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EFFECTIVENESS OF POLYA PROBLEM-SOLVING AND TARGET-TASK COLLABORATIVE LEARNING APPROACHES IN ELECTRICITY AMONGST HIGH SCHOOL PHYSICS STUDENTS

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Abstract. *This research reports on the effectiveness of Polya Problem-Solving and Target-Task collaborative learning approaches in electricity amongst high school physics students. It also includes a gender focus. It was an experimental research with a pre-test post-test control group design. The experimental groups were exposed to Polya Problem-Solving approach and Target-Task collaborative learning approach while the control group were exposed to conventional teaching. A total of 180 students were selected and divided equally into three groups, 60 (male adolescent and female adolescent) each. The students were initially pre-tested, followed by teaching and learning in electricity using the treatments, and finally they were post-tested using the Performance Test in Current Electricity (PTCE). Data were analyzed quantitatively with descriptive statistics and ANCOVA, and the research hypotheses were tested at .05 alpha level of significance. The research confirmed that both the treatments, Polya Problem-Solving and Target-Task collaborative learning approaches enhanced the performance of the students based on gender and scoring abilities compared with the conventional teaching.*

Keywords: *collaborative learning, conventional teaching, gender, performance, physics students', Polya problem-solving, target-task.*

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Introduction

Problem-solving skills are of immense value to society and it has produced noticeable results in teaching and learning physics especially in students' academic performance in high school physics. Physics is one of the essential disciplines that plays a vital role in advancement of science and technology through exposing and improving students' proficiency in solving complex problems (Docktor & Mestre, 2014; Elvira, 2016). While there are lots of earlier research, especially in America, indicating that problem solving strategies taught has somewhat improved the solving of physics problems (Heller & Reif, 1984; Hsu, Brewe, Foster, & Harper, 2004; Leonard, Dufresne, & Mestre, 1996; Van Heuvelen, 2001), current studies globally however, show that both male and female students are still performing poorly in physics and in physics problem solving aspect (Bryant & Swinton, 2001; Gonzuk & Chagok, 2001) and particularly so in Africa (Josiah, 2013; Olaniyan & Omosewo, 2015). Research undertaken in different topics in high school physics showed that methods of teaching and problem-solving skills are major factors to be considered for better performance in the subject (Brewton, 2001; Çalışkan, Selçuk, & Erol, 2012; Gonzuk & Chagok, 2001; Orji, 2000). In studies of Akinbobola and Afolabi (2010), Okoronka and Wada (2017) and Omaga, Iji and Adeniran (2014), guided discovery, problem-based learning approach and analogy instruction strategy were used. It was observed that the experimental groups performed better than the control group, but their findings varied between the performance of male and female students. Okoronka and Wada observed no difference in male and female performance, while Omaga, Iji and Adeniran observed variation in the performance of male and female students in electricity. Engelhardt and Beichner (2004) researched students' understanding of direct circuits and noted that girls and women did not perform as well on the test given as boys and men, either in high school or at universities. They conducted interviews that showed that, at universities, women had more misconceptions about dc circuits than men, but this difference was not observed between boys and girls in high school. In addition, male students were much more confident in their answers than female students, though reasons for this difference were not explored.

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The research by Danili and Reid (2004) confirmed that the mental capacity (m-space) with students' ability to deal with problem-solving is a significant factor to be considered in solving complex problems. They also stated that there is a relationship between working memory capacity and science achievement at all levels. It was also noted in Bodner and Herron (2002) that students with high and low memory capacity perform significantly different in chemistry at high school level. In addition, other researchers found that using different problem-solving approaches in physics produce varied results (Leak et al., 2017; Mogari & Lupahla, 2013). Recently, in Africa, Olaniyan and Omosewo (2015) observed that Target-Task problem solving approach emphasized that students' collaboration and group participation enhanced better performance of high, medium and low scoring level students, and particularly of low scoring students.

For teaching and learning to be effective, the physics teacher has to be able to bring various teaching strategies such as collaboration, practical work, use of ICTs, active engagement and explicit problem-solving skills into the physics classroom to address effective learning of both male and female students of different scoring abilities (Çalışkan et al., 2012; Leak et al., 2017; Lorenzo et al., 2006). Recently, research effort has been put in place to combine various methods of teaching such as practical, concept mapping, etc. with collaborative efforts of students in the classroom settings (Barkley, Cross, & Major, 2014; Duit & Treagust, 2003). Physics teachers can diversify their problem-solving approaches by creating several pathways of making students learn by combining problem-solving approaches with collaborative learning. Collaborative learning (CL) has been documented as an important strategy with regards to improving the scoring ability of students in physics (Govender, 2015; Harskamp & Ding, 2006) {Govender, 2015 #22; Harskamp, 2008 #40}. For example, Govender (2015) concluded that collaborative learning enhanced the subject matter knowledge of difficult concepts in Electromagnetism among pre-service physics teachers' when concept maps and collaborative learning were integrated.

