EFFECTS OF PEER-TUTORING AND JIGSAW STRATEGIES ON CHEMISTRY STUDENTS' ACHIEVEMENT IN THE CONCEPT OF PAPER CHROMATOGRAPHY

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Abstract

This study investigated the effects of peer-tutoring and jigsaw strategies on chemistry students' achievement in the concept of paper chromatography. Two research questions and two research hypotheses guided the study. A quasi experimental and non-randomized pretest posttest design was used for the study. The population of the study was all the one thousand two hundred and sixty (1,260) senior secondary one (SS1) students in all the 14 public coeducational secondary schools in Itu Local Education Authority of Akwa Ibom State. A sample of one hundred and twenty (120) SS1 students were selected from two schools using simple random sampling technique. Instrument for data gathering was Achievement Test on Paper Chromatography (ATPC). Instrument reliability was .81 using Kuder-Richardson Formulae-21. Data collected were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). Findings of the study showed that students taught using peer tutoring strategy performed significantly better than those taught using jigsaw strategy. Gender on students' achievement was not statistically significant. Recommendations among others were that chemistry teachers should encourage the use of peer tutoring in teaching the concept of paper chromatography. Students should be taught using effective strategies that involve students' participation to stimulate interest on career paths.

Keywords: Peer-tutoring, students' achievement, jigsaw strategy, paper chromatography

Introduction

Science is dynamic and its objectives promote students' knowledge, skills, attitudes and values towards the understanding and workings of natural phenomena. Science has the ability to explain principles, concepts and laws guiding occurring phenomena. In the process, it allows the mind to question, criticise and carry out investigations that attempts to find answers to problems. In other words, the process of science leads to new discoveries that change the way we think and create new information that evolve to transform society. This therefore means that, sound objectives are to be formulated to aid learners' understanding of science. The objectives of science are to encourage and enable students develop minds of inquiry and curiosity about science and the natural world; acquire knowledge, conceptual understanding and skills to solve problems and make informed decisions in scientific contexts. Popper (2007) states that science aspires to develop scientifically informed, caring and responsible individuals who can think critically and make informed choices about themselves, the environment and society. These happen when students engage in opportunities that expose them to new ideas, interests and curiosity such as in paper chromatography. In this way, they evolve knowledge creatively. In order to make the knowledge of science relevant to students, science education that encourages engagement in developing critical

thinking and intellectual curiosity becomes the modus operandi because it improves learners preparedness to acquiring science skills and literacy. According to Okon-Enoh (2008) science education is a way of seeking information and accumulating knowledge resulting from research. This makes learning realistic and sustains students' interest in actualizing the objectives of science education.

The objectives of science education as stipulated in the National Policy on Education (FRN, 2013) are to: provide a preparation for further training in science: provide basic scientific literacy for everyday living; and to stimulate curiosity. To achieve these objectives, there is need to make science education a highly activity-oriented course with emphasis on skill forming and driven by broad-based principles and concepts. Science activities that aims at skill acquisition and development of positive scientific attitudes through proper procedures and teaching techniques are to be adequately employed to teach concepts. These are necessary requirements to equip students.

Inspite of the intervention of government through the provision of science kits, chemistry students' performance in Nigeria has been low. These science kits are used for one time demonstration during a once-in-a-year gathering of teachers for workshops as they are inadequate to go round schools. Furthermore, the unavailability of these science kits to teachers also serves as a limitation for improved performance of students. The fall in standard of achievement in chemistry is also attributed to poor understanding, comprehension and application of chemistry concepts by learners. This is also blamed on poor instructional delivery approaches adopted by teachers in schools. This encourages rote memorization of scientific concepts and principles without teachers and learners having deep understanding of scientific phenomena, concepts and theories (Okoli and Egbunonu, 2012). The resultant effects are therefore, poor performance in both internal and external examinations and inability of students to develop appropriate scientific skills. To nib these problems in the bud, teaching strategies could be varied to meet teaching needs.

