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An Investigation of Incorporating Dialogical Argumentation into Peer Instruction (PI) for Pre-Service Teacher Learning of Current Electricity

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Abstract

The study is a quasi-experimental research employing the pretest-posttest design. 52 pre-service teachers from a college of education were sampled with 26 pre-service teachers in both the control group (CG) and experimental group (EG). The instruments used to collect data were Physics Achievement Test (PAT), Peer Instruction Dialogical Argumentation Questionnaire (PIDAQ), and Adopted Physics ConcepTest (APC) for teaching the experimental group. The instruments were validated by experts in science education and physics. The reliability of the PAT, based on a pilot test conducted, shows that the Cronbach's alpha coefficient is 0.876. The data obtained were analyzed using t-test, Analysis of Covariance (ANCOVA), and descriptive statistics. Findings revealed that the incorporation of DA into PI has an impact on the students' learning of current electricity. The study considered some implications of the findings on the teaching and learning of physics.

Keywords: dialogical argumentation, peer instruction, conceptest articulation, collaboration.

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Introduction

Current electricity is an aspect of electromagnetism that students must study at all levels of Physics education in Nigerian schools, including pre-service teacher trainees. Literature shows that students' academic performance in this branch of physics is poor for many reasons, and one of these is attributed to misconceptions of both teachers and students. Many times, misconceptions hinder students from gaining adequate knowledge of basic concepts in electricity (Urban-Woldron, 2013).

The dialogical argumentative-based instruction and peer instruction are both student-centered strategies that have the potential to improve students' scientific understanding (Acar, 2015; Crouch, Watkin, Fagen, & Mazur, 2007; Driver, Newton & Osborne, 2000). The two are believed to be in the constructivist paradigm of learning (Acar, 2015; Aina, 2017), and therefore deemed appropriate to incorporate them into students' science learning.

Scientific argumentation is an attempt to validate or refute a claim by reasons in a manner that reflects the values of the scientific community (Norris, Philips, & Osborne 2007). According to Bricker and Bell (2009), argumentation is a core epistemic practice of science. Therefore, the goal of science education must not only be mastery of scientific concepts, but also learning how to engage in scientific discourse. Science will be no different to any other subject if it depends only on the mastery of concepts. Therefore, students must be able to engage in scientific discourse.

Abell, Anderson, and Chezem (2000) underscore the relevance of argumentation in science education because the goal of scientific inquiry is the generation and justification of knowledge claims, beliefs and actions taken in order to understand nature. It has been widely endorsed that the concept of science as an argument and the view that engaging in scientific argumentation should play a vital role in science education (Kuhn, 2009). Exploring science teachers' understanding of argumentation during pre-service teacher education is essential as it provides the opportunity to address any weaknesses in their knowledge of argumentative nature of science (Aydeniz & Ozdilek, 2015). Argumentative-based instruction is student-centered, as is peer instruction which is developed to make students active during teaching and learning.

Peer Instruction (PI) is a research-based pedagogy for teaching large introductory science courses (Fagen, 2003). It is a method created to help make lectures more interactive and to intellectually engage students with what is going on in the classroom. It has been tested in many classes and found to be useful for improving students' performance and also used to identify areas of difficulty for students.

Peer Instruction is an instructional strategy for engaging students during class through a structured questioning process that involves every student (Crouch et al., 2007). PI provides students with the opportunity to voice their ideas and resolve misunderstandings by talking with their peers (Gok, 2012).

According to Crouch, Watkin, Fagen, and Mazur, PI increases student mastery of both conceptual reasoning and quantitative problem-solving. It increases conceptual learning and traditional problem-solving skills (Lasry, Mazur, & Watkins, 2008). According to Gok (2012), PI encourages students to take responsibility for their learning and emphasizes understanding. Peer Instruction engages students during class through activities that require each student to apply the core concepts being presented, and then to explain those concepts to their fellow students. Lectures in PI involve the use of *ConcepTests*, which are short conceptual questions posed in a multiple-choice format on the topic of discussion.

