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Students effective learning: are learning styles and corresponding teaching methods factors?

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ABSTRACT

The study was conducted to ascertain if learning styles and corresponding teaching methods are factors that influence effective learning. The study employed a non-equivalent planned variation quasi-experimental design. The study's sample comprised 362 chemistry students from six senior high schools in Delta State. The students were selected using a basic random selection technique. The instruments used for data collection were the chemistry achievement test (CAT) and the chemistry learning style questionnaire (CLSQ). The instruments were adequately validated, and reliability (R=0.81 and 0.79, respectively) was determined before usage. Data analysis involved the use of mean and independent sample t-tests. The findings showed: i) a significant difference in the performance of students instructed with the puzzle instructional strategy group with their learning styles and those instructed with the lecture method with their learning styles and ii) learning styles with teaching method and sex have no significant effect on students' achievements. It was concluded that learning styles and corresponding teaching methods are factors influencing students' achievement, and it was therefore recommended that teachers employ methods with similar characteristics to students' learning styles.

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1. INTRODUCTION

The essence of education is for effective learning to take place. Learning is a permanent change in learners' behaviour [1]. For learning to occur, students must engage in activities promoting learning. Students, during learning, engage in various activities in different ways, like answering and asking questions, carrying out scientific investigations, probing findings, reading and writing, watching and listening to visual, and audio teaching aids. Learning styles are the various ways students process and learn from this information. Learning styles, according to İlçin *et al.* [2], refer to a learner's preferred pattern of processing information that is new for effective learning. In the view of Dunn and Dunn [3], it is that unique way students have developed themselves to learn something difficult. Learning styles may be defined differently depending on one's perspective [4]. Learning style is a theory that explains how different individual's learning patterns can affect how information is absorbed and understood [5]. Learning styles are a range of methods through which individuals learn most effectively. It is also based on the belief that individuals within groups often acquire knowledge most efficiently through distinct and preferred modalities [6]. Each learning style describes how a learner best receives, interprets, organizes, and stores information [7]. It is assumed that learners learn better if their learning styles match the format of their instruction [8]. According to Mohsenipouya *et al.* [9], once a person identifies their learning styles, they can tailor their study strategies to suit their needs and preferences,

and this can lead to more effective learning and better retention of information when a person's learning style is identified. It is good to utilise learning materials to facilitate the styles to potentially make learning possible [10]. The learning styles of individuals are different and unique [11]. Understanding the various learning styles can drastically impact how teachers handle students, set up group projects, and adopt individual learning [12]. Every learner's progress is unique in pace, depth, and quality of knowledge acquisition. Possible causes of this diversity in approach to instruction are students' unique histories, strengths, weaknesses, goals, motivation, and learning styles [2].

Students may benefit from having their learning styles identified to understand better how they learn and how their instructors teach. The reason is that knowing one's learning preferences can be gleaned from analyzing one's learning styles. There are different learning styles: visual, auditory, and kinesthetic/tactile. Other classifications are field-dependent and field-dependent learning styles [13], complexity, conforming, and autonomy [14]. Each style has its peculiar characteristics. In addition, independent learners take a self-reliant approach to their learning and can manage their learning process with minimal external guidance. These learners are self-motivated, resourceful, and critical thinkers, while dependent learners rely more heavily on external sources and guidance during teaching and learning. Their major characteristics include needing external direction, lacking self-motivation, and possessing limited self-regulation. Some individuals can exhibit more than one mode of learning style. Understanding how students' learning styles impact their performance in chemistry classes is essential since different people process information in various ways [15].

