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Interactive-Invention Instructional Strategy and Secondary School Students' Achievement in Selected Electromagnetic Concepts in Ibadan North Local Government Area (LGA), Nigeria

Edidiong Enyeneokpon Ukoh (PhD),
Science and Technology Education Department,
University of Ibadan, Nigeria

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Abstract

Physics translates scientific discoveries to technology but students' achievement in the subject has been observed to be below expectation at all levels of education in Nigeria. Electromagnetism aspect of physics is one of the areas in physics that has been reported to be very wide in coverage and abstract in nature, but students have difficulty understanding it. This paper focuses on determining the effect of interactive-invention instructional strategy on secondary school students' achievement in electromagnetic concepts in Ibadan North LGA of Nigeria. Mixed methods research design was adopted for the study. Three senior secondary schools were randomly selected from Ibadan North LGA and also randomly assigned to the two treatment groups and control group. Intact classes from the selected schools were used and a total of 125 students participated in the study. The two treatment groups were taught using the interactive-invention instructional strategy with the electric motor/generator learning kits. Treatment group I participants worked individually while Treatment group II worked in groups of five. The control group were taught using the conventional lecture method. Physics Achievement Worksheets (PAW), Physics Students' Attitude Questionnaire (PSAQ), and in-class discussion guide were the instruments

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used. The result of the study indicates a significant main effect of treatment on students' academic achievement in the Experimental groups ($F(2, 124) = 88.00$; $p<0.05$, partial $\eta 2 = 0.61$) and a significant main effect of students' attitude on their academic achievement in the treatment groups ($F(1, 124) = 5.80$; $p<0.05$, partial $\eta 2 = 0.49$). It was recommended that physics teachers should adopt interactive-invention instructional strategy in teaching electromagnetism concepts.

Keywords: Interactive-invention instructional strategy, learning electromagnetic concepts, electric motor, electric generator, abstract nature of physics

Introduction

Scientific and technological developments are the quest of every nation of the world because the level of these developments determine its classification as developed, developing or underdeveloped. This is the reason developed nations emphasize the teaching of science at all levels of education. Thus, Nigeria, in her attempt to follow suit, has enshrined in the National Policy on Education that the teaching of science should be emphasized at all levels of education in the country (FRN, 2014). At the Senior Secondary School (SSS) level in Nigeria, science is taught as physics, chemistry, and biology. Among these science subjects, the position of physics is unique because it is the link between science and technology (Ukoh, 2012). This has prompted the call for effective teaching of physics as the nation desires to join the league of developed nations.

Among the topics to be taught in SSS physics is electromagnetic field of which electric motor and electric generator are subtopics under this topic (NERDC 2008). Electromagnetic field is a field that represents the joint interaction between electric and magnetic forces. At this educational level in Nigeria, while electric motor is treated as an application of electromagnetic field, electric generator is treated as an example of electrical device using electromagnetic induction. On one hand, teaching electric motor to this level of students equips them with the knowledge of basic working principle of electric motor. On the other hand, teaching them about electric generator also equips them with the knowledge, skills, and techniques of constructing an electric generator.

In addition, these two devices are interesting and unique. The reversal process for the production of one of the devices actually produces the other device. Electric motor is a device that transforms electrical energy to mechanical energy, while electric generator transforms mechanical energy to electrical energy. These two devices are very useful in the industry and in homes. Electric motors are used for pumping fluids, conveying items, grinding, in vehicles and many more, while electric generator generates electricity used in running machines, powering systems, telecommunications, lighting and so on. The standard of life would have been unimaginable without electricity.

Nevertheless, as useful as these devices are, including them in the physics curriculum at this level depends on students acquiring good understanding about them as well as their capability to utilize the knowledge in real life situations. However, Okeke and Ukoh (2020) observed that achieving the objectives of physics is usually difficult. One of the major reasons for this difficulty is identified by Thomas, Marr, and Walker (2005). According to them, the electromagnetic aspect of physics has been reported to be among the difficult topics in secondary schools. Most students perceive this topic to be difficult because of its abstract nature (Ukoh, 2016). Secondly, most teachers do not cover these topics before examination. Thirdly, the conventional method most teachers in Nigerian secondary schools use in teaching physics encourages mere memorisation of the concepts with little or no understanding (Ukoh, 2016).

