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Research Article

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Using Peer Instruction (PI) to Investigate Pre-service Physics Teachers Academic Performance in Nigeria

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Abstract This research study used Peer Instruction (PI) as a pedagogy to investigate pre-service physics teacher's academic performance in electromagnetism in a Nigerian college of education. PI is a research-based pedagogy developed for teaching large introductory science courses. The study is a quasi-experimental of pretest-posttest control group design. The design is an equivalent pretest-posttest where the researcher randomly assigns the participants to experimental and control groups. The underpinning theories for the study are social constructivism theory (SCT) and constructive controversy theory (CCT). 52 pre-service physics teachers of College of Education (Technical) Lafiagi was purposively sampled for the study. The pre-service teachers were sampled because of the central position teacher holds in any educational system. Instruments for the study are Electromagnetism Physics Assessment (EPA) and the Dialogical Argumentation Questionnaire (DAQ). Data collected for the study were analyzed using, descriptive statistics, t-test, and Analysis of Covariant (ANCOVA). The study provided answers to three research questions. Finding reveals that there is a significant difference between students taught with PI and those taught with the traditional lecture method. However, the study indicates that there is no significant different between male and female that was taught with PI. The study also reveals that PI helps students to get rid of misconceptions in physics. The study suggests the adoption of PI for the teaching of science at all level of education in Nigeria schools.

Keywords peer instruction, dialogical argumentation, academic performance, conceptest, misconception

Introduction

Studies show that teachers' method of teaching is one of the causes of poor students' academic performance in physics courses [1]. It has been observed [2] that the effectiveness of physics instruction is very dependent on the pedagogical expertise of the teacher. This indicates that even when a teacher is using a good method of teaching that he or she is not familiar with, students may still not learn maximally. The teacher is expected to make students actively involved in the classroom because it has been observed that active learning stimulates inquiry [3]. However, research studies show that the traditional lecture approach still dominates teaching in most post-secondary schools [4].

Watkins and Mazur (2013) attributed failure in science to poor teaching pedagogy [5]. Crouch, Watkins, Fagen and Mazur (2007) affirmed that traditionally taught courses do little to improve students' understanding of the central concepts of physics [6]. Research shows that commonly used teaching methods such as the traditional lecture method does not help the students acquire sufficient functional understanding of physics [7]. Rote learning is a common experience of the students in physics; they learned to forget because it is by memorization [8].

Studies have shown that the students' academic performance in physics is usually poor in schools in Nigeria. The poor performance is not only limited to secondary schools. The students' academic performance in physics, both at secondary and post-secondary schools in Nigeria has been a source of concern for everyone [9]. Students' dwindling performances in physics in public examinations are worrisome [10].

There are different opinions about the students' academic performance based on the gender. There are gender differences in physics performance among colleges of education students [11]. Stephen (2010) posited that male students performed better in physics than female students in secondary school [10]. Crouch and Mazur (2005) observed that there is no gender gap in conceptual understanding of introductory physics among university students taught with interactive pedagogy [12]. According to Gok (2013), male students performed better than female students in physics in the area of problem-solving skill [13].

A misconception in physics is another problem of learning in Nigerian schools. According to Stein, Larrabee, and Barman (2008), science educators supposed to develop experiences that will specifically challenge common misconceptions held by students [14]. Gooding and Metz opined that the longer a misconception remains unchallenged, the more likely it is to become entrenched. To solve the problem of students' misconceptions, teachers must first identify those misconceptions [15].

Colleges of education are teacher training, tertiary institutions in Nigeria established for training teachers for primary and junior secondary schools. The academic programme of these colleges includes physics education for prospective physics teachers. Students admitted into the physics programme are those who have successfully completed their secondary education and passed physics at credit level.

Peer Instruction (PI) is a research-based pedagogy for teaching large introductory science courses [8]. It is a method created to help make lectures more interactive and to get students intellectually engaged with what is going on in the classroom. It has been tested in many classes (not in Nigeria) and found to be effective for improving students' performance and also used to identify students' difficult areas. Peer Instruction is an instructional strategy for engaging students during class through a structured questioning process that involves every student [6]. PI provides a structured environment for students to voice their ideas and resolve misunderstandings by talking with their peers [16]. Peer instruction is a cooperative learning technique that promotes critical thinking, problem-solving, and decision-making skills [17] and it was designed to improve the learning process [18].