Some researchers state that during PI not much is known about the dynamics of the peer discussion before students registered their answers (James, 2006). Porter, Lee, Simon, and Zingaro (2011) voiced concerns about whether a student truly learns or just copies the correct answer from other group members. This concern is the reason this current study considered incorporating dialogical argumentation instruction into PI.

The principal objective of the current study is to combine DA with PI. Specifically, effort was made to find out if there was any difference in student understanding of current electricity before merging DA with PI. Additionally, the study investigated any difference between those students who participated in DA and those who did not. Finally, the study examined if incorporating DA into PI impacts on students' learning of current electricity.

The study is deemed significant because, according to Acar (2015), students who received argumentation-based instruction develop their scientific reasoning better than those who do not. One of the reasons why argumentation has received such significant attention is because it is believed that learning science through argumentation helps students to develop an improved understanding of the nature of science (Driver et al., 2000). Exposure to dialogical argumentation can help learners learn to think critically and independently about important issues and contested values (Sisebo & Ogunniyi, 2012). It is critical that the science teacher education community take pre-service science teachers' understanding of scientific argumentation seriously (Aydeniz & Ozdilek, 2015).

The current study sought answers to the following three research questions:

Q1: Is there any difference between the pretest of the CG and the pretest of the EG?

Q2: Is there any difference in the academic performance of pre-service teachers participating in DA and those who do not?

Q3: Does the incorporation of DA into PI impact on the pre-service teachers' learning of current electricity?

Methodology

The current study is a quasi-experimental of a pretest-posttest control group design. The design utilizes a pretest-posttest where the researcher randomly assigns participants to the experimental and control groups. It is a commonly used experimental design because of its strength in controlling threats to internal validity (Levy & Ellis, 2011). Beaumont (2009) postulates that the design results in a high degree of external validity but a small degree of internal validity. Despite the identified weakness of the design, according to Barry (n.d.), it is widely used across a range of scientific disciplines, more importantly for measuring change resulting from experimental treatments. According to Dimitrov and Rumrill (2003), the design is extensively used purposely to compare groups and to measure change arising from experimental treatments.

The experimental group was subjected to eight weeks of teaching. Physics ConcepTests adopted from the Peer Instruction User's Manual by Mazur (1997) were utilized for the teaching. The participants in this group attended two hours of teaching each week. The teacher introduces a ConcepTest to the class using a projector. After two minutes, the teacher asked for the students' answers by responding with flashcards. When the percentage of correct answers exceeds 70%, the teacher provides a brief summary of the ConcepTest and moves on to another ConcepTest.

When the percentage of correct answers does not exceed 70%, the students are separated into different groups to discuss question and their answer with their peers. The students are given time to interact and argue out the correct answer in each group. The teacher moves around the class to observe and listen to the students as they discus among themselves. The teacher concludes the argument session with an explanation on the ConcepTest as the case demands.

A purposive sampling of fifty-two physics students at the Alasela (pseudonym applied for ethical considerations) College of Education, Nigeria was sampled. The purposive sample was homogeneous regarding internal and external factors such as academic background (all have at least a West African Secondary School Certificate in physics). These students were from different departments. They were sampled because all are physics students who combined physics with one other science subject as stipulated by the government.

In order to generate data for this study, three different instruments were designed. The instruments used in the study are the Physics Achievement Test (PAT), Peer Instruction Dialogical Argumentation Questionnaire (PIDAQ), and Adapted Physics ConcepTest (APC). The PIDAQ questionnaire contained both structured and open-ended questions. It was drafted for the purpose of allowing the students to report their experiences about peer instruction using dialogical argumentation for current electricity.

The PAT was submitted to a physics lecturer and science education expert from universities in South Africa and Nigeria for validation. This study used inter-scorers reliability which measured the degree of agreement between two or more scorers, judges or raters. Any item scoring an average of three or less was discarded. The reliability statistics of the instrument was calculated after a pilot test using SPSS software. The Cronbach's alpha was found to be 0.876. According to Pallant (2011), a Cronbach's alpha above 0.7 is reliable.

