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# Effects of Game-Based and Exploratory Strategies on Science Content Knowledge and Science Processing Skills of Pre-Primary Children

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## ABSTRACT

Pre-primary school children have less exposure to science-related activities possibly because of the strategy adopted during teaching activities, which might likely affect their acquisition of science knowledge and processing skills later. Hence, this study adopted game-based and exploratory strategies to engage the pre-primary children in some concepts in pre-primary science. The purposive random sampling technique was used to select three pre-primary public schools in one local government. Two were assigned to experimental groups of game-based and exploratory strategies respectively while one was assigned to the control group. 59 pre-primary children participated. Pre-test-post-test control group quasi-experimental design was adopted. Six research questions were answered and three hypotheses were tested at a 0.05 level of significance. Five research instruments were used to collect data. Data were analyzed using analysis of covariance (ANCOVA) and Scheffe posthoc test. Results showed significant effects of treatments on pre-primary children's science knowledge and processing skills. There were mean gains of 2.0 (game-based); 1.63 (explorative) and 0.55 (conventional) points in science knowledge. There were also mean gains of 19.45 (game-based); 20.58 (exploratory) and 10.55 (conventional) points in the processing skills of pre-primary children. The exploratory strategy was more effective than the game based on science process skills and knowledge. The conventional strategy was less effective than the two. Game-based and exploratory strategies were recommended for pre-primary teachers in teaching science concepts.

**Keywords:** Game-Based and Exploratory Strategies, Science Knowledge, Science Process Skills



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## 1. INTRODUCTION

The gains of science to global, national, society development and sustainability demand that its knowledge and skills should be exposed to every citizen as early as possible especially children during the early years. The early years are known as the period of rapid development when solid foundations should be laid for the knowledge and skills needed for meaningful living and learning. The education provided for children during the early years is basically to give them a strong beginning. This implies children should have a strong beginning in every area of learning including science. Science is derived from two Latin words “Scientia” which means “to know” or to have “knowledge” and “Scio-ire-ivi-iture” which also means “to know” to have skill in” or “to know how to’’. It is simply a way to gain knowledge about how and why things happen the way they do by engaging senses or equipment to observe the world and experiments to investigate how it works. UNICEF (2023) says science shows that life is a story for which the beginning set the tone. It has been described as man’s efforts to understand and solve problems that exist or will exist in the environment. However, Lind (1998) affirmed that children are not too young to be scientifically literate

The introduction of science in the education of children has attracted justifications from scholars globally. Some of these focused on future learning while some considered children’s nature as a major factor to be considered for bringing in science as early as possible. Eshach (2006) expresses that an early introduction to science can lead to a better understanding of science concepts studied later in a more former way. According to Mantzicopoulos & Samarapungavan, (2007), early engagement in science has the capacity to stimulate the development of concepts of oneself as a science learner and a participant in the process of science. Brenneman (2011) opines that early exposure to science can serve as the foundation for future learning. Akintemi (2019) also opine that those early years are considered the right time to expose children to meaningful science learning, prepare them for science in primary school and to lay the foundation for science learning at other levels of education.

The basis of the nature of children as a factor for the inclusion of science activities in the early years expresses that right from birth, children have an innate predisposition to explore and experiment with things around them. They are curious about the world around them, this is invariably the beginning of science. The natural curiosity in children could be encouraged and adequately nurtured by science activities to further prepare them in understanding the world around them and contribute to its development and sustainability. Howitt and Blakes (2010) say that where there is a child, there is curiosity, and where there is curiosity, there is science. Science meets the natural curiosity of children of their environment (Carulla, 2020). Children usually enter school with their curiosity about the world. They talk about things, ask questions and find out why certain things are and some are not (Ogunsanwo, 2003). Since natural skill which is curiosity is already available in them, science activities will further equip them to satisfy it.

The justifications for the inclusion of science during the early years had created space for it in the pre-primary curriculum at both the national and international levels. Science is being introduced into the Swedish curriculum for children to “develop their understanding of science and relationships in nature as well as knowledge of plants, animals and also simple chemical processes and physical phenomena (The National Agency for Education, (2010) cited by Brostrom 2015). Also, in the Danish curriculum, the Ministry of Social Affairs (2003) made nature and natural phenomenon a major theme, and it stipulated that children should act and get first experiences with nature animal, plants and materials, and get experiences with causes and connections. The Nigerian government is not left out in the race to expose children to science during the early years. Inculcation of the spirit of inquiry is one of the objectives of early childhood education (Federal Government of Nigeria (FGN), 2013). This objective as brief as it is, was more expounded in the curriculum designed specifically for the one-year pre-primary to get it achieved and produce children who will be inquisitive about the environment. Thus, science and technology is included as one of the themes to be taught in the one-year preprimary curriculum (NERDC, 2014).