Research has shown that teaching methods are another factor that influences students' learning [16], [17]. Teaching methods refer to strategies and approaches educators use to facilitate students learning and help them acquire knowledge and skills based on the stated objectives. Teaching methods can be categorised into major parameters based on the theories of learning. They are teacher-centred and student-centred methods of teaching. In the teacher-centred methods of teaching, the teachers are the foremost authority. In contrast, in the student-centred method of teaching, the teachers are facilitators in the teaching and learning process. An example of the teacher-centred method of teaching is the lecture method, and the learner's methods include role play, cooperative learning, competitive learning, and puzzle instructional strategy. Since it has been upheld in the literature that variation in effective learning due to different backgrounds, learning strategies, weaknesses, ambitions, levels of motivation, and learning styles [2] and teaching methods, it becomes necessary for instructors and teachers to identify students learning styles and apply the appropriate teaching methods in teaching. Observation and experience have shown that teachers neither identify their students' learning styles before teaching nor teach them using appropriate teaching methods or a method that will take care of all the learning styles. An empirical review of literature showed that most of the work on learning styles were foreign-based. Besides, studies on learning styles were carried out in physiotherapy using Turkish physiotherapy students [2] and in science, mathematics, English, Thai language, and physiology. Only a few studies have been done on learning styles and teaching styles. The one by Awla [8] looked at learning styles and their relation to teaching styles. Damrongpani and Reungtragul [18] investigated the matching of learning and teaching styles on ninth-grade students' academic achievements. The study argued that students will have better achievements if their teachers' styles of instruction match their learning styles. Almigbal [19] studied the relationship between the learning style preferences of medical students and academic achievement in Saudi Arabia and found no significant relationship between learning style preferences and a student's academic achievements. This suggests the need for a similar study to affirm or refute this claim. This is the gap this study investigated and filled.

An x-ray of the learning styles and the various teaching methods shows similarities between the learning styles and the teaching methods. For example, field-dependent learners, based on their characteristics, can be taught using student-centred methods of teaching where they will be made to collaborate among themselves and between themselves and the teachers. In the field, independent learners can be taught using the teacher-centred method of teaching, where they can be made to work independently to a considerable extent.

The lecture method is one teacher-centred method that can be used to teach the field-independent learner. According to Patrick [20], the lecture method is the talk/chalk method of teaching that can be used for any class size but is usually used for large classes. The lecture method can also be described as the widely used traditional teaching approach where the educators deliver the content to be learned in the form of information with little or no explanation. In the use, the mode of communication is verbal, students are passive, and extensive content areas are covered within a short period.

On the other hand, the puzzle instructional strategy, according to Dika and Oluwaseyi [21], uses a problem-designed activity to teach and test students' knowledge. With the puzzle instructional strategy, students are expected to organize pieces together logically to solve the poised problem. As an entertaining learning tool, puzzles can help students develop their analytical and problem-solving abilities. Pratiwi *et al.* [22] asserted that there are many positive outcomes for students when they play with puzzles. These outcomes include: building their vocabulary, introducing them to intellectual humour, improving their comprehension and creativity, and fostering stronger peer relationships. There are different types of puzzles-

crosswords, jigsaw, Sudoku, riddles, picross, and logic grid puzzles. In teaching chemistry, various puzzles like chemical equation balancing puzzles, periodic table puzzles, chemical nomenclature puzzles, molecule building puzzles, stoichiometry puzzles, and reaction mechanism puzzles. This study examines the impact of different teaching strategies on students' chemistry achievement, explicitly looking at lecture approaches and puzzle instructional strategies.

Learning styles can be described as individual differences in how people learn. They are classified and applied in active and passive activities that require students' participation [23]. For Odofin *et al.* [24], there are different ways a person can learn, and this is not only due to the circumstances in which it occurs but also as a result of the cognitive structures of the individual. Long-term learning activities gradually form learning styles, which rarely change with the changes in the learning environment [25]. Theories of learning styles suggest that individuals think and learn best in different ways [26]. According to Anyamene and Odalonu [27], the most expressed learning styles are visual, audiovisual, and kinaesthetic. Knowing a student's learning style will help them use the correct method and tools to gather information [28]. Studies show that teachers cannot accurately assess their students' learning styles [29]. Most teachers use their teaching method and teach their students rather than considering the student's learning styles [30]. In the view of Obro [31], teachers should consider factors like motivation, age, learning styles, personality, gender, and strategies, in presenting materials to students so that knowledge, skills, and attitudes can be accepted by students using a mixed learning approach throughout the course work can help a teacher cater for the different type of learning style [32]. Learners' individual differences have increasingly attracted researchers' attention [33]. Literature has shown the influence of learning styles on students' performance [2], [34], [35].

