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Peer Instruction Dialogical Argumentation Model (PIDAM) for Authentic Learning of Science

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ABSTRACT
The research is a pretest-posttest experimental design that integrated peer instruction into the dialogical argumentative instruction to investigate the authentic learning experience among College students. The participants were pre-service physics students of a College of Education in Nigeria. The mixed-method approach was adopted to obtain data for the study. The research instruments were Electromagnetism Physics Test (EPT) and Semi-structured interviews. The ANOVA and thematic coding were used to analyse the data obtained. The outcome of the research shows that students' authentic learning was enhanced with the integration of PI into the dialogical argumentation instruction. It also shows that the gender difference in academic performance was not significant. The study makes some recommendations; one of them is further studies on PIDAM because this is the first study on PIDAM in a College.

INTRODUCTION

Peer Instruction (PI) is a teaching paradigm employed to teach students in a group of two or three in a class [1]. It is a method created to develop students' knowledge. Peer Instruction is an interactive teaching-learning process between colleagues, which encourages students to actively reflect and discuss concepts instead of being passive [2]. However, there are criticisms that the PI does not enhance the understanding of the poor students because they copied correct answers from the brilliant ones. Therefore, the current study integrates the PI into the Dialogical Argumentation Instruction for the PIDAM to mitigate the criticism. Argumentation involves dialogue, an instructional technique that teachers use to help students overcome challenges of abstract concepts [3]. Schwarz and Shahar in Rapanta [4] refer to argumentation as the process by which arguments are dialogically and dialectically constructed.

Therefore, the need for the Peer Instruction Dialogical Argumentation Model (PIDAM) to investigate authentic learning in a physics topic arises. In an authentic learning context, all students are active, and the issue of students copying each other is practically minimal or not existing [5]. Figure 1 conceptually explains the model. All the aspect of the PIDAM is essential; however, as indicated in the developed model in figure 1, the critical thinking period is crucial. After the ConcepTest is posted, the next period is to allow students to think critically before the choice of the correct answer [6].

The gender gap in science achievement has been an age-long debate in science education in various countries of the world, including Nigeria [5] [7] [8] [9]. Acquiring skills in science learning is also sometimes depends on gender [10] [11].

