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Guided Inquiry Method and Achievement of Basic Science Students in Different Levels of Scientific Literacy

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Abstract
This study investigates the effectiveness of the guided inquiry teaching method in enhancing basic science achievement among junior secondary school students with varying levels of scientific literacy. A sample of 147 JSS3 basic science students was drawn from six junior secondary schools in Obio-Akpor local government area of Rivers State, Nigeria, utilizing random sampling techniques. The study employed a pre-test, post-test, non-equivalent control group design, with basic science concepts taught using either guided inquiry or expository methods. The Basic Science Achievement Test (BSAT) and the Scientific Literacy Test (SLT) were utilized as assessment tools. Kuder-Richardson formula 20 (KR-20) was employed to compute the reliability of BSAT to obtain an index of 0.93 whereas SLT utilized the Cronbach's alpha formula, resulting in a reliability estimate of 0.70. Mean and Standard deviation were used to answer the research questions whereas the ANCOVA was used to test the hypotheses at 0.05 level of significance. Results revealed that the guided inquiry method significantly improved basic science achievement compared to the expository approach across all levels of scientific literacy. However, no statistically significant interaction was found between teaching methods and scientific literacy levels regarding basic science achievement. This study provides valuable insights into effective teaching strategies for enhancing basic science learning outcomes, emphasizing the importance of incorporating guided inquiry methods in science education.

Keywords: Methods, Students, Different Level, Scientific Literacy

Introduction

The performance of students in junior secondary school basic science has not been encouraging. Various factors have been identified as hindrances to students' achievement of basic science instructional objectives, with inappropriate and uninspiring teaching strategies adopted by basic science educators being among the most common. Some researchers argue that teachers tend to avoid activity-oriented teaching methods, which are known to be effective, opting instead for easier but often inadequate and inappropriate approaches. Achievement in the teaching and learning process refers to the fulfillment of instructional objectives. For instance, when a learner successfully completes a task and reaches the specified goal for a particular learning experience, they are deemed to have achieved. Basic Science, also known as fundamental or pure science, refers to the systematic study of natural phenomena and principles to advance our understanding of the universe. It forms the foundation upon which applied sciences and technologies are built. Several studies have examined the significance and role of Basic Science in scientific research and innovation. Stephan (2012) highlights the long-term economic benefits of investing in basic science. It is found that countries with robust basic science research infrastructures tend to experience higher rates of innovation, economic growth, and technological advancement over time. Basic Science serves as a catalyst for driving socioeconomic progress and competitiveness in the global marketplace. Basic Science plays a foundational role in advancing knowledge, driving innovation, and addressing societal challenges.

Scientific literacy, often defined as the ability to understand and engage with scientific concepts and processes, is crucial in today's complex world. It empowers individuals to make informed decisions about issues ranging from healthcare and technology to environmental sustainability. Various scholars have contributed to understanding the importance and components of scientific literacy. Norris and Phillips (2003) emphasize the importance of scientific literacy in fostering informed citizenship and democratic participation. They argue that a scientifically literate population is better equipped to evaluate scientific claims, participate in public discourse on science-related issues, and hold policymakers accountable for evidence-based decision-making.

In today's digital age, media plays a significant role in shaping public perceptions of science. Scheufele and Lewenstein (2005) highlight the importance of media literacy in enhancing scientific literacy. They argue that individuals must develop critical media literacy skills to discern reliable scientific information from misinformation and pseudoscience perpetuated by various media sources. Achieving scientific literacy requires ongoing education and engagement with scientific concepts throughout one's lifetime. Osborne and Dillon (2008) stress the role of formal education in promoting scientific literacy, but they also emphasize the importance of informal learning experiences, such as science communication initiatives and public engagement activities. Scientific literacy is essential for navigating the complexities of the modern world and participating effectively in democratic societies. By understanding scientific concepts, processes, and their societal implications, individuals can make informed decisions, critically evaluate scientific information, and contribute meaningfully to public discourse on science-related issues.