Teaching methods refer to strategies and approaches educators use to facilitate students learning and help them acquire knowledge and skills based on the stated objectives. Teaching methods can be categorised into significant parameters based on the theories of learning. They are teacher-centred and student-centred methods of teaching. In the teacher-centred method of teaching, the teachers are the leading authority, while in the student-centred method of teaching, the teachers are facilitators in the teaching and learning process [36]. The teachers-centered teaching techniques are characterized by the following features: the focus is mainly on the teachers, the teacher talks while learners listen, knowledge of the subject matter is a priority, and students work independently. An example of the teacher-centred method of teaching is the lecture method [37].

The lecture technique is an instructional approach where the teacher imparts information verbally to the students. It is the oldest method used in teaching. Several researches on the use of lecture methods only compared the technique with other methods of teaching that have different characteristics without matching the methods with the learning styles' characteristics [38], [39].

Another teaching method with characteristics different from the lecture method is the puzzle instructional strategy. Dika, and Oluwaseyi [21] defines puzzle instructional strategy as a strategy that uses problem-designed base activity to teach and test students' knowledge. One good characteristic of the puzzle is that it cannot be solved by rote, and they are instrumental in making students think. A review of related literature has shown that the use of a puzzle instructional strategy has a relationship with achievement. One such study is that of Stetzik *et al.* [40], which compared the effects of different pedagogies on students' performance in an undergraduate lab course in human anatomy and physiology II: puzzle-based versus standard lecture.

a. Research questions

- Is there a disparity in the average achievement scores among chemistry students with identical learning styles who are instructed using the puzzle instructional technique against those instructed using the lecture method?
- Is there any difference in the mean achievement of scores between male and female chemistry students with the same learning styles instructed with puzzle instructional strategy and those instructed lecture method?

b. Research hypotheses

H_{01}: there is no significant difference in the mean achievement scores between chemistry students with the same learning styles instructed with puzzle instructional strategy and those instructed with lecture method.

H_{02}: there is no significant difference in the mean achievement of scores between male and female chemistry students with the same learning styles instructed with puzzle instructional strategy and those instructed with lecture method.

2. METHOD

2.1. Design of the study

The study used a pre-test-post-test non-equivalent planned variation quasi experimental design to examine how well chemistry instructors in Delta State, Nigeria, could adapt their pedagogical approaches to their student's learning styles. The design comprises two types of instruction (puzzle and lecture) and two sets

of testing (pre- and post-test). The participants are male and female chemistry students. Subjects were not randomly assigned to groups in this method; complete classes were utilised. This is because using intact classes to assign patients to groups randomly was not feasible; this strategy is deemed adequate. Among the factors that will be considered in this study are the following: teaching techniques (i.e., the lecture method and the puzzle instructional strategy), sex (the intervening variable), and achievement (the dependent variable).

2.2. Sample of the study

The study sample comprises six mixed secondary schools randomly selected from the three senatorial districts with three hundred and sixty-two senior secondary school chemistry students. Two schools each were selected from each senatorial district. Six senior secondary schools, six chemistry teachers, and six intact classes made up the sample for the study. The sampling technique used in selecting the schools and classes was the simple random sampling technique (balloting) using the withdrawal with replacement strategy. In doing this, all the mixed secondary Schools in the senatorial districts were listed. The names of the schools were written on pieces of paper, folded, and put into a blind bag. The required numbers of schools were selected using withdrawal with the replacement balloting method. Only public schools were used because they all have almost the same learning environment and are governed by a central body, the post-primary education board.