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Research

Effectiveness of Interactive-Participatory and Mind-Mapping Instructional Strategies on Cognitive Skills Acquisition of Primary School Pupils

Ojo Oluyemi Christianah* and Oloyede Hammed Olawale**

Department of Early Childhood Care and Education, Adeyemi Federal University of Education, Ondo, Nigeria. E-mail: roose4me@yahoo.com
Department of Chemistry, Adeyemi Federal University of Education, Ondo, Nigeria. E-mail: hammedoloyede150@yahoo.com

Highlights

- The study assessed interactive-participatory and mind-mapping strategies on pupils' cognitive skills.
- A quasi-experimental design was used in Ondo State schools.
- The CSAT test (KR-20 = 0.82) measured cognitive performance.
- Interactive-participatory strategy significantly improved skills ($F(1, 86) = 52.300$, $p < .05$).
- The study recommends adopting both strategies and training teachers.

Abstract

This study examines the effectiveness of interactive-participatory and mind-mapping instructional strategies on the cognitive skills acquisition of primary school pupils. A non-equivalent pretest–posttest control group quasi-experimental design was adopted. The population comprised all early childhood pupils in Ondo State. A random sampling method was used to select one local government and three primary schools, which were then assigned to two experimental groups and a control group. A self-designed and validated research instrument, the Cognitive Skill Achievement Test (CSAT), was used; it yielded a high reliability coefficient (Kuder-Richardson 20 = 0.82). The findings revealed that the interactive-participatory instructional strategy had a significant effect on pupils' cognitive skills in Basic Science, $F(1, 86) = 52.300$, $p < .05$. Moreover, the three-way interaction effect of treatment, sex, and age on pupils' cognitive performance in Basic Science was not significant, $F = 1.871$, $p > .05$. The study, therefore, recommends that both instructional strategies be adopted in primary school teaching and that pre-service teachers in university faculties and colleges of education receive thorough training in the effective use of interactive-participatory and mind-mapping strategies.

Keywords: Instructional strategies, interactive-participatory, mind-mapping, cognitive skills, primary school pupils.

***Correspondence**
Akinsemolu Adenike A., akinsemoluaa@aceondo.edu.ng
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1.0 Introduction

Science is a vital tool in the development of any nation. A nation is considered strong when it is technologically advanced; the greater a nation's technological advancement, the more likely it is to be classified as developed. Nations are generally classified as developed, developing, or underdeveloped based on their strength in science and technology. There is no doubt that basic science is the foundation of all scientific study. It represents the first step in the study of science, and it is imperative to foster an interest in the subject among pupils. Basic science is essential for pupils to become scientifically literate and to contribute to the nation's economic development in the near future. Thus, a love for science should be inculcated early in life to foster a scientific mindset that enhances cognitive development.

The primary aim of teaching basic science in primary schools is to create a solid foundation in science, upon which further learning can build. However, several challenges face science teaching and learning at the primary school level, including poor cognitive performance and a dwindling interest in the subject. Oduolowu (2004), Okoruwa (2007), and Ekine (2010) attributed the poor academic performance of pupils in pre-primary and primary school to, among other factors, low instructional self-esteem. Pupils' acquisition of cognitive skills is derived from their life experiences. Childhood represents a unique period of both opportunity and vulnerability, and the goal of cognitive skills acquisition is to promote and enhance pupils' overall well-being and capacities. In this study, the concept of acquisition is used to denote the maximum development of children's cognitive skills.

Education plays a crucial role in developing a child's personality, talents, and mental and physical abilities. One of the objectives of primary education is to provide children with opportunities to develop cognitive skills that will enable them to function effectively in society. Moreover, education should lay a sound basis for scientific and reflective thinking. According to the National Policy on Education, education should inculcate in children the spirit of enquiry and creativity through the exploration of nature, the environment, art, music, and play.

Cognitive development in science, within the context of this study, involves fostering attitudes such as curiosity, observation, prediction, experimentation, sorting, matching, problem solving, perseverance, open-mindedness, tolerance, and cooperation. The extent to which children acquire cognitive, emotional, social, moral, spiritual, and physical competencies is largely determined by their life experiences and the social, cultural, economic, and emotional environment in which they grow up (Howes, 1992). Children should therefore be provided with an environment that offers optimum opportunities for development through adults' guidance and direction.