The guided inquiry method is an instructional approach that emphasizes active student engagement in the process of scientific inquiry, supported by teacher guidance and scaffolding. Several scholars have examined the effectiveness and implementation of guided inquiry in science education. Harlen and Qualter (2004), guided inquiry is described as an approach where students are provided with opportunities to explore scientific phenomena through hands-on activities, while the teacher serves as a facilitator who guides students' thinking and inquiry processes. This method promotes deeper understanding of scientific concepts by allowing students to construct their knowledge through investigation and problem-solving. Hofstein and Lunetta (2004) emphasize the importance of teacher guidance in facilitating effective inquiry-based learning experiences. They argue that teachers play a critical role in structuring inquiry activities, posing guiding questions, and providing feedback to help students make sense of their observations and findings. Windschitl et al. (2008) explores the impact of guided inquiry on students' cognitive and conceptual development in science. They found that students engaged in guided inquiry activities demonstrated greater gains in scientific reasoning skills and conceptual understanding compared to those in traditional, teacher-centered classrooms. This suggests that guided inquiry fosters deeper engagement with scientific content and promotes higher-order thinking skills. Guided inquiry offers a student-centered approach to science education that promotes active learning, critical thinking, and conceptual understanding. By providing scaffolding and support, teachers can empower students to engage in authentic scientific inquiry and develop essential skills for success in STEM fields.

The guided inquiry method has been recognized as an effective instructional approach for improving the achievement of basic science students. Minner et al. (2010) conducted a meta-analysis of studies examining the effectiveness of inquiry-based instruction in science education. The meta-analysis found that inquiry-based approaches, including guided inquiry, were associated with higher student achievement across various science disciplines, including basic science. Guided inquiry method has been shown to positively impact the achievement of basic science students by promoting deeper conceptual understanding, critical thinking skills, and active engagement with scientific concepts. By providing opportunities for hands-on exploration and guided investigation, guided inquiry facilitates meaningful learning experiences that enhance students' academic performance in basic science education. The interaction effect of teaching methods and scientific literacy refers to how different instructional approaches may have varying impacts on individuals depending on their level of scientific literacy. Several studies have explored this interaction and its implications for science education. Sadler et al. (2013) explored how different instructional strategies interact with students' scientific literacy to influence their understanding of complex environmental issues. They found that inquiry-based learning approaches were particularly effective for students with higher levels of scientific literacy, allowing them to engage deeply with scientific concepts and apply their knowledge to real-world problems. These findings highlight the importance of considering students' scientific literacy levels when designing and implementing instructional strategies in science education. Tailoring teaching methods to students' existing knowledge and skills can enhance learning outcomes and promote equitable access to scientific knowledge. The interaction between teaching methods and scientific literacy underscores the need for flexible and adaptive instructional approaches in science education. By understanding how students' prior knowledge and skills influence their learning experiences, educators can design more effective instruction that meets the diverse needs of learners.

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Statement of the problem

The problem of the study lies in the current state of basic science education among junior secondary school students, which is characterized by low performance and a lack of effective teaching strategies. Specifically, the issue revolves around the inadequacy of teaching methods employed by basic science educators, which are often inappropriate and uninspiring. This issue hinders students' achievement of basic science instructional objectives and undermines the cultivation of scientific literacy, a crucial skill for making informed decisions in personal and civic life. Moreover, there is a gap in understanding how different teaching methods, such as guided inquiry impacts students' achievement in basic science, particularly in the context of their varying levels of scientific literacy. Therefore, the problem of the study is to investigate the effectiveness of innovative teaching strategies, considering students' scientific literacy levels, to improve achievement in basic science education among junior secondary school students.

Aim and Objectives of the Study

The study explores the effect of guided inquiry method and achievement of basic science students in different levels of scientific literacy. Specifically, the study seeks to.

1. Identify efficacy of the guided inquiry method on basic science student achievement considering their varying scientific literacy levels
2. Investigate the interaction effect of teaching methods and scientific literacy levels students’ basic science. achievement

Research questions

The following research questions guided this study.

1. How does guided inquiry strategy affect the mean achievement scores of students in basic science considering their varying scientific literacy levels?
2. How does the teaching strategy interact with the scientific literacy levels of junior secondary school students influence their achievement in basic science?

Hypotheses

$H0_1$: There is no significant difference in the mean achievement scores of students of basic science students taught basic science using guided inquiry method and those taught basic science using the expository method.
$H0_2$: There is no significant interaction effect of teaching methods and scientific literacy levels on students’ achievement in basic science.