PI is more effective at developing students' conceptual understanding than traditional lecture-based instruction [19]. PI increases student mastery of both conceptual reasoning and quantitative problem solving [6]. PI encourages students to take responsibility for their learning and emphasizes understanding [16]. It is not a rejection of the lecture format, but a supplement that can help engage students who have a range of learning styles [18].

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 consist of the short presentations on the main points, each followed by a Conceptest**.** Conceptest is a short conceptual question, typically posed in a multiple-choice format, on the subject being discussed. As learning theories are central to the study, a review of the theoretical framework follows.

Theoretical Framework

The theory is vital in educational research as the term is commonly used in papers, books and even doctoral theses [19]. According to Leedy and Ormrod (2005), the theory is defined as an organized body of concepts and principles intended to explain a particular phenomenon [21]. The theory has many functions in educational research. Tellings opined that theory provides predictions and explanations as well as guidelines for actions and behaviour. The author further explained that theory provides a safeguard against unscientific approaches to a problem, an issue or a theme. The underpinning theories for this study are social constructivism theory (SCT) and constructive controversy theory (CCT) of learning [20].

Social Constructivism Theory

Constructivism emphasizes the importance of the knowledge, beliefs and skills that an individual brings to the experience of learning [22]. Social constructivism was developed by Vygotsky, who argued that learning is a social and collaborative activity where people create meaning through their interactions with one another [23]. Students created ideas through interaction with the teacher and other students.

Interaction is very crucial to students' learning. Educause Learning Initiative argued that successful learning is closely link to interaction. Learning is a process of interaction through which the learners develops their understanding by assembling facts, experiences, and practices [24].

Powell and Kalina said collaboration and social interaction are incorporated in social constructivism. This theory believes in the social interaction of students in the classroom along with the critical thinking process. Creating a deeper understanding of learning requires cooperative learning. These authors contended that social learning is a part of creating asocial constructivist classroom. The theory believes that students have plenty to offer one another by not only working one-on-one with the teacher but also with other students [25].

According to Kim, individual create meaning through their interactions with each other and with the environment they lived. The author argued that meaningful learning could only take place when students are engaged in social activities [26]. Andrews, social constructivism is concerned with the nature of knowledge and how it is created [27]. Social constructivism believes that both the context which learning occurs and the social contexts that the learners bring to the classroom is imperative [26].

Social constructivism has a perspective that focuses on the relationship between people and their environment [26]. This author believed students learned with their mind and at the same time interacts with the environment as learning is going on, it is, therefore, difficult to separate learning from the environment. Bredo (1994) and Gedler concurred that if the environment and social relationships among groups of students change, obviously the tasks of each student also change [28]. Thus, Kim said learning should not and cannot take place in isolation from the environment [26].

Constructive Controversy Theory (CCT)

The Constructive controversy involves deliberative discussions aimed at creative problem solving [29]. Students must be skilled collaborators, and follow the norms of cooperation and the rules of rational argumentation. Students are strongly motivated to produce solutions, and display high-level reasoning and greater mastery and retention of new knowledge gained. They generate high quality and creative solutions.

Constructive controversy exists when one person's idea, conclusions, and opinions are not compatible with another person's ideas, conclusion and opinion, but the two seek to reach a consensus on the solution to the problem or the course of action to take in a situation [30]. Constructive controversy is not a debate nor is it an individualistic approach to a controversial issue. It is a procedure for cooperative learning where individuals with different, incompatible views agree on the best position based on evidence and reasoning [31]. Constructive controversy builds on the basis that discussions and controversies may create a good starting point in an attempt to understand a complex problem. Students will improve their innovative and constructive thinking skills to find solutions to complex and difficult problems. The ultimate goal of constructive controversy theory is when one person's ideas, information, conclusions, theories, or opinions are incompatible with those of another -- and the two seek to reach an agreement [32].

Numerous theories of learning in education could be considered for this study, but social constructivism and constructive controversy theories are considered the most appropriate for this study. These theories are active learning theories that considered students to be at the center of teaching and learning. Both theories considered students' interaction among themselves paramount, and that constructive argumentation helps students develop their critical thinking ability. Constructive controversy theory is much more unique in classroom argumentation leading to a consensus among conflicting views and opinions. The research questions the study provided answers to are stated below.

Research questions

1. Does PI have any effect on the pre-service teachers' academic performance in physics?
2. Is there any difference between male and female students' academic performance in physics after being taught with the PI?
3. Can the peer instruction help student get rid of misconceptions in physics?