Science has two basic components; the science body of knowledge and the science process skills by which the knowledge is produced. Akintemi (2019) expresses that science is taught at pre-primary schools to foster scientific knowledge and skills needed for learning science at primary school and beyond. There are contents included in the curriculum that children are expected to possess knowledge of across the globe. This will provide the basic foundation for children about science. According to Rull (2014), scientific knowledge provides a platform to meet the needs of society as well as improve its standard of living as this cuts across all facets of human endeavors such as health, agriculture, education, transportation and communication, and construction among others. This has spurred many nations of the world to be making efforts to advance the teaching and learning of science right from the early childhood level.

Truncles and Shackles (2012) identified three broad content areas that have emerged for preschool science: life science, physical science, and earth/space science. Head Start Bureau (2004) suggests that children are required to have knowledge of their bodies (life science) and the environment (earth science) and also develop a growing awareness of ideas and language related to attributes of time and temperature (physical science). Others like Conezie and French (2002); French and Woodring (2012) argued against the three content areas, they believed they were too broad for children. The authors suggested that children’s science content should focus on observable phenomena that the children can experience in their daily activities such as color and light. NERDC, (2014) documented what to teach the pre-primary children in Nigeria in science and technology under the sub-theme of exploration and discovery which were further broken down to the use of measurement, patterns and designs, problem-solving, pre-basic science pre-basic technology.

Despite the inclusion of these contents in the pre-primary curriculum, it has been reported that children are either not or fully engaged in science-related activities during the early years especially in the public pre-primary school. The teaching of science in the early years has not received a full commitment from preschool teachers. Different scholars have identified many factors that were responsible for this. It is a common practice in the pre-primary that attention is given to numbers and literacy activities more than other areas of learning. Although this is not peculiar to Nigeria, Bostrom (2015) reports that low priority in science is seen in other countries such as America. A report from American research indicated that children’s emergent skills in science learning are not taken into consideration in early childhood classrooms (Tu, 2006; Saçkes et al., 2011). It was also reported that compared with studies on early literacy and mathematics, children have fewer opportunities to learn science (Early et al., 2010; Greenfield et al., 2009). In Nigeria, Ejieh (2006), Shoaga (2010) and Majebi & Oduolowu (2020) had earlier established that priority is given to learning of alphabet and memorisation of facts, information, poems above other areas of learning. This calls for a conscious intervention on science related activities at that level.

The head knowledge of the content of science is not sufficient to have basic foundation in it, process skills are needed to apply the knowledge to situation. Knowledge acquired cannot be effectively applied or practiced without the processes of doing science. Ogunsanwo (2003) asserts that when science is taught mainly in the classroom as a body of knowledge which requires facts and formulas, children are made to memorize facts and there is a lack of active participation in their learning for scientific skills to develop. The science process skills are the skills that scientists use in the process of doing science. Science utilizes a set of skills that could significantly assist in fostering creative and critical thinking in children. These skills which are six in number are referred to as the basic science process skills. Durham (2017) views science process skills as the skills involved in the process of doing science which involves observation, communication, measurement, classification, inference, and prediction. The processes and activities are instrumental in the production of new knowledge which ultimately is known as science.

Observation skills are ranked as the first and most basic skill among the science process skills (Ango, 2002). Observation involves the ability to watch or see an object intensely with the aid of an ordinary sense organ (eye) or accompanied by other instruments (magnifying glasses, microscope, binoculars etc) in order to provide a piece of information or description of what has been seen. The information could be quantitative or qualitative, - a black dog with four legs, the bacteria is alive. Communication skill comes after observation in the science process skill. Communication is the ability to express one's self when describing a situation or an object with the appropriate terms. It could be in written or oral forms. This skill helps children to describe what they observe through the senses or an instrument during a science-oriented activity. Mansfield and Farland-Smith, (2015) confirm that the skill of communication helps children to share their science experiences with others. Measuring skill is another process skill needed in doing science. It involves the use of both standard and non-standard measures to describe or measure the quantity or dimension of an object or liquid. A measurement statement contains two parts, a number to tell how much or how many, and a name for the unit to tell much of what. The use of the number makes a measurement a quantitative observation. Martin (2001) identified five basic entities that children in early childhood programmes measure in science, they include length, volume, weight, temperature, and time. The same areas were included in the pre-primary science theme in Nigeria which the children were exposed to during the course of this study.