There is growing evidence that when children are given opportunities to participate actively in the development of their capabilities, they achieve higher levels of competence (Lansdown, 2005). The environment – including adults' attitudes, interactions, stimulation, and the opportunities for children's participation – must be rich enough to foster all-round development (cognitive, social, emotional, physical, spiritual, and linguistic) (Woodhead, 2001). Interactive participation provides children with the opportunity to influence matters that affect them, to learn new skills, to enjoy themselves, and to develop a closer connection to their community. It also helps adults to understand children's perspectives (Aileen, 2000). The process of participation not only aids skill acquisition but also empowers children by instilling self-respect and responsibility. Children who are given opportunities to participate develop negotiation and communication skills, learn the importance of listening to others, and understand the need to abide by agreed decisions. Although observation is one aspect of learning, it offers only a minimal opportunity for skill development compared to interactive-participatory methods.

Mind-mapping is a non-linear approach to learning that encourages radial thinking. In this method, students use key words and images that are non-linearly connected. A mind map resembles a programme of instruction, similar to a computer flowchart, in which only essential words, clauses, and phrases are used; the result is a pictorial representation of information that highlights the interconnections between concepts (Michelini, 2000). Omolara (2014) found that mind-mapping, when used in conjunction with mastery learning, effectively improves students' learning outcomes in physics. However, its use in enhancing cognitive development and life skill acquisition remains limited. This study posits that learning should occur beyond the classroom under natural conditions, where practical activities support development through interaction and participation. Without practical application, theoretical learning alone cannot evolve pupils' capacities. For example, a farmer's son who accompanies his father to the farm learns by observing and actively participating in daily tasks, receiving immediate correction and guidance. This "learning by doing" through active interaction with adults and the environment is essential.

Every pupil is unique in terms of physical, behavioural, cognitive, and interaction styles, as well as in their preferred methods of learning. In conventional teaching methods, all pupils are dependent on the teacher's chosen programme, and success is measured by the ability to recall information. Obih and Ekomaru (2011) have noted that Nigerian teachers are often criticised for their inability to make learning meaningful, engaging, and practical due to their failure to involve pupils actively in the exploration and discovery of knowledge. Most primary school teachers still rely on a teacher-centred, rote-learning approach that rewards pupils for their ability to recall information in tests and examinations. Research has shown that such conventional methods contribute little to conceptual learning and skill acquisition.

Singh (2004) argued that the conventional method is content-centred and renders teachers active but less effective cognitively. This type of classroom resembles a one-person show with a passive audience. Rao (2001) opined that the conventional method emphasises the recall of factual knowledge and largely ignores higher-order cognitive outcomes. Consequently, science learning becomes monotonous, leading to a lack of motivation and interest among pupils. Yore (2001) concluded that a teacher-centred approach, which involves transferring thoughts and meanings to passive students, leaves little room for pupil-initiated questions, independent thought, or interaction among pupils. He further argued that this approach overlooks critical thinking and the integration of unifying concepts, which are essential for true science literacy and skill appreciation. Similarly, Lord (1999) maintained that teacher-centred methods assume uniform background knowledge and learning pace among all pupils, which is rarely the case, thereby widening the gap between high- and low-ability learners.

Zolleer (2000) reported that teacher-centred lessons can be unproductive and, in some cases, detrimental to the learning process. In such lessons, pupils are often required to learn by rote, and even when alternative methods are used, practical support is lacking. To make teaching and learning more natural, interesting, and effective, it is necessary to incorporate practical illustrations and activities. Although the classroom environment may sometimes be insufficient for practical sessions, pupils can be taken outside the classroom to observe phenomena in their natural setting, or real objects can be used to enhance the learning experience. Ogunleye (1993) reported that many pupils develop negative attitudes toward science due to teachers' inability to meet their aspirations and goals in terms of teaching methodology.

Pupils are grouped in the classroom regardless of age and sex. Adelekan (2009) reported that sex has a significant effect on political education, suggesting that it may influence performance in specific tasks (Ajiboye & Salami, 2011; Macdonald & Hara, 2010). However, other studies (e.g., Oluwatosin & Bello, 2015; Ige, 2013; Gbadamosi, 2012; Kehinde-Awoyele, 2012) have revealed that sex has no significant effect on learning outcomes. Bello and Famakinwa (2014) concluded in their study on the comparative effectiveness of generative and predict–observe–explain approaches that there is no significant difference in the cognitive skills of Basic Science based on gender.

Children are active beings who acquire knowledge through their interactions with the environment. They can only develop their capacities when given opportunities to interact with materials and explore their surroundings. Unfortunately, children have long been regarded as passive recipients of instruction from more knowledgeable individuals, a perspective that limits their capacity development. This situation must be addressed through practical approaches that enable children to realise their full potential. Consequently, it is necessary to investigate the effect of interactive-participatory and mind-mapping instructional strategies on the cognitive skills acquisition of lower primary school pupils.

