

Inquiry learning approach and students' academic achievement in Mathematics and Physics in Calabar Municipality of Cross River State, Nigeria

¹Ekpenyong Effiong Ibok, Ph.D
ibokekpenyong@yahoo.com

¹Joseph Effiom-Edem Ntibi, Ph.D
joseph.ntibi23@gmail.com, joseph.ntibi@unical.edu.ng
¹Department of Science Education
Faculty of Education
University of Calabar, Calabar



Abstract

This paper investigated the influence of inquiry learning approach on students' academic achievement in Mathematics and Physics. The research employed pretest-posttest control quasi experimental design. Multi-stage random sampling technique was used to select 100 students who participated in the study. Mathematics/Physics Achievement Test (MPAT), used as Pre-Test (PREMPAT), Post-Test (POSTMPAT) and Post-post test (PPMPAT) were developed by the researchers and validated by experts, with a reliability coefficient of 0.75. Two hypotheses were formulated and tested at 0.05 level of significance. The control group was taught Mathematics and Physics for four weeks using only the conventional method while the experimental group was also taught Mathematics and Physics for four weeks with inquiry learning approach. POSTMPAT was administered to all the subjects after four weeks. Two weeks after the administration of POSTMPAT, the PPMPAT was administered to both groups. The results show that the students taught Mathematics and Physics using inquiry learning approach achieved and retained better than those taught with conventional method. It was also discovered that there is a significant difference between the achievement of male and female students taught Mathematics and Physics using inquiry teaching approach. This method was recommended for adoption in schools to enhance academic achievement.

Keywords: Achievement, inquiry, learning, Mathematics, Physics

Introduction

The success of a good mathematics and science (Physics) curriculum depends upon the method or style of teaching as can be seen in the context of motivation of learners and students' achievement in scientific attributes such as scientific skills, literacy in

science and mathematics as well as rationality in judgment. Unfortunately, the strategies commonly used in the classroom have not sufficiently eased the learning process of the subjects, almost at all levels. The traditional method contributes very little to the knowledge structure of the learner and therefore cannot promote reflective thinking in more critical and abstract manner. Also, this approach of learning largely encourages students to memorize concepts even in the area of problem-solving, explanation of observed phenomena and comprehension, which may lead to poor performance of students in Mathematics and Physics (Yagger & Akcay, 2010). The problem of poor conceptual understanding and the high rate of failure in Mathematics and Physics in secondary schools show that teaching and learning in these subjects have been teacher-centred instead of student-centred (Siemo, 2004). The need for improved achievement in Mathematics has driven teachers and researchers to seek appropriate instructional strategies. These instructional strategies are the ones that will allow students to control their learning process as well as develop the required interest in Mathematics and Physics.

Inquiry teaching approach complements traditional instruction by providing a vehicle extending and applying the learning of students in a way that connects with their interests within a broad thematic framework. It is a method used in Science and Mathematics teaching that includes the way of questioning, seeking knowledge, information or finding out about phenomena; it involves investigating data and arriving at a conclusion (Sola & Ojo, 2007). In inquiry situation, students learn not only concept but also self direction, responsibility and social communication. It also permits students to assimilate and accommodate information. It is the way people learn when they are left alone. Ajayi (2002) holds the view that inquiry is important in the generation and transmission of knowledge. It helps students to learn to investigate and construct ideas. Cheval and Hart (2005), classify inquiry teaching method into three (3) classes, namely: structured inquiry, guided inquiry and open inquiry. All these types of inquiry can be useful to students to learn Mathematics and sciences when taught appropriately. Structured inquiry is the most teacher-centered of the three types of inquiry. This type of inquiry is commonly seen in science classrooms in the form of laboratory exercises. The teacher provides fairly structured procedures for the inquiry activity, and students carry out the investigations. Structured inquiry could be described as the most traditional approach to inquiry (Cheval & Hart, 2005). The open inquiry on the other side is a type of inquiry which requires the least amount of teacher intervention and is student centered. Students, in this case, often work in groups and plan all phases of their investigations, while guided inquiry falls in the middle of the inquiry instructional spectrum. This type of inquiry is commonly used when students are asked to make tools or develop a process that results in a desired outcome. The teacher provides the problem and materials and the students develop the method using their own scientific process or procedure (Cheval & Hart, 2005).