The data collected were analyzed using t-test, ANCOVA, and descriptive statistics tool parameters. Descriptive statistical analyses are used for organizing and describing the characteristics of educational variables in concise and meaningful quantifiable terms (Daramola, 2006).

Before the start of this study, written permission was obtained from each of the participants, who all took part voluntarily. When the research began, the participants were made aware as to when, where and how the research will be conducted. The researcher ensured no harm or injury of any form came to any of the participants as a result of the study.

The dignity and integrity of the participant was not violated, and the participants' anonymity and confidentiality were respected. For the purposes of anonymity, the real name of the sampled college was renamed as the Alasela College of Education. The researcher granted any participant freedom to withdraw from the research at any stage if he or she felt the need to do so.

Findings

Table 1. Students' Correct Answer Responses in Control and Experimental Group

Question	Control Group		Experimental group	
	Pretest	Posttest	Pretest	Posttest
1	17 65.4%	10 62.5%	17 65%	15 57.7%
2	7 26.9%	2 12.5%	11 42.3%	5 19.2%
3	2 7.7%	2 12.5%	2 7.7%	3 11.5%
4	5 19.2%	4 25%	15 57.7%	9 34.6%
5	5 19.2%	2 12.5%	5 19.2%	11 42.3%
6	4 15.4%	1 6.3%	3 11.5%	6 23.1%
7	6 23.1%	9 56.3%	8 30.8%	10 38.7%
8	1 3.8%	3 18.8%	3 11.5%	4 15.4%
9	5 19.2%	3 18.8%	8 30.8%	12 46.2%
10	8 30.8%	9 56.3%	0 0%	7 26.9%
11	6 23.1%	9 56.3%	9 34.6%	5 19.2%
12	6 23.1%	3 18.8%	8 30.8%	11 42.3%
13	12 46.2%	3 18.8%	11 42.3%	8 30.8%

Q1: Is there any difference between the pretest of the CG and the pretest of the EG?

Table 2. T-test Comparing Pretest of CG and EG

		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
Score	EVA	.144	.705	1.09	50	.280	2.885	2.644	-2.425	8.194
	Not EVA			1.09	48.367	.281	2.885	2.644	-2.430	8.199

Note: EVA: Equal variances assumed, Not EVA: Equal variances not assumed

Table 2 shows non-violation of the assumption of equal variance because the significant value of 0.705 is greater than the probability value of 0.05. The t-test for the equality of mean value has 0.280 (2-tailed) which is larger than the probability value of 0.05: this implies that there is no significant difference between CG and EG.

Q2: Is there any difference in the academic performance of the pre-service teachers participating in DA and those who do not?

Table 3. ANCOVA Analysis

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1054.345[a]	2	527.173	3.745	.031	.133
tercept	5288.417	1	5288.417	37.565	.000	.434
e	98.018	1	98.018	.696	.408	.014
roup	1012.579	1	1012.579	7.193	.010	.128
ror	6898.174	49	140.779			
tal	52911.000	52				
rrected Total	7952.519	51				

Table 3 shows a significant difference between the groups because the 0.01 significant value is less than the probability value of 0.05. The eta square value of 1.128 (12.8%) indicates a large size effect. The significant value .408 of the covariate (pre-intervention PAT) is greater than 0.05, which shows there was no relationship between the covariate and the post-intervention test. This implies the students' scores before the intervention had no influence on the scores after the intervention.

Q3: Does the incorporation of DA into PI impact on the pre-service teachers' learning of current electricity?

Peer Instruction Dialogical Argumentation Questionnaire

95% of the students were hearing and participating in the DA in science class for the first time. All the students reported the peer instruction in science class as absorbing. However, only 77% of these students agreed that the DA was fascinating because it gave them a deeper conceptual understanding of current electricity. The students also agreed that it gave them a better knowledge of the application of current electricity in a real-world situation.

Only 54% of the students were able to achieve correct answers to the ConcepTest after the group discussion. All of the students agreed that the DA in peer instruction helped them to better understand many concepts of current electricity.