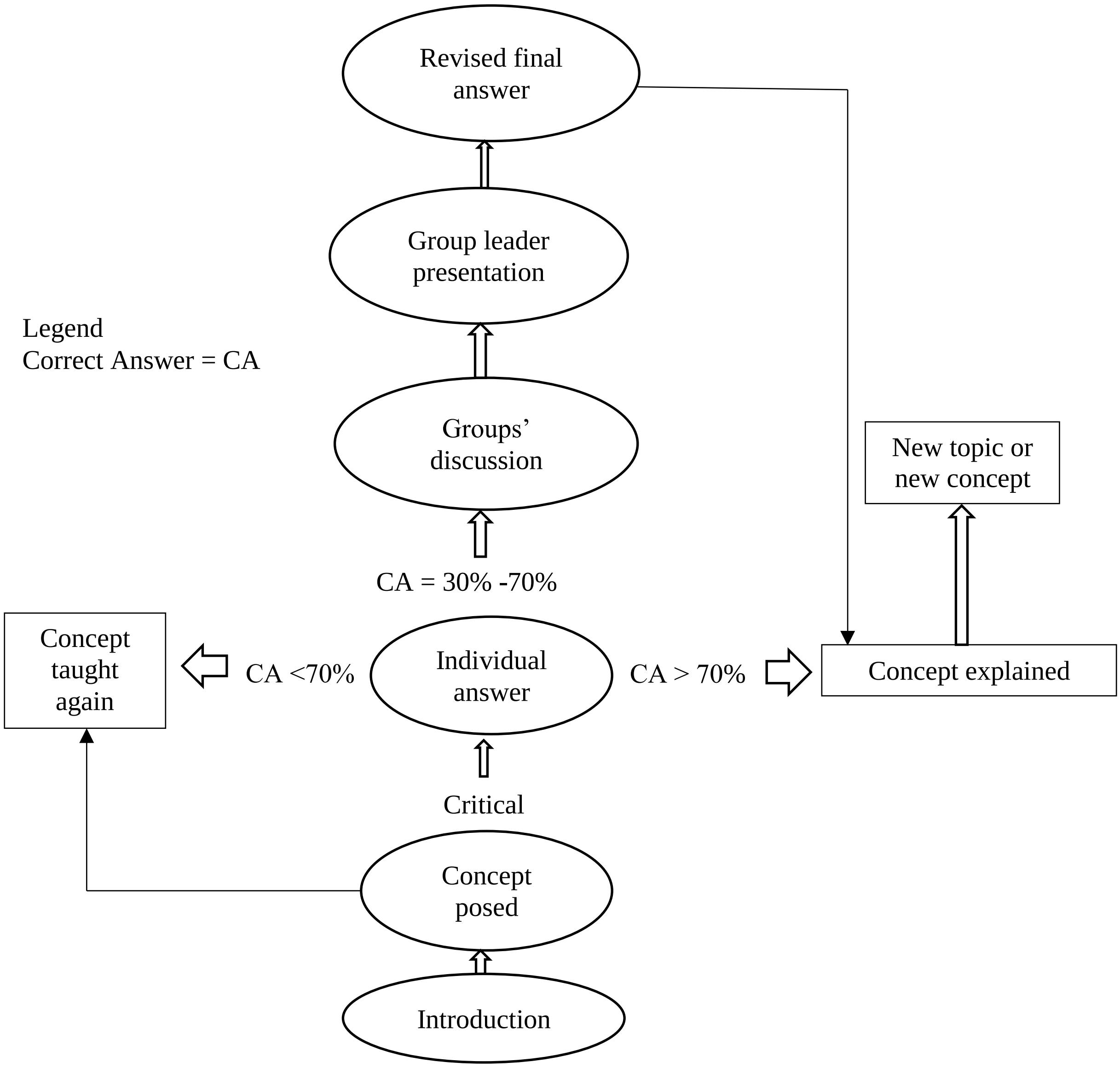

Fig 1. *Peer Instruction Dialogical Argumentation Model (PIDAM)* [3]

Science learning in most Nigerian schools is by rote strategy. This may be the reason why many science students are unable to perform efficiently at the workplace after graduation or apply what was learned to real-life problems [12]. The rote mode of learning does not give sufficient opportunity for students' participation in the learning process. Conversely, authentic learning is learning by doing. According to Pearce [13], authentic learning is the one designed to link what students learn in the classroom to the real-life issue, problem, and applications. Authentic learning is targeted towards a real problem that will have a possible impact outside the classroom [14].

Observation shows that students' learning must be made real before such knowledge could be useful in a real-life situation. For learning to be real, it needs to be student-centred: where students determine and direct the learning by themselves. The role of the teacher in such learning is to guide and not to control the learning. Thus, the needs for authentic learning become imperative.

Problem Statement

Most Nigerian Physics graduates lacked the skills required in the labour market in the 21st century due to how these graduates learned physics in schools. Learning science is evolving; students need to possess skills, not only certificates. The teacher needs to adopt teaching paradigms that will enhance skill acquisition, not the one supporting rote learning as it is present in most Nigerian schools. Previous studies in physics education laid more emphasis on inquiry learning. However, inquiry learning has not been able to produce graduates who can successfully apply physics to solve real-life problems. Several studies suggest that authentic learning having nine elements can provide students who could apply classroom experience to solve real-life challenges [15]. Therefore, the need for a paradigm shift in the way the teacher teaches [16] to make physics more interactive for skills acquisition is the kernel of this study. Thus, the peer instruction dialogical argumentation model for authentic learning in introductory electromagnetism is the focus of the present study. Electromagnetism is a vital branch of physics because of its usefulness in many areas of human life [17].

Purpose of the Study

The principal purpose of this study is the assessment of the authentic learning experience of introductory electromagnetism students of a Nigerian College of Education through the PIDAM. The study also examined the gender impact of PIDAM of introductory electromagnetism learning.

Research Questions

Two research questions were generated for the study. The research questions are stated below.
RQ1: Does the PIDAM enhance the students' authentic learning experience in introductory electromagnetism?
RQ2: Is there any gender impact of PIDAIM on students in the learning of electromagnetism?

Theoretical Framework

Theory is critical in educational research: it provides predictions, explanations, and guidelines for actions and behaviour [18]. The constructivism and constructive controversy theories underpin the study. Constructivism holds that students acquired new knowledge through what they already knew [19]. Students could only benefit from the new learning contexts in terms of existing knowledge [20]. Constructive controversy is a learning strategy where students in a group argue for and against conflicting views to seek a consensus that supports the best evidence and reasoning from both positions [21]. According to O'Neill et all [22], the goal of constructive controversy theory is to seek agreement between people when ideas, information, conclusions, theories, or opinions are not compatible with one another.