In inquiry learning, students develop explanations from the evidence and connect explanations to existing knowledge to construct new knowledge (Hermann & Miranda, 2010). Students engaged in many of the activities and thinking processes that scientists use to produce new knowledge. However, new knowledge construction should not be the end of the inquiry learning cycle. The inquiry cycle should include knowledge sharing and learning for life (Marriott, 2014). Teaching strategies that actively engage students in the learning process through scientific investigations are more likely to increase conceptual understanding than are strategies that rely on more passive techniques, which are often necessary in the current standardized-assessment laden educational environment (Minner, Levy & Century, 2010). Brown (2012) suggested that teachers can provide genuine learning experiences by engaging active student discourse through inquiry learning approach. Minner, Levy and Century (2010) concluded that there is a positive impact in the students' learning outcome when an inquiry-based learning method is used instead of traditional lecture-based learning. They praised instruction that emphasizes students' active thinking instead of passive consumption of traditional lectures.

A guided inquiry teaching method revolves around students learning through 'hands-on minds-on' activities. Instructional approaches which have been shown to be effective for improving students' performance in science are active learning strategies. Guided inquiry teaching method has been described as problem solving, critical thinking, reflective inquiry, deductive thinking and not mere personal assumptions. It is a method of teaching that involves probing, finding out, investigating, analyzing, synthesizing, discovering, evaluating, questioning and thinking (Nanda & Ranjan, 2011). Guided inquiry teaching method allows students/pupils to engage in experimentation similar to that of real scientists. Through these activities of inquiry, teachers can encourage their students to expand their critical thinking skills and use their logic to derive answers to scientific quandaries. Agboola and Oloyede (2007) maintained that inquiry approach is more suitable for "intuitive and creative children who are full of enthusiasm." German (1989), in his own view concerning the competency of the teacher, said; "if the method is used by a competent teacher, it has great deal to offer but if used incompetently as fashion, it is probably more disastrous to learning than exclusive reliance of the former methods." Adejo (2015) examined the effects of guided inquiry method on academic performance of chemistry students in selected senior secondary schools in Kaduna State and found that students taught using inquiry teaching method performed significantly better than their counterparts taught using traditional teaching method. The findings are in line with what Ezeugwu (2007) stated that teachers' instructional method can greatly influence students' achievement of acquisition of skills. Ifeanyi-Uche (2013) examined the effect of inquiry based method on academic achievement of secondary school students and found that the experimental group (inquiry based method) achieved significantly

higher than the control group (lecture method). Abdi (2014) examined the effect of Inquiry-based learning method on students' academic achievement in science courses and found out that students who were instructed through inquiry-based learning achieved higher scores than the ones who were instructed through the traditional method.

Gender differences are a recurrent theme throughout the literature in academic studies in general and in Mathematics and science studies in particular. Mathematics and science subjects are often considered to be a domain in which boys are higher achievers, both in terms of attitudes and self-concept. As far as mathematics and Science (Physics) is concerned, there is the belief that boys perform better than girls. It was posited that boys are superior to girls in school achievement (Ochu & Atagher, 2010).

Abdo-Raheem (2012) investigated the influence of gender on secondary schools students' academic performance in South-West, Nigeria. The results of 2003/2004 to 2007/2008 West African School Certificate Examinations (WASCE) were collected on various subjects including Mathematics and Physics from 10 Secondary Schools selected from 5 States in South-West, Nigeria. The result of the analysis, amongst others, revealed that male students performed better than their female counterparts in Mathematics and Science subjects. This similarity in performance between males and females is clear in the meta-analysis conducted by Lindberg et al. (2010) with data from 242 studies representing 1,286,350 people, indicating no gender differences, and nearly equal male and female variances.

Ibrahim, Hamza, Bello and Adamu (2018) carried out a study on effects of inquiry and lecture methods on students' academic performance and retention ability and found that the experimental group which was taught using the inquiry teaching method performed significantly better than the control group which was taught using the traditional lecture method. Other findings of the research were that inquiry method of instruction was gender-sensitive and that it enhances retention.

Research Questions

The following questions were posed to guide the study:

1. What differences exist between the mean achievement scores of students taught Mathematics and Physics using inquiry learning approach and traditional method?
2. Do male and female students who are taught mathematics and Physics using inquiry learning approach differ significantly in their mean achievement scores?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

Ho1: There is no significant difference between the achievement of students who are taught mathematics and Physics concepts using inquiry learning approach and those taught using traditional method.