Teaching these abstract concepts verbally without instructional aides to facilitate learning may result in misconceptions and difficulty to conceptualise the ideas, which makes learning difficult and tasking. According to Linsday (2011), abstract concepts are foreign to the everyday existence of most students which presents a challenge to the students since individuals inhabit a world of things and not ideas. Meanwhile, Linsday also noted that the task of teaching abstract concepts is a shared classroom experience as it cuts across all disciplines. More so, the method that teachers commonly employ to fulfil that task is the same. However, he pointed out that there is something amiss with that method and correcting its central flaw involves a remarkably simple adjustment. This conventional method places more burden on students' memory and makes teaching learning process monotonous because the teacher does all the talking while the students only listen and jot down some important points (Iroegbu, 1998).

Subsequently, this method of teaching mystifies physics and discourages many from continuing in the subject. Furthermore, the objective of helping students acquire knowledge and skills of constructing electric generator and motor will not be achieved if the concepts are taught with the teacher-centred method of teaching. This conventional method of teaching physics has been reported by Uwizeyimana, Yadav, Musengimana and Uwamahoro (2018) in Rwanda, and Ukoh (2013) in Nigeria, to be responsible for the high failure rate in physics experienced in those countries.

In introducing abstract concepts to students, Linsday (2011) reported that teachers in all subjects commonly take the following four steps: First, they write the concept on the board. Second, they offer a pithy definition of it (something to memorize for test and examination). Third, they explain what that pithy definition really means. Fourth, they offer a few examples to further clarify their explanation. Linsday further noted that the essential elements and shortcomings of this pedagogical approach lies in its order. Therefore, he criticised the approach by stating that every step is an effort to remedy the conceptual opacity of the previous one as the definition seeks to capture the word, the explanation seeks to clarify the definition, and the examples seek to concretize the explanation instead of each step preparing students for the following one. Also, each approach is reduced to doing damage control for the preceding one.

By starting with the foreign and unfamiliar (the concept) and then working back to the familiar (the explanation with concrete examples), Linsday observed that several things may have happened and the most problematic among them indicates that in offering a term and a definition, the teacher has invited what he described as *cognitive paralysis* before students can even understand its meaning. He explained this to mean a sense of despair that makes whatever explanation the teacher may provide more difficult to follow. Starting from unknown to known creates confusion and deprives students of the motivation to learn and this should be avoided in physics class (Linsday, 2011).

An alternative way of introducing the abstract concepts is suggested by Linsday (2011) who inverted the order of the four steps discussed above. He also provided examples followed by an explanation of the conceptual similarities those examples share. Thereafter, he introduced the summary of the definition of that concept and revealed the word used for the concept. He argues that by starting with the concrete and moving to the abstract, the students' understanding is used at each step as a springboard to the next one. In this way, the movement is driven by understanding rather than confusion since the concrete is a useful conceptual introduction to the abstract. Therefore, it is more logical to place the concrete at the beginning of understanding rather than at the end since it is easier to grasp than the abstract.

To say that the concrete provides a useful motivational introduction to the abstract is to say that students are more motivated to learn when they are given the opportunity to be actively involved in the learning process through learning activities that are hands-on, eyes-on, and minds-on. This in turn connects the subject matter with various aspects of their own lives and interest since students at this level are always curious and inquisitive. Also, the practices and activities in which students engage while learning shapes what is learned. This is the reason a teacher's ability to create active learning experiences is very crucial for physics learning. According to the research finding report of Greeno, Moore, and Smith (1993) on the situated nature of

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cognition, the way people learn a particular domain of knowledge and skills and the context in which they learn it forms a basic part of what is learned. Also, when students learn, they learn both information and a set of practices, and it is evident that the two are undoubtedly related.