This study is on the premise that students learn through individuals and groups interaction based on the understanding brought into the learning contexts. Besides, they also learn through arguments to resolve conflicting issues during learning. Therefore, the theories are justified.

Literature Review

Authentic learning is concern with the experience of linking the real-world to the classroom [23]. Authentic learning environments provide students with valuable skills and opportunities to construct knowledge and in ways that make sense to their existing knowledge, which is based on prior experiences [24]. The teacher would not be seen as "the knower" but would depend upon a resource-based approach where students would generate their investigations, which would require access to various and copious amounts of current and static data [25]. According to Herrington & Oliver [26], the nine elements of authentic learning are learning context, learning activities, expert performance, multiple roles and perspectives, collaboration, reflection, articulation, coaching and scaffolding, and authentic assessment.

Knowledge cannot be transmitted directly from person to person, but instead is individually and idiosyncratically constructed or discovered [27]. Thus, the constructivist perspective is that learners should be active in a learning context to create knowledge personally. According to Fox [28], constructivism supports the active participation of learners rather than the passive perception, memorization, and all the mechanical learning strategies in traditional didactic lecturing. According to Brandon & All [29], constructivism theory is founded on observation and scientific study about how people learn. Constructive controversy is a thoughtful discourse, where there is a discussion of the advantages and disadvantages of proposed actions to synthesize novel solutions [30]. Learning is enhanced by challenge and inhibited by threat, which is why the classroom climate should be challenging but not threatening to students.

Peer instruction is a teaching paradigm designed for the active involvement of students in the class, which through conceptual multiple-choice questions and group discussion activities to provoke students' critical thinking [31]. Research studies suggest that peer instruction enhances learning and problem-solving skills of students [32] [33]. PI is a widely used technique teaching in most countries of the world: China [34], Kenya [35], Saudi Arabia [36], Norway [37], and Germany [38].

Argumentation remains a critical method of creating cognitive conflict constraining students' identification of their present conception and helping them to engage in the act of cognitive comparison and evidence evaluation [39]. According to Sampson et al [40], students must be given more opportunities to practice scientific arguments and involve in discussions requiring the students to support and challenging claims based on evidence. A study by Acar [41] shows that students taught with argumentation-based instruction developed their scientific reasoning better than students who do not.

Gaps in gender learning is a continuous global problem which has been a debate for an extended period [7] [8] [9]. According to Crouch et al [42], there is no gender gap in the conceptual understanding of introductory physics among university students when taught with an interactive paradigm.

METHOD

Research Design

The study is an experimental pre-post-test control group design. It is a robust design that has control over the threats to internal validity [43]. The design allows the researcher to assign participants to groups. Below is the symbol system of the design.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental Group	O_1	X	O_2
Control Group	O_3		O_4

Where:

O_1, O_3 = pretest before the treatment
O_2, O_4 = posttest after the treatment
X = the treatment implemented

The experimental group had eight weeks of lecturing through peer instruction. Twenty adopted Electromagnetism ConcepTests from Peer Instruction User's Manual by Mazur [44] were utilized for the lectures. The pre-service teachers in this group attended two hours of lectures every week. The teacher introduces ConcepTest using a projector and gives some minutes for the students to think about the concepts. After few minutes, students responded to the ConcepTest by flashcards. When the percentage of the correct answer was more than 70%, the teacher gave a summary of the ConcepTest and moved to another ConcepTest.

At the occasion when the right answer is below 70%, the students moved to different groups to discuss the solution with their peers. The students had the opportunity to argue out and reach a consensus on the right answer in each group. The teacher moved around the class to observe and listen to the students as they discussed among themselves. The groups selected a leader among themselves to explain their answer with the whole class while members of the class were free to object to the solution with the reason(s). The teacher concluded the argumentation session with an explanation on the ConcepTest as the case required.

The control group also attended two hours of lectures every week in Electromagnetism, with teachers only using the traditional lecture method for this group. The researcher taught both the experimental and the control groups by himself throughout the intervention period.