1.1 Research Hypotheses

The following hypotheses will be tested at the 0.05 level of significance:

Ho1. There is no significant difference in the effect of interactive-participatory instructional strategies on the cognitive skills of lower primary school pupils.

Ho2. There is no significant moderating effect of sex and age on the relationship between instructional strategies and the cognitive skills of lower primary school pupils in Basic Science.

2.0 Methodology

The study adopted a non-equivalent pretest–posttest control group design to verify the effect of interactive-participatory and mind-mapping instructional strategies on the cognitive skills acquisition of lower primary school pupils. This design, a type of quasi-experimental design, was chosen because primary schools operate in intact classes, and randomisation of pupils into groups for experimental purposes is not permitted to avoid the disintegration of classes. Measurements were taken both before (pretest) and after (posttest) the introduction of the intervention. The pretest served to assess baseline differences between the experimental and control groups and to establish a benchmark for the treatment effect.

Two experimental groups were exposed to interventions using the interactive-participatory and mind-mapping instructional strategies, while the control group experienced the conventional instructional strategy. The research design is schematically represented as follows:

Experimental Group A: Y_1 (pretest) → X_1 (interactive-participatory instructional strategy) → Y_2 (posttest)

Experimental Group B: Y_3 (pretest) → X_2 (mind-mapping instructional strategy) → Y_4 (posttest)

Control Group C: Y_5 (pretest) → X_3 (conventional instructional strategy) → Y_6 (posttest)

where:

Y_1 and Y_2 represent the pretest and posttest scores for Experimental Group A;

Y_3 and Y_4 represent the pretest and posttest scores for Experimental Group B;

Y_5 and Y_6 represent the pretest and posttest scores for the control group (conventional classroom practice);

X_1 = Interactive-Participatory Instructional Strategy (IPIS);

X_2 = Mind Mapping Instructional Strategy (MMIS); and

X_3 = Conventional Instructional Strategy (Control).

The population for the study comprised all primary school pupils in Ondo State. According to the Ministry of Education, there are approximately 267 registered primary schools in the Ondo West Local Government Area of Ondo State. A simple random sampling technique was used to select three primary schools, which were then randomly assigned to Experimental Groups A and B and Control Group C.

A single research instrument, the Cognitive Skill Achievement Test (CSAT), was used. The CSAT was divided into two parts. Part A gathered demographic information (e.g., sex, class, age, and school name), and Part B consisted of 25 structured multiple-choice questions. The CSAT was administered as both a pretest and a posttest to determine the effect of the interventions on the pupils' cognitive skills acquisition. Two education experts reviewed the instrument for face validity, and their suggestions were incorporated into the final selection of items. Field testing was conducted with 20 pupils outside the scope of the study, and a test–retest method was employed to generate two sets of scores, which were then correlated to determine the reliability of the instrument.

3.0 Results

3.1 Hypothesis 1 (Ho1)

There is no significant difference between interactive-participatory and mind-mapping instructional strategies on the cognitive skills of primary school pupils.

Table 1: ANCOVA of the Achievement Exposed to the Interactive-Participatory and Mind-Mapping Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Effect Size
Corrected Model	9,955.178^a	3	3,318.393	27.819	.000	.493
Intercept	4,735.923	1	4,735.923	39.703	.000	.316
Pretest	2,168.756	1	2,168.756	18.182	.000	.175
Interactive-Participatory	6,238.521	1	6,238.521	52.300	.000	.378
Mind-Mapping	93.265	1	93.265	.782	.379	.009
Error	10,258.377	86	119.283			
Total	510,098.000	90				
Corrected Total	20,213.556	89				

$R^2 = .493$ (Adjusted $R^2 = .475$)

As shown in Table 1, the null hypothesis is rejected for the interactive-participatory strategy, indicating a significant effect on pupils' cognitive skills acquisition in Basic Science, $F(1, 86) = 52.300$, $p = .001$. However, for the mind-mapping instructional strategy, the null hypothesis is accepted, as the strategy had no significant effect on pupils' cognitive skills acquisition in Basic Science, $F(1, 86) = .782$, $p = .379$. The average cognitive skill score for pupils exposed to the interactive-participatory strategy ($M = 86.87$) was significantly different from that of pupils exposed to the mind-mapping strategy ($M = 68.37$) and the conventional strategy ($M = 66.10$). These results suggest that the interactive-participatory strategy is more effective in developing cognitive skills.