Therefore, this study utilised the interactive-invention instructional strategy. This strategy provides students with, and emphasizes rich and effective in-class interactions with their teacher, peers, and learning materials and also ‘invent’ the knowledge they are expected to learn in the process. Interactive–invention instructional strategy was first used by Ukoh in 2012 to teach NCE pre-service teachers some electromagnetic concepts in physics and was found to improve students learning outcomes in physics. In this study, the learning material provided was a fabricated device that is used to demonstrate electric generator and electric motor at the same time since both machines are identical in construction. Hence, the fabricated learning material could be used to illustrate the working principle of electric generator and electric motor. The working of the material is discussed fully in the methodology section.

The teacher demonstrates this experiment to the students and explains the working of the electric generator and electric motor while they observe. They were given a booklet that contains the experimental procedure with guiding questions and an observation sheet to record their observations as they follow the procedure. The teacher begins the experiment by fixing all the parts of the device together and ensures that they are firmly fixed. Thereafter, the handle of the wheel is steadily turned fast and light comes on the bulb which indicates the presence of current. The teacher then explains the link between turning the wheel and the light. The belt attached to the rotor rotates as the wheel turns, thereby causing the coil to turn in the magnetic field. While cutting through the magnetic lines of force, an induced electromagnetic force is produced. After the teacher’s demonstration, students take turn in groups and individually as the case may be (experimental group I students worked individually while students in experimental group II worked in groups of five (5)) to carry out the experiment and to record their observations as they answered the guiding questions in the booklet while the teacher guided them through it.

The teacher acts as a guide in the process of learning by providing clues and answering students’ questions as they work with the learning materials, manipulate the materials, make observations, take readings, record their observations, and answer the questions on the booklet. Providing these hands-on activities first before introducing the students to the concept of concrete-to-abstract order as suggested by Linsday (2011) facilitates a more detailed understanding. Consequently, the students’ understanding is used at each step as a springboard to the next one and this movement is driven by understanding rather than confusion since concrete is a useful conceptual introduction to the abstract. This is because it is more logical to place the

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concrete at the beginning of instruction rather than the end since it is easier to grasp than the abstract.

Students were also free to clarify issues from classmates whenever the need arises in order to enforce collaborative learning. This provided an active learning approach where learners are active in experimenting and making their observations as they take note of the experimental results. The interesting thing here is that the experimental findings provide evidence of the principles underlying in the concepts to be learnt. The teacher uses the experimental evidence to explain to the students the concepts they are to learn, which provides concrete support for the students to construct their knowledge of the concept.

In this study, students' attitude to physics was also considered as a moderator variable because there are numerous research findings that show that students have negative attitude to physics (Ibrahim, Aiman, Zakiang, & Damio, 2019; Olusola & Rotimi, 2012; Veloo, Nor, & Khalid, 2015; Tytler & Osborne, 2012). Nonetheless, the focus of this study is to establish if the method used by the physics teacher could interact with the attitude of the students to the subject. Attitude is a psychological construct that explains how one feels about an issue, event, object, a person or anything. Attitude could be positive or negative and could also be explained to mean favourable or unfavourable disposition to anything. Cherry (2021) defines attitude as a set of emotions, beliefs, and behaviors towards a particular object, person, thing or event which is usually as a result of experience or upbringing that has strong influence on behavior. Okeke (2016) asserted that the attitude of students to physics is a problem facing the teaching and learning process of the subject.

Going by Cherry's assertion that attitude is as a result of experience, one could ask if students' experiences in physics classes have been favourable or not and if the methods used by teachers make it easy for students to understand physics or not. However, as noted earlier, the conventional teacher-centred method of teaching physics mystifies the subject which inferably makes students develop this negative disposition. This study therefore sought to determine the effect that interactive-invention instructional strategy and learning kits would have on students' achievement in physics. In using this strategy, students have good learning support and are given opportunities to be involved in hands-on activities in order to construct their knowledge about electric motor and generator. This is based on constructivist theory of learning where learners are allowed to take active part in the learning process while working with materials and gaining learning experiences that translate to knowledge.