Population and sample of the study
The population for the research was made of all the Physics students in the College. The sample was made of the entire first-year pre-service teachers who enrolled as Physics students at a College of Education (Technical) in Nigeria. Physics is a course that always has students' low enrolment in Nigerian schools. Therefore, due to this and attrition, scores of sixty students were recorded and utilized in this study. The sample was homogeneous regarding some internal and external factors, such as academic background.

The Research Instruments
The research instruments were Electromagnetism Physics Test (EPT) and Semi-structured interviews. The EPT was made up of conceptual questions, real-world problems, and problem-solving issues. The conceptual and real-world problem questions were ten in number. The semi-structured interviews involved a series of open-ended questions soliciting students' narratives about their experience in PIDAM [45]. The choice of this type of interview sought to cater to issues that may arise during the researcher-student dialogue [46].

Experts validated the instruments at the University of the Western Cape, South Africa. The reliability of EPT using Cronbach's alpha is 0.88. The data obtained from the instruments were analysed using the independent ANOVA, frequency counts, percentage, and thematic coding.

Before the start of this study, written permission was obtained from each of the participants. The participants took part in the research voluntarily. When the investigation began, the participants were made aware as to when, where, and how the study will be conducted. The dignity and integrity of the participant are essential and was not violated. For anonymity purposes, the real name of the sampled College was replaced by Bojo College of Education (pseudonym) throughout the study.

RESULTS AND DISCUSSIONS

The triangulation of data was employed to answer the research questions. The data obtained through the achievement test conducted using EPT, and the results of the semi-structured interviews were triangulated.

Does the peer instruction enhance the students' authentic learning experience in electromagnetism?
Analysis of EPT reveals that questions of this instrument were grouped into conceptual questions, problem-solving, and questions related to authentic learning (real-world problems). Items 2, 6, 8, and 12 are real-world problems relating to authentic learning.

30% of the students got the right answer for question 2 at the pretest, while the percentage drops to only 13% at posttest. Similarly, 15% of the students got the correct answer for question 6 at pretest and dropped to 6% at posttest. For item 8, no student got the right solution at pretest, but at the posttest, 19%

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of the students got the question correct. The percentage of students who had the correct answer to question 12 was 23% but dropped to 19% at the posttest. The figure below summarizes the analysis.

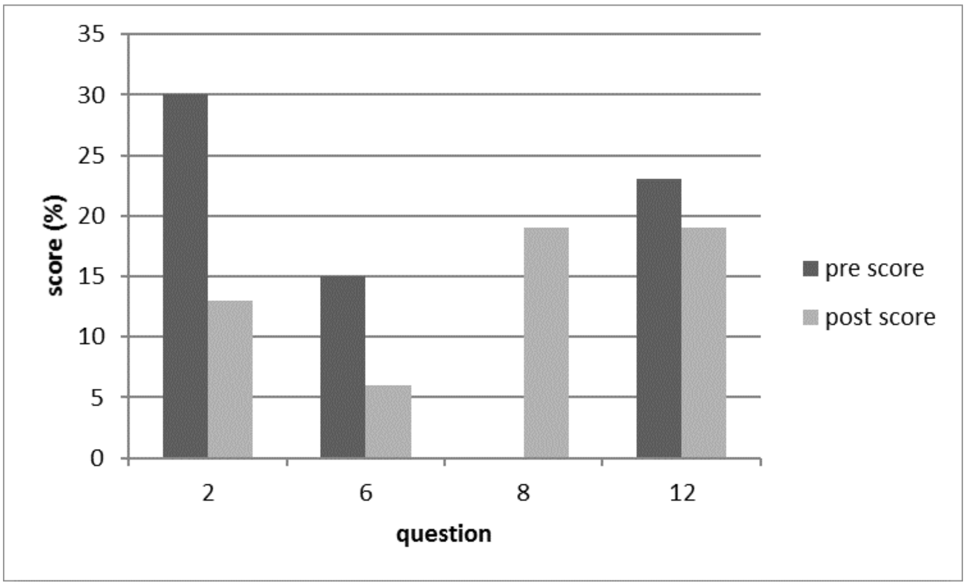

Fig 2. *The Authentic Learning Questions*

Figure 2 above shows that students' scores in question 8 increased from 0% at pretest to 19% at posttest. This is an indication that the students' ability to apply classroom experiences to solve the real-world problem had increased. It must, however, be highlighted that the increase is minimal because it was only observed in one question out of four. This confirmed by Rule [14] and Lombardi [47] arguments about authentic learning in applying classroom experience to solve real-life problems outside the classroom.

