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Inquiry-Based Teaching Method to Create Conceptual Understanding of Measurement of Temperature among Students at the Basic Junior High School

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ABSTRACT

This action research aimed to assess the effectiveness of inquiry-based teaching activities compared to traditional teaching methods in teaching temperature measurement to Junior High School 2 (JHS 2) students at Meduma M/A JHS and to improve student participation in science lessons. The study included 60 JHS 2 students and two science teachers who were purposively sampled. Questionnaires, tests, and observations were used to collect data, which were analyzed using descriptive statistics and independent sample t-tests. Results showed that both teachers and students supported inquiry-based teaching and learning, but teachers found it time-consuming compared to traditional methods. Student participation in inquiry-based classrooms was higher than in traditional classrooms. The study recommends in-service training for teachers on inquiry-based teaching and encouraging students to work collaboratively to benefit from the inquiry-based classroom.

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1. INTRODUCTION

Science is a form of knowledge obtained from the chronological study of the physical world which involves measurement, experimentation analysis, and the development of theories, to describe and interpret the outcome of these activities (Pangaribuan *et al*., 2020; Sesto & García-Rodeja, 2021).

The art of science took off from the inception of creation (Bar & Galili, 1994). However, it is only in the late thirties that the study of science was given tremendous attention and has become a very essential subject (Bar, 1989). This is seen at all levels of the academic arena in Ghana. It has become very prominent for solving scientific problems that emanate from everyday life processes and also as a profession. The acquisition and application of the knowledge of science demand variable concepts which are best taught using the inquiry-based method. Whilst teaching at Meduma Junior High School as a mentee, it was observed that students' interest and participation in science lessons were too poor that they cannot be over-emphasized (Levins, 1992).

There is no doubt that the demonstration method of teaching should be applied to ensure effective lesson delivery (Jose, 2022). This will ginger students to ask questions, become anxious and contribute highly in class to sustain their interest in the learning process of the subject. Effective teaching and learning take place in the classroom when there is also a good atmosphere with a particular reference to the pupils' interest in the class. Because of this, students need to be motivated and encouraged through classroom activities through the creation of a conducive atmosphere in a class by the teacher.

This can be achieved by placing the learners at the center of the learning process to sustain their interest in science lessons at Meduma Junior High School. Even though there is a slow rate of expansion in recent times, schools are compelled to admit more students despite the limited facilities available (Ravanis & Bagakis, 1998). This is because of the free education at the basic level. Students are dispersed in developing an interest to study the subject (science) at the basic level even to a higher level because the teaching of science is executed using the lecture method of teaching by science teachers (Dechavez *et al*., 2023).

In this study found that employing the inquiry learning paradigm caused a change in the attitudes of the students. The results also showed that the majority of students from the two groups achieved a good level and that the learning outcomes of the inquiry learning model were met (Russel *et al*., 1989). This indicates that one strategy for raising student achievement is to adopt inquiry-based learning. There are differences between the learning outcomes of a group of students who use the group inquiry learning model and a group of students who use the conventional learning model, with the inquiry learning model students achieve higher values than the conventional learning model students (Tytler, 2000).

Inquiry-based learning is a successful teaching strategy in the field of education. This affects the growth of technological information acquisition, the improvement of problem-solving abilities, and the capacity for making important decisions (Ravanis et al., 2013). The investigation fosters the growth of all potential pupils, including their emotional and skill development.

The foregoing discussions advance the argument that the inquiry-based learning method of teaching produces better results than the traditional method of teaching. Learners in this school have something in common with the inquiry-based learning model (Putra & Sakti, 2022). Meduma is a suburb in the Kwabre-East District of the Ashanti Region. The main occupation of the people here is farming and Kente weaving. This means that the people are

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largely people who like to explore the natural environment. Hence, the choice of this teaching method is only apt for their level of interaction with the natural environment.

This section reviews previous research into the issue that has been conducted by various researchers. The following subheadings provide information about the review process, various authors' interpretations of temperature, misconceptions I encountered while teaching, solutions to the misconceptions, inquiry-based learning activities for teaching temperature at the basic school, applications of temperature in daily life, and areas of the basic school curriculum where the temperature is covered (Alwan, 2011).

2. METHODS

In this study, we highlight the research design and the instrument used in the research. It also describes the procedures employed in obtaining data for the study. The methodology of the research is divided into sections as follows: research design, the population and sample selection, research instrument, data collection procedure, and intervention processes (Babalola, 2022).