Statement of the Problem

The performance of physics students' has been observed over time to be below expectation at all levels of education in Nigeria. This is unacceptable because

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of the crucial role the subject plays in translating science to technology which controls the world today. Electromagnetism aspect of physics is one of the areas in physics that has been reported to be very wide in coverage but students have difficulty learning it. Researchers in the field have identified the causes of this problem and many strategies have been developed to improve students' achievement and attitude in physics but the problem still persists. Therefore, this study focused on determining the effect of interactive-invention instructional strategy with teaching-learning kit for electric motor and electric generator on secondary school students' achievement in electromagnetic concepts in Ibadan Metropolis, Nigeria. Attempt was also made to find out the effect for students working in groups of five and for those working individually as well.

Research Questions

1. What are the experiences of students learning electromagnetic concepts through Interactive-Invention instructional strategy using the electric motor/generator learning kits?
2. Did the students prefer to be taught electromagnetic concepts with the electric motor/generator learning kits to being taught verbally by their teacher?

Hypotheses

Three null hypothesis was tested at 0.05 level of significance

$H_0$1: There is no significant main effect of treatment on students' achievement in some concepts in electromagnetism.

$H_0$2: There is no significant main effect of students' attitude on academic achievement in some concepts in electromagnetism.

$H_0$3: There is no interaction effect of treatment and attitude on academic achievement in some concepts in electromagnetism.

Materials and Methods

Mixed methods research design was adopted for the study. Both qualitative and quantitative data were concurrently generated in the study and the qualitative data were used to answer the research questions. The quantitative aspect made use of pre-test post-test control group quasi experimental design. Three senior secondary schools were randomly selected from Ibadan North LGA and also randomly assigned to the two treatment groups and control group. Intact classes from the selected schools were used and a total of 125 students participated in the study consisting of Treatment group I (44), Treatment group II (39) and control group (42). The two treatment groups were taught using the interactive-invention instructional strategy with the electric motor/generator learning kits. The treatment group I participants worked individually, while Treatment group II worked in groups of five. However, the control group were taught using the conventional lecture method. Content covered were electromagnetic field, application of electromagnetic field, and electrical device using electromagnetic induction.

Physics Achievement Worksheets (PAW), Physics Students' Attitude Questionnaire (PSAQ), and in-class discussion guide were the three research instruments that was structured and used to gather data for the study. PAW contains 3 sections, namely Section I, Section II, and Section III. On one hand, Section I contains background information on the concepts of electromagnetic field, electromagnetic induction, transformation of mechanical work into electrical energy using magnetic field-electric generator, and the reverse of producing mechanical work using electricity-electric motor, while Section II consists of experimental procedure. On the other hand, Section III comprises of worksheets where the students filled in details as they manipulated the learning kits and made observations. Face and content validity was carried out on this instrument and it was found to be valid and reliable.

PSAQ is a 12 item self-structured questionnaire that sort to elicit information about students' attitude to electromagnetism aspect of physics on a 4 point likert scale of strongly agreed, agreed, disagreed, and strongly disagreed. This instrument was subjected to both face and content validity and had a reliability coefficient of 0.83.

In-class Discussion Guide

This guide was developed by the researcher and it contained 4 items in form of questions:

1. Did you enjoy learning electromagnetic concepts through Interactive-Invention instructional strategy using the electric motor/generator learning kits?
2. What would you want to say about learning electromagnetic concepts with this method and learning kits?
3. Would you want your physics teachers to continue using this method and learning kits to teach you physics?
4. How would you describe your experience in this class?

Research Procedure

Experimental Group I and II were taught using this Interactive-Invention instructional strategy. The only difference between the two treatment groups was that while participants in group I worked individually, those in group II worked in groups of five and the control group were taught using conventional lecture method.

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In the set-up, there is a wheel and a handle connected to a rotor by a belt and a bulb connected to the rotor to indicate the presence of electric current. The rotor has a horse-shoe magnet to provide the magnetic field and an armature (a rectangular coil consisting of a large number of turns of insulated wire wound on a laminated soft iron core). When the wheel handle is turned, the wheel revolves and causes the armature coil to rotate at a steady speed about a fixed axis in the magnetic field and it cuts through the magnetic lines of force. As a result, electromagnetic force is produced in the terminals of the coil by electromagnetic induction and the bulb is lit. Turning the handle at a higher speed increases the brightness of the light. Through this means, the device works as a generator of electricity by converting the kinetic energy of the wheel to electric energy in the bulb. This same device could be made to work as an electric motor, which is a device that converts electrical energy to mechanical energy. This happens if an external battery is connected to the setup such that the wheel is made to rotate there by turning electrical energy to mechanical energy.