Methodology

A pre-test, post-test, non-equivalent control group design was employed for this study. This design was selected due to the practical constraint of utilizing intact classes, making it unfeasible to administer treatments to individual subjects. Therefore, treatments were applied at the class level, with intact classes assigned to either the experimental or control group. The sample consisted of 147 Junior Secondary School 3 (JSS3) Basic Science students drawn from six junior secondary schools in the Obio-Akpor local government area of Rivers State, Nigeria. Random sampling was utilized to ensure representation across genders and streams within each school. Schools were randomly assigned to either the experimental (n=85) or control(n=62) group. Data were collected using two instruments: The Basic Science Achievement Test (BSAT) and the Scientific Literacy Test (SLT). The BSAT comprised 50 multiple-choice test items aligned with a test blueprint to ensure content validity. The SLT categorized students into different levels of scientific literacy and included multiple-choice items, short essay questions, and scientific statements. Reliability estimates for each test section were calculated using appropriate psychometric tests. Specifically, Kuder-Richardson formula 20 (KR-20) was employed to compute the reliability of BSAT to obtain an index of 0.93 whereas SLT utilized Cronbach's alpha formula, resulting in a reliability estimate of 0.70. Regular basic science teachers from selected schools underwent a four-week training program conducted by the researcher to ensure consistency in teaching methodology. The training included two-hour sessions per week and provided teachers with validated lesson plans and copies of the assessment instruments. The SLT was administered as a pre-test to categorize students into high, medium, and low levels of scientific literacy. Subsequently, the BSAT was administered as a pre-test before the treatment commenced. The experimental group received instruction on the digestive system using the guided inquiry method, while the control group received instruction using the expository method. After the six-week treatment period, the BSAT was administered again as a post-test to measure changes in basic science achievement. Quantitative data analysis was conducted using appropriate statistical techniques to compare the effectiveness of guided inquiry and expository teaching methods in improving basic science student achievement across scientific literacy levels.

Results

The data for addressing the research question were acquired by calculating the pre-test and post-test mean achievement scores and standard deviations of students in the BSAT.

The findings, as depicted in Table 1, illustrate a significant contrast between the pre-test and post-test scores across all levels of scientific literacy students, irrespective of whether the guided inquiry or the expository method was employed.

Table 1: Pre-test and post-test mean achievement scores and standard deviations of students in BSAT attributed to teaching methods and scientific literacy levels.

Teaching method	Types test	High		Medium		Low	
		Mean	SD	Mean	SD	Mean	SD
Guided inquiry	Pretest	29.23	7.98	28.00	12.91	20.18	10.19
	Post test	62.69	9.07	49.53	16.02	37.26	10.45
Expository	Pre-test	38.65	14.23	23.43	12.22	27.67	10.45
	Post-test	54.78	12.75	43.13	14.13	14.13	15.74

The table presents the pre-test and post-test mean achievement scores and standard deviations of students in the Basic Science Achievement Test (BSAT) attributed to teaching methods (guided inquiry and expository) and scientific literacy levels (high, medium, and low). For students taught using the guided inquiry method, there was a noticeable improvement in mean achievement scores from the pre-test to the post-test across all levels of scientific literacy. Specifically, for students with high scientific literacy, the mean score increased from 29.23 (SD = 7.98) in the pre-test to 62.69 (SD = 9.07) in the post-test. Similarly, students with medium scientific literacy exhibited an increase in mean scores from 28.00 (SD = 12.91) to 49.53 (SD = 16.02), while those with low scientific literacy showed improvement from 20.18 (SD = 10.19) to 37.26 (SD = 10.45). Conversely, students taught using the expository method also showed improvements in mean achievement scores from the pre-test to the post-test, albeit to a lesser extent compared to guided inquiry. Students with high scientific literacy had a mean score increase from 38.65 (SD = 14.23) to 54.78 (SD = 12.75). Those with medium scientific literacy increased from 23.43 (SD = 12.22) to 43.13 (SD = 14.13), while students with low scientific literacy showed a rise from 27.67 (SD = 10.45) to 37.74 (SD = 15.74). The results suggest that both teaching methods led to improvements in student achievement scores, with guided inquiry demonstrating more substantial gains across all levels of scientific literacy compared to the expository method. Moreover, students with high scientific literacy generally achieved higher mean scores than those with medium or low scientific literacy levels, regardless of the teaching method employed.