2.1. Research Design

The study is purely action research carried out at Meduma m/a JHS. Action research is a study whereby a problem is identified with close reference to the entire teaching and learning process and immediate solutions are found to curb the identified problem. The action research was chosen to find solutions to immediate problems specifically how to help the students to understand temperature measurement through inquiry-based learning activities.

2.2. Population and Sample Selection

Population refers to the number of students/teachers chosen for the study. It emphatically deals with those concerned under the study. Teachers and students were the subjects used in the research. The teachers were selected due to their failure to involve students through activities in teaching but not because of their in-depth knowledge and professionalism. They are precise, science teachers in junior high school. The scope of the study was also limited to science classes only to assess the current state of students' interest concerning their participation in class discussions and to improve their academic performance in science.

The sample size of students for the study was sixty. They were drawn purposively from classes A and B of the school. The number was made up of 28 boys and 32 girls. To a comparison between Inquiry-based learning (IBL) and the traditional method of teaching, the sample size was dived into two groups namely experimental and control groups. Thus, the control group has a sample size of 30 and the experimental group had a sample size of 30 students with a balance of gender. It is interesting to note that all the students are natives of Meduma in the Kwabre East District of the Ashanti Region. Since the junior high school has only two science teachers, they were automatically selected for the study.

2.3. Research Instruments

The instruments used for data collection were questionnaires and tests. A questionnaire is printed material, usually a set of questions or statements together with responses or alternatives. There are closed-ended and open-ended forms of the questionnaire. The closed-ended contain definite concrete and directed questions. The open-ended form of the questionnaire allows the respondent to arrange the form of statements of the question. The questionnaire designed for this study was a three-point Likert Scale which was used to elicit

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teachers' and students' views on the use of inquiry-based learning as against that of the traditional method of teaching (Arciosa *et al*., 2022).

The test used for this study was constructed by experts in education from the Department of Science, Wesley College of Education. A test is many questions set to measure one's ability and knowledge. To examine the student's level of knowledge and ability acquired in science, a pre-test was organized for the class (Thomaz *et al*., 1995). This was to ascertain the entry behavior of the students regarding what they knew about the measurement of temperature before inquiry-based learning was instituted as an intervention. The test contained five (5) test items that demanded correct answers to be supplied by the students.

Each question attracted two (2) marks making a total of ten (10) marks. To assist students to obtain accurate and reliable responses, the demand of the test and instructions were explained to the students. Provisions were made to ensure a sustainable examination condition with rules and regulations observed. Twenty (20) minutes was the duration of the test.

2.4. Data Collection Procedure

We undertook the study at the Meduma m/a JHS in October through to November 2021 when school was in progress. The data collection was done by using the instruments mentioned earlier. It was envisaged that the administration of the instruments by We would result in receiving more cooperation among respondents than to collect the data/information.

(i) Responses. Questionnaires were distributed to science teachers and students as well during school hours, and after one week, they were collected. Table 1 shows the population, instrument, number of administered, the number returned and the percentages returned. To involve students in the lesson presentation, we gave room for exploration via inquiry-based activities; that is written extracts and real objects during the lesson such as identification of objects, labeling of diagrams, etc.

Table 1. Population instrument.

Final Clarification Output				
Population	**Instruments**	**No. of Administered**	**No. returned**	**Percentage (%) Returned**
Teachers	Questionnaire	2	2	100
Students	Questionnaire	60	60	100

(ii) Intervention Design. The intervention of the study refers to the suitable methods, processes, and techniques through which the research solved the identified problem with close reference to students. The intervention of the research has three sections. Pre-intervention Intervention and Post-intervention.

(iii) Pre-Intervention Stage. We designed an intervention based on the problem identified during the study, meeting with the headmaster, assistant head, and mentor on 25 October 2021 to deliberate on some of the pertinent issues and the problems being encountered in the teaching process (Husnah *et al*., 2021). They also tried to find possible ways of addressing them, particularly with the science department with regards to, how to help students to understand temperature measurement, it was suggested that: Teachers should motivate the students to participate in class activities and it can be carried out through the following techniques. Involving the students in the learning process. This could be done through discussion and asking questions. Teaching and

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learning materials should be effectively used to make learning easy as students learn by themselves through the handling of objects. Teachers should arrange guidance and remediation courses for students to subdue their learning difficulties in specific subject areas, especially science. On the issue of teaching methods, the following were suggested: Teachers should come out with comprehensive and appropriate methods that can be applicable for a particular level of class whilst plans are far advanced for the use of recommended methods from the National Council for Curriculum and Assessment (NaCCA) of Ghana. Teachers should endeavor to indicate or develop in students to eschew the attitude of laughter when a colleague goes wrong.