Methodology

Research Design

The study is a quasi-experimental of pretest-posttest control group design. The design is an equivalent pretest-posttest where the researcher randomly assigns the participants to experimental and control groups.

Pretest-posttest designs are widely used primarily to compare groups and/or measuring change resulting from experimental treatments [33]. The instruments for the study are Electromagnetism Physics Assessment (EPA).

The instruments were submitted to science education experts at the University of the Western Cape, South Africa and a physics lecturer at the Ekiti state University Ado Ekiti, Nigeria for rating. 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 3 or less was discarded. The reliability statistics of the instrument was calculated using SPSS software to get the Cronbach alpha coefficient to be 0.876.

The data collected for the study were analyzed using Analysis of Covariance (ANCOVA) and t-test statistics. With randomized designs, the main purpose of ANCOVA is to reduce error variance because the random assignment of subjects to groups guards against systematic bias [33].

Procedure

The experimental group was subjected to eight weeks of lecturing interspersing lecture method with peer instruction. Twenty developed conceptests from electromagnetism were used for the lectures. Conceptests are short conceptual questions, typically posed in a multiple-choice format, on the subject being discussed. The pre-service teachers in this group attended two hours lecture in a week. The teacher introduces a conceptest using a projector and gives students two minutes to think about the conceptest. After two minutes, students responded to the conceptest by flash cards. When the percentage of the correct answer is more than 70%, the teacher gives a brief summary of the conceptest and move to another conceptest.

When the percentage of the correct answer is less than 70%, the students go into different groups to discuss the answer with their peers. The students are given time to argue out the correct answer in each group. The teacher move around the class to observe and listen to the students as they argued among themselves. The groups selected a leader among themselves to discuss their answer with the whole class while any member of the class may object the answer with reason(s). The teacher concludes the argument session with an explanation on the conceptest as the case demand. The time for this session is 30 minutes.

Participants

52 pre-service physics teachers of College of Education (T) Lafiagi, Kwara state, participated in this study. The students were purposively sampled because they were in their introductory class. Electromagnetism as a course in physics was used for the study because of poor academic performance in electromagnetism among physics students in colleges of education [34].

The purpose of this study is to investigate the academic performance of the pre-service physics teachers in Nigeria using the PI. Specifically, effort was made to find out:

If there is any difference in academic performance between students taught with the PI and the traditional lecture method; if there is any difference between student taught with PI and the lecture method based on gender; and if there are any misconceptions held by the physics students.

Discussion and Finding

Table 1: ANCOVA Analysis

Dependent Variable: post						
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	1054.345[a]	2	527.173	3.745	0.031	0.133
Intercept	5288.417	1	5288.417	37.565	0.000	0.434
Pre	98.018	1	98.018	0.696	0.408	0.014
Group	1012.579	1	1012.579	7.193	0.010	0.128
Error	6898.174	49	140.779			
Total	52911.000	52				
Corrected Total	7952.519	51				

a. R Squared = 0.133 (Adjusted R Squared = 0.097)

From Table 1, the independent variable (group) has a significant value of 0.010 which is less than the probability value of 0.05; this implies that there is a significant difference between the groups. Therefore, there is a significant difference between the independent and dependent variable. The partial eta squared indicates a large effect of this difference with the value of 0.128 (12.8%). The table also shows that the relationship between the covariate and the dependent variable is not significant with 0.408, higher than the probability value of 0.05.

Table2: Descriptive statistics

Gender		**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Score	Male	15	30.27	13.900	3.589
	female	11	27.82	9.898	2.984

Table 2 shows there is a difference in the mean values of the groups; however, calculation of eta squared value of 0.010 indicates a small size effect.

Table 3: Independent t-test analysis

		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	Equal variances assumed	0.921	0.347	0.498	24	0.623	2.448	4.918	-7.703	12.600
	Equal variances not assumed			.525	23.994	0.605	2.448	4.668	-7.185	12.082

Table 3 shows non-violation of the assumption of equal variance because the significant value of 0.347 is greater than the probability value of 0.05. The t-test for the equality of mean value has 0.623 (2-tailed) which is greater than the probability value of 0.05: this implies that there is no significant difference between the groups.