The semi-structured interview with the students reveals lots of understanding about the authentic learning experience of the students. The interview was conducted only for the students in the experimental group. The interviews centered on finding out the students' knowledge on (1) peer instruction, (2) dialogical argumentation, and (3) the authentic learning based on the nine fundamental elements highlighted in the literature. Names used in this research are pseudonyms to protect the privacy of participants.

Researcher: *Have you heard about peer instruction since you start schooling?*
Shade: *I am hearing and participating for the first time in PI. However, it is interesting.*

Researcher: *Tell me your personal experience about the dialogical argumentation in your group discussion.*
Adex: *I learned well and understood many things in Electromagnetism I never knew before.*
Ahmed: *When my answer was wrong, or I had the wrong idea about a ConcepTest at the beginning of the class, everything changes after the collaborative discussions.*

More than 90% of the students agreed that they learned better in the peer instruction class than using textbooks and the lecture method.

Researcher: *How can you compare your learning using the textbook and teacher's lecture with your knowledge during the dialogical argumentation in the PI?*
Raff: *I find it easy to retain what I learned in PI than in traditional lecturing.*

The students agreed they enjoyed higher collaboration in learning during peer instruction than in traditional lecturing. One student said she listened to different opinions and interacted with different students to get correct answers.

Researcher: *How did you personally get the correct answers to the ConcepTests in the PI classes?*
Suit: *During the group discussion, I listened to different opinions, which helped me in knowing the correct answers to ConcepTests*.
Kcy: *If I had the wrong answer before group discussion, I find it easy to adjust during group discussion to the correct answer because I listen to different opinions.*
Titi: *There were different opinions during the group discussions through which I arrived at the correct answer, even if I was wrong in my first answer.*

More than 90% of the students said that group leader presentation after group discussion helps their confidence in the public argument of the personal idea. Only one student said that there was no benefit in the group leader's presentation. However, many believed they benefitted from the group leader's presentation.

Researcher: *Do you think the group leader's presentation is necessary since you have agreed in your group on the right answer?*
Aje: *Before now, I cannot stand up in public to talk, but now I can do.*

Researcher: *Tell me what you do when you divide into the group during the PI*
Jose: *We are all teachers in the group. We do not allow a single student to dominate the discussion because everybody struggles to contribute.*

Question 8 of EPT deals with using the knowledge of Ohm's law and electrical power to solve domestic electrical connection. The result shows the students scored 0% at the pretest, but after the PI intervention posttest increase to 19%. This indicates the students had improved in the application of Ohm's law and electrical power-knowledge.

Authentic learning requires that students can apply scientific laws and principles to solve a real-life problem. This aligns with Mazur [44] that students learned laws in Physics, but are unable to address simple problems as they emerge anywhere in the world.

The outcome of this study indicates that students' ability to use laws and formulas to solve real-life related problems improved after the PIDAM intervention. However, the improvement witnessed here is weak, according to figure 2. According to Herrington [48], in authentic learning, students learning conditions for applying knowledge. One fundamental purpose of the PIDAM was for the Physics students to solve real-life problems using their classroom experience.

One excellent feature of the study well appreciated by the students as against the traditional way of learning is relevant to real-life in the PIDAM. The students indicate their interest in the interview. The interview revealed the mind of these students. Students learning by themselves are typically representing the authentic learning experience in nature. Here the students had control over what they learned, which represents an authentic learning environment. According to Watters & Ginns [49], any authentic learning environment should establish a sense of personal control over what and how the learner learns. In this study, students learned by themselves throughout the study.

The authentic activities were designed for the students to complete as they interact in the PIDAM class to enable them to incorporate the feature of real-life tasks. Authentic activities comprise complex tasks to be studied by students over a sustained period, requiring a significant investment of time and intellectual resources [47]. The tasks require students to work for some hours to complete them.

The students spent the time to make exploration as they collaborated to get problems solved. The students in each group are actively involved in identifying the requirements needed to solve problems presented through the ConcepTests. Besides identifying what it requires to solve the problems, students broke the problems into sub-topics with everybody participating and get the problems solved. The general submission of the students during the interview could best be reported by a student (**Titi)** thus: *There were different opinions during the group discussions through which I arrived at the correct answer, even if I was wrong in my first answer.*

The learning environment in authentic learning resembles that of the real-world where students talk to the teacher and talk to one another. Students connect with others who share their passions and collaborate for a higher purpose [50]. The author explained further that the authentic learning environment encourages and nurtures the open sharing of ideas.