(iv) Intervention Stage. The collaborators consist of resource persons, and teachers of the science department and We have designed appropriate methods to facilitate the teaching and learning of science in the school. A guidance and counseling committee was set up to give special guidance and remediation courses for the JHS 2 students which are working effectively. Teachers were guided by the circuit supervisor to prepare a comprehensive lesson plan based on the following headings: Observation, Introduction, Development, Application, and Conclusion. With regards to how to help students to understand temperature measurement, which is the maiden objective of the study, We took the students through inquiry-based activities on the topic 'temperature measurement' (Yeo *et al*., 2021). The activities helped to get rid of the misconception of students about science (Sözbilir, 2003). Allowing the learners to make their findings made them so anxious to manipulate and explore objects in their environment during science periods. The details of the activities have been presented in this content. The activities lasted for three weeks.

To be able to tell the advantage of the inquiry-based method over the traditional method of teaching, the experimental group was taken through the topic using inquiry-based learning and the control group was also taken through the same topic using the traditional method of teaching.

2.4.1. Week one

2.4.1.1. Activity one: Body temperature

We asked students to review **Figure 1** and answer the subsequent inquiries:

(i) What observations do you make?
(ii) When did you last experience illness?
(iii) Did you have a fever?
(iv) Who was responsible for taking your temperature?
(v) What device did you employ to measure your temperature?
(vi) What kind of thermometer did you utilize?
(vii) Is it possible to measure your temperature?
(viii) Are you familiar with other types of thermometers?
(ix) What functions can they serve?

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Figure 1. Feverish woman.

2.4.1.2. Activity two: Objects with different temperatures

Several points are considered:

(i) Tools: Pictures of objects of different temperatures.
(ii) Procedure: Sort the items on the photographs from coldest to warmest based on your personal experience.
(iii) Objective: By relying on personal experiences, students will be able to make an educated guess about the temperature of different objects. The items are Hot milk, Iron switched on to the maximum, Ice cream, Hot soup, and Orange juice.

2.4.1.3. Activity three

Several points are considered:

(i) Heating of ice-cold water Tools: a laboratory thermometer, drinking water (1 L), 2 glasses, ice cubes, electrical kettle, and glass stick.
(ii) Calculate the water's temperature while adding some ice to it **(Figure 2).** Include the lab thermometer into the chilled water (Abdullah & Putra, 2017). Check the temperature. Record the temperature reading in a table that has already been created. Was your estimation accurate?

Figure 2. Iced water in glass.

We guided the various groups to boil some water in an electrical kettle and poured it into the glass. They inserted the laboratory thermometer into the glass of hot water (Kaliampos & Ravanis, 2019). They slowly poured some hot water into the ice-cold water, stir it with a glass rode and measure the resulting temperature (Nandiyanto, 2017).

2.4.1.4. Activity four

Each group was made to present their observations. We discussed their findings with the entire class and students realized that different objects have different temperatures and also the temperature changes when hot water is poured into cold or iced water (Satria & Nandiyanto, 2022).

(i) Evaluation: Students wrote short notes on objects with different temperatures and the changes that occur when hot water is added to iced water.

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(ii) Remarks: The activity was successfully carried out.

2.4.2. Week two: Home-made thermometer

Several points are considered:

(i) Objective: To describe how liquid volume expansion varies with temperature

(ii) Tools: test tube, narrow glass tube, water, ink, food colouring, a cork with an opening for the tube, an electric kettle, two glass containers (e.g., beakers).

Each group filled a test tube with cold water and coloured it with a few drops of either food colouring or ink. Why is there ink in the water? Place the glass tube within the cork aperture, then cork-seal the test tube **(Figure 3).**

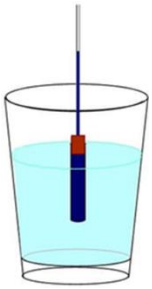

Figure 3. The glass of water.

Several activities are:

(i) Activity one. An electric kettle full of water will be heated for you by your teacher (Kampeza *et al*., 2016). A glass container will be filled with hot water by the instructor. Insert the test tube with the ink **(Figure 3)** into the glass jar.

(ii) Activity two. Make predictions about what will occur. Keep an eye on what's going on. Explain and explain the changes that happened during the experiment.

(iii) Activity three. Each group was instructed by We to take a test tube out of a glass container containing hot water, place it in a container containing cold water, and predict what would happen.

