

Effects of Gender and Collaborative Learning Approach on Students' Conceptual understanding of Electromagnetic Induction

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Abstract

The study investigates the effect of gender and collaborative learning approach on students' conceptual understanding of electromagnetic induction in Secondary Schools in Nigeria. Three research questions and 2 hypotheses were formulated to guide the research. The research design adopted for this study is the quasi-experimental design. In particular, the design is the non-randomized, pretest-posttest, control group design. The population of the study is made up of the 323 Senior Secondary III physics students in all 6 public co-educational Senior Secondary schools in Port Harcourt local Government area. A sample of 90 students, comprising of 60 male and 30 females were selected for the study. The research instrument developed and used for this study is the Test on Electromagnetic Induction (TOEI). The instrument is composed of 50 questions covering the content area and testing the various levels of understanding. Simple means, standard deviation and variance were used to answer research questions while inferential statistics such as t-test, Analysis of variance (ANOVA) and 2x2 factorial analysis of variance were utilized for the testing of the hypotheses. The results show that gender does not significantly affect the understanding of students in electromagnetic induction when taught with collaborative teaching approach. The study also showed that gender and teaching approaches do not jointly affect students' conceptual understanding of electromagnetic induction at the secondary school level.

Keywords: *gender; collaborative learning; conceptual understanding; electromagnetic induction*

1. Introduction

Electromagnetic induction is a phenomenon whereby an electro motive force (e.m.f) is produced or induced in a conductor due to the relative motion of an electric conductor and a magnetic field. Electromagnetic induction is the production of voltage across a conductor moving through a magnetic field. It underlies the operation of generators, transformers, inductor motors, all electric motors and solenoids. Michael Faraday is generally credited with the discovery of the electromagnetic induction phenomenon in 1831. Faraday studied the magnetic field around a conductor carrying a Direct Current (DC) and established the basis for the electromagnetic field concept in physics. He discovered electromagnetic induction and his inventions of electromagnetic rotary devices formed the foundation of electric motor technology, and it was largely due to his efforts that electricity became viable for use in technology (Perry, 2010). Joseph Henry discovered the electromagnetic phenomenon of self-inductance and mutual inductance independently of Michael Faraday, but did not publish his findings until Faraday published his results (Perry, 2010). This is why the discovery of electromagnetic induction is credited to Faraday.

Electromagnetic induction is taught in senior secondary school (SSS) three physics in the current 6-3-3-4 system of education in Nigeria. In a study conducted by Ivowi (1983) as cited by Akpan (1999), physics students performed worst in conservation principles and fields (where electromagnetic induction is taught). The study also reported that teachers did worst in the same concept (fields). Studies have shown that the major cause of difficulty in the formation of physics concepts at the secondary school level has been the improper teaching of the subject (Maduabum, 1989; Akpan, 1999; Dayal, 2007).

It is evident from the foregoing that science educators and indeed all stakeholders in the teaching and learning of

science are in search of better teaching and learning strategies that will enable physics students gain proper understanding and application of physics concepts and principles. Several science educators have outlined methods of teaching science (Gbamanja, 1999; Alamina, 2001; Achuonye and Ajoku, 2003; Dayal, 2007). Some of the methods mentioned include lecture, question-answer problem solving, play-way, discovery, field trip, demonstration, project method; Computer Assisted Instruction (CAI) and collaborative approach. The choice of any or some of these methods in science teaching depends on the age, content availability of resources, previous knowledge and the teacher's versatility (Gbamanja, 1999; Alamina, 2008). In this study, collaborative teaching approach is used with gender as an intervening variable to investigate students' conceptual understanding of electromagnetic induction. Students in the control group were taught using the demonstration method.