Andersson & Andersson [51] observed that authentic learning is built on participation, genuine interest, and interaction with more experienced people. Students participated in group discussions to share ideas in the study. In the current study, learners directed their learning. PI uses ConcepTest, and the learners have every opportunity to revisit any ConcepTest when it is not understood. Learning in PIDAM is personal, the teacher only provides the information through the ConcepTest, but the individual learners make choices.

Rule [14] asserted that in authentic learning, problems must have a personal frame of reference and be open-ended. PIDAM does not restrict or limit students' responses to ConcepTest: students' discussion on any learning task was not restricted. Students made their choices of interpretation in PI. Personalizing instruction by allowing the learner to choose from the wide variety of pathways is an essential characteristic of authentic learning [14]. The students exercise higher levels of thinking. No direct principle or formula was given to solve any problem in PIDAM. The questions were given, and the students were expected to provide answers through the thinking skill and inquiry. All the options provided in the ConcepTest were related to the topic under discussion. Therefore, whichever option choosing leads to the learning of Electromagnetism. In other words, the submission of the Hidden Curriculum [52] that authentic learning is assumed to be designed around open-ended questions without a clear right or wrong answers was valid in the PIDAM.

The students explain that the learning of Electromagnetism through the PIDAM was impressive as they had the time to learn to themselves. Learning in the PIDAM is not about acquiring factual knowledge but about the students themselves. Meaningful learning requires that instruction is beyond the mere presentation of factual knowledge [53] [54].

During the PIDAM class, the students worked together in small collaborative groups of 3-5 students in a group. Working collaboratively together is very advantageous in learning, as commented by the students. A female student (**Suit)** has this to say:
During the group discussion, I listened to different opinions and which helped me in knowing the correct answers to ConcepTests. Another student(**Ahmed**) says: *when my answer was wrong, or I had the wrong idea about a ConcepTest at the beginning of the class, everything changes after the collaborative discussions.*

The constructive controversy theory believed in resolving intellectual controversy in learning contexts [55], as observed in the students' discourse. It supports students organising information to arrive at conclusions in the learning situation [55], which occurs in the student submission above. The advantages of collaboration are significant and crucial to the authentic learning experience. One of the benefits of collaboration that is evident in the study is joint problem-solving. Throughout the study period, students were seen arguing and dialoguing together to get problems solved. All the students agreed that they were all teachers in the group.

A frequently mentioned advantage of students collaboratively working together was that the partner often helps by telling or explaining something that the student did not know or understand [48]. It was observed that the students understand themselves better than they understood their teachers. The students in this study explain things to themselves more clearly than the teacher could do. Going to the groups, the lecturer sees the students explaining to themselves concepts and principles in Electromagnetism. All the students interviewed testified that they had a good time for collaboration during their PIDAM classes. Collaboration is an essential element of authentic learning because it is integral and required for task completion [56].

Students articulated their understanding of Electromagnetism in peer instruction in two ways: the discussion with their partner during the research and the group leader's presentation. The students being able to verbalize what they have learned are consistent with Lave & Wenger [57] that being able to speak the vocabulary and tell the stories of a culture of practice is fundamental to learning.

It was common during the study to see more knowledgeable students articulating their understanding by explaining facts to their partners. Experience had shown that words spoken out are not quickly forgotten like those not spoken out. Some students believed to be able to remember a memorized law and principle in Physics fast is to recite many times in the presence of their colleagues. In this study, even students who are not sure of the correct answer to a question struggled to say something to other group members. The group leaders' presentation is another means of articulating students' understanding of peer instruction. After many minutes of collaborative discussions, a group leader from any of the groups was picked to defend their group consensus. During this period, any member of the class can contribute to the presentation either to support or not with evidence. This has been very helpful, as revealed by the interviews. Many of the students commented that the group leaders' presentation helped them gained more confidence in the public display of their understanding of Electromagnetism.

Over 90% of the students reported that this helped them in the public presentation of their ideas in Electromagnetism. Articulation is an essential element of authentic learning. Articulation provides students with an opportunity to speak and write about their growing understanding [15]. Articulation enables the student to be able to make a public presentation to defend his or her position and ideas. The students' opportunity to verbalize their thoughts in pairs enabled them to be aware of their learning and to make appropriate links to incorporate it into their cognitive frameworks [26].