Classification skill is also part of the process skill in science. It involves grouping or ordering objects or events into categories based on their attributes or properties such as similarities, differences and interrelationships. For example, children can classify things into living and non-living things, they can also categorise according to the same or different colors, sizes, height, lengths, etc. The skill of inference is another process skill necessary in doing science. It covers the explanation or interpretation that follows after observation. It is the ability to provide a reason for an occurrence or what was observed, data or experienced. For example–it is an observation to say that the weather is cloudy and it is inference to explain that it might rain because the weather is cloudy. Prediction skill is the last of the science process skill. This involves stating the outcome of a future event based on a pattern of evidence or experience. It involves making guesses based on observation and inferences already made. For example, all living things will die if they don't breathe in air. The skill of inferring and predicting are more commonly used among students than children.

Children need these science skills to practice the science knowledge they have acquired. Conezio and French (2002) express that science process skills are very essential skills that children should acquire before they begin primary school. Akintemi (2019) also affirms that the basic science process skills are essential for children to learn science because they form the basis for the development of scientific skills that will be used in the early years and beyond. According to Ekine and Abay () access to the fruits of science at the individual and collective levels, lies primarily with those endowed with scientific knowledge and skills. However, Oduolowu and Akintemi (2017b) reported that children in Ibadan exhibited deficiency in the basic science process skills of observing, communicating, classifying, measuring, predicting and inferring. This calls for an intervention program that will rescue children from this skill deficiency.

Different factors have been associated with these deficiencies in the acquisition of science knowledge and process skill. Most scholars have focused on factors like teachers' attitudes toward the teaching of science in the early years, some teachers do not see the need to expose children to science during the early years (Ejby-Ernst, 2012; Thulin, 2011). Utilization of conventional teaching methods such as memorization, and recitation in teaching science and the lack of opportunities for professional development of science teachers have been identified as some of the factors responsible for the dearth in scientific knowledge and achievement of science education goals right from formative stage to tertiary level (Olaleye, 2002; Onose, Okogun, and Richard (2009) and Oduolowu and Akintemi 2017a).

The most effective way young children learn science is when they are actively engaged in hands-on activities (Bredekamp and Copple, 1997; Lind, 1999; Ogunsanwo, 2003; Moravick, Nolte and Feneey, 2013, Salami 2014). Game-based and exploratory strategies can be used to gainfully engage children during the teaching of science. These strategies promote discoveries, exploration, and experimentation. They provide opportunities to expose children to activities that are hands-on which is essential to lay fthe oundations for science knowledge and science processing skills. They also provide children the opportunity to express their natural nature of play. Ogunsanwo (2003) concluded that learning science involves practice. A lot of activity is required to develop scientific skills. Both Game-based and exploratory strategies could be instrumental in facilitating children's imaginative and creative thinking as well as developing physical, social, moral, cognitive, and emotional strength.

A game-based strategy could be viewed as a learning strategy that facilitates learning by actively involving and engaging children in different types of games that are age, developmentally, and culturally appropriate to teach or explain concepts. Trybus (2015) posited that game-based strategy is the borrowing of certain game principles and applying them to real-life settings to engage users. O'Connolly et al, (2012) argued that game-based strategy is a means of using games in educational contexts to reach educational objectives and these games could be entertaining games or educational games.

Educational games have been found to be viable in connecting scientific knowledge and real-life contexts (Spires, Rowe, Mott & Lester, 2011). Schaaf (2012) concluded that game-based learning is most effective when it aligns with students' needs and curriculum content. Liu and Chen (2013) reported that elementary school children learn science-related concepts by participating in games with educational cards. The use of puzzle games in science lessons has attracted the attention of educational researchers in their various studies (Scott, 2006 & Bowers, 2006). A puzzle is described as anything in the form of a toy, usually requiring children to put pieces of materials together to form a specialised whole (Aremu and Aiyelagbe, 1997). Scott (2002) sees puzzles as problems that are fun to solve. The Cambridge Advance Learner Dictionary (2008) defines puzzles as a game or toy in which you have to fit separate pieces together or a problem or question which you have to answer by using skill of knowledge. Thus, puzzle can be described as a form of hands on, minds on activity where the whole words or pictures deliberately put in piece are to be fixed in appropriate places to form a meaningful word or picture.