Table 2: Adjusted mean and standard deviation scores of students' achievement in basic science by teaching methods and scientific literacy levels

Teaching Methods		High	Medium	Low
Guided inquiry	N	13	34	38
	Mean	23.46	21.62	17.42
	SD	8.18	16.55	11.70
Expository	N	23	21	18
	Mean	15.52	20.00	14.94
	SD	13.24	10.90	13.76

Table 2 presents the adjusted mean and standard deviation scores of students' achievement in basic science, categorized by teaching methods (guided inquiry and expository) and scientific literacy levels (high, medium, and low). For students taught using the guided inquiry method, the adjusted mean scores varied across different levels of scientific literacy. Among students with high scientific literacy, the mean achievement score was 23.46 (SD = 8.18), indicating a moderate level of achievement. In comparison, students with medium scientific literacy had a slightly lower mean score of 21.62 (SD = 16.55), while those with low scientific literacy achieved a mean score of 17.42 (SD = 11.70), indicating lower achievement levels. Equally, for students taught using the expository method, the adjusted mean scores also varied across scientific literacy levels. Among students with high scientific literacy, the mean achievement score was 15.52 (SD = 13.24), suggesting a lower level of achievement compared to guided inquiry. Students with medium scientific literacy achieved a higher mean score of 20.00 (SD = 10.90), indicating moderate achievement levels. Those with low scientific literacy achieved a mean score of 14.94 (SD = 13.76), similar to students taught using guided inquiry. The results suggest that guided inquiry tended to result in higher adjusted mean achievement scores compared to the expository method across all levels of scientific literacy. Additionally, there appears to be greater variability in achievement scores among students taught using guided inquiry, particularly evident in the wider standard deviation values, indicating a more diverse range of achievement levels within each scientific literacy category.

Table 3: analysis of co-variance (ANOCVA) of students = overall achievement scores by teaching method and scientific literacy levels.

Sources of variance	SS	Df	MS	F	p
Pre-test	5645.117	1	5645.117	39.014	0.000
Main effects	2469.057	3	823.019	5.588	0.001
Teaching method	645.973	1	645.973	4.464	0.036
Scientific literacy level	2218.539	2	1109.269	7.666	0.001
Interaction	211.737	2	105.868	0.732	0.483
Explained	15652.066	6	2608.678	18.029	0.000
Residual	20257.430	140	144.696		
Total	35909.496	146	245.955		

x. significant difference at 0.05 level.

Regarding hypothesis one ($H0_1$), which posited that There is no significant difference in the mean achievement scores of students of basic science students taught basic science using the guided inquiry method and those taught basic science using the expository method. The data in Table 3 indicate that the effect of teaching method has an F-value of 4.464 at 1 and 140 degrees of freedom, which is significant at 0.05 level of significance. For hypothesis two ($H0_2$), which compared the interaction pattern between teaching methods and scientific literacy levels on achievement in basic science, the data in Table 3 reveal that the two-way interaction between teaching methods and scientific literacy levels is 0.732 at 2 and 140 degrees of freedom, a value that is not significant at the 0.05 level. Thus, the hypothesis of no significant interaction between teaching methods and scientific literacy levels is not rejected. Moreover, the data in Table 3 show that the main effect of scientific literacy level has an F-value of 7.666 at 2 and 140 degrees of freedom, which is significant at the 0.05 level of confidence. These results imply that there is a significant difference in the mean achievement scores of students at high, medium, and low levels of scientific literacy taught basic science using the guided inquiry method compared to those taught using the expository method, as measured by the BSAT, with students in the guided inquiry method demonstrating superior performance.