The role of a teacher in authentic learning is that of coaching and scaffolding. The teacher only provides the skills, strategies, and links that the students were unable to afford to complete the task not to take over the whole teaching [48]. In this study, the teacher gave support to the students when needed and allow the students to take full responsibility for their learning.

During the intervention, the students were often encouraged to write down relevant information as the lecture progresses. The essence of note-taking was for the students to be able to reflect on what they have learned. Students asked questions from the lecturer (researcher). The students, after studied the written down notes, then come to class and ask questions. For example, a student asked a question: *what is the difference between a diode and a resistor?*

Reflection is an essential element of authentic learning. Many learning opportunities in school are wasted when students are not given a chance to reflect upon and consolidate their knowledge [58]. The students had an opportunity to share their experience at the end of each class; besides, they also share ideas with their senior Physics students.

The first opportunity to reflect is that students had the chance to revisit any ConcepTest they have learned at any time of the intervention. The collaborative process also facilitates students' reflection with each student contributing to their experiences. The note-taken opportunity for the students helped them to be able to make a connection between the existing prior knowledge and the new one.

The lecturer (researcher) provides coaching and scaffolding in addition to what is provided by the partners in each group. At the beginning of the lesson, the teacher introduced the use of ConcepTest and gave short instructions to students on how to use ConcepTest. As soon as the students start working in groups, the lecturer makes himself available to the students for any assistance. The lecturer moves around the class to encourage the students to seek any assistance but not enforced it on them to seek such assistance. The students, on many times, consulted with the lecturer for help and clarifications.

Observation and interaction with the students showed that they were euphoric with the procedural assistance: this deals with the general procedure of the peer instruction and dialogical argumentation. The procedural problems are usually solved by the lecturer (researcher) himself. The students did not often seek assistance relating to the subject matter. Nevertheless, where such assistance is requested, the lecturer did not supply the solution but gave enough guides to lead the students to the next stage. From the preceding, six elements of authentic learning were identified, which are the authentic content, authentic activity, collaboration, articulation, coaching and scaffolding, and reflection.

Is there any gender impact of PIDAM on the pre-service science teacher in the learning of electromagnetism?
The students who participated in the intervention were divided into male and female: seventeen males and thirteen females. The achievement test scores of these students in the EPT were analysed using ANOVA. The study used these statistical tools because it compares the mean scores of two different groups of people.

Table 2. Descriptive Statistics

	Sex	Mean	Std. Deviation	N
Control	Male	28.7647	10.21353	17
	Female	26.4615	13.99771	13
	Total	27.7667	11.83124	30
Treated	Male	32.0000	13.89244	17
	Female	30.4615	11.10267	13
	Total	31.3333	12.57346	30

Table 2 shows the gender descriptive statistics in PIDAM. It indicates that the mean score of male students in both the control and treatment groups are slightly higher than their female counterparts. This outcome suggests that the intervention has no gender significant effect on the students' understanding of Electromagnetism. The ANOVA of Test of Between-Subject Effect in Table 3 also confirms the result of Table 2.

Table 3. Test of Between-Subject Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	51015.692	1	51015.692	231.027	.000
Sex	54.359	1	54.359	.246	.624
Error	6182.991	28	220.821		

The statistics in Table 3 indicate that there was no significant main effect of gender (Sig. > 0.05). It thus implies that gender does not affect academic performance in the PIDAIM intervention.

The current result agreed with Kola [59] that gender did not influence the academic performance of the pre-service teachers in the peer instruction. This outcome also confirms the result of Gok [60] that both genders have their comprehension improved with interactive strategies.

CONCLUSION AND SUGGESTION

Given the above analysis, vis-a-vis the two research questions stated at the start of the study, the significant findings are reported below. The study enhances introductory electromagnetism students' authentic learning experience in the application of Ohm's law in real-life situations. The study also had a positive impact on the students' understanding of the introductory electromagnetism. The achievement test scores indicate that students who participated in the peer instruction had better grade than those that did not.

Given the above findings, it is recommended as follow: 1) More studies are needed on the issue of the authentic learning among the university students; 2) The government could ensure the PIDAM is adopted as one of the strategies for teaching at all levels of the national educational system; 3) Teachers need conferences, seminars, and workshops to be able to implement this paradigm of teaching in schools effectively.

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