2. Collaborative Learning as a Teaching Strategy

Collaborative learning is a situation in which two or more people learn or attempt to learn something (Dillenbourg, 1999). Collaborative learning is a constructivist strategy. More specifically, collaborative learning is based on the model that knowledge can be created within a population where members actively interact by sharing experiences and take on asymmetry roles (Mitnik, Recabarren, Nussbaum, & Soto, 2009). Collaborative learning refers to methodologies and environments in which learners engage in a common task where each individual depends on and is accountable to each other. Very often, collaborative learning is used as an umbrella term for a variety of approaches in education that involve joint intellectual efforts by students and teachers (Smith & MacGregor, 1992).

The teaching of physics should show how facts are established by experiment and observation, how generalizations are built upon this knowledge and concepts developed. When this is achieved, our secondary school leavers should be able to adapt to the rapid and drastic changes in technology and social culture. Unfortunately, the current trend in the teaching and learning of physics, where materials for teaching are not available in public schools (Onwioduokit, 2001), has forced most teachers to use the traditional lecture method in teaching physics (Dayal, 2007; Alamina, 2008). Some research evidence suggests that the use of traditional lecture methods for the teaching and learning of sciences has not been effective in supporting students' learning and equipping them with necessary skills of the process of science (Raine & Collett, 2003; Taner, 2013; Adolphus, Onwioduokit & Dike, 2015). This has made it difficult for students to attain expected levels of achievement thereby undermining the realization of the relevance and importance of physics in our national development. This research work therefore explores the effects of collaborative learning approach on male and female students' conceptual understanding of electromagnetic induction.

3. A Review on Some Learning Theories

Jean Piaget is the major exponent of the cognitive developmental approach to learning. Cognitive psychologists believe that learning takes place as a result of the internal processes of the learner (Odili, 2006). The cognitive theory of learning is of the view that learning can be explained by mental processes as well as by observable behavior and that learning is conceptualized as a mental change rather than a behavioral change.

Mental processes involve thinking, feeling motivation, paying attention, studying and remembering (Ormrod, 2003). Cognitive development occurs as a result of maturation of the learner influenced by environmental factors. Cognition refers to the learners' action or adaptation of its action towards the objects in its environment. The development of knowledge seems to be the result of a process of elaboration that is based, essentially on the activity of the learner. It is in acting with the external world that the learner elaborates a more and more adequate knowledge of reality (Olanrewaju and Ologunmeta, 2002). As the organism develops, its cognitive structure changes. Piaget distinguishes four main stages of cognitive development - the sensory – motor stage (0-2years), pre-operational stage (2-7years), the Concrete operational stage (7-12years) and formal operation stage (12-end of adolescence), (Huitt & Hummel, 2003). Growth is understood through the knowledge that children exhibit at each stage of development and that mental or intellectual growth is dependent upon growth from outside (Achuonye & Ajoku, 2003). Unlike Piaget who divided cognitive development stages into four, Brunner was of the opinion that mental development evolves through three stages, which are enactive, iconic and symbolic modes of representation. (Achuonye and Ajoku, 2003).

Constructivism is a psychological theory of knowledge which argues that humans generate knowledge and meaning from their experiences (Alamina, 2008). Constructivism is not a specific pedagogy. In past centuries, constructivist ideas were not widely valued due to the perception that children play was seen as aimless and of little importance. Jean Piaget did not agree with this traditional view. He saw play as an important and necessary part of the students' cognitive development and provided scientific evidence for his views. Some historical figures who influenced constructivism included Giambattista Vico, Immanuel Kant, John Dewey, Jean Piaget, Lev Vygotsky, Jerome Brunner, Herbert

Simon, Paul Watzlawick, Ernst von Glasersfeld and Edgar Morin. However, formalization of the theory of constructivism is generally attributed to Jean Piaget who articulated mechanism by which knowledge is internalized by learners (Glaserfeld, 1996; Maltinez- Delgado, 2002). Constructivist theories of learning stress the importance of learners being engaged in constructing their own knowledge (Mayer, 2004; Palinesar, 1998).