Puzzles contribute to achieving meaningful learning. Aremu and Aiyelagbe (1997) and Majebi (2017) established that puzzles make learning to be fun and exciting for the learner, thereby leading to the achievement of desirable outcomes. In the same vein, Anany and Mary (2002) also express that the use of puzzles in teaching and learning improve understanding of abstract concepts and develops problem-solving abilities in students. Gardner (2006) remarks that puzzle-solving is an active type of learning as it engages students with materials more than the passive type of review does. Despite the fact that children have a lot to gain when puzzle is being adopted for teaching, the use of puzzles in teaching and learning in Nigerian schools have been scored very low because they are often used for entertainment and relaxation. Idowu and Ige (2007) and Majebi (2017) reported that the use of puzzles in teaching especially in concepts that are abstract in nature especially in the pre-primary classroom is very scarce. Letina (2021) also reported that teachers generally use game-based learning once to twice a month to motivate students and practice skills, since it has been established that puzzle plays significant roles in teaching and it is rarely used prompted its adoption in this study.

The second strategy adopted for this study is the exploratory strategy. It is an instructional approach that highlights children's interaction in the learning environment. It is a child-centred teaching method that focuses more on the learner. Free flow of creative ideas, experiences and proper understanding of concepts are the keys focus of this learning approach. One way to motivate the students to involve in learning the activity is through the use of an exploratory approach. Concepts are more develop and remembered if they do it by themselves (Narag, 2016). Thus, exploratory learning can be defined as an approach to teaching and learning that encourages learners to examine and investigate new material with the purpose of discovering relationships between existing background knowledge and unfamiliar content and concepts (Murali, 2018). The teaching and learning of science thrive in environment where children are free to explore by moving around and using all their senses to find and gain understanding of the world around them (Ogunsanwo, 2003). Exploratory strategy is a learner-centred pedagogy that proffers different hands-on and minds-on learning experiences to learners to foster active involvement and construct knowledge.

Gender of pupils is a variable that is assumed to affect the learning of science in pre-primary schools. Modern psychology studies have shown that gender as a variable relates to performance (Ezeugo and Agwagah, 2000). Most researchers have found boys performing better than girls (Adeleke, 2008) especially on higher order knowledge, a few others saw girls out-performing boys while some others established no significant difference particularly during early education.

Both Game-based and exploratory strategies are based on the experiential learning theory. The theory was propounded by David Kolb (1984). It states that, "Learning is the process whereby knowledge is created through the transformation of experience". Kolb states that learning involves the acquisition of abstract concepts that can be applied flexibly in a range of situations. In Kolb's theory, the impetus for the development of new concepts is provided by new experiences. Kolb's experiential learning style theory is typically represented by a four stage learning cycle in which the learner touches all the bases. The four stages include: concrete experience (a new experience of situation is encountered, or a reinterpretation of existing experience), reflective observation (of the new experiences, of particular importance are any inconsistencies between experience and understanding), abstract conceptualisation (reflection gives rise to a new idea, or a modification of an existing abstract concept) and active experimentation (the learner applies it to the world around them to see what results). The theory is relevant because children in public pre-primary school were exposed to the contents of pre-basic science which linked with their existing experiences on each of the topics were permitted to generate new ideas. Active experimentation was involved through the use of game and exploratory strategies.

This study examined the effectiveness of game-based and exploratory strategies on the science knowledge and science process skills of pre-primary children. Gender of children is also investigated as a variable that could impact the learning of science knowledge and science process skills in pre-primary schools in spite of the effectiveness of Game-based and exploratory learning strategies.

## 2. METHOD

Three hypotheses were formulated and tested at a 0.05 level of significance:

H01: There is no significant main effect of treatment on pre-primary children
A. science knowledge
B. Science process skills

H02: There is no significant main effect of gender on pre-primary children
A. Science knowledge
B. Science process skills

H03: There is no significant interaction effect of treatment and gender on pre-primary children
A. Science knowledge
B. Science process skills

The study employed a 3x2 pretest-posttest control group quasi-experimental design which involves two experimental and one control group of intact classes. The experimental group was exposed to intervention strategies of game-based and exploratory strategies while the control group was taught using the conventional teaching strategy. The target population consisted of pre-primary children in public schools within Akinyele local government. Purposive random sampling was used to select three pre-primary schools within the local government. The pre-primary schools that have 5-year-oldhildren in pre-primary classes and are operating on the one-year pre-primary curriculum recommended by the FGN were selected.