For research in selected physics topics like electricity, high performance in problem-solving is rare and the reasons for this include the abstract and counterintuitive nature of many essential concepts (Mulhall, McKittrick, & Gunstone, 2001; Stott, 2017), students' sloppiness and lack of ambition (Dayioğlu & Türüt-Aşik, 2007; Stanton, 1990), limited understanding of the topics by the teachers (Duit, 2009), the lack of creativity in terms of improvisation (Omaga et al., 2017; Orji, 2000), poor background of the students at the developmental stages of schooling (Olaniyan & Omosewo, 2015) and gender differences (Olaniyan & Omosewo, 2015; Orji, 2000). In particular, Orji (2000) and Olaniyan and Omosewo (2015) have shown significant differences in performance of male and female physics students and differences in their performances based on low, medium and high scoring abilities.

Researchers in several studies had examined students' performance in physics and the reasons for their poor performance in problem-solving. However, this research seeks to improve students' performance in physics, specifically in current electricity by the use of two activity-based approaches, namely, Polya-Problem-Solving and Target-Task collaborative learning. It also seeks to bridge the gender gap and compares the effectiveness of Polya Problem-Solving and Target-Task collaborative learning approaches on male and female students' performance and their scoring abilities in Electricity in high school physics.

The following research questions are addressed:

i. What is the effectiveness of Polya Problem-Solving approach on performance of male and female students in electricity?
ii. What is the effectiveness of Target-Task collaborative learning approach on performance of male and female students in electricity?
iii. What is the effectiveness of the treatments (Polya Problem-Solving and Target-Task collaborative learning approaches) on students' performance in physics in electricity?
iv. What is the effectiveness of the treatments (Polya Problem-Solving and Target-Task collaborative learning approaches) on performance of low, medium and high scoring students in electricity?
v. Why do students perform in the way they do in the research questions i-iv above?

Theoretical Frameworks

Problem-solving requires a lot of teacher planning and preparation before effective learning can take place in the class. Efforts have been put in place to ensure that what goes on in the classroom shifts from the traditional chalk and talk teaching methods to activity-based methods. In this research, effort was directed in comparing the effectiveness of two activity-based learning methods, namely, Polya Problem-Solving (PPS) and Target-Task collaborative learning (TTCL) approaches on students' performance in physics. The earlier studies on collaborative learning and problem-solving in physics (Tao, 1999, 2001) encompassed Piaget's and Vygotsky's work as theoretical underpinnings. Piaget (1985) stated that the benefit of collaboration lies in the cognitive conflicts created from students' divergent views. Piaget focused on the individual perspective of learning, treating peer collaboration as merely providing a useful context or vehicle for students' personal sense-making and knowledge construction (Tao, 2001). Vygotsky (1978), however, stressed both the individual and social perspectives of learning. He regarded learning as a social process in which meaning-making and understanding are first rehearsed between people before they are developed within the individual in a process of internalization.

Polya Problem-Solving approach is in the context of Piaget's theory, an individual constructivist's theory which allows students to work on their own as individuals after been exposed to the approach. This theory is based on the dynamic view of a constructivist who believes that learning is the result of the interaction between what learners are taught and their current ideas. Duit and Treagust (2003) noted that certain limitations on the constructivists' ideals in the early 1990s led to its merger with social constructivists' ideas. The Target-Task collaborative learning approach is an ideal of the construction of learning as espoused by social constructivists. Vygotsky's theory is one of the foundations of social constructivism. It asserts two major themes regarding social interaction that are integral to the process, namely, the more knowledgeable other, and the zone of proximal development (Vygotsky, 1978). Vygotsky in his application of the theory opined that many schools have traditionally held a 'transmissionist' or 'instructionist' approach in which an educator 'transmits' information to their students. His theory promotes learning contexts in which students play an active role in learning. Roles of the teacher and student are therefore shifted whereby the teacher or mentor should collaborate with his or her students to facilitate construction of 'meaning' in students. Learning therefore becomes a reciprocal experience for both, the student and the teacher. Problem-Solving has been a long-standing interest for teachers and researchers in physics education. Efforts had been made to research on problem-solving skills in physics to enhance students' performance in the subject (Gustafsson, Jonsson, & Enghag, 2015; Harskamp, Ding, & Suhre, 2008; Maloney, 1994; Orji, 2000). The research findings showed that students find it difficult to relate the right knowledge to the problem; some have difficulty analyzing a problem or carrying out the appropriate calculation. Based on a comprehensive review of research on problem-solving in physics, Maloney (1994) summarized that successful students' problem-solving strategies at least contain conscious qualitative analysis of a problem, such as, making a sketch of the problem, restating the problem in one's own words, and conscious quantitative review of equations or theorems that fit the problem. The students perform better in solving physics problems when the teaching-learning pedagogy has been directed towards the use of appropriate physics problem-solving approaches. Hence, in social constructivism, understanding the roles of a mentor, mentee and approaches to problem-solving in the teaching-learning pedagogy are vital. Problem-solving approaches have also been linked directly with collaborative learning strategies.