Collaborative learning approach as an aspect of constructivism is often associated with pedagogic approaches that promote active learning, or learning by doing. In science (and Mathematics) education, von Glasersfeld's radical constructivism (Von Glasersfeld, 1992) is most often employed as reference position of the constructivist view. A review of research in science teaching shows an almost exclusive domination of males over females in learning achievements in selected science concepts. Maduabum and Odili (2007) reported that boys perform better than girls in mathematics and further mathematics achievements and that, they performed better on tasks requiring logical operations. However, Adaramola and Onwioduokit (2010) have argued that boys will do better than girls if not taught with proper problem solving models. This underscores the place of teaching approaches in students' achievement. Collaboration among learners where solutions to problems are commonly sought among group members of different ratings and mixed gender in co-educational schools is usually advocated. Gurian, Henley and Trueman (2001) argued that from preschool to high school brain differences between the sexes call for different teaching strategies. According to them boys are more difficult to teach and have more learning and discipline problems. The female brain, according to them, has a learning advantage because it is more complex and active. They however opined that the male brain does excel at abstract thinking and spatial relations.

An overview of the reviewed literature shows that most of the studies on collaborative learning and conceptual understanding of students on electromagnetic induction are foreign. Very few literatures could be cited on collaborative learning and gender effect on conceptual understanding in electromagnetic induction and science in general. It therefore becomes necessary to study the relative effects of collaborative and demonstration approaches on students' conceptual understanding and application of electromagnetic induction in secondary school physics.

4. Purpose of the Study

The purpose of this study was to investigate the effect of gender and collaborative teaching approach on students' conceptual understanding of electromagnetic induction. More specifically, the research intends to:

1. Determine the effects of collaborative learning approach on male and female students' conceptual understanding of electromagnetic induction.
2. Determine the joint effect of collaborative teaching approach and gender on students' understanding of the concept of electromagnetic induction.

5. Hypotheses

The following null hypotheses will be tested:

1. There is no significant difference between male and female students understanding of electromagnetic induction when taught with collaborative learning approach.
2. There is no significant joint effect of teaching approach and gender on students' understanding of the concept of electromagnetic induction.

6. Methodology

The research design adopted for this study is the quasi-experimental design. In particular, the design is the non-randomized, pretest-posttest, control group design. The independent variables were the teaching approaches while students' understanding is the dependent variable with gender as the intervening variable. The design is structurally represented as shown in Figure 1.

| Group | Pretest | treatment | Post-test |
|--------------|----------------|----------------|----------------|
| Experimental | O ₁ | X ₁ | O ₃ |
| ----- | | | |
| Control | O ₂ | X ₂ | O ₄ |

Figure 1. Quasi-experimental, Pretest-Post test, Non-randomized Control Group Design

Nwankwo (2010) defined quasi –experimental study as a study in which some threats to internal and external validity cannot be properly controlled because of unavoidable situations associated with the study when human beings are used for experimental study.. The students were not randomized and the teaching approaches- constructivist (collaborative) and demonstration (for the control group) as treatment were applied to them in their respective classroom settings. That is, intact classes were used to avoid disrupting the school schedule.

6.1 Sample

The population of the study is made up of all 323 Physics students in SSS III. By stratified random sampling, two (2) co-educational schools located strategically in area of study were chosen for the study. A random sample of 90 students, comprising of 60 male and 30 females were selected for the study. The research instrument developed and used for this study is the Test on Electromagnetic Induction (TOEI). The instrument is composed of 50 questions covering the content area and testing the various levels of understanding. The TOEI is made up of standard objective questions adapted from past question papers of Senior Secondary School Certificate Examinations (SSCE), National Examination Council (NECO) and Joint Admission Matriculation Board (JAMB) Examinations. The TOEI was used for both pre-test and post-test. The TOEI is designed to measure students' understanding and application of electromagnetic induction.

7. Findings and Results

Hypothesis 1

There is no significant difference between male and female students understanding of electromagnetic induction when taught with collaborative learning approach.