Stratified random sampling was used to assign one school out of the selected three schools to control group while the remaining two schools were assigned to the experimental groups. The pre-basic science theme employed for teaching in this study was selected from the One Year Pre-primary School Education Curriculum, the topics include: living and non living things, identification and uses of sense organs, measurement (capacity, length and height). The 5 year old pre-primary children were selected for the study because they are still at the pre-operational level of cognitive development which demands active learning experiences. Five research instruments were used namely: Instructional Guides for Teachers on Game-Based Strategy (Puzzle Game), Exploratory Strategy, Conventional Strategy, Pre -primary Children's Science Knowledge Assessment Worksheet (PCSKAW) and Science Process Skills Rating Scale (SPSRS). The face and content validity of the response instruments were ascertained by two experts in the early childhood education unit and statistical analyst. The approved version of PCSKAW and SPSRS were field tested, their reliability were determined using Test-Retest method which yielded a reliability coefficient of 0.84. The data collected was analyzed using analysis of Covariance (ANCOVA) to determine the significant main and interaction effects with pretest scores as covariates. Estimated Marginal Means (EMM) aspect of ANCOVA was employed to detect the magnitude of the mean scores of each group while Scheffe post-hoc analysis was used to determine the sources of significant effects observed in more than two groups. All hypotheses were tested at 0.05 level of significance ($p < 0.05$).

## 3. RESULTS AND DISCUSSION

**Table 1: Demographic Analysis of Treatment Versus Gender**

| | | GENDER | | Total |
|---|---|---|---|---|
| | | MALE | FEMALE | |
| **TREATMENT** | Game-based | 12 | 8 | **20** |
| | Exploratory | 10 | 9 | **19** |
| | Conventional | 12 | 8 | **20** |
| **Total** | | **34** | **25** | **59** |

The sample for this study was made up of 59 children, 20, 19 and 20 participants were exposed to game-based, exploratory and conventional strategies respectively. Of those exposed to game-based, 60% are male and 40% are female. Of those exposed to exploratory, 53% are male and 47% are female and out of those exposed to conventional strategy, 60% are male while 40% are female participants. Generally, 58% of the entire participants are male and 42% are female. This implies that the two sexes are well represented in the study.

*Research Question 1*

What is the mean gain in science knowledge among children exposed to game-based instructional strategy?

**Table 2: Mean Gain in Science Knowledge and Process Skills among those exposed to Game-Based Strategy**

| S/N | Measure | N | Pre-mean score | Post-mean score | Mean Gain (Points) |
|---|---|---|---|---|---|
| **1** | Knowledge | 20 | 11.75 | 13.75 | 2.00 |
| **2** | Process Skill | 20 | 17.30 | 36.75 | 19.45 |

Knowledge among the 20 children exposed to game-based is less than the post-measure mean score (13.75). The treatment was able to add a mean gain (2.0) points. This reflects a little effectiveness of game-based strategy on the science knowledge of the children.

*Research Question 2*

What is the mean gain in science processing skills among children exposed to game-based instructional strategy?

Table 2 revealed that the pre-measures mean score (17.30) in science processing skills among the 20 children exposed to game-based is less than the post-measure mean score (36.75). The treatment was able to add a mean gain (19.45) points. This reflects a huge effectiveness of game-based strategy on the science processing skills.

*Research Question 3*
What is the mean gain in science knowledge among children exposed to exploratory instructional strategy?

**Table 3: Mean Gain in Science Knowledge and Process Skills among those Exposed to Exploratory Strategy**

| S/N | Measure | N | Pre-mean score | Post-mean score | Mean Gain (Points) |
|---|---|---|---|---|---|
| **1** | Knowledge | 19 | 8.74 | 10.37 | 1.63 |
| **2** | Process Skill | 19 | 15.53 | 36.11 | 20.58 |

Table 3 revealed that the pre-measures mean score (8.74) in science knowledge among the 19 children exposed to exploratory is less than the post-measure mean score (10.37). The treatment was able to add a mean gain (1.63) points. This reflects a little effectiveness of exploratory strategy on the science knowledge of the children.

*Research Question 4*
What is the mean gain in science processing skills among children exposed to exploratory instructional strategy?
Table 3 indicated that the pre-measures mean score (15.53) in science processing skills among the 19 children exposed to exploratory is less than the post-measure mean score (36.11). The treatment was able to add a mean gain (20.58) points. This reflects a huge effectiveness of exploratory strategy on the science processing skills.