The teacher demonstrates this experiment to the students and explains the workings of the electric generator and electric motor while they observe. They were given a booklet that contains the experimental procedure with guiding questions and an observation sheet to record their observations as they follow the procedure. The teacher begins the experiment by fixing all the parts of the device together and ensures that they are firmly fixed. Thereafter, the handle of the wheel is steadily turned fast and light comes on the bulb which indicates the presence of current. The teacher then explains the link between turning the wheel and the light. The belt attached to the rotor rotates as the wheel turns, thereby causing the coil to turn in the magnetic field. While cutting through the magnetic lines of force, an induced electromagnetic force is produced. After the teacher's demonstration, students take turn in groups and individually as the case may be (experimental group I students worked individually while students were put in groups of five (5) in experimental group II) to carry out the experiments and to record their observations as they answered the guiding questions in the booklet while the teacher guided them through it.

Students were also given background knowledge on the concept and a worksheet containing procedure and questions to guide them in the experiment. Thus, students carried out the experiment while following the procedure in the worksheet and made observations as they experimented and answered the questions.

Interactive-invention strategy

Step 1: The teacher introduced the topic for the day.

Step 2: Students take note.

Step 3: Students read the background information in the worksheet.

Step 4: Teacher demonstrates to the students how the learning kits work while the students watch.
Step 5: Students follow the experimental procedure in the worksheet to carry out the experiment and to make observations. Then they use what they observe to answer the questions and fill the worksheet while the teacher guides them through it.
Step 6: Students make submissions based on their findings.
Step 7: Teacher summarises the lesson and gives home work.

Control Group were taught conventionally.
The steps
Step I: The teacher introduces the lesson.
Step II: The teacher asks questions based on the previous lesson.
Step III: The teacher presents the topic and discusses the content of the lesson.
Step IV: The teacher directs students to write the chalkboard summary of the topic taught in their physics notebooks.
Step V: The teacher evaluates the lesson by asking students some questions.
Step VI: The teacher gives assignment/homework on the topic taught.
The pre-test was administered to all the participants before the commencement of the treatment and the post-test was administered to the students after the various treatments were administered. The students' worksheets were collected and marked accordingly. This was followed by the interview session.

Method of Data Analysis

The qualitative data collected were analysed through thematic approach while the quantitative data collected were analysed using inferential statistics – Analysis of Covariance (ANCOVA) with pre-test scores as covariates. Estimated Marginal Means was used to determine the magnitude of mean differences across the treatment groups. Bonferroni post hoc test was used for pairwise comparison.

Result and Discussion

In this section, the qualitative data is used to answer the research questions while the quantitative report is also presented and used to test the hypotheses.

The qualitative data was generated using the class discussion and reported based on specific theme and sub themes. The main objective of the discussion was to find out the participants' perception of the use of the interactive-invention instructional strategy with electric motor/generator learning kits and their learning experiences when this strategy is used.

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Respondents	Major Theme	Sub themes
Students	Students' perception of the strategy	Making learning easy
		Enjoying learning
		Wishing their teachers continue to use the method
		Expression of their experiences

Research Question 1

1. What are the experiences of students learning electromagnetic concepts through Interactive-Invention instructional strategy using the electric motor/generator learning kits?

Making Learning Easy

From the class discussion analysis, there was a general perception among the participants that the strategy enabled them to learn physics with ease.

'This method makes me understand the topic very well and easily'
'This method makes learning physics real as we worked with real materials'
'I love this way of teaching physics with real materials'
'Because I did it, I know it'
'It is interesting studying with this strategy'

It was not surprising that the students found this strategy to be a good aid to learning the concept because the strategy has good engaging learning activities, which indicates that the outcome of the activities provided evidence of the concepts they were to learn. They also had the opportunity to manipulate and observe the experimental outcomes which foster mastery learning. This altered the usual way physics is being taught in most schools in Nigeria. However, Karamustafaoglu (2009) asserted that students are made to become active participants in the learning process when they are taught with learning activities.

