INFLUENCE OF GUIDED INQUIRY APPROACH ON STUDENTS' PERFORMANCE IN FURTHER MATHEMATICS AT SENIOR SECONDARY SCHOOLS IN LAGOS STATE, NIGERIA

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Abstract

This study delved into the extent of influence of Guided Inquiry Approach on Students' performance in Further Mathematics at senior secondary schools in Lagos State, Nigeria. The study adopted descriptive survey research type. The sample size for the study consists of 240 respondents from eight randomly selected co-educational schools in Education District III in Lagos State. Two research questions guided the study. The instrument used for data collection was Further Mathematics Guided Inquiry Approach (FMGIA) 17-item questionnaire which was developed by the researchers. The reliability index of the instrument was 0.71 using Cronbach Alpha formula. Data collected were analyzed using mean and standard deviation. This study concluded that effective usage of Guided Inquiry Approach can facilitate learning. It was therefore recommended that teachers should endeavor to adopt Guided Inquiry Approach in instructions when teaching Further Mathematics and other Science subjects.

***Keywords**: Influence, Further Mathematics, Guided Inquiry, Inquiry Education, Teaching Approach.*

Introduction

Teaching approach is an essential ingredient for effective teaching and meaningful learning. Rabiu, Jamilu and Mukhtar (2017) cited that variety of teaching strategies have been advocated for use in Science and Mathematics classroom, ranging from teacher-centered approach to more of student-centered approach. However, we must note that the teaching and learning process cannot be effective without the teacher (Onyekuru & Ibegbunam, 2013; Attah & Guwam, 2017). Hence, in order to capture and sustain students' attention and interest, a teacher must actively engage the students in discovery activities that demonstrate the mathematical concepts using guided inquiry approach.

Guided inquiry approach of teaching promotes students' active participation in the learning process of Mathematics. It increases students' ability to be disciplined and involve in everyday life, thereby making Mathematics more relevant to students. Abakpa, Anyor and Amo (2016) described Mathematics as an indispensable tool for functional education in all nations of the world. Its usefulness is noticeable in the fields of humanities, technology and science. Kurumeh, Onah and Mohammed (2012) opined that, its usefulness cannot be underestimated because it is the originator of scientific discoveries and inventions. This implies any nation that refuses to pay attention to the study of Mathematics will remain underdeveloped. That is why the Federal Republic of Nigeria (FRN, 2013) having recognized the importance of Mathematics made it compulsory at the basic education and senior secondary education levels.

Ojo and Daramola (2019) noted that Further Mathematics is a highly respected subject and is recognized for its challenging content. It is particularly popular with and provides an essential base for students wishing to continue advanced and undergraduate study in Mathematics, Science, Engineering courses. Further Mathematics affords senior secondary school students' opportunity to be introduced to some topics in Advanced Level Mathematics in order to prepare them to study Mathematics or Mathematics related courses in their next level of education. Moreover, all students offer Mathematics, only few science students normally offer Further Mathematics (National Council for Curriculum Assessment (NCCA), 2005).

Inquiry as a Teaching Approach

Inquiry used within an educational setting is recognized as both a learning objective and a teaching methodology. Inquiry activities are developed to give students ample opportunity to explore, apply prior knowledge, examine, extend understanding towards new learning and to evaluate their progress of developing new understandings. Inquiry education is most effective when students are able to recognize the importance or validity of their learning and how it can be applicable to their own lives.

Levels of Inquiry

Arikewuyo (2014) cited Banchy and Bell (2008) clearly by outlining four levels of Inquiry which are as follows:

1. Level 1 – Confirmation Inquiry. The teacher has taught a particular science theme or topic. The teachers then develop questions and a procedure that guides students through activities where the results are already known. This method is great to reinforce concepts taught and to introduce students into learning to follow procedures, collect and record data correctly and to confirm and deepen understandings.
2. Level 2 – Structured Inquiry. The teacher provides the initial question and an outline of the procedure. Students are to formulate explanations of their findings through evaluating and analyzing the data collected.
3. Level 3 – Guided Inquiry. The teacher only provides the research questions for the students. The students are responsible for designing and following their own procedures to test the questions and then communicate their results and findings to the teacher.
4. Level 4 – Open Inquiry. Students formulate their own research questions, design and follow through with a developed procedure and communicate findings and results to the teacher.

Guided Inquiry Approach

Kuhlthau (2004) explained that guided inquiry is an innovative team approach to teaching and learning where teachers and school librarians with other experts and specialists, join together to design and implement inquiry learning. It engages students in constructing personal knowledge, while using a wide range of sources of information and creatively sharing knowledge with their fellow students in an inquiry community.

Guided inquiry design is grounded in the research of the Information Search Process (ISP) that describes students' process of learning from a variety of information sources in extensive research projects. The ISP research goes inside the inquiry process to reveal ways to guide students in deep engaging learning.