(iv) Activity four. We asked each group to write their observations and discussed their findings with the whole class.

(v) Evaluation. In groups, students explain the principle of thermometers

(vi) Remarks. The activity was successfully carried out.

2.5. Post Intervention

This is the third section of the intervention plan; it tries to examine the success and effectiveness of the intervention or otherwise. To evaluate the intervention plan, a post-test was organized for both groups experimental and control groups. The test was conducted under strict supervision which helped to obtain accurate results. The details of the results have been presented in the ensuing chapter.

2.6. Data Analysis Procedure

In order to enhance the study, we decided to build tables based on the different variables from the information gathered in order to find out the true reflection of the impact of the intervention. The data gathered were analysed using simple descriptive statistics. The T test independent sample was carried out to compare the means and standard deviations of the two groups in order to find out whether there was statistically significant difference between

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the two groups in terms of their performance hence the strengths and weaknesses of the two methods.

3. RESULTS AND DISCUSSION

Research question one is What is the effectiveness of the inquiry-based method of teaching the topic "Temperature Measurement" at K.O Methodist JHS 2 as against the use of the traditional method of teaching the same topic? This question was answered through the descriptive statistics in **Table 2** and **Figure 4**.

Table 2. Group statistics for experimental and control groups on the pre-test.

		N	Mean	Std. Deviation	Std. Error Mean
Marks of Students in Pre-Test	**Experimental Group**	32.00	4.190	1.203	0.213
	Control Group	32.00	3.500	1.078	0.191

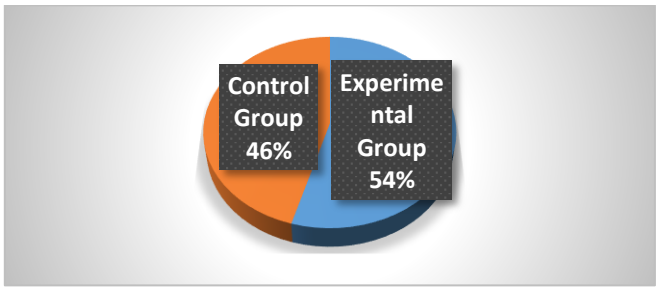

Figure 4. Pie chart for means of control and experimental groups on the pre-test.

Group data on the pre-test for the control and experimental groups are shown in **Table 2** and **Figure 4**. The mean values for the experimental and control groups were calculated to be 4.19 and 3.50, respectively. The groups' respective standard deviations were recorded as 1.203 and 1.078.

Table 3 demonstrates that, with a confidence interval of 95% between the lower and upper limits, the independent sample t-test (T-test) reveals no significant discrepancy in pre-test scores between the experimental and control groups.

Table 4 and **Figure 5** present the post-test group statistics for both the experimental and control groups. The experimental group had a mean value of 8.00 and a standard deviation of 0.916, while the control group had a mean value of 4.50 and a standard deviation of 1.391.

Table 3. Independent samples test for pre-test.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	95% Confidence Interval of the Difference	
									Lower	Upper
Marks of Students in Pre-Test	**Equal variances assumed**	0.004	0.951	2.408	62.000	0.019	0.688	0.286	0.117	1.258
	Equal variances not assumed			2.408	61.262	0.019	0.688	0.286	0.117	1.258

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Table 4. Group Statistics for experimental and control groups on Post-Test.

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Post Test Marks	Experimental Group	32.000	8.000	0.916	0.162
	Control Group	32.000	4.500	1.391	0.246

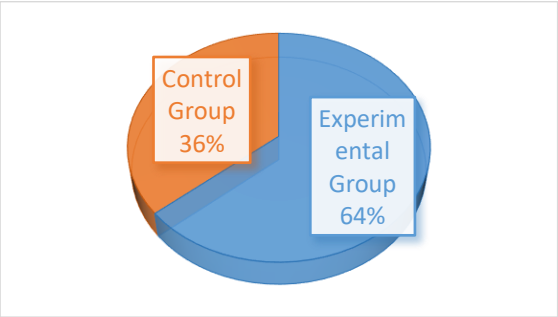

Figure 5. Pie chart for means of control and experimental groups on Post-Test.

The independent sample-tailed test (T-test) results in a significant difference between the post-test results of the experimental and control groups, with the experimental group scoring higher, shown in **Table 5**. Although the control group received instruction using the conventional teaching strategy, the experimental group was taught utilizing an inquiry-based learning approach (Marasabessy, 2021). Between the lower and higher boundaries, there was a 95% confidence interval where the significant difference occurred. The statistics as a whole show that the experimental group did better than the control group.

