engagement, allowing learners to develop responsibility for their own learning outcomes. Simulation games strongly support discovery and inquiry-based learning, long advocated by educational theorists such as John Dewey, Jerome Bruner, and Joseph Schwab. Key features of this approach include immersion in problem situations, formulation of hypotheses, informed guessing, experimentation, and evaluation of outcomes. These processes mirror authentic scientific inquiry and help learners understand science as a dynamic and investigative discipline.

Another important implication concerns the evolving role of the teacher. In simulation-based instruction, the teacher does not dominate the learning process or dictate outcomes. Instead, the teacher functions as a facilitator, organizer, and guide. Responsibilities include planning the activity, explaining objectives and rules, assigning roles, arranging the learning environment, monitoring progress, and leading post-simulation discussions. By stepping back from direct instruction, the teacher empowers learners to think independently, collaborate effectively, and construct knowledge through experience. However, simulation games occupy a vital place in science education by promoting experiential learning, motivation, emotional engagement, collaboration, critical thinking, and learner autonomy. When thoughtfully planned and effectively implemented, they enrich science teaching and contribute significantly to the holistic development of learners.

Conclusion

One of the critical challenges confronting contemporary science education is the need to strengthen learners' capacity to apply scientific tools, concepts, and principles to novel and real-life problem-solving situations. This competence is gradually developed through meaningful learning experiences provided within the science classroom. However, conventional instructional approaches often fall short in creating rich, interactive, and realistic learning environments that foster such higher-order skills. In response to these limitations, there is an urgent need for a thoughtful reappraisal of teachers' classroom strategies. Simulation gaming techniques, by replicating real-life scientific situations in an engaging and experiential manner, offer considerable potential for improving the quality, depth, and effectiveness of science instruction. Their deliberate and sustained integration into science teaching can significantly enhance learners' understanding, motivation, and ability to transfer knowledge beyond the classroom. Consequently, greater emphasis should be placed on the systematic adoption of simulation games as a viable instructional strategy in science education.

Suggestions

Based on the issues discussed in this paper, the following suggestions were proposed to strengthen the adoption and effectiveness of simulation gaming strategies in science education:

1. Curriculum planners should integrate African simulation gaming activities into science syllabi to make learning more interactive and culturally relevant.
2. Head-teachers should provide the necessary resources and support for teachers to implement simulation games effectively in classrooms.
3. Teachers should receive regular training and workshops on designing and facilitating simulation games for diverse science concepts.

4. Education policymakers should encourage collaboration between schools to share best practices and successful simulation game models.
5. Teachers should use continuous assessment and feedback to evaluate the impact of simulation gaming on students' understanding and engagement in science.

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