Phases of Guided Inquiry Design Framework

Kuhlthau, Maniotes and Caspari (2012) listed the phases of Guided Inquiry as follows:

(a) Open
(b) Immerse
(c) Explore
(d) Identify
(e) Gather
(f) Create and Share
(g) Evaluate

The Guided Inquiry Design process begins with 'open' the inquiry to catch students' attention, get them thinking and help them make connections with their world outside the school. Next is immerse, which is designed to build enough background knowledge to generate some interesting ideas to investigate. Then explore those ideas for an important, authentic engaging inquiry questions. Next, pause to identify and clearly articulate the inquiry questions before moving on to gather information. After gathering, create and share what students have learned and then evaluate to reflect on content and process and assess achievement of learning. The Guided Inquiry Design helps the Further Mathematics teacher to build students confidence and interest in the learning process.

Open phase consists of invitation to inquiry, open minds, and stimulate curiosity. Open phase of inquiry is the invitation to inquiry at the beginning of the inquiry process. It is a distinct and important phase of the process that sets the tone and direction of the inquiry. Once the learning team has decided on the learning goals, they need to create a powerful opener that invites the learners in and introduces the general topic to engage all the students. The main goal is to open students' minds and stimulate curiosity and inspire them to pursue the inquiry. The opener is designed to spark conversations and stimulate students to think about the overall content of the inquiry and to connect with what they already know from their experience and personal knowledge. It sets the stage for learning.

Immerse phase of inquiry consists of build background knowledge, connect to content, and discover interesting ideas. In the immerse phase, the students build background knowledge together through an immersion experience. The Further Mathematics teacher designs engaging ways for students to immerse in the overall ideas of the curriculum area under study; for example, reading a book, story or article together; viewing a video or visiting a museum, a field site or an expert. The main task of immerse is to guide students

to connect with the overall content and to discover interesting ideas that they want to explore. As they build background knowledge together, each student reflects on ideas that matter and worth further reading and investigation.

Explore phase of inquiry consists of explore interesting ideas, look around, and dip in. In the explore phase of guided inquiry, students' browse through various sources of information exploring interesting ideas to prepare to develop their inquiry question. The Further Mathematics teacher guides students to apply the reading strategies of browsing and scanning a variety of sources. Students dip into a few texts to read lightly in order to make sense of the information they find and to raise lots of questions. 'Dipping in' is a reading strategy that enables students to go further into interesting ideas without becoming overwhelmed by a multitude of specific facts. Students can easily become overwhelmed by all the information and confused by facts that do not fit together. The learning team guides them to keep an open mind as they explore and reflect on new information. They are encountering and to begin to find questions that seem particularly important to them. Guiding students through the explore phase leads them to form a meaningful inquiry question.

Identify phase of inquiry consists of pause and ponder, identify inquiry question, and decide direction. In the identify phase, learners pause in the inquiry process to develop a meaningful inquiry question and form a focus. In Guided inquiry, they have had lots of preparation for this phase. Students are ready to identify an important question for their inquiry because of the time they have spent immersing and exploring to build enough background knowledge to ask meaningful questions. The main task of the identify phase is to construct an inquiry question from the interesting ideas, pressing problems and emerging themes they have explored in various sources of information. The Further Mathematics teacher introduces strategies that enable each student to think through information and ideas to clearly articulate a focused question that will frame the rest of their inquiry.

Gather phase of inquiry consists of gather important information, go broad, and go deep. A clearly articulated question gives direction for the gather phase. Gather sessions are designed to help students collect detailed information from a variety of sources. In this way they are learning to determine importance in what they are concentrating on their reading, listening and observing. The Further Mathematics teacher guides students in locating, evaluating and using information that leads to deep learning. The main task of the gather phase is for students to choose what is personally meaningful and compelling about their inquiry question in the information sources they find and reflect upon. The Further Mathematics teacher guides students in a structured approach for managing their search and documenting what they are learning. First, students 'go broad' to find a range of sources that are useful for understanding their inquiry question. Next, students 'go deep' by choosing a core of the most useful sources to read closely and reflect with sustained attention as they find connections and gain personal understanding.

Create phase of inquiry consists of reflect on learning, go beyond facts to make meaning, and create to communicate. After students have thoughtfully gathered enough information to construct their own understandings of their inquiry question, they are ready to organize their learning into a creative presentation during the create phase. Creating a way to communicate what they have learned about their inquiry requires students to articulate what is most important about their subject and enables them to integrate their ideas more firmly into deep understanding. The Further Mathematics teacher guides students to go beyond simple fact finding and reporting and to summarize, interpret and extend the meaning of what they have found and create a way to share what they have learned. Create sessions are designed to guide students to reflect on all they have learned about their inquiry question and decide what type of presentation will best represent their ideas for a particular audience. The Further Mathematics teacher will further guide students in creating a meaningful, interesting, clearly articulated, well documented presentation that tells the story of what they have learned.