62% of the students had a better understanding of resistors and resistor-related concepts through DA in peer instruction. 85% of the students had a deeper understanding of capacitors and capacitor-related concepts. 54% of the students had an in-depth understanding of the concept of conductors and insulators through DA. However, batteries and battery-related concepts were better understood by only 23% of the students, whilst 54% of the students better understood the concept of diodes, and 23% better understood electrical circuits and current through DA in the peer instruction.

Transcript of Dialogical Argumentation

The transcripts of the students' discourse during the group argument are presented in this section. These are individual conversations during the discussion and the group conclusions after the argument. The individual students' conversation, the group judgment and the remarks on the conclusion are recorded. The remark was judged to be accurate when the conclusion is considered to fully correct, and inaccurate when the answer was not wrong but also not fully correct.

Table 4 shows the conversation for only three students, but does not imply that there are three students in a group. The researcher purposefully selected three students in each cluster whose conversation differed from each other.

Table 4. Transcription of Group Discourse

Student	Conversation	Conclusion per group	Remarks
1	Fuse box installed at home is to confirm voltage.	Group 1	
2	Fuse box limits the amount current used at home.	Fuse box prevents electric shock at home.	Conclusion inaccurate
3	It allows the home to record the electricity used.		
5	The capacitor is the same with the capacitance.	Group 2	
	Capacitance is the ratio of charge to the potential difference.	Capacitor is an electrical device used to store charge.	Conclusion accurate
6	The capacitor is used in electricity.		
7	The insulator is the thing used to protect the wire.	Group 3	

Student	Conversation	Conclusion per group	Remarks
8	Conductor carries current in the wire.	Both conductor and insulator carry charge. Charge moves in a conductor; that is why it is a conductor. Charges in insulator do not move and cannot conduct current.	Conclusion accurate
9	There are charges in a conductor but not in the insulator.		
10	A semiconductor material that carries electrons is a diode.	Group 4	
11	Diode, capacitor and transistor work the same way.	Diode is a semiconductor that conducts electrons in only one direction.	Conclusion accurate
12	Diode and resistor are the same.		
13	Resistor and resistance mean the same thing.	Group 5	
14	The resistor is a disturbance to the current.	Resistor and resistance are not the same. Resistance is the opposition to the flow of charge while resistor is the material that opposes the flow of charge.	Conclusion accurate
15	Resistance is opposition.		
16	The power supply is transmitted with a high voltage to allow it pass through a transformer.	Group 6 It is to prevent heat loss.	
17	No! It is to increase power.		Conclusion inaccurate
18	For me, it is to make power travel fast.		

Conclusion and Discussion

The significant difference recorded between those students who participated in the dialogical argumentation (DA) and those who did not is evidently due to the dialogical argumentation incorporated into the PI. It is apparently clear from the findings of Question 1 that there was no significant difference between the two groups before participating in DA. Thus, the difference that was recorded must be due to the treatment. This outcome is in agreement with Acar (2015) that there existed a difference between students who received argumentation-based instruction and those who did not.

The PIDAQ reveals that before the DA in peer instruction intervention, the pre-service physics teachers held many misconceptions regarding current electricity. The common misconceptions the students identified before the intervention were: how an insulator works, diodes, resistors and resistance, electrical circuits, capacitors and capacitance.

Meredith and Marrongelle (2008) asserted that students had learning difficulty with capacitors. The outcome of Question 10 from Table 1 cannot be separated from this assertion. Question 10 tested students' knowledge about the use of capacitors and inductors. No student answered the question correctly before the intervention, but many students subsequently answered it correctly after the intervention. This implies that the DA incorporated into PI intervention improved the students' knowledge with regard to this question. A similar thing happened with Question 9, where the percentage of correct answers increased from 30.8% at pretest to 46.2% at posttest.

This issue of argumentation in science learning is not new. The students' arguments that were transcribed indicate an improvement in the students' understanding of current electricity. According to Jimenez-Aleixandre (2007), the argumentation approach to teaching science has gained momentum in recent years. Aydeniz and Ozdilek (2015) reported that argumentation had received such significant attention because it is believed that learning science through argumentation helps students to develop and improve their understanding of the nature of science. Acar (2015) found that students who received argumentation-based instruction developed their scientific reasoning.