Table 1. Showing Male and Female Students' Pre and Post Test Scores When Taught with Collaborative Teaching Approach

| Gender | | Pre test | Post test | Gain | % gain |
|--------|------|----------|-----------|-------|--------|
| Male | Mean | 27.00 | 41.03 | | |
| | N | 60 | 60 | 14.03 | 51.96 |
| | SD | 8.66 | 9.49 | | |
| Female | Mean | 25.00 | 40.07 | | |
| | N | 30 | 30 | 15.07 | 60.28 |
| | SD | 8.17 | 10.18 | | |

Table 1 shows male and female students' pre and post test scores when taught with Collaborative Teaching Approach. The result shows a 51.96 % gain for male students while female students had a 60.28% gain when the pre and post test scores were compared. Also, male students had a mean of 41.03% in the post test while female students had a mean score of 40.07%. The standard deviations of 9.49 and 8.66 for males and 10.18 and 8.17 for females show that the scores of male students are more homogeneous than those of female students in both the pre- and post-tests.

Table 2. t-test Comparison of Male and Female Students' Understanding of Electromagnetic Induction When Taught with Collaborative Learning Approach

| Gender_ | Mean(\bar{X}) | SD | N | df | t _{cal} | t _{crit,} $\alpha=0.05$ | Significance |
|---------|-------------------|-------|----|----|------------------|-------------------------------------|-----------------|
| Male | 41.03 | 9.49 | 60 | 88 | 0.42 | 1.987 | Not Significant |
| Female | 40.07 | 10.18 | 30 | | | | |

As illustrated in Table 2, the calculated t-value (0.42) is less than the critical t-value (1.987) at $\alpha = 0.05$. We therefore accept the hypothesis, there is no significant difference between male and female students understanding of electromagnetic induction when taught with collaborative learning approach.

Hypothesis 2

There is no significant joint effect of teaching approach and gender on students' understanding of the concept of electromagnetic induction.

Table 3. Showing the Relative Effects of Collaborative Teaching Approach and Gender on Students' Understanding of Electromagnetic in Induction

| Teaching Approach | Gender | Pre test | Post test | Gain | % gain |
|-------------------|--------|----------|-----------|-------|--------|
| Collaborative | Male | 27.00 | 41.03 | 14.03 | 51.96 |
| | Female | 25.00 | 40.07 | 15.07 | 60.28 |

Table 3 illustrate that the post test scores in terms of teaching approach and gender were higher than the pre-test scores. Also, the mean score of students taught with the collaborative approach is higher for male (41.03%) than for female (40.07%). The result also revealed that girls had a gain % of 60.28 while that of the boys was 51.96. This shows a higher gain percent for the girls than the boys.

Table 4. 2x2 Analysis Of Variance of Post Test Scores of Students' Understanding of the Concept of Electromagnetic Induction with Respect to Teaching Approaches and Gender

| Source of Variance | SS | Df | MS | F | Significance at $\alpha=0.05$ |
|---------------------|----------|-----|---------|-------|-------------------------------|
| Teaching Approaches | 7270.75 | 1 | 7270.75 | 91.44 | Significant |
| Gender | 27.77 | 1 | 27.77 | 0.35 | Not significant |
| Interaction | 0.72 | 1 | 0.72 | 0.01 | Not significant |
| Between groups | 7299.24 | 3 | 2433.08 | | |
| Within group | 13994 | 176 | 79.51 | | |
| Total | 21293.24 | 179 | | | |

Table 4 shows that for teaching approaches with $F_{cal} = 91.44$, greater than the Table value of 3.84 (with df 1, 176 at $\alpha=0.05$), there is a significant effect of teaching approach on conceptual understanding of electromagnetic induction. The approaches investigated were collaborative and demonstration. A further investigation shows that with collaborative learning approach, students achieved better scores than those taught using the demonstration method. This is however not part of the present study and is therefore not reported here. For gender, the F_{cal} value of 0.35 is less than the Table value of 3.84, showing that gender does not significantly affect students understanding of electromagnetic induction. For the interaction between teaching approaches and gender, the F_{cal} value is 0.01 which is less than the Table value of 3.84. The null hypothesis is therefore upheld. This implies that there is no significant joint effect of teaching approach and gender on students' understanding of the concept of electromagnetic induction.