This finding supports Adodo's (2013) assertion that mind-mapping, when used as an instructional approach, is potent in increasing students' achievement scores, knowledge, and retention. Similarly, Metu and Metu (2012) demonstrated that mind-mapping as a note-taking approach in Economics helps students to encode important data and serves as an external memory device.

3.2 Hypothesis 2 (Ho2)

There is no significant moderating effect of sex and age with instructional strategies on the cognitive skills of lower primary school pupils in Basic Science.

Table 2: ANCOVA Showing the Effect of Interactive-Participatory and Mind-Mapping Instructional Strategies on Cognitive Skills of Pupils in Basic Science (Hierarchical Method)

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta^2
Covariates						
Cognitive pre-achievement skills	8,808.285	1	8,808.285	101.527	.000	0.351
(Combined)	3,343.923	4	835.981	9.636	.000	
Main Effects						
Treatment	3,290.345	2	1,645.173	18.963	.000	0.416
Sex	42.329	1	42.329	.488	.487	0.047
Age	11.249	1	11.249	.130	.720	0.024
(Combined)	1,056.355	5	211.271	2.435	.042	
2-Way Interactions						
Treatment × Sex	655.289	2	327.644	3.777	.027	0.114
Treatment × Age	342.320	2	171.160	1.973	.146	0.033
Sex × Age	5.735	1	5.735	.066	.798	0.000
3-Way Interactions						
Treatment × Sex × Age	324.631	2	162.316	1.871	.161	0.046
Model	13,533.195	12	1,127.766	12.999	.000	0.601
Residual	6,680.361	77	86.758			
Total	20,213.556	89				

Model goodness of fit for factors and covariate:

R = 0.765; R^2 = 0.601

To examine the moderating effects of age, gender, and instructional strategies on pupils' cognitive skills (achievement) in Basic Science, an analysis of covariance using the hierarchical method was conducted. Table 2 displays the interaction effects of age and gender on pupils' cognitive skill achievement. The results indicate that there is no significant interaction effect between age and treatment (i.e., instructional strategies) on pupils' cognitive skills in Basic Science, $F(2, 77) = 1.973$, $p > .05$. Therefore, the null hypothesis for the moderating effect of age was accepted in the two-way interaction. The interaction of age and instructional strategies accounted for 3.3% of the variation in pupils' cognitive ability in Basic Science.

Conversely, the results showed a significant interaction effect between sex and treatment on pupils' cognitive skills, $F(2, 77) = 3.777$, $p < .05$. Thus, the null hypothesis is rejected for the moderation effect of sex on cognitive skills, with the interaction accounting for 11.4% of the variation in pupils' cognitive achievement in the subject.

Finally, when examining the three-way interaction effect of treatment, sex, and age, the results indicated no significant interaction effect on pupils' cognitive performance in Basic Science, $F = 1.871$, $p > .05$, with 4.6% of the variation in pupils' cognitive skills attributable to the interaction of these three factors. Overall, the entire model explains 60.1% of the variance in pupils' cognitive skills.

4.0 Conclusion

Based on the results, it can be inferred that the interactive-participatory instructional strategy is more effective in the cognitive skills acquisition of pupils in Basic Science than the mind-mapping strategy. Although the interactive-participatory strategy showed a significant effect on cognitive skills, the difference in mean scores indicated that the interactive-participatory approach resulted in higher achievement compared with both the mind-mapping and conventional strategies. This finding supports previous research (e.g., Mansaray & Ajiboye, 2002; Oyetade, 2003; Falade, 2007; Kehinde-Awoyele, 2012) suggesting that interactive-participatory strategies enable participants to be actively involved in learning activities.

Furthermore, the results indicated that the age of pupils did not significantly affect cognitive skills, and the combined effects of sex and age did not influence cognitive skills in Basic Science. The three-way interaction effect of sex, age, and instructional strategies was also not significant, which contrasts with some earlier studies (e.g., Bello & Famakinwa, 2014; Jegede & Inyang, 1990) that reported differences in academic performance based on gender.

5.0 Recommendations

Based on the findings of this study, the following recommendations are made to improve the cognitive skills acquisition of pupils in Basic Science:

1. Adoption of Instructional Strategies: Curriculum planners should incorporate interactive-participatory and mind-mapping instructional strategies as approved methods for teaching in primary schools.
2. Teacher Training: Pre-service teachers in university faculties and colleges of education should receive comprehensive training in the effective use of interactive-participatory and mind-mapping strategies to enhance teaching effectiveness.
3. Practical Application: Schools should ensure that practical, hands-on learning experiences complement theoretical lessons to support cognitive development and improve pupils' engagement with Basic Science.

6.0 References

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Data availability statement

Data will be made available on request.

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Conflict of Interest

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