Table 5. Independent samples test for post-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	95% Confidence Interval of the Difference	
									Lower	Upper
Post Test Marks	**Equal variances assumed**	2.492	0.120	11.887	62.000	0.000	3.500	0.294	2.911	4.089
	Equal variances not assumed			11.887	53.619	0.000	3.500	0.294	2.910	4.090

The effectiveness of a learning model is influenced by the competence of teachers in delivering lessons. For teachers to perform their duties proficiently, they need to possess a consistent and comprehensive understanding of the teaching and learning process. This includes being knowledgeable about the stages required for assignments to be completed successfully and achieve the desired results. With the demands of the 21st century, there is a need for teaching and learning techniques that define the appropriate actions required to achieve the set objectives. When selecting a teaching and learning strategy, various factors need to be considered. These may include the availability of teaching and learning resources, the geographical location of students, the socio-cultural and socio-economic background of the students who will benefit from the lesson, and the objectives of the lesson to be treated.

The inquiry-based learning unites all these factors hence, proves very effective and efficient when properly executed. The inquiry-based learning unites the interest of the

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student with that of the teacher making the learning outcome a shared responsibility which is consistent assertion that the learning outcomes can be seen from the perspectives of both students and teachers. For teaching activities to be completed a teacher must have a comprehensive understanding of how teaching and learning occur and the procedures involved. A less exact model of learning may result in boredom and fatigue, a failure to grasp concepts, and repetitious learning, all of which lower student motivation to learn.

As a result, an inquiry learning model is one of the learning models that is based on the effectiveness of all pupils. Having students perform in lessons and be actively involved in activities must be the joy of every teacher. The results of the comparison are highlighted in the pie charts in **Table 6** and **Figure 6**.

Table 6. Results.

Groups	Mean pretest	Mean posttest
Control group	3.50	4.50
Experimental group	4.18	8.00

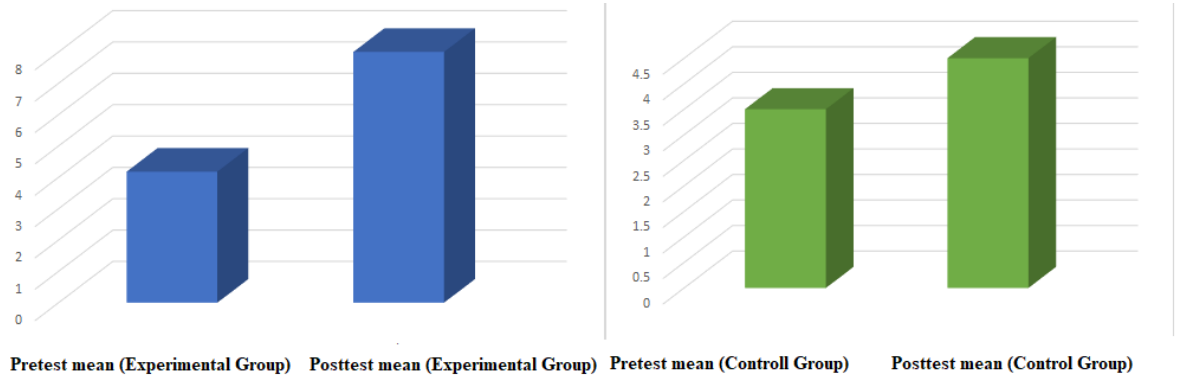

Figure 6. Comparison of pre-test mean and post-test mean for each group.

4. CONCLUSION

It was concluded that the inquiry method is more capable of causing a conceptual change in learners than the traditional method of teaching. The control did not improve much when they were taking the interventional lessons. Comparing the means of the group before and after the intervention of both control and experimental groups shows that the experimental group improved in conceptual change significantly after they were taken through the intervention. Individual differences are seen in all spheres of life. There will always be a varying range of individual differences among students of all learning ages. However, the levels of thinking, interest, and paces of learning must be expeditiously explored by competent science teachers to meet all students at the points of their educational needs. This study has therefore outlined many recommendations that will help in ensuring that students are short-changed when it comes to teaching and learning:

(i) Teachers on the field should be engaged in in-service training to upgrade their knowledge in the use of the inquiry process.
(ii) Curriculum developers must design curriculums that allow for inquiry-based learning
(iii) Learners should be motivated by the efforts that they make in any inquiry moves.
(iv) Government should support teachers who use the inquiry-based teaching method to deliver their lessons.

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6. AUTHORS' NOTE

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