*Research Question 5*
What is the mean gain in science knowledge among children exposed to conventional instructional strategy?

**Table 4: Mean Gain from Science Knowledge and Processing Skills among those Exposed to Conventional Strategy**

| S/N | Measure | N | Pre-mean score | Post-mean score | Mean Gain (Points) |
|---|---|---|---|---|---|
| **1** | Knowledge | 20 | 7.85 | 8.40 | 0.55 |
| **2** | Process Skill | 20 | 18.85 | 29.40 | 10.55 |

Table 4 showed that the pre-measures mean score (7.85) in science knowledge among the 20 children exposed to conventional strategy is less than the post-measure mean score (8.40). The treatment was able to add a mean gain (0.55) points. This reflects a very little effectiveness of conventional strategy on the science knowledge of the children.

*Research Question 6*
What is the mean gain in science process skills among children exposed to conventional instructional strategy?
Table 4 revealed that the pre-measures mean score (18.85) in science processing skills among the 20 children exposed to conventional is less than the post-measure mean score (29.40). The treatment

was able to add a mean gain (10.55) points. This reflected a huge effectiveness of conventional strategy on the science process skills of the children.

*Hypothesis 1a*

There is no significant main effect of treatment on pre-primary children science knowledge. To test this hypothesis, summary of Analysis of Covariance (ANCOVA) is presented in Table 5

**Table 5: Summary of 3x2 Factorial Analysis of Covariance on Science Knowledge**

| **Tests of Between-Subjects Effects** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Dependent Variable: Post Knowledge** | | | | | | | | |
| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
| Corrected Model | 397.717[a] | 6 | 66.286 | 6.923 | .000 | .444 | 41.536 | .999 |
| Intercept | 313.513 | 1 | 313.513 | 32.742 | .000 | .386 | 32.742 | 1.000 |
| Preknowledge | 27.354 | 1 | 27.354 | 2.857 | .097 | .052 | 2.857 | .382 |
| Treatment | 140.193 | 2 | 70.096 | 7.321 | .002 | .220 | 14.641 | .925 |
| Sex | 17.285 | 1 | 17.285 | 1.805 | .185 | .034 | 1.805 | .261 |
| treatment * sex | 50.952 | 2 | 25.476 | 2.661 | .079 | .093 | 5.321 | .506 |
| Error | 497.910 | 52 | 9.575 | | | | | |
| Total | 7838.000 | 59 | | | | | | |
| Corrected Total | 895.627 | 58 | | | | | | |
| a. R Squared = .444 (Adjusted R Squared = .380) | | | | | | | | |
| b. Computed using alpha = .05 | | | | | | | | |

It could be seen from Table 5 that there is a significant main effect of treatment on pre-primary school children science knowledge ($F(2; 52) = 7.32$; $p<0.05$; Partial $\eta 2 = .002$). Therefore, the null hypothesis 1a is rejected.

To know the magnitude of performance across the groups, Table 6 presents the Estimated Marginal Means.

**Table 6: Estimated Marginal Means on Science Knowledge**

| **Variable** | **N** | **Mean** | **Std. Dev.** |
|---|---|---|---|
| Intercept | | | |
| Pre-score | 59 | 9.458 | - |
| Post-score | 59 | 10.889 | .409 |
| Treatment | | | |
| Game-based | 20 | 13.237 | .784 |
| Exploratory | 19 | 10.650 | .719 |
| Conventional | 20 | 8.775 | .753 |

Table 6 reveal that children exposed to Game-based strategy have the higher science knowledge mean score (13.24), followed by those exposed to exploratory strategy (10.65) while those exposed to conventional strategy had the lowest mean score (8.78). To know the source of significant difference, Scheffe's post-hoc analysis is performed and Table 7 presents the summary.

**Table 7: Summary of Shceffe's Post-hoc Analysis Showing Source(s) of the Significant Effect**

| Treatment | Mean | Game-based | Exploratory | Conventional |
|---|---|---|---|---|
| Game-based | 13.24 | | * | * |
| Exploratory | 10.65 | * | | |
| Conventional | 8.78 | * | | |

Table 7 shows that the significant main effect of treatment exposed by Table 5 is as a result of the significant difference between (a) Game-based and Exploratory (b) Game-based and Conventional strategies. But there is no significant difference between Exploratory and Conventional Strategies in the children performance in science knowledge. This implies that Game-based is better than exploratory and conventional strategies in impacting science knowledge to pre-primary school children.