Collaborative learning is mutual combination of ideas of learners in a classroom environment for solving problems. It involves participants working together on the same task, rather than in parallel on separate portions of the task (Dillenbourg, 1999; Govender, 2015). Collaborative interactions are characterized by shared goals, symmetry of structure, and a high degree of negotiation, interactivity, and interdependence. Interactions producing elaborated explanations are particularly valuable for improving student learning. Collaboration takes place within a joint problem space, which provides the structure needed to allow meaningful conversations about the problem. To construct a joint problem space, partners must have ways to introduce and accept knowledge, monitor exchanges for evidence of divergent meanings, and repair any divergences identified (Roschelle & Teasley, 1995). Collaborative learning activities allow students to provide explanations of their understanding, which can help students elaborate and reorganize their knowledge (van Boxtel, van der Linden, Roelofs, & Erkens, 2002). Social interaction stimulates elaboration of conceptual knowledge as group mates attempt to make themselves understood. Research provides evidence that providing elaborated explanations improves student comprehension of concepts. Once conceptual understandings are made visible through verbal exchange, students can negotiate meaning to arrive at convergence, or shared understanding (Lai, 2011). According to Dillenbourg (1999), a true mark of collaborative learning is the quality of interactions, especially the degree of interactivity and negotiability. Interactivity refers to the extent to which interactions influence participants' thinking. Negotiability refers to the extent to which no single group member can impose his view unilaterally on all others, but rather all group members must work towards a common understanding. Research has shown that when students are actively engaged through group interactions, they take responsibility for their own learning and become highly motivated towards mastery, rather than performance-based learning (Govender, 2015). It was also observed that better performance

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among students, based on their learning abilities, was obtained when students with low learning abilities were allowed to collaborate with others (Saner, McCaffrey, Stetcher, Klein, & Bell, 1994).

Students' thinking and reasoning ability as a variable also varies in terms of gender. Gender is one of the variables that have been related to differences in academic performance of students. Gender is referred to as social attributes and opportunities associated with being a male or a female (Sayid & Milad, 2001). It has to do with the relationships between women and men, boys and girls (Lorenzo et al., 2006). These attributes and opportunities are socially constructed and learned through the socialization process. Gender determines what is expected, allowed and valued in a woman or a man in a given context (Gallagher & Kaufman, 2004). Gender is related to differences in motivational functioning, in self-regulated learning and academic achievement. Sayid and Milad (2001) demonstrated the existence of different attribution patterns in boys and girls, such that, while girls tend to give more emphasis to effort when explaining their performance (Egbugara, 1989; Young & Fisler, 2000), boys appeal more to ability and luck as causes of their academic achievement (Harskamp et al., 2008).

Methodology of Research

General Background

The research considered the effectiveness of Polya Problem-Solving (PPS) and Target-Task collaborative learning (TTCL) approaches on electricity amongst upper secondary school physics students. It was a quasi-experimental non-randomized, non-equivalent pre-test and post-test control group design carried over six weeks. The research population was 621 senior secondary school physics students in a state in North Central geopolitical zone of Nigeria while the target population were senior secondary school physics students purposively selected from three schools within the state. Each school selected was randomly assigned one of the teaching approaches, namely, PPS, TTCL and conventional teaching. The research was conducted within the space of six weeks during the first term.

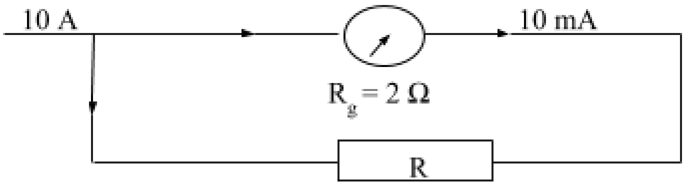
Sample

Three different intact classes of 60 physics students in each class were used, making a total of 180 students, which is 29 percent of the total population. The three intact classes were purposively selected from the research population based on three criteria, which include, physics teachers' qualification and experience, availability of physics laboratory and participation in external examinations. The three schools selected were those whose physics teachers have minimum a Bachelor's degree in Physics Education with at least 5 years of teaching experience, standard and functional physics laboratory and are currently presenting students for external examinations. The three schools were later randomly assigned to the experimental and control groups. One experimental group was exposed to Polya Problem-Solving (PPS), the other experimental group to Target-Task collaborative learning (TTCL). The control group was exposed to conventional teaching. Permission was sought from appropriate authorities of the three schools (the principals, heads of science department and the physics teachers). The students were informed about the research that involved six weeks of classroom teaching and learning in the first semester in 2015. The teacher of each intact class taught their classes using the assigned approaches of either PPS, TTCL or conventional teaching.

Instrument and Procedure

The research instrument used is the Performance Test on Current Electricity (PTCE). It consists of ten (10) test items on topics selected from the aspect of current electricity selected for the research. The test items encompassed Bloom's Taxonomy criteria selected from previous standardized examination questions of West African Examination Council. The face and content validation of the test were done by two science education experts (a professor and a senior lecturer) and two high school physics teachers. The test items were pilot tested using two schools which were not part of the subjects. Reliability test was conducted on the test items and a reliability index of 0.84 was obtained using Kuder-Richardson Formula 21(KR21). Two samples of the PTCE test items are given as follows:

1. The diagram below illustrates the conversion of a galvanometer **G** of resistance 2 Ω to an ammeter. The galvanometer gives a full-scale deflection for a current of 10 mA. Calculate the value of R.



2. The maximum permissible current through a galvanometer G of internal resistance 10 Ω is 0.05 A. A resistance R is used to convert G into a voltmeter with a maximum reading of 100 V. Find the value of R and state how it is connected to G.

Table 1 presents the research procedure that was conducted during the space of six weeks.

Table 1. Procedure for data collection.

Week	Activities
Week One	Training of teachers Grouping into scoring levels Pre-test
Week Two- Five	Teaching and learning using the approaches
Week Six	Post-test, marking and recording of data

In the first week the physics teachers for the experimental groups were trained by the researcher on the use of PPS and TTCL. Each teacher selected a teaching approach and were exposed to the content stage by stage for a period of one hour and thirty minutes each. Having gone through the content, the teachers were allowed to ask questions and the researcher gave the necessary clarifications. The teachers were encouraged to ensure that each approach was used appropriately. They were well guided by the researcher and the researcher ensured that the lessons were well monitored by checking on the classes at intervals during the lesson periods, for proper checks on the use of the approaches and for quality control during the experiment. The students were pre-tested with the PTCE test. During the first week the teacher collected the final physics examination scores from the previous year from the school and used the examination scores and pre-test scores to group the students into three scoring ability categories - high (75% and above in the final examination and 55% and above in pre-test), medium (between 50% and 74% in the final examination and scored between 45% and 54% in pretest) and low (below 50% and 45% in terminal exam and pre-test scores respectively). The criteria were used to ensure uniformity in the experimental groups. The grouping was done without the knowledge or awareness of the students. The researcher with cooperation of the teacher of TTLC experimental group placed the students in smaller groups. Students of different ability levels were placed together in small groups with special focus on low ability students, at least one low scorer in a group. The small groups comprised of six students per group as target task is an activity-based approach in which students worked together in small groups. The activities of the TTLC included: i) A Pre-Task: the teacher introduced the topic, explained the topic in detail and ensured the students understood what they are to do at the task stage. ii) A Task: the students completed the task in pairs or groups, while the teacher monitored and offered encouragement. iii) Planning: students prepared a written report on what they went through during the task in their group. iv) A Report: the students made their reports available to the teacher for assessment. After correction, the teacher presented the report back to the students. v) An Analysis: the teacher highlighted relevant parts of the learning on the board and vi) Practice: the teacher selected areas of practice for the students while students solved the problems as individuals.

In the Polya Problem-Solving approach, the experimental group were only grouped on record based on learning ability. PPS is an activity-based approach which allowed students to learn as individuals as the teacher exposed them to the four steps, namely, understanding the problem, devising a plan that will lead to the solution, carrying out the plan and looking back and evaluating their answers.

Teaching and Learning was done for four weeks (week two-five) using the treatments, Polya Problem-Solving approach for one intact class of experimental group, Target-Task collaborative learning approach for another intact

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class of experimental group and conventional teaching method was used for control group. At the end of the sixth week, the students were post-tested using the same PTCE test and marking and recording was done.

Data Analysis

Data were collected from each intact class (raw post-test scores) and analyzed using descriptive statistics (mean, standard deviation) and analysis of covariance (ANCOVA) by comparing the means of each group. The pre-test was used as covariates to post-test scores with gender and scoring levels as factors. The research null hypotheses were tested, and various conclusions were drawn. The Tables 2-4 contain the mean scores of each group exposed to the approaches.

Results of Research

The research hypotheses were tested on interval of 95% confidence level of $p<.05$ alpha level of significance. The research results are discussed as follows.

Result by Gender

The mean scores of students exposed to PPS and TTCL by gender is shown in Table 2.

Table 2. Mean scores of male and female exposed to the treatments.

Approach	No 60		Standard Deviation		Mean Scores Male		Mean Scores Female		Mean Gain Score	
	M	*F*	*M*	*F*	Pre-Test	Post-Test	Pre-Test	Post-Test	Male	Female
PPS	27	33	9.344	9.098	24.95	34.28	21.29	35.18	9.33	13.89
TTCL	29	31	13.263	9.674	15.71	33.86	12.71	25.55	18.15	12.84

The post-test score of female students exposed to Polya Problem-Solving approach (PPS) is 35.18, pre-test score is 21.29 and mean gain score is 13.89 while the post-test score of male is 34.28, pre-test is 24.95 and the mean gain score is 9.33. Comparing the mean gain scores of male and female in each approach, female students have higher mean gain score in Polya Problem-Solving approach (PPS) while male students have higher mean gain score in Target-Task collaborative learning approach (TTLC). PPS produced better and noticeable performance among female while TTLC produced better performance among male students. The null hypothesis tested stated that there is no significant difference in the effectiveness of Polya Problem-Solving approach on performance of male and female students. The null hypothesis was rejected, there was a significant difference in effectiveness of PPS on the performance of males and females. The conclusion is that PPS was more effective on female students than on males. In the case of Target-Task collaborative learning approach, the research hypothesis tested stated that there is no significant difference in the effectiveness of TTLC on performance of male and female students. The null hypothesis was also rejected because male students perform better than females, hence there was a significant difference. The conclusion is that TTCL was more effective on male students than female. Figure 1 showed clear difference between mean scores of male adolescents and female adolescents.

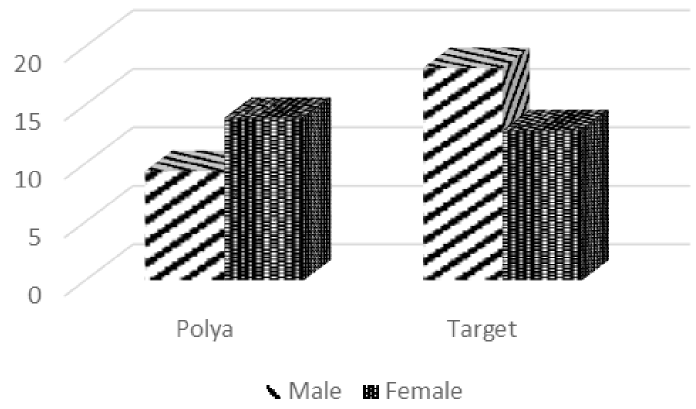

Figure 1. Chart comparing the mean gain scores of male and female students exposed to the treatment.

Figure 1 further describes the relationship between the mean gain scores of male and female students exposed to both PPS and TTCL. The research hypotheses were rejected, hence there was a significant interaction effects of the treatments on gender.

Result by Scoring Ability

The scores of students exposed to the PPS and TTCL based on their scoring ability is given in Table 3.

Table 3. Mean scores of high medium and low scorers exposed to the treatments.

Approach	Number 60			Standard Deviation			Mean Scores High Scorer		Mean Scores Medium Scorer		Mean Scores Low Scorer		Mean Gain Scores		
	H	M	L	H	M	L	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	H	M	L
PPS	16	23	21	5.567	2.745	4.607	31.06	44.94	25.57	34.09	16.67	23.86	13.88	8.52	7.19
TTCL	12	18	30	6.368	2.787	5.601	20.37	45.70	18.40	33.67	15.55	44.90	25.33	15.27	29.35

The results of post-test scores showed better performance of the three scoring ability groups irrespective of the approach used in teaching in Table 3. The post-test scores increase across board in the three-ability level. Comparing the performance of students exposed to each treatment, it is observed that Target-Task collaborative learning approach enhanced better performance of students in all ability levels compared with Polya Problem-Solving approach. The mean gain scores of high, medium and low scorers exposed to TTCL are 25.33, 15.27 and 29.35 respectively while mean gain scores of high, medium and low scorers exposed to PPS are 13.88, 8.52 and 7.19 respectively. Specifically, it is noteworthy that amongst the three levels in TTCL, low scoring ability students have highest mean gain score of 29.35. Comparing this with the three levels in Polya Problem-Solving approach, low scorers in PPS have the lowest mean gain score of 7.19. It is concluded that Target-Task collaborative learning approach enhanced better performance among students with low scoring ability compared with Polya Problem-Solving approach.

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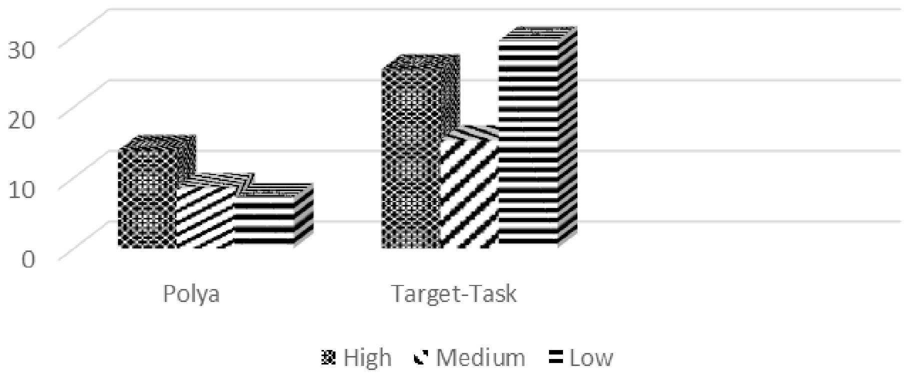

Figure 2. Chart comparing mean gain scores of high, medium and low scorers exposed to the treatments.

Figure 2 further describes the performance of students with the three ability levels exposed to the two approaches. The research hypothesis was rejected, hence there was a significant interaction effect between the treatment of PPS and TTCL and students' scoring ability.

Result by Treatment

The mean scores of students exposed to PPS, TTCL and conventional teaching.

Table 4. Mean scores of students by approaches.

Approach	Number	Standard Deviation Pre-test	Standard Deviation Post-Test	Pre-Test Mean Score	Post-Test Mean Score	Mean Gain Score
PPS	60	8.662	9.305	13.90	29.57	15.67
TTCL	60	5.911	12.191	12.56	33.40	20.84
Conventional	60	6.738	8.871	11.32	12.30	0.98

Table 4 reflects that on a general note, both treatments enhanced better performance among students in all categories as compared with the conventional teaching approach. Pre-test scores of PPS, TTCL and conventional teaching are 13.90, 12.56 and 11.32 respectively while post-tests scores of the same are 29.57, 33.40 and 12.30 respectively. Also, the mean gain scores of PPS, TTCL and conventional teaching are 15.67, 20.84 and 0.98 respectively. However, it could also be deduced that out of the two treatment groups, students exposed to Target-Task collaborative learning approach performed better than students exposed to Polya Problem-Solving approach as reflected in the mean gain scores of the two treatments.

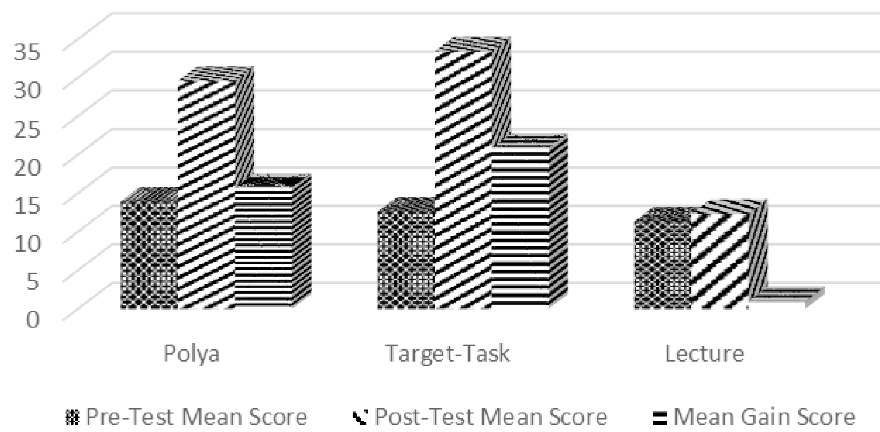

Figure 3. Chart comparing pre-test, post-test and mean gain scores of students in the experimental and control groups.

Figure 3 further illustrates the differences in the pre-test, post-test and mean gain scores of the experimental and control groups.

Discussion

Polya Problem-Solving approach (PPS) was found to be relatively more effective among female students and enhanced better performance compared with Target-Task collaborative learning (TTCL) approach where female scores were lower than males. Female students had higher mean gain score using PPS, this may be because the approach is student friendly and simple, clearly stated with steps in a step-by-step approach which made females to be more acquainted with this procedural approach to problem-solving as it consists of four straight steps with rote or task to be performed. Females may also likely be inclined to the 'recipe', in other words since Polya Problem-Solving approach has 'recipe' for solving problem, and it seems they prefer it over Target-Task collaborative learning approach. From the researcher's interaction with the students it was observed that the female students have affinity for more rote learning, less engagement in practical activities and have more interest in literature and language. This result concurs with Gabelko (1997) and Egbugara (1989) which posited that female students performed better than male students who were exposed to problem-solving approaches in their different research. In an interactive session the researcher held with the students after the research, it was observed that some of the female students don't enjoy activities related to electricity such as connecting wires or having to put the apparatus together in the practical class. This may be one of the reasons why females in this research performed less in Target-Task collaborative learning approach because they tend to allow the male students to take a lead during the class sessions. It was also observed that they were more docile and passive than active and possibly their learning is less constructive than it is expected during group work when they allow male students to dominate. This finding agrees with 2012 West Africa Examination Council report of 2012 (Olaniyan & Omosewo, 2015) and report of Sencar and Eryilmaz (2004) which stated that female students performed very poor in physics practical examination because they were not highly active during the lessons. Another study by Hazari, Tai, and Sadler (2007) confirmed the deficient performance by female students in their physics practical examination in their study on gender difference in introductory physics performance and the influence of high school physics.

Another observation why female students performed better in Polya Problem-Solving approach compared with Target-Task collaborative learning approach was also traced to the fact that female students prefer to learn at their own pace rather than working in groups. Even those who are weak (low scorers among females) will rather keep quiet while in a group, even when they know, than to show their concerns before other students in the group. Male students do speak out and show their concerns more in the groups. It was also observed that female students prefer to research alone and have a tendency for competing rather than cooperating. Polya Problem-Solving approach is more of competitive learning compared to Target-Task collaborative learning, a type of cooperative

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learning. The high-ability ones among the Target-Task collaborative learning groups tend to keep quiet rather than take a lead in the group because they feel the group slows down their pace especially as the classes are made up of mixed-ability groups. This may not be the case in a homogeneous group. This possibly resulted in female students performing lower than males in Target-Task collaborative learning - being a cooperative group learning approach. This inference is in agreement with Harskamp et al. (2008) and Webb (1984). Harskamp et al. (2008) research on group composition and its effect on female and male problem-solving in science education found out that student interaction during cooperation indicated that females in mixed-gender pairs were less overtly active in seeking solutions than males, females in mixed-gender groups are not as involved concerning the solution of problems as their male partners. The reverse is the case in Polya Problem-Solving approach where the students work as individuals and this allows opportunities for competition and students to work at their own pace. This finding is also supported by Okebukola (1986) and Gavin (1996). Okebukola found that students who prefer competition do not do as well in cooperative settings as those students who prefer cooperative learning environments. Gavin studied talented college females majoring in mathematics and found that these students enjoyed competition, participating in individual activity and liked to be the best. Therefore, cooperative learning in heterogeneous groups may not always be the best problem-solving strategy to use with females.

Target-Task collaborative learning approach was found to be relatively more effective among male students and low scoring ability students. The male students were often more interested in collaboration, work better in groups than female counterparts. They have affinity to explore innovative ideas and to face new challenges and are more likely to take initiative when it comes to experimenting, exploring and analyzing. This tendency enhanced critical thinking among males and gave them a head start in Target-Task collaborative learning compared with males who were exposed to Polya Problem-Solving approach, working alone as individuals. In an after class one-on-one discussion which the teacher and the researcher had with the students, it was observed that most of the male students commented that working in groups made them learn better using Target-Task collaborative learning approach because they were able to brainstorm and think together and these tasks and group spaces gave them opportunities to learn more and understand the concepts better. Such that when they were to solve problems alone later during the examination, the concepts and the principles they acquired in their separate groups helped them to score better as individuals. Target-Task collaborative learning approach also strengthened the performance of male student who have low scoring ability and may have improved their self-confidence. Working in a group possibly made them bond well with those who are better than them thereby impacting on them and may have improved their cognitive knowledge of the concepts and applicative approach to solving problems. Female students in these groups, especially low scorers also benefited in this, but the male students benefited more because of their ability to work better in groups. It was also observed that the male students have better ability to take initiatives, explore and lead. This agrees with the research of Li (2002) and Webb and Mastergeorge (2003) who confirmed that in a mixed-gender group class, male students often take the initiative than females. It also agrees with research findings of Engelhardt and Beichner (2004) on students' understanding of direct current resistive electrical circuits which confirmed that male students are more confident in their approach and respond to questions better than female students.

Another probable reason attributed to better performance of male students in Target-Task collaborative learning approach is teachers' influence on the male students. Teachers most of the times often assume that male students are better learners in physics classes (Dayioğlu & Türüt-Aşik, 2007). Teaching and learning in physics classroom has been skewed in favour of male students, pedagogy that works for one student may not work for another and traditional physics pedagogy has historically catered for the male majority (Hazari et al., 2007). Over the years, research had shown poor performance of females in physics compared with males (Okebukola, 1997; Olorundare, 1989). Teachers can be gender bias and construct gender positively towards males, they give better attention to male students, and they think male students are better problem solvers, work independently with little assistance from the teacher, and male students know what to do (Gallagher & Kaufman, 2004). On the contrary it is believed that female students demand for more attention from the teachers rather than learning from their colleagues in the group. In a class where there are many students to attend to, there is a tendency for such female student(s) to be left out by the teacher especially in such large classes that were used for this research. This position agrees with Howe (1997) and Gallagher and Kaufman (2004) who confirmed that teachers often think that female students have more difficulty in solving problems independently while male students are more assertive and can solve problems independently.

Problem-Solving and Collaborative learning approaches being activity-based on teaching-learning pedagogy generally enhanced better performance of students who were exposed to them compared with students exposed to conventional teaching. This conclusion agrees with Harbor-Peter (1989) who stated that Target-Task enhanced better performance among students exposed to it than students taught with conventional method during geometric concepts in mathematics. Omaga, Iji and Adeniran (2014) also support this finding whereby students taught with Problem-based approach-an activity-based teaching performed better than students taught with conventional teaching methods. Okoronka and Wada (2014) also found that physics students who were taught with activities based performed better those who were taught with the lecture method. The findings are also in agreement with Govender (2015) who established that pre-service teachers' subject matter knowledge of electromagnetism was enhanced and improved scores when integrating concept maps and collaborative learning activities.

Conclusions

The research focused on effectiveness of Polya Problem-Solving and Target-Task collaborative learning approaches on students' performance in electricity in physics versus conventional teaching. The effectiveness of the two experimental groups were compared at the end of treatments in relation to scoring abilities and gender effects. In terms of scoring abilities, the two treatments enhanced performance of all the students in the three ranges high, medium and low scoring abilities. However, Target-Task collaborative learning approach enhanced performance among low scoring ability students compared with low scoring ability in the other treatment group. In terms of gender effects, Polya Problem-Solving approach enhanced performance among female students than male students, compared with females in Target-Task collaborative learning approach. In addition, Target-Task collaborative learning enhanced performance among male students compared with males in the other treatment group. Overall, Polya Problem-Solving and Target-Task collaborative learning approaches enhanced performance of the students based on gender and scoring abilities compared with the conventional teaching in electricity amongst high school physics students.

Implications

Based on the findings of the research, it is suggested that Target-Task collaborative learning approach can be used more in teaching problem-solving in electricity in high school physics to improve the performance of students who are low scorers. Also, teachers should endeavor to use Target-Task collaborative learning approach more than Polya Problem-Solving approach during teaching and learning of high school physics content.

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