Enjoying Learning

During the class discussion, the responses from the students to ascertain if they enjoyed learning with the strategy indicates that all of them enjoyed learning physics with this strategy. This was evident during the

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classes as they felt the class should continue. Although the period was over, they wanted to continue interacting with the learning materials.

Students' Expression of their Experience

From the interview transcript analysis, there was a general expression of satisfaction and excitement. Expressions such as:

'Learning physics is fun'

'Learning physics is exciting'

'Learning with this method makes it easy for me to understand physics'

'It is interesting'

'I love this'

The responses came out this way probably because this strategy could be said to have accepted and effected the change to the new perspectives. Shrimali (2019) recommended that interesting learning materials should be provided.

Research Question 2

Did the students prefer to be taught electromagnetic concepts with the electric motor/generator learning kits to being taught verbally by their teacher?

The respondents all wished their physics teacher should use the strategy to teach physics always.

Hypothesis 1: There is no significant main effect of treatment on students' achievement in some concepts in electromagnetism.

Table 1. Analysis of Covariance (ANCOVA) of Post-test by Treatment and Attitude

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3414.288[a]	12	284.524	30.636	.000	.766
Intercept	2289.399	1	2289.399	246.513	.000	.688
Pre-test	30.121	1	30.121	3.243	.074	.028
Treatment	1626.959	2	813.480	87.592	.000*	.610
Attitude	53.665	1	53.665	5.778	.018*	.049
Treatment * Attitude	37.701	2	18.850	2.030	.136	.035
Treatment * Attitude						
Error	1040.160	112	9.287			
Total	18755.000	125				
Corrected Total	4454.448	124				

R Squared = 0.77 (Adjusted R Squared = 0.74) * denotes significant p<0.05

Table 1 indicates a significant main effect of treatment on students' academic achievement in the Experimental groups ($F_{(2, 124)} = 88.00$; $p<0.05$, partial $\eta^2 = 0.61$). The effect is 61.0%. This indicates that, within the treatment groups, 61.0% out of the 77.0% (Adjusted $R^2 = 0.74$) total variation in students' post-test score in physics is due to the result of the significant main effect of the treatment. Thus, hypothesis 1 was rejected. To explore the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups were carried out and the result is presented in Table 2.

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Table 2. Estimated Marginal Means for Post-18 by Treatment and Control group

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Treatment Group 1	12.51	.506	11.510	13.515
Treatment Group 2	16.71	.862	15.002	18.418
Control Group	3.26	.604	2.064	4.459

Table 2 indicates that students in Treatment Group 2 had the highest adjusted post-achievement mean score (16.71). This is followed by their counterparts in the Treatment Group 1 (12.51), while those in the Control Group (3.26) had the least adjusted post-achievement mean score. This order follows through as Treatment Group 2 > Treatment Group 1 > Control Group. In order to determine which of the groups causes this significant main effect, the Bonferroni post-hoc analysis is carried out across the treatment groups and the result is presented in Table 3

Table 3. Bonferroni Post-hoc Analysis of Post-18 by Treatment and Control Group

Treatment	Mean	Treatment Group 1	Treatment Group 2	Control Group
Treatment Group 1	10.78		*	*
Treatment Group 2	15.24	*		*
Control Group	7.95	*	*	

Table 3 shows that the post-achievement mean score of students in the Treatment Group 2 is significantly different from their counterparts in Treatment Group 1 and the Control Group.

Hypothesis 2: There is no significant main effect of Attitude on students' academic achievement in some electromagnetic concepts of physics.

Table 1 indicates that the main effect of students' attitude on their academic achievement in the treatment groups ($F_{(1, 124)} = 5.80$; $p<0.05$, partial $\eta^2 = 0.49$) is significant. The effect size is 49.0%. This indicates that 49.0% difference in the students' academic achievement in some electromagnetic concepts of physics is accounted for by their attitude. Thus, hypothesis 2 was rejected. This implies that students' attitude has effect on their academic achievement.

Hypothesis 3: There is no significant two-way interaction effect of treatment and attitude on the academic achievement in some electromagnetic concepts of physics.