*Hypothesis 1b*

There is no significant main effect of treatment on pre-primary children science process skills. To test this hypothesis, summary of Analysis of Covariance (ANCOVA) is presented in Table 8.

**Table 8: Summary of 3X2 Factorial Analysis of Covariance on Science Processing Skills**

| **Tests of Between-Subjects Effects** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
| Corrected Model | 1207.831[a] | 6 | 201.305 | 2.883 | .017 | .250 | 17.297 | .853 |
| Intercept | 8273.018 | 1 | 8273.018 | 118.478 | .000 | .695 | 118.478 | 1.000 |
| Preprocessskills | 50.773 | 1 | 50.773 | .727 | .398 | .014 | .727 | .133 |
| Treatment | 821.198 | 2 | 410.599 | 5.880 | .005 | .184 | 11.760 | .856 |
| Sex | 181.805 | 1 | 181.805 | 2.604 | .113 | .048 | 2.604 | .354 |
| treatment * sex | 268.586 | 2 | 134.293 | 1.923 | .156 | .069 | 3.846 | .381 |
| Error | 3631.016 | 52 | 69.827 | | | | | |
| Total | 73247.000 | 59 | | | | | | |
| Corrected Total | 4838.847 | 58 | | | | | | |
| a. R Squared = .250 (Adjusted R Squared = .163) | | | | | | | | |
| b. Computed using alpha = .05 | | | | | | | | |

Table 8 revealed that there is a significant main effect of treatment on pre-primary school children science process skills ($F(2; 52) = 5.88$; $p<0.05$; Partial $\eta 2 = .184$). Therefore, the null hypothesis 1b is rejected.

To know the magnitude of performance across the groups, Table 9 presents the Estimated Marginal Means on science process skills.

**Table 9: Estimated Marginal Means on Science Process Skills**

| Variable | N | Mean | Std. Dev. |
|---|---|---|---|
| Intercept | | | |
| Pre-score | 59 | 17.254 | - |
| | 59 | 34.054 | 1.104 |
| Post-score | | | |
| Treatment | | | |
| Game-based | 20 | 36.977 | 1.908 |
| Exploratory | 19 | 36.542 | 1.936 |
| Conventional | 20 | 28.642 | 1.923 |

Table 9 indicated that children exposed to Game-based strategy have the higher science process skills mean score (36.98), followed by those exposed to exploratory strategy (36.54) while those exposed to conventional strategy had the lowest mean score (28.64). To know the source of significant difference, Scheffe's post-hoc analysis is performed and Table 10 presents the summary.

**Table 10: Summary of Scheffe's Post-hoc Analysis Showing Source(s) of the Significant Effect**

| Treatment | Mean | Game-based | Exploratory | Conventional |
|---|---|---|---|---|
| Game-based | 36.98 | | | * |
| Exploratory | 36.54 | | | * |
| Conventional | 28.64 | * | * | |

Table 10 shows that the significant main effect of treatment exposed by Table 8 is as a result of the significant difference between (a) Game-based and Conventional (b) Exploratory and Conventional strategies. But there is no significant difference between Game-based and Exploratory Strategies in the children performance in science processing Skills. This implies that Game-based and Exploratory strategies are better than conventional strategies in impacting science processing skills into pre-primary school children.

*Hypothesis 2a*

There is no significant main effect of gender on pre-primary children science knowledge.
Table 5 revealed that there is no significant main effect of gender on pre-primary school children science knowledge ($F(1; 52) = 1.81$; $p>0.05$; Partial ɳ2 = .03). Therefore, the null hypothesis 2a is not rejected.

*Hypothesis 2b*

There is no significant main effect of gender on pre-primary children science processing skills.
Table 8 reveals that there is no significant main effect of gender on pre-primary school children science process skills ($F(1; 52) = 2.60$; $p>0.05$; Partial ɳ2 = .05). Therefore, the null hypothesis 2b is not rejected.

*Hypothesis 3a*

There is no significant interaction effect of treatment and gender on pre-primary children science knowledge.
Table 5 reveals that there is no significant interaction effect of treatment and gender on pre-primary school children science knowledge ($F(2; 52) = 2.66$; $p>0.05$; Partial ɳ2 = .09). Therefore, the null hypothesis 3a is not rejected.

*Hypothesis 3b*

There is no significant interaction effect of treatment and gender on pre-primary children science process skills.
Table 8 revealed that there is no significant interaction effect of treatment and gender on pre-primary school children science processing skills ($F(2; 52) = 1.92$; $p>0.05$; Partial ɳ2 = .07). Therefore, the null hypothesis 3b is not rejected.