Share phase of inquiry consists of learn from each other, share learning, and tell your story. Share is the culminating phase in the inquiry process, when students share the product they have created; to show what they have learned. Students have become experts on the question for their inquiry community. They now have the opportunity and responsibility to share their insights with their fellow students and communicate their learning to others. Their inquiry products may be shared with a wider audience such as their parents or another group of students in their school or in another school, perhaps online. An important component of guided inquiry is the collaborative learning that takes place when students share what they have learned in the inquiry process

Evaluate phase of inquiry consists of evaluate achievement of learning goals, reflect on content, and reflect on process. The evaluate phase, which occurs at the close of the inquiry process is the integral part of the guided inquiry. Although guided inquiry incorporates assessment for determining students' progress throughout all of the phases of the inquiry process, evaluation occurs at the end when the learning team evaluates students' performance of the learning process. In addition, the Further Mathematics teacher guides students in reflection for self-assessment of their content learning and their progress through the inquiry process. Students' self-reflection takes place while the entire process is fresh in the minds to reinforce content learning and their progress through the inquiry process. Students' self-reflection takes place while the entire process is fresh in the minds reinforce content learning and establish good habits and competencies for learning and literacy.

Guided Inquiry Design for Teaching and Learning in the Information Age of Schooling

Competency in using all kinds of information for clear, deep understanding is essential for every child in today's world. Guided Inquiry provides opportunities for students to learn strategies in locating, evaluating and using a wide range of media and a variety of texts and puts all of their strategies and skills into action throughout the inquiry process. Starting at youngest age, students are introduced to inquiry as a way to learn that prepares them for living and working in the information age, as students continue through the elementary and middle schools and on to high school.

Guided inquiry creates an environment that motivates students to want to learn. It engages them in determining importance and meaning by connecting the curriculum with their world for deep lasting learning. The guided inquiry design framework is an innovative, dynamic approach to teaching and learning for providing information age education for students across the world.

Statement of the Problem

Some of the students studying General Mathematics find it difficult and challenging to register Further Mathematics at the West African Senior Secondary Certificate Examination because it is not a compulsory but a necessary subject for students going for advanced study in Mathematics, Science and Engineering. Hence, there is need to use students-centered approaches like Guided Inquiry Approach to enhance students' performance in Further Mathematics. Active participation of students can be fostered and they are properly guided by the teacher.

Aim and Objectives of the Study

The aim of the study was to find out the influence of guided inquiry approach on Further Mathematics Students' performance in Lagos State, Nigeria. Specifically, the study sought to determine:

1. The mean rating of students on the extent of influence of guided inquiry approach on improvement of students' achievement in Further Mathematics.
2. The mean rating of students on the extent of influence of guided inquiry approach to enhance career advancement in Science and Engineering.

Research Questions

The following research questions guided this study:

1. What is the mean rating of students on the influence of guided inquiry approach on improvement of students' performance in Further Mathematics?
2. What is the mean rating of students on the influence of guided inquiry approach to enhance career advancement in Science and Engineering?

Research Method

The instrument used was Further Mathematics Guided Inquiry Approach (FMGIA) 17-item questionnaire which was developed by the researchers and was validated. The reliability index gave 0.71 using Cronbach Alpha formula. It adopted a 4-point Likert scale of Very High Extent (VHE) as 4; High Extent (HE) as 3; Moderate Extent (ME) as 2 and Low Extent (LE) as 1. Data collected were analyzed using mean and standard deviation to answer the research questions for the study. A criterion mark of 2.5 was adopted for decision making, hence, a calculated mean greater than or equal to 2.5 is assumed to be high while a calculated mean value less than 2.5 is assumed to be low.

Results

Research Question One

What is the mean rating of students on the influence of guided inquiry approach on improvement of students' performance in Further Mathematics?

Results from Table 1 indicated that the questionnaire items 1, 2, 3, 4, 5, 7 and 9 had mean scores values of 3.00, 2.91, 2.79, 2.50, 2.98, 3.31 and 3.12 respectively which are above the criterion mark for mean slated as 2.50. Their standard deviations are 1.04, 0.93, 0.91, 0.97, 0.96, 0.95 and 0.84 respectively. While items 6 and 8 had mean scores values of 1.85 and 2.21 respectively which are below the criterion mark for mean slated as 2.50. Their standard deviations are 0.88 and 1.07 respectively. The Grand Mean of 2.74 indicated that the Guided Inquiry Approach is relevant in the improvement of students' performance in Further Mathematics.