Most of the arguments transcribed corroborate the PIADQ on the problem of students' misconception of current electricity. Cross, Taasoobshirazi, Hendricks, and Hickey (2008), as cited in Garcia-Mila, Gilabert, Erduran, and Felton (2013), said argumentation facilitates students' review of their prior knowledge, and helps them to overcome misconceptions. Argumentation-based learning lowers the level of students' misconception (Sekerci & Canpolat, 2014).

The cases of students 13, 14 and 15 in Table 4 indicates the students in Group 5 lacked a proper understanding of resistors and resistance. It also confirms Goodman (2015) that the dialogical argumentation instructional improved learners' conceptions of the capacitor. All the conversations recorded show that most students responded to the ConcepTest based on their understanding, as opposed to any fear that students had copied others.

The argumentation assisted the students understanding, and it reflected in their PAT scores. The discourse of students 1, 2 and 3 in Table 4 shows that the group conclusion on electrical fuses during the argument was not entirely correct, yet it influenced their understanding in PAT. Comparing this with Table 1 indicates a 19.2% score at pretest and a

42.3% at posttest. The outcome of this current study shows that the instruction based on argumentative practices is valid in concept teaching in science education (Kaya, 2013).

The students' discourse as evidenced by the transcripts confirms the views of Aufschnaiter, Erduran, Osborne, and Simon (2008) that students learn science while arguing. The authors assert further that an increase in students' conceptual understanding occurs when they are exposed to argumentation. The evidence of this submission is seen in the various groups shown in Table 4. For example, for Group 2, the discourse of students 5, 6, 7 and the group conclusion shows an increase in the conceptual understanding of capacitors. Also in Table 4, the argument of students 16, 17, 18 and the group conclusion indicates an improvement in the conceptual understanding of the electrical power supply.

This is evidenced in a question related to electrical power in the PAT as recorded in Table 1. The pretest students' scores, i.e. before the students participated in the dialogical argumentation, was 30.8% which increased to 38.7% after the argument. The same applies to a question on resistance and temperature: the pretest score was 30.8% while the posttest was 46.2%. This indicates an improvement in the scientific reasoning ability of the pre-service teachers as supported by Acar (2015) that argumentation-based learning enhances students' scientific reasoning.

The study revealed no significant difference in the students' current electricity understanding before the integration of DA into PI. Nevertheless, a significant difference existed in the understanding of current electricity between those students who participated in DA and those who did not. This difference is deemed to be due to their DA instruction. Besides, the integration of DA in PI impacted on the pre-service teachers learning about current electricity. There was an improvement in the conceptual understanding and students were able also to identify and correct some misconceptions in learning current electricity. Finally, the study shows that student responses to the ConcepTest were based on their understanding as against the notion that they copied one another. The students in DA worked as a group and interacted together across all the groups. For argumentation to take place, students need to be able to work in groups, listen to each other and articulate their ideas (Simon, Erduran, & Osborne, 2006). For students to be proficient in science, there is a need for the teacher to engage them in scientific argumentation as part of the teaching and learning (Sampson & Schleigh, 2013). Proficiency requires every student to be able to articulate his or her scientific knowledge anywhere and at any time. The implication of this is that students collaborate in learning and also articulate their understanding. Collaboration and articulation are two essential elements of authentic learning. Thus, integrating DA into PI promotes authentic learning in physics education (Aina, 2017).

Another implication is that teachers must be knowledgeable about scientific argumentation. Teachers need to provide students with increased opportunities to craft scientific arguments and participate in discussions that require them to support and challenge claims based on evidence (Sampson, Enderle, & Grooms, 2013). Therefore, the success of implementing the dialogical argumentative-based instruction lies greatly on the expertise of the teacher. Besides the teacher having knowledge of argumentation, it is crucial for the teacher also to have a sound pedagogical content knowledge (PCK). If not, the teacher could cause more problems for the students. Aina and Olanipekun (2015) suggest that PCK is an educational construct that a teacher must acquire for success in using any teaching method.

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