The DAQ contains structured, and unstructured,open-ended questions to get students ideas of their personal experience about the PI. 85% of the students agreed they had many misconceptions in electromagnetism which they were able to overcome through PI. According to these students, the misconceptions they overcame through the PI are the following: how insulator works, diode, resistor and resistance, electrical circuit, capacitor, and capacitance. The students submitted that the sequential orders of getting the correct answer be personal thinking, active involvement in argument and considering others contributions. The next focus is the summary and the major findings of the study.

Summary of the Finding

Given the analysis and the discussion above there is a difference between students taught with the PI and the traditional lecture method. This findings is providing an answer to the research question 1 of the study. The finding also provides an answer to the research question 2 that there is no significant difference in the performance of male and female students taught with PI. Through DAQ analysis, it was revealed that the students had misconceptions in physics which they got rid of through the PI.

The finding on the PI is in support of Crouch and Mazur; Fagen and Mazur that PI has the potential of improving the conceptual and problem-solving skill understanding of physics students [8, 12]. The finding is also on the same page [12] that there is no gender gap in conceptual understanding of introductory physics among university students taught with interactive pedagogy.

Besides, the PI helps to get rid of some misconceptions held by the students in electromagnetism as supported by *Porter et al* and Crouch *et al*. The concern raised by some authors on how students get the correct answers in PI might be laid to rest as students described the sequential order of getting their answers [6, 35]. However, more research is needed in this area. Based on the above findings, the following recommendations are suggested:

Recommendations

Given the above findings, the following are proposed as recommendations:

PI should be adopted as a method of teaching science subjects in Nigerian school in particular among the students higher schools.

The dialogical argumentation instruction should always be used along with PI to strengthen its power in solving the problem of students' misconceptions in sciences.

Researchers in Nigeria and Africa countries should do more study in PI because finding shows that more than 90% of the research carried out on PI is outside African schools.

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References

[1]. Wanbugu, P.W., Changeiywo, J.M., & Ndiritu, F.G. (2013). Investigations of experimental cooperative concept mapping instructional approach on secondary school girls' achievement in physics in Nyeri County, Kenya. *Journal of Education and Practice,4*(6), 120-130.

[2]. Malcolm, D. H. and Wells, G. S. (1994). A modeling method for high school physics instruction. *American Journal of Physics*, *63*(7), 606–619.

[3]. McCarthy, J. P., & Anderson, L. (2000). Active Learning Techniques versus Traditional Teaching Styles: Two Experiments from History and Political Science. *Innovative Higher Education*, *24*(4), 279–294. http://doi.org/10.1023/B:IHIE.0000047415.48495.05.

[4]. Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science (New York, N.Y.)*, *332*(2011), 862–864. http://doi.org/10.1126/science.1201783.

[5]. Watkins, J., & Mazur, E. (2013).Retaining Students in Science, Technology, Engineering, and Mathematics (STEM) majors. *Journal of College Science Teaching*, *42*(5), 36-40.

[6]. Crouch, C.H, Watkins,J.,Fagen, A.P. &Mazur, C. (2007). *Peer Instruction: Engaging students one-on-one, all at once.* Research-Based Reform of University Physics. Retrieved from www.mazur.harvard.edu/sentFiles/Mazurpubs_537.pdf.

[7]. Bernhard, J, et al. (2007). Making physics visible and learnable through interactive lecture demonstrations. *Physics Teaching in Engineering Education PTEE.*

[8]. Fagen, A.P., & Mazur, E. (2003). *Assessing and enhancing the introductory science coursesin physics and biology: Peer Instruction, classroom demonstration, and genetic vocabulary.* (Doctoral thesis, Harvard University) Cambridge, Massachusetts.

[9]. Stephen, U.S (2010).Technological Attitude and Academic Achievement of Physics Students in Secondary Schools. *African Research Review, 4*(3a), 150-157.