Teaching strategies are the techniques, methods, styles and means a teacher adopts to carry out functions of imparting information, principles and skills to learners. They are tools used for meeting goals and laid down instructional objectives. A resourceful teacher goes beyond laid down objectives to find ways to enhance students' ability, competence and skills to effectively manage learning. He does this by equipping them with knowledge through the application of effective teaching strategies which survives beyond the classroom. This makes students become active participants in solving daily occurring problems with ease (Etiubon, 2016). Learners therefore, can achieve meaningful learning when appropriate teaching strategies are used to teach paper chromatography. Teaching strategies such as lecture, expository, guided-discovery, field-trip, demonstration, guided- inquiry and discussion approaches are teaching strategies teachers are familiar with. Holbrook (2011) and Etiubon (2011) posits that these teaching methods should involve dominance and active participation of the learners so that they are able to cognitively construct their own knowledge and ideas. Students acquire understanding through the experiences gained from participatory activities in this way. This according to Nwagbo and Chikelu (2011) fosters effective and meaningful learning in chemistry.

Chemistry is an intellectual science discipline that is indispensable to everyday living. Chromatography of which paper chromatography is a part, occurs in everyday activities and it is a concept taught in chemistry. These every day activities form teaching and learning experiences to be explored. These activities include the manufacture of different brands of toothpastes such as colgate, close-up, aqua-fresh, darbur and pepsodent to brush teeth and improve mouth odour. It also includes the usefulness and application for separating valuable products like amino acids, finger print detection, histamines and dyes embossed in biro pens for writing. Paper chromatography is

taught in senior secondary chemistry classes and forms a bulk of wider knowledge that can help students gain experience for its applications to live beyond the classroom. It cannot be taught in abstraction. Learners need to be productively engaged to test their ideas and familiarize themselves with it. Paper chromatography is a method of separation that takes place in homes, offices, business centres and schools. This involves the mixture to be separated and distributed between two phases- a stationary phase and a mobile phase that consist of samples to be separated and the solvent that moves samples through the column, taking advantage of different rates of movement in a solvent over an absorbent medium. Paper is placed in a glass container with a shallow layer of solvent and sealed. As the solvent rises through the paper, it meets the sample mixture which travels up the paper with the solvent and separates out. Components of the sample readily separates according to how strongly they adsorb onto the stationary phases. Effective teaching approaches are therefore, needed to promote conceptual understanding of the processes involved in paper chromatography. These methods are characterized by shared responsibilities between students and tutees/teachers because they are learner-centred and activity-oriented. These methods include peer-tutoring and jig-saw teaching strategies. These strategies are known to enhance the acquisition of science process skills, aptitudes and conceptualization (Akporekwe and Onwioduokit, 2010). A teacher interprets and translate complex paper chromatography concepts to the level appropriate to the learning experiences of students when he is favourably disposed to using appropriate teaching strategies. In order to achieve the objectives of science education, methods involving high learners participation is highly useful for effective teaching and understanding of paper chromatography. This could be achieved with learner-centred and friendly teaching strategies of peer-tutoring and jigsaw approaches.