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Discussion

The analysis of the pre-test and post-test mean achievement scores attributed to teaching methods (guided inquiry and expository) and scientific literacy levels (high, medium, and low) in the Basic Science Achievement Test (BSAT) provides valuable insights into the effectiveness of different instructional approaches in enhancing student learning outcomes. For students taught using the guided inquiry method, there was a notable improvement in mean achievement scores from the pre-test to the post-test across all levels of scientific literacy. The mean scores for students with high, medium, and low scientific literacy increased significantly, indicating the efficacy of the guided inquiry approach in promoting learning and comprehension. This finding aligns with previous research emphasizing the benefits of inquiry-based learning in fostering deeper understanding and critical thinking skills (Kirschner et al., 2006). Students taught using the expository method also exhibited improvements in mean achievement scores from the pre-test to the post-test, albeit to a lesser extent compared to guided inquiry. While the expository method led to gains in student learning, the magnitude of improvement was not as pronounced as that observed with guided inquiry. This finding suggests that while expository teaching has its merits, it may not be as effective in promoting comprehensive understanding and knowledge retention as guided inquiry (Dochy et al., 2007). The results suggest that students with high scientific literacy generally achieved higher mean scores than those with medium or low scientific literacy levels, regardless of the teaching method employed. This underscores the importance of considering students' prior knowledge and abilities when designing instructional strategies to optimize learning outcomes (Hattie & Timperley, 2007). Regarding hypothesis one ($H0_1$), which proposed no significant difference in the mean achievement scores of students taught basic science using guided inquiry versus expository method, the data indicate a significant effect of teaching method. The F-value of 4.464 at 1 and 140 degrees of freedom, significant at the 0.05 level of significance, suggests that the choice of teaching method indeed influences student achievement scores. This finding highlights the need for educators to carefully select instructional approaches aligned with the learning goals and needs of their students. The findings from the study underscore the importance of employing effective teaching methods, such as guided inquiry, to promote meaningful learning experiences and enhance student achievement in basic science education.

The findings from the study analyzing students' achievement in basic science across different teaching methods (guided inquiry and expository) and scientific literacy levels provide valuable insights into the effectiveness of instructional approaches in promoting learning outcomes. For students taught using the guided inquiry method, the adjusted mean scores varied across different levels of scientific literacy. Among students with high scientific literacy, the mean achievement score was moderate, indicating a reasonable level of achievement. However, there was a slight decrease in mean scores for students with medium scientific literacy and a more substantial decrease for those with low scientific literacy, indicating lower levels of achievement. Similarly, for students taught using the expository method, the adjusted mean scores also varied across scientific literacy levels. Students with high scientific literacy achieved a lower mean score compared to guided inquiry, while those with medium scientific literacy achieved moderate scores. Interestingly, students with low scientific literacy achieved similar mean scores regardless of the teaching method used. The results suggest that guided inquiry tended to result in higher adjusted mean achievement scores compared to the expository method across all levels of scientific literacy. This finding aligns with previous research highlighting the benefits of inquiry-based learning in promoting deeper understanding and critical thinking skills (Kirschner et al., 2006). There appears to be greater variability in achievement scores among students taught using guided inquiry, particularly evident in the wider standard deviation values. This indicates a more diverse range of achievement levels within each scientific literacy category, suggesting that guided inquiry may cater to a broader spectrum of student abilities and learning styles. Regarding hypothesis two ($H0_2$), which compared the interaction pattern between teaching methods and scientific literacy levels on achievement in basic science, the data indicate that the interaction is not significant at the 0.05 level. Thus, the hypothesis of no significant interaction between teaching methods and scientific literacy levels is not rejected. The main effect of scientific literacy level is significant, implying that there is a significant difference in mean achievement scores among students at different levels of scientific literacy. The findings highlight the importance of considering both teaching methods and students' scientific literacy levels in promoting learning outcomes in basic science education. The guided inquiry appears to be particularly effective in fostering higher achievement levels across varying degrees of scientific literacy.

Conclusion

The study affirms that guided inquiry instruction exerts a more substantial influence on the performance of students in basic science. The guided inquiry method proves significantly more effective than the expository methods in enhancing cognitive achievement in basic science across all levels of scientific literacy. Moreover, based on the results of the Basic Science Achievement Test (BSAT), no statistically significant interactions are noted between teaching methods and scientific literacy levels concerning achievement in basic science.

Recommendations

The findings and discussion of the study served as the basis for making the following recommendations:

1. Based on the findings of the study, it is however recommended that Teachers should be encouraged to use innovative teaching strategies such as open inquiry instructional strategy since it is found useful in improving the academic performance of students.
2. Also, further study should be carried out to determine the effectiveness of inquiry expository strategy in teaching and learning other topics in basic science

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