[10]. Dupe, O.B. (2013). Predicting students' achievement in physics using academic self- conceptand locus of control scale scores. *International Journal of Social Science and Education, 3*(4), 1149-1155
[11]. Aina, J.K.,&Akintunde, Z.T. (2013). Analysis of gender performance in physics in colleges of education, *Nigeria. Journal of Education and Practice, 4*(6), 1-5.
[12]. Crouch, C.H., & Mazur, E. (2001). Peer instruction: ten years of experience and results. *American Journal of Physics, 69*(9),970-977. DOI: 10.1119/1.1374249.
[13]. Gok, L. (2013). A comparison of students' performance, skill and confidence with peer instruction and formal education. *Journal of Baltic Science Education, 12*(6), 747-758.
[14]. Stein, M., Larrabee, T.G., & Barman, C.R. (2008). A study of common beliefs and misconceptionsin physical science. *Journal of Elementary Science Education, 20*(2), 1-11.
[15]. Gooding, J., & Metz, B. (2011). From misconceptions to conceptual change: tips for identifying and overcoming students' misconceptions. *The Science Teacher*, 34-37.
[16]. Gok, T. (2012). The Impact of Peer Instruction on College Students' beliefs about Physics andconceptual understanding of electricity and magnetism. *International Journal of Science and Mathematics Education, 10*(2011), 417–437.
[17]. Rao, S. P., &DiCarlo, S. E. (2000). Peer instruction improves performance on quizzes. *Advances in Physiology Education, 24*(1), 51-55.
[18]. Rosenberg, J. L., Lorenzo, M., & Mazur, E. (2006). Peer instruction: making science engaging. In *Handbook of college science teaching* (pp. 77–85).
[19]. Lasry, N., Mazur, E., & Watkins, J. (2008). Peer instruction: From Harvard to the two-year college. *American Journal of Physics*. http://doi.org/10.1119/1.2978182.
[20]. Tellings, A. (2012). The role of theory in educational research. The Research Council of Norway, UTDANNING2020. Retrieved from www.rcn.no/utdanning.
[21]. Leedy, P.D. & Ormrod, J.E. (2005). Practical research: planning and design (8th ed,). Pearson Educational International and Prentice Hall: New Jersey.
[22]. Garbett, D. (2011). Constructivism deconstructed in science teacher education. *Australian Journal of Teacher Education, 36*(6), 36-49 http://dx.doi.org/10.14221/ajte.2011v36n6.5.
[23]. Schreiber, L.M. & Valle, B.E. (2013). Social constructivist teaching strategies in asmall group classroom. *Small Group Research*, 44(4), 395-411.DOI: 10.1177/1046496413488422.
[24]. Educause Learning Initiative (2005). Interaction: Principles and Practice. ELI Summer Session(August 2005). pp. 1-9.
[25]. Powell, K.C.,& Kalina, J.C.(2010). Cognitive and social constructivism: developing tools for effective classroom. Education, 130(2), 241-249.
[26]. Kim, B. (2001). Social constructivism. In M. Orey (Ed), Emerging perspectives on learning,Teaching, and technology. Retrieved from http://www.coe.uga.edu/epltt/Social Constructivism.htm.
[27]. Andrews, T. (2012). What is social constructivism? *Ground Theory Review, 11*(1), 39-46.
[28]. Bredo, E. (1994). Reconstructing educational psychology: situated cognition and Deweyian Pragmatism. *Educational Psychologist,29*(1), 23-25.
[29]. Johnson, D.W., Johnson, R.T. & Tjosvold, D. (2000). Constructive Controversy: The Value of Intellectual Opposition.In M. Deutsch and P. T. Coleman, (Eds), *The handbook ofconflict resolution: Theory and Practice* (pp. 65-85).San Francisco: Jossey-Bas Publishers.
[30]. Johnson, D. W., & Johnson, R. (2003).Controversy and peace education. *Journal of Research in Education, 13*, 71–91.
[31]. Johnson, D. W., & Johnson, R. T. (2007).*Creative controversy: Intellectual challenge in The Classroom*(4th ed.). Edina, MN: Interaction.
[32]. Smith, K.A. (2013). Introduction to Constructive Controversy: The Art of Arguing to Enhance Learning. Retrieved from http://www.personal.cege.umn.edu/.../Smith-MSU-4-11-13-controversy.pdf.
[33]. Dimitrov D.M. &Rumrill, P.D. (2003). Pretest-posttest designs and measurement of change. *Speaking of Research*. Retrieved from www.ncbi.nlm.nih.gov/pubmed/12671209.
[34]. Aina, J.K.,&Adedo, G.A. (2013). Correlation between continuous assessment (CA) and students' performance in physics.*Journal of Education and Practice, 4*(6), 6-9.
[35]. Porter, L., Lee, C.B., Simon, B., & Zingaro, D. (2011). Peer Instruction: Do Students Really Learn from Peer Discussion in Computing? Retrieved from https://www.academia.edu/2141146/Experience_ report_ peer_instruction_in_introductory_computing.