**Discussion**

The findings from Table 2, 3 and 4 revealed the mean gain in science knowledge and science process skills among children exposed to game-based, exploratory and conventional instructional strategies respectively. The effect of each of the treatments reflects a little effectiveness on children's science knowledge while the same treatment reflected huge effectiveness on science process skills of children. This corroborates the findings of Ukume et al (2019) that revealed that there was a significant difference in the mean English Grammar Achievement Test scores of students taught English grammar using puzzle-game strategy and those taught using the conventional strategy. The finding of Guo et al (2014) also showed that children exhibited significant gains in science content knowledge over the course of the preschool year.

It was revealed in Table 5 that there was a significant main effect of treatment (game-based and exploratory instructional strategies) on science knowledge and science process skills. Table 6 also revealed that children who are exposed to Game-based strategy have the highest science knowledge mean score followed by those exposed to exploratory while those exposed to the conventional strategy had the lowest mean score. Game-based strategy was shown to be better than exploratory and conventional strategies in impacting science knowledge to pre-primary school children in Table 7. This is in line with the result of Arcagog (2021) which revealed that the game-based teaching practices applied in different curricula affect the students' academic achievement positively compared to traditional practices. Omeodu and Fredrick (2019) revealed that students taught the concept of quadratic equation using game teaching method achieved better than their counterparts who were taught using expository method. Ezeugwu, et al (2016) result showed that the use of Game-based instructional technique in teaching affects students' achievement and interest in Algebra. The study carried out by Liu and Chen (2013) shows that game-based learning improved students' scientific knowledge, enhanced students' social skills, and improved their skills in understanding and solving problems.

The findings in Table 8 also clearly showed that there is a significant effect of treatment (game-based and exploratory instructional strategies) on children's science process skill; children who were exposed to game-based strategy have the highest mean followed closely by those exposed to exploratory strategy and lastly conventional strategy with the lowest mean. This indicates that the experimental groups which were exposed to both Game-based and exploratory strategies achieved significantly better than their counterpart in the control group. These significant positive result is in conformity with the previous report by Karadag (2015) where he reinstated the effectiveness of game based strategy to develop cognitive skills, concept/content understanding, higher ordered thinking skills, memory and thinking skills (recall). Kopainsky (2009) submitted that both performance and understanding of learners were significantly better for the experimental group than for the control group when exposed to exploratory strategy. Dejonckheere et. al (2016) also reported that preschool teachers are convinced about the fact that lessons should take place in the form of explorations and that rich experiences can best contribute to learning when the teacher prepares the environment. The two types of puzzles (three Dimensional Puzzle-based and paper and pencil puzzle-based) adopted by Adedoja et.al (2013) were effective at improving pupils' achievement and attitude in Social Studies.

Tables 5 and 8 respectively show that there is no significant main effect of gender on pre-primary children science knowledge and science processing skills. This could be as a result of the fact that children at this stage could not differentiate between one subject or the other. Studies conducted by

David, Kumar and Stanley, Helgeson, (2000), Freedman, (2002), Abayomi, Arigbabu and Mji, (2004), Bilesanmi-Awoderu, (2006) reported that there are no longer distinguishing differences in the cognitive, affective and psychomotor skill achievements of students in respect of gender. Oludipe and Oludipe (2018) also revealed in their study that students' academic achievement in basic science was gender invariant. Though there was slight difference in the post-test mean scores of female (24.89) and male (23.66) students, the difference was not significant.

Tables 5 and 8 respectively further revealed that there is no significant interaction effect of treatment and gender on pre-primary school children's science knowledge and science process skills.

## 4. CONCLUSION

Three main points have been established based on the findings from this study. Firstly, a Game-based strategy is more effective in teaching science concepts in pre-primary school, it suffices to say that both Game-based and Exploratory strategies are both appropriate for teaching science content and processing skills taking into consideration the learning goals to be achieved. Secondly, gender is not a viable factor in learning science concepts, especially during the early years, this implies that the early years can be used to equip children with the knowledge needed to develop in children's interest in science will last till adulthood. Studies have proven beyond all reasonable doubt that gender is of no significance in acquiring science knowledge and processing skills. Thirdly, children love outdoor and active learning because they are active beings, both game based and explorative strategies afford them a wide range of opportunities to observe, explore, experiment and make connections with their environment and thereby experiencing meaningful learning.

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