8. Discussion

The result of the study showed that students taught by collaborative learning approach obtained higher mean scores when their pre test and post test results are compared. The result of the present study suggests that the use of collaborative learning approach in the teaching and learning of physics in secondary schools has the potential of enhancing students' achievement. The result also shows that although female students had higher % gain in their mean scores than the boys, their difference in scores was not statistically significant. The better performance of students taught with the collaborative approach may be attributed to the collaborative efforts of students learning together in groups. The result justifies the observation of Guthrie *et al* (2004), Kim (2005), Kalendar (2007) and Chui (2008) that students engaged in collaborative learning capitalize on one another's resources and skills and so, improve on their learning. This view is supported by Baribor (2003), Dayal (2007) and Adaramola and Onwioduokit (2010) that modern science teaching is focused on changing from teacher-centered approach to student centered approach which encourages students to take more interest in learning and that activity oriented methods avail students opportunity of peer tutoring. For peer tutoring and collaborative learning to be effective especially in the science, schools would need to be adequately equipped with basic science laboratory and other related resources. Unfortunately in Nigeria, several scholars have decried the poor state and quality of science teaching and learning with the lack of adequate laboratory facilities and resources in most schools (Omosewo, 1993; Onwioduokit, 2001; Adeyemi, 2005). However, Elson (2005) differed in his opinion on the use of collaborative Learning for first year Legal Research, Writing and Analysis Course for legal students. He argued that such students are unlikely to gain sufficient working knowledge of the essential skills required for the Legal Research, Writing and Analysis Course and that such collaboration is likely to interfere with the progressive stages of the writing process.

The result of this study also showed that gender does not significantly affect the understanding of students in electromagnetic induction and that there is no significant joint effect of teaching approach (collaborative learning) and

gender in students' understanding of electromagnetic induction. This finding does not agree with the findings of Onah and Ugwu (2010) who indicated that performance in physics at the secondary school level is dependent on gender. The ScienceDaily (Nov 25, 2010) has attributed this gap predominantly from differential preparations prior to college and psychological factors, rather than differences in ability. Guman, Henley and Trueman (2001) had argued that from preschool to high school, brain differences between the sexes call for different teaching strategies. It is thought that the use of activity oriented approaches like collaborative learning that encourages free integration among learners will reduce the gender gap in performance in the sciences. However, finding of this study agrees with the view of Adaramola (2011) that gender was found insignificant in her research on the effects of activity-oriented methods on the performance of students with dyscalculia in secondary school mathematics. These views are opposed to that of Maduabum and Odili (2007) who reported that boys perform better than girls in Mathematics and Further Mathematics achievement and that boys performed better on tasks requiring logical operations. This view may have been reached from studies based on traditional teaching approaches which present mathematical concepts as highly abstract, formulae dependent and rote memorization.

The finding of this study has shown that collaborative learning approach significantly affects students' understanding of electromagnetic induction whereas gender does not significantly affect students' understanding of the concept. The implications of the findings of the study are that educational institutions, government and relevant authorities that train, recruit and monitor the professional development of physics teachers would need to ensure that teachers receive appropriate training and skills needed for the facilitation of collaborative learning in their classes. This can be achieved by the incorporation of content on collaborative learning and peer-tutoring strategies in the training and re-training of student teachers. Two. government needs to as a matter of urgency, provide adequate laboratories and physics teaching and learning resources in all schools to support student-centered guided discovery and collaborative learning among secondary school students. Three, teachers on their part would need to understand the various aspects of the physics curriculum that students can learn better by collaborative learning and use all available resources to support and facilitate students' participation. Four, there is also the need of equipping students with necessary skills to enrich their science learning experience by collaborative learning. Finally, teachers would need to devise appropriate approaches that encourage the interaction of boys and girls in the learning process so as to drastically reduce or remove the gender gap in performance in science subjects.

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