Table 1 shows that there is no significant two-way interaction effect of treatment and attitude on students' academic achievement in some electromagnetic concepts ($F_{(2, 124)} = 2.030$; $p<0.05$, partial $\eta^2 = 0.035$). Thus, hypotheses 3 was not rejected. This means that treatment and attitude have no interaction effect on the academic achievement in some electromagnetic concepts of physics.

Discussion of Findings

The result shows a significant main effect of treatment on students' academic achievement in the Experimental groups. This means that interactive-invention instructional strategy with the learning kits improved students learning of some concepts in electromagnetism because students from the two treatment groups did better than the control group. On the other hand, students that worked in groups performed better than those that worked individually. It is not surprising that the treatment groups performed better because the interactive-invention instructional strategy, which is a student-centred strategy, has very good learning support structures such as hands-on activities with real materials where students become active participants in the learning process. Karamustafaoglu (2009) had earlier reported that using such methods to teach physics equips students to become active learners since they are usually more effective. This in turn brings about permanent learning of physics (Karamustafaoğlu & Akdeniz, 2007).

In addition, Ukoh (2013), Onifade (2017), and Ukoh and Onifade (2020) also found that interactive-invention instructional strategy helps students to learn physics contents and improves students' science process skills. Also, Ogunbowale (2014) reported the effectiveness of this strategy in teaching abstract biology concepts. However, to make the strategy more effective, a learning kit of electric motor and generator was introduced, which made the students readily excited to work with the strategy.

The control group was taught using the conventional lecture method, which is a teacher-centred method that had been reported to make the learning of physics difficult and boring (Shrimali, 2019; Iroegbu, 2008). This method of learning does not give students the opportunity to be involved during the lesson, but rather they are expected to sit passively to receive knowledge from the teacher. This method has been criticized in most literature by Karamustafaoğlu and Akdeniz (2007). Nevertheless, teachers seem to be reluctant to stop using it because they feel it helps them to prepare students better for external examination, which is the obvious yard stick to measure students' performance. The point here is not to abandon the conventional method completely but it needs to be worked on. This can be done by integrating activities into it so that the advantage of helping teachers to cover much content could be harnessed knowing that physics content is very wide (Ukoh, 2016).

Students in treatment group II performed better than those in treatment group I. In treatment group II, students worked in groups of five, while students in treatment group I worked individually. This result supports the advantages of cooperative learning which has been recommended over the years to be used in science classes as a method that fosters team work and provides a platform to support struggling students to learn. When students work in groups, they have the opportunity to learn from their group mates by asking questions on what is not clear to them. Students working in groups in the interactive-invention instructional strategy were given shared task for group members. In a situation where any group member encountered a difficulty, other group members would come in to assist because the group goal must be met. This cooperation, however, was lacking in treatment group I. This could have been the reason for their lower performance.

Students' attitude was found to have significant effect on achievement of students in physics. This result is in agreement with the findings of Hegarty (2014) and Vilia, Candeias, Neto, Franco, and Melo (2017) which connotes that if students' attitude is positive, the students' performance in the subject is likely to be very good. This means that when a person has a positive attitude, the student is likely going to be more involved in activities that would lead to effective learning which will translate to good performance.

Conclusion

Based on the findings of this study, the interactive-invention instructional strategy improves students' achievement in the selected electromagnetic concepts in physics and students enjoyed lessons taught with this strategy. Students taught with this method had enough opportunity to be engaged in the learning process and are able to see the practical aspect of the concepts. Therefore, they are not just memorising facts but they have understanding of the concepts. Interactive-invention instructional strategy provides good learning support to the learners through good learning experiences. It also provides opportunities for learners to put into practice what they learn, which enforces the learning and makes it permanent. In conclusion, students' attitude significantly affects their performance in physics.

Recommendation

1. Physics teachers should adopt interactive-invention instructional strategy when they want to teach electromagnetism concepts
2. Curriculum planners should recommend this strategy for teachers to use in teaching some topics in physics.
3. Teachers should be trained and retrained on the use of learning materials as this would improve students' engagement during lessons.

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