Table 1: Improvement of Students' Performance in Further Mathematics

S/N	Items	VHE	HE	ME	LE	Mean	Standard Deviation	Decision
1.	The guided inquiry approach enhances instruction of Further Mathematics in the class.	102	65	45	28	3.00	1.04	High
2.	The guided inquiry approach enhances easy assimilation of concepts in Further Mathematics taught.	74	90	56	20	2.91	0.93	High
3.	The guided inquiry approach encourages fast retention in Further Mathematics.	62	84	76	18	2.79	0.91	High
4.	The guided inquiry approach improves the students' performance in exercises and examinations.	35	98	58	49	2.50	0.97	High
5.	Through the guided inquiry approach, students get opportunity to learn various concepts in Further Mathematics.	95	60	69	16	2.98	0.96	High
6.	It is not possible to use the guided inquiry approach because it is slow in nature and requires a lot of time.	14	36	90	100	1.85	0.88	Low
7.	The guided inquiry approach can only be used properly if the teacher is creative.	140	51	32	17	3.31	0.95	High
8.	The guided inquiry approach encourages domination by few students.	40	48	74	78	2.21	1.07	Low
9.	The guided inquiry approach enhances team teaching to solve problems as a unit in Further Mathematics.	86	112	27	15	3.12	0.84	High
	Grand Mean					2.74		

Research Question Two

What is the mean rating of students on the influence of guided inquiry approach to enhance career advancement in Science and Engineering?

Results from Table 2 indicated that the questionnaire items 1, 2, 3, 4, 5, 6 and 8 had mean scores values of 2.62, 2.84, 2.65, 2.98, 3.13, 3.07 and 2.99 respectively which are above the criterion mark for mean slated as 2.50. Their standard deviations are 0.94, 1.11, 1.05, 0.81, 0.95, 0.89 and 0.95 respectively. While item 7 had mean score value of 2.43 which is below the criterion mark for mean slated as 2.50 and the standard deviation computed was 0.88. The Grand Mean of 2.84 indicated that the Guided Inquiry Approach is relevant in career advancement in Science and Engineering.

Table 2: Career Advancement in Science and Engineering

S/N	Items	VHE	HE	ME	LE	Mean	Standard Deviation	Decision
1.	The guided inquiry approach gives room to solve basic real-life challenges.	46	88	75	31	2.62	0.94	High
2.	The guided inquiry approach enhances learners' interest in Science and Engineering courses.	90	65	42	43	2.84	1.11	High
3.	The guided inquiry approach motivates students to develop and design improved learning skills.	52	106	28	54	2.65	1.05	High
4.	The guided inquiry approach leads to advancement of career in Science and Engineering.	75	108	34	23	2.98	0.81	High
5.	The guided inquiry approach makes the students to be comfortable with taking responsibility for their own learning in Further Mathematics.	107	77	37	19	3.13	0.95	High
6.	The guided inquiry approach enables students to think deeply and critically about their own learning in Further Mathematics.	82	116	19	23	3.07	0.89	High
7.	The guided inquiry approach helps students absorb information throughout the day for career advancement.	36	60	116	28	2.43	0.88	Low
8.	The guided inquiry approach empowers students to take ownership of their learning in Further Mathematics	95	60	72	13	2.99	0.95	High
	Grand Mean					2.84		

Discussion of the Findings

The study determined the influence of guided inquiry approach on students' performance in Further Mathematics at senior secondary school level. The study was guided by two research questions. The study discovered that the guided inquiry approach is relevant in the improvement of students' performance in Further Mathematics. This is in line with the findings of Odupe and Opeisa (2019) which revealed that the guided inquiry-based learning approach is a compelling alternative to the more conventional classroom

strategy utilized in the past. Also, Rabiu and Madagu (2019) revealed that students showed good results if they were taught with guided inquiry approach. Secondly, the study revealed that the guided inquiry approach is relevant in career advancement in Science and Engineering. This view is supported by Mensah-Wonkyi and Adu (2016) which revealed that the traditional approaches to the teaching of Mathematics do not seem to help students to achieve the intended learning outcomes in the curriculum for future study in other fields.

Conclusion

Based on the findings of the study, it has been established that usage of guided inquiry approach can facilitate learning when it is properly adopted by the teacher to teach Further Mathematics. Also, students can think critically to bring about desirable result and outcome that will go a long way to enhance their performance in Further Mathematics and other Science related subjects.

Recommendations

Based on the findings in this paper, these recommendations were made:

1. Ministries of Education should organize regular workshops to train Further Mathematics and other Science based teachers on how to apply guided inquiry approach for instructional purposes.
2. Public and Private Schools should create enabling environment for the utilization of guided inquiry approach for teaching and learning of Further Mathematics and other Science subjects.
3. Further Mathematics and other Science-based teachers should endeavor to adopt guided inquiry approach in their lessons.

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