Peer-tutoring is a teaching strategy that consists of students partnership. It is a systematic, peer mediated teaching strategy that prepares students to learn and practice academic task together. It offers one-to-one assistance for students having difficulties in a specific course (Okoroma, 2013). It provides a welcoming environment that gives opportunity for self-sufficiency and confidence building. It increases students interest to study, get motivated and provides a source for materials to meet expectations of academics. In other words, it encourages collaborative learning, enriches specific academic content with students helping each other to understand their challenges and compete effectively. Paul (2016) defines peer tutoring as an instructional strategy that partners students to help one another learn materials, reinforce skills and practice a learned task and this often results in high academic standard as well as enhance emotional and social gains for the students involved. This strategy links high achieving students with low achieving students or those with comparable achievement for structured reading and mathematics study session (Rohrbeek, 2013). The pair of students can be of the same or different ability and/or age range. Peer-tutoring educate and help learners share their challenges and find solutions to problems themselves. In this way, students take ownership of the strategic planning of their lessons to make maximum benefit from it. Peer-tutoring encompasses a variety of instructional approaches such as cross-age tutoring and peers' assisted learning. Whatever the variation, peer interaction has a powerful influence on academic motivation (Miller, 2010). Socialization experiences occurs during peer-tutoring which benefits both the tutor and the tutee. This means of socializing motivates students learning and increases social standing among peers (Fush, Yazdin and Powel, 2012). When students understand the benefit of peer-tutoring and have the tools to become effective tutors and tutees, they make greater progress than those who are not given any instruction on how to work together. With appropriate tools, student-student interaction improves, students gain broad-based knowledge that inspires change in their lives.

Peer-tutoring allow teachers to accommodate a classroom of diverse learners with different learning abilities. The strategy helps to increase response opportunities for students and provides additional time for positive feedback and the time a student stays on a task. When a tutor spends time and pays adequate attention to mentor a tutee, the tutee gains greater insight and clarity into minute details that may have been previously overlooked. This equips the tutee to make greater progress on a task to be learnt. Topping (2005) posits that regardless of achievement level, content area, and classroom arrangement, peer-tutoring facilitates the education curriculum. This improves higher order thinking skills and content teaching effectiveness. When students practice academic tasks together they increase their cognitive ability to reason scientifically.

Implementing peer-tutoring lesson is important for the teacher training students on the process of using the strategy to fulfil tutor-tutee roles. The teacher assigns partners; students retrieve tutoring materials prepared by the teacher. This enables the student to follow a highly structured tutoring procedure that provides feedback for the teacher and the tutee. Communication effectiveness is enhanced by this means. Another effective strategy that could improve students' performance is the jigsaw teaching strategy.

Jigsaw teaching strategy is a method of organizing classroom activity that makes students dependent on each other to succeed. This strategy is an efficient way for students to become engaged in learning, learn a lot of materials quickly, share information with other groups, minimize listening time and be individually accountable for their learning. The strategy involves breaking of classes into groups and splitting assignment into pieces that the group assembles to complete. In this strategy, members of the class are organized into jigsaw groups. The students are then reorganized into 'experts' groups containing one member from each jigsaw group. The members of the expert group work together to learn the material or solve the problem. They then return to their jigsaw groups to share their learning. In this way, the work of the jigsaw group is quickly disseminated throughout the class with each person taking responsibility for sharing a piece of puzzle (Bratt, 2010). Since each group needs its members to do well for the whole group wellbeing, jigsaw strategy maximizes interaction and establishes an atmosphere of cooperation and respect (Aronson, 2008). The author stressed, that monitoring each students' participation within the group provide teachers with information about how much the students already know about a topic. This allows the teacher to tailor instruction accordingly. Aronson (2008) suggest the following steps in developing jigsaw strategy:

- Preparation of lesson: students select materials to be explored which are a collection of documents such as images, charts and series of questions. Decisions of how many students would like to work together in an expert group of between 3-5 students is taken. Selection is done to balance strengths, needs and interest.
- Students work in expert groups: small group of students who are termed experts are responsible for reviewing specific materials so that they can share information with their peers. This group works best when each student has clear expectations about the type of information he/she is to present to the peers. All group members need to understand the work they are responsible for presenting task to be solved. Teachers come in at this point to review and approve content before presentation of information is shared with other groups to avoid any misleading information.
- Students meet in teaching groups: After expert groups have had a solid understanding of the material and know how they will be presenting or proffering solutions to the problem at hand; teaching groups are assigned to students, experts take turns presenting information. In jigsaw strategy, students are made to think and compete and this gives rise to broad-based knowledge.