Ho2: Gender does not significantly influence student's achievement in mathematics and Physics when taught using inquiry teaching approach.

Methodology

The research design adopted was pretest – posttest control group quasi-experimental design. Two intact classes were assigned to the Control group (C) and the Experimental group (E) each. The target population of the study was Senior Secondary II (SS2) science students from public secondary schools in Calabar Municipality Local Government Area of Cross River State, Nigeria. Multi-stage random sampling technique was employed during sampling. The coeducational schools were selected from the study area and two schools were later randomly selected. An intact class was randomly selected from each of the two schools. One of the intact classes was randomly selected to serve as the experimental group, while the other was used as the control group. The sample for this study consisted of 100 SS2 science students, fifty (50) from experimental group while another fifty (50) were from control group; of which twenty-six (26) were females, while twenty-four (24) were male from each group.

The instrument used for data collection was the Mathematics/Physics Achievement Test (MPAT), used as Pre-Test (PREMPAT) and Post-Test (POSTMPAT). The POSTMPAT was used to determine achievement after treatment. This instrument was made up of 50 multiple choice objective test items which were selected from past Unified Tertiary Matriculation Examination (UTME) and Secondary School Certificate Examination (SSCE) questions on Mathematics and Physics based on SS 2 syllabus; 25 questions were selected for each subject. The test items selected were distributed among the six intellectual levels of Bloom's taxonomy in the cognitive domain. The Mathematics/Physics Achievement Test (MPAT) was subjected to face and content validity. In order to ensure the reliability of the instrument (MPAT), a pilot study was done. The reliability coefficient obtained using Spearman-Brown prophecy formula was 0.75.

The research assistants who were the Mathematics/Physics teachers in the sampled schools were trained by the researchers on how the teaching was to be carried out. A pretest PREMPAT was administered to subjects in both groups to measure and to determine their academic achievement in the subjects. The control group was taught Mathematics/Physics for four weeks using only the conventional method and the

experimental group was taught the Mathematics/Physics for four weeks with inquiry teaching approach. At the end of the four weeks, the POSTMPAT was administered to all the subjects. Mean, standard deviation and t-test were used to analyse the data.

Presentation of results

The results of the research question one and two are presented in tables 1 and 3 while the results of testing of the hypotheses are presented in tables 2 and 4. The hypotheses were tested at .05 significant level.

Research Question One: What differences exist between the mean achievement scores of students taught Mathematics and Physics using inquiry learning approach and traditional method?

Table 1: Mean and standard deviation scores of students on pre-test and post-test classified by groups

Teaching method	Sample Size	Pre-test		Post-test		Mean Differences
		\bar{x}	SD	\bar{x}	SD	
Inquiry (Experimental)	50	13.4	4.4	59.7	5.5	46.3
Traditional (control)	50	8.8	3.4	42.5	3.2	33.7

In Table 1, the results show that students who were taught Mathematics and Physics using inquiry learning approach had post-test pre-test mean difference of 46.3 while students taught using traditional method had 33.7. This result shows that students taught mathematics and Physics using inquiry learning approach performed better than students taught using traditional method.

Ho1: There is no significant difference between the achievement of students who are taught Mathematics and Physics concepts using inquiry learning approach and those taught using traditional method.

The independent variables in this hypothesis are inquiry learning approach and traditional method while the dependent variable is students' academic achievement in Mathematics and Physics. To test this hypothesis, respondents were classified into two groups (experimental group and control group). based on the classification, the mean scores of inquiry learning approach and traditional method were compared using the independent t-test analysis and the result is presented in Table 2.

Table 2: Independent t-test analysis of students’ achievement in Mathematics and Physics performance test taught using inquiry learning approach and traditional method

Groups of students	N	\bar{x}	SD	df	t-cal	t-crit	p
Inquiry (Experimental)	50	59.7	5.5	98	19.113	1.65	0.000
Traditional (control)	50	42.5	3.2				

Table 2 shows that students taught Mathematics and Physics using inquiry learning approach have mean score of 59.7 which is greater than the mean score of 42.5 for students taught using traditional method. The table also shows that the calculated t-value of 19.113 is greater than the critical value of t (1.65) at 98 degree of freedom. This implies that students taught Mathematics and Physics using inquiry learning approach performed significantly better than students taught using traditional method. Hence the null hypothesis is rejected.

Research Question Two: Do male and female students who are taught Mathematics and Physics using inquiry learning approach differ significantly in their mean achievement scores?

Table 3: Mean and standard deviation scores of students on pre-test and post-test classified by gender

Gender	Sample Size	Pre-test		Post-test		Mean differences
		\bar{x}	SD	\bar{x}	SD	
Male	24	12.51	4.6	54.7	5.3	42.19
Female	26	14.22	4.9	64.3	6.2	50.08

Table 2 shows that male and female students taught Mathematics and Physics using inquiry teaching approach had post-test pre-test mean difference of 42.19 and 50.08 respectively. The result shows that both male and female students taught Mathematics and Physics using inquiry teaching approach do differ in their achievement scores.

Ho2: Gender does not significantly influence student’s achievement in mathematics and Physics when taught using inquiry teaching approach.

The independent variable in this hypothesis is gender while the dependent variable is students’ academic achievement in Mathematics and Physics. To test this hypothesis, respondents were classified into two groups (Male and female). based on the

classification, their mean scores were compared using the independent t-test analysis and the result is presented in Table 4.

Table 4: Independent t-test analysis of male and female students' achievement in mathematics and Physics performance test taught using inquiry teaching approach.

Gender	N	\bar{x}	SD	Df	t-cal	t-crit	p
Male	24	54.7	5.3				
				48	5.899	1.65	0.000
Female	26	64.3	6.2				

Table 4 reveals that the t-calculated value (5.899) is greater than the critical value of t (1.65). This implies that there is a significant difference between the achievement of male and female students taught Mathematics and Physics using inquiry learning approach. Hence, the null hypothesis is rejected. Table 4 also shows that male students taught Mathematics and Physics using inquiry teaching approach have mean of 54.7 which is less than their female counterparts who have mean of 64.3. This implies that female students performed significantly better than their male counterpart when taught using inquiry teaching approach.

Discussion of the findings

The result of the first hypothesis reveals that students taught Mathematics and Physics using inquiry learning approach performed significantly better than students taught using traditional method. The finding is in line with that of Ajayi (2002) who stated that inquiry approach is important in the generation and transmission of knowledge which helps students to learn to investigate and construct ideas. The finding is in agreement with the finding of Minner, Levy, and Century (2010) who concluded that there is a positive impact in the student's learning outcome when an inquiry-based learning method is used instead of traditional lecture-based learning. They praised instruction that emphasizes students' active thinking instead of passive consumption of traditional lectures. Ifeanyi-Uche (2013) and Abdi (2014) in their separate studies on the effect of inquiry based method on academic achievement of secondary school students, found that the experimental group (inquiry based method) achieved significantly higher than the control group (lecture method). Also Adejo (2015) examined the effects of guided inquiry method on academic performance of Chemistry students in selected senior secondary schools in Kaduna state and found that students taught using inquiry teaching method performed significantly better than their counterparts taught using traditional teaching method.

The result of the second hypothesis revealed that there is a significant difference between the achievement of male and female students taught mathematics and Physics using inquiry learning approach. The finding agreed with Abdo-Raheem (2012) who investigated the influence of gender on secondary schools students' academic performance in South-West, Nigeria and found a significant difference in achievement of male and female students. The finding also was in line with the finding of Ibrahim, Hamza, Bello and Adamu (2018) who carried out a study on effects of inquiry and lecture methods on students' academic performance and retention ability and found that there is gender-sensitivity in their achievement. The finding was contradicted to the finding of Lindberg et al. (2010) on the same subject matter who found no gender differences, and nearly equal male and female variances.

Conclusion

Based on the findings of this study, it could be concluded that inquiry teaching approach in teaching and learning is very necessary and essential because it enhances better academic performance. Hence, the inquiry teaching method produced students with significantly higher academic performance in Mathematics and Physics irrespective of gender.

Recommendations

On the basis of the findings of the study the following recommendations were made:

1. Since the inquiry teaching method produced students with significantly higher academic performance in Mathematics and Physics, it is therefore recommended that the use of inquiry teaching method should be encouraged in all Secondary Schools in Cross River State and other states in Nigeria to enhance students' academic achievement in Mathematics and Physics.
2. Government should sponsor teachers to attend various workshops and seminars on appropriate and effective use of the inquiry teaching method.
3. Mathematics teaching and evaluation strategies should be free from gender bias. This will make males and females to see themselves as equal, capable of competing and collaborating in school activities.

References

- Abdi, A. (2014). The Effect of Inquiry-based Learning Method on Students' Academic Achievement in Science Course. *Universal Journal of Educational Research*, 2(1), 37-41.
- Abdo-Raheem, B.O. (2012). The Influence of Gender on Secondary School Students' Academic Performance in South-West, Nigeria. *Journal of Social Sciences*, 31(1), 93-98.

- Adejo, O. L. (2015). Effects of inquiry method on academic performance of chemistry students in senior secondary schools in Kaduna State, Nigeria. An unpublished MEd theses, Ahmadu Bello University, Zaria.
- Agboola, O. S. & Oloyede, E. O. (2007). Effect of Project, Inquiry and Lecture-Demonstration Teaching Method on Academic Achievement on Senior Secondary Students in Separation of mixture practical test. *Educational Research and Review*, 2(6), 124-132.
- Ajayi, K. (2002). *Teaching and Administering in the Nigeria Educational System*. Abeokuta: Research and publishers committee.
- Brown, K. B. (2012). Seeking questions, not answers: The potential of Inquiry-based approaches to teaching library and information science. *Journal of Education for Library & Information Science*, 53(3), 189-199.
- Cheval, J. V. & Hart, K. (2005). The Effects of Active Learning on Student Characteristics in Human Psychology. *Clearing house*, 74(1), 1-6.
- Ezeugwu, E. N. (2007). Effects of self Regulated and lecture method on students' achievement in Biology. *Nigerian Journal of Functional Education*, 5(1), 82-91.
- German, P. J. (1989). Directed-inquiry Approach to Learning Science Process Skills: Treatment Effect and Aptitude -Treatment Interaction. *Journal of Research in Science Teaching*, 26, 237-250.
- Hermann, R. S. & Miranda, R. J. (2010). A template for open inquiry. *Science Teacher*, 77(8), 26-30.
- Ibrahim, M. S., Hamza, M. Y., Bello, M. & Adamu, M. (2018). Effects of Inquiry and Lecture Methods of Teaching on Students' Academic Performance and Retention Ability among N.C.E 1 Chemistry Students of Federal College of Education, Zaria. *Open Access Journal of Chemistry*, 2(3), 1-8.
- Ifeanyi-Uche, U. P. (2013). The effect of inquiry based method on academic achievement of secondary school students in Home Economics in Umunze, Anambra State. *Journal of Educational and Social Research*, 3(4), 109-113.
- Lindberg, S. M., Hyde, J. S., Petersen, J. L. & Linn, M. C. (2010). New trends in gender and mathematics performance: a meta-analysis. *Psychological Bulletin*, 3(6), 1123—1135.
- Marriott, C. E. (2014). Just wondering. *Knowledge Quest*, 43(2), 74-76.
- Minner, D. D., Levy, A. J. & Century, J. (2010). Inquiry-based science instruction - what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, 47(4), 474- 496.
- Nanda, O. & Ranjan, V. (2011). Effectiveness of inquiry Training Model over Conventional Teaching Method on Academic Achievement of Science Students in India. *Journal of Innovation Research in Education*, 1(1), 7-20.

- Ochu, A. A. O. & Atagher, K. F. (2010). Gender imbalance in secondary school Physics in Vandeikya Local Government Area of Benue State: Implications for sustainable development. *Journal of Research in Curriculum and Teaching*, 5(1), 387-396.
- Siemo, D. (2004). Multiplicative thinking. Retrieved December 7, 2016 from www.eduweb.vic.gov.au/edulibrary/public/teachlearn/ppmultithinking.pdf
- Sola, A. S. & Ojo, E. (2007). Effect of project, Inquiry and Lecture-Demonstration Teaching method on Achievement on Senior Secondary Student in Separation of Mixtures practical test. *Educational Research and Review*, 2(6), 124-134.
- Yagger, R. E. & Akcay, H. (2010). The Advantages of an Inquiry Approach for Science Instruction in Middle Grades. *School Science and Mathematics*, 110, 5-12.