This approach transforms learning experiences into exciting-fun-involving activities. This study also places premium on gender as one of its variables.

Gender effect on students' academic achievement has long been debated. Some studies show superiority of male students above those of their female counterparts in chemistry; while others show female superiority over those of their male counterparts especially when speech and memory cues are incorporated into learning experiences given that the females have more advanced verbal activities. Nasr and Ashar (2011) and Okoro (2011) shows a significant difference in the achievement of male and female students in the sciences and report that female students are inclined to learning while the males get up and move around to avoid static learning experiences. Nbina (2012) posits that concrete and visual teaching materials are enjoyed by and effective with boys such as moveable clocks, protractors and thermometers that ensure hands-on activities while females do well with reading. Still others show that male and female students perform equally when exposed to the same learning conditions. Abubakka and Dokubo (2011) and Achor (2013) posits that when both male and female students are given opportunity and allowed to be actively involved and participate with same activities, both gender usually achieve equally.

Statement of the Problem

Some topics in chemistry seem abstract and difficult for teachers to teach and learners to learn. Paper chromatography is one such topic that learners find difficult to assimilate. It is termed difficult because it involves reactions based on several criteria. In such a topic, improper assimilation may set in to confuse the students as several activities and reactions are involved. Poor academic achievement results from such misconceptions and leads to rote memorization of facts and ideas about the concept and in turn is consequent upon poor teaching strategies. Some teachers have mastery of the topic but do not use effective student-centred teaching strategies to impart the knowledge. Others do not have adequate knowledge of the concept to equip learners and therefore use ineffective methods that do not sufficiently convey understanding. Poor teaching strategy pose serious challenges in teaching, and with growing concerns about unemployment, there is need to explore student-centred, activity-oriented focused teaching strategies with radical applications to enhance the teaching of paper chromatography. It is on this basis that this study seeks to determine the effects of peer-tutoring and jigsaw strategies on chemistry students' achievement in paper chromatography.

Purpose of the study

The study investigates the effects of peer-tutoring and jigsaw teaching strategies on chemistry students' academic achievement in paper chromatography. Specifically, the study seeks to achieve the following objectives:

1. to compare the achievement mean scores of students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy.

2. to compare the achievement mean scores of male and female students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy.

Research Questions

1. What are the achievement mean scores of students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy ?

2. What are the achievement mean scores of male and female students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy ?

Research Hypotheses

1. There is no significant difference among the achievement mean scores of students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy.

2. There is no significant difference among the achievement mean scores of male and female students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy.

Research Design

A quasi experimental and non-randomized pretest posttest design was used for the study. Two groups that were not created by manipulated variables were compared by naturally occurring non-manipulated variables. The population of the study was all the one thousand two hundred and sixty (1,260) senior secondary one (SS1) students in all the 14 public coeducational secondary schools in Itu Local Education Authority of Akwa Ibom State. A sample of one hundred and twenty (120) SS1 students were selected from two schools using simple random sampling technique. Students in intact class setting were used for the study. They were randomly assigned experimental group 1 and experimental group 2. Experimental group 1 was treated with peer tutoring strategy while experimental group 2 was treated with jigsaw strategy respectively. The pretest provided a check on the non-random assignment of participants to groups and the process of equating the research groups. Instrument for data gathering was Achievement Test on Paper Chromatography (ATPC). The ATPC was a 25-item multiple choice achievement test drawn from the concept of paper chromatography. Content coverage of test was on stationary and mobile phases, adsorbents, dyes, analyte, eluate, eluent and retention factor to ensure even distribution of items in ATPC. Each question had 4-options A, B, C and D with only one correct answer and three wrong answers. Each correct answer was scored 4 marks and incorrect answers scored zero (0), hence, hundred (100) was the maximum score and zero was the minimum. Instrument validity was done by two experts in test construction in the Faculty of Education, University of Uyo. The reliability of the instrument using Kuder-Richardson Formulae-21 was .81.

Treatment Procedure

The subject teachers in the selected schools were trained as research assistants with the use of peer tutoring and jigsaw strategies using validated lesson packages on paper chromatography developed by the researchers. Achievement test on Paper Chromatograpy (ATPC) was administered by the research assistants as pretest; then students were taught using dyes from biro pens of black, blue, red and green to explore knowledge doing practical activities on paper chromatography. They were in their intact class settings using the prepared lesson packages during chemistry periods. After treatment, a reshuffled version of ATPC was administered by the research assistants as posttest. The

treatment lasted two weeks. Pretest and posttest administration and the teaching of paper chromatography were strictly supervised by the researchers. Scripts were collected immediately after each administration of pretest and posttest items. Data obtained were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA).

Data Analysis Results

Research Question 1: What are the achievement mean scores of students on paper chromatography when taught using peer tutoring and when taught using jigsaw strategies ?

Table 1: Mean, Standard Deviation and Summary of independent t-test analysis of students' posttest scores classified by treatment groups on paper chromatography

Treatment Groups	Sample Size	Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain score
Peer tutoring strategy	58	26. 16	6.14	63.89	3.76	37.73
Jigsaw strategy	62	26. 18	5.23	54.58	5.96	28.40

Data in Table 1, show the pretest and posttest mean scores and standard deviation scores of students taught using peer tutoring and jigsaw strategies with pretest scores of 26.16 and 26.18 respectively and posttest mean scores of 63.89 and 54.58 for peer-tutoring and jigsaw respectively. The mean gain score show that those in peer tutoring had best mean gain of 37.73. The two treatment groups had higher mean scores than the pretest mean scores. The differences in the mean scores of the treatment groups is examined by testing hypothesis one.

Hypothesis One: There is no significant difference among the achievement mean scores of students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy.

Table 2: Summary of independent t-test analysis of students' posttest scores classified by treatment groups.

Treatment Groups	N	Mean Score	SD	std Error	df	tcal	sig	Decision at p< .05
Peer tutoring	**58**	**63.89**	**3.72**	**.43**	**118**	**12.37**	**.00**	**Significant**
Jigsaw strategy	**62**	**54.58**	**5.96**	**.64**				

Data in Table 2 show the calculated t-ratio for the effect of teaching strategies at df 118 is 12.37, while the corresponding calculated level of significance is .00 alpha. The level of significance is less than .05 decision level. This indicates a significant difference in the academic achievement of students taught paper chromatography using peer-tutoring and jigsaw strategies. The null hypothesis one is therefore rejected. This means that there is a significant difference among the mean scores of students on the concept of paper chromatography in chemistry when taught using peer-tutoring and when taught using jigsaw strategy in favour of those taught with peer-tutoring.

Research Question 2: . What are the achievement mean scores of male and female students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy ?

Table 3: Mean and standard deviation of students' pretest and posttest scores classified by treatment groups and gender

Treatment Groups	Gender	Sample Size	Pretest		Posttest		Mean Gain Score
			Mean	SD	Mean	SD	
Peer tutoring	Male	32	26.91	5.51	65.49	4.13	38.58
	Female	26	25. 37	6.75	62. 58	3.07	37.21
Jigsaw	Male	29	24. 73	5.03	52. 96	5.16	28. 23
strategy	Female	33	26. 85	5.26	54.87	6.38	28.02

Data in Table 3 shows the pretest and posttest mean scores and standard deviation scores of male and female students taught using peer-tutoring and jigsaw strategy. The mean scores for male and female students show 26.91 and 25.37 for peer tutoring group, with standard deviation of 5.51 and 6.75 respectively. The posttest mean scores are 65.49 and 62.58 for male and female students respectively, with standard deviation scores of 4.13 and 3.07 respectively. Mean gain scores for male and female students are 38.58 and 37.21 respectively. With respect to students in the jigsaw group, pretest mean scores of male and female students are 24.73 and 26. 85 with standard deviation scores of 5.03 and 5.26 respectively. The posttest mean scores are 52.96 and 54.87 for male and female students, while standard deviation scores are 5.16 and 6.38 respectively. This shows that the male students in peer-tutoring group had highest mean gain scores followed by their female counterparts in the same group; the male and females in the jigsaw group in decreasing order. The differences in the mean scores of the treatment groups is examined by testing hypothesis two.

Hypothesis Two: There is no significant difference among the achievement mean scores of male and female students in the concept of paper chromatography in chemistry when taught using peer tutoring and when taught using jigsaw strategy.

Table 4: Summary of Analysis of Covariance (ANCOVA) of male and female students' posttest scores classified by treatment groups with pretest scores as covariate.

Source alpha	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision at P< .05
Pretest	345.84	1	345.84	14.79	.00	Significant
Treatment	3834.83	1	3834. 83	162.53	.00	Significant
Gender	19.85	1	19.85	.83	.33	Not Significant
Treatment* Gender	52.05	1	52.05	2.18	.12	Not Significant
Error	3469.69	115	23.43	-	-	-
Total	539725.00	120	-	-	-	-
Corrected Total	7859. 86	119	-	-	-	-

a. R Squared = .562 (Adjusted R Squared= .548)

Data in Table 4 show the calculated F-ratio for the main effect of teaching strategy at df 1, 119 is 162.53, while its corresponding calculated level of significance is .00 alpha. This is less than .05 level of significance for decision, showing a significant difference in academic achievement of students in the concepts taught given the teaching strategies used. The F-cal for the main effect of gender at df 1, 119 was .33 while its significant level is .12. This significant level is greater than .05 alpha indicating that the influence of gender on students' achievement was not statistically significant, hence, null hypothesis two was upheld.

Discussion of Findings

The findings of the study with regards to students that were taught paper chromatography using peer tutoring and jigsaw strategy were statistically significant. Students taught using peer tutoring strategy performed significantly better than those taught using jigsaw strategy. The statistically significant better enhancing effect of peer tutoring on the students' learning achievements may be attributed to strong student-partnership and willingness to tackle problems by themselves. This is consistent with Topping and Thurston (2010) who posits that when more attention is given to each student their confidence will increase with practice and similar social groupings who are not professional teachers will also benefit as they help each other to learn and learning to do it themselves. The peers' question, discussions and debates helped to extend the thinking of their partners.

Gender influence on students' achievement on paper chromatography in chemistry when taught using peer tutoring and jigsaw strategies was not statistically significant. This indicates that gender is not a strong determinant of students' academic achievement. This finding agrees with Abubakka and Oguguo (2011) and Etiubon (2016) that when both male and female students are given equal opportunities and allowed to be actively involved and fully participate in the learning process, they explore their abilities and perform equally. This made the lesson gender unbiased.

Conclusion

Based on the findings of the study, it is hereby concluded that of the two teaching strategies investigated, peer tutoring is the more effective in facilitating students' academic achievement in the concept of paper chromatography in chemistry. Study findings also show that gender has no statistically significant influence on the students' achievement. Paper chromatography is a separation technique of interest in chemistry, industry and medicine and should be taught effectively to involve students' participation to stimulate interest in the concept. This enhances students' achievement towards lifelong career paths.

Recommendations

Based on the findings and conclusions reached, the following recommendations are made;

1. Chemistry teachers should encourage the use of peer tutoring in teaching the concept of paper chromatography in chemistry.

2. Curriculum planners should ensure that peer tutoring strategy is incorporated in the teaching and learning of chemistry concepts.

3. Professional bodies like science teachers association along with other educational stakeholders should organize and sponsor science teachers to participate in regular workshops to train them on the use of peer tutoring.

4. Pre-service teachers should be trained on how to develop and make use of peer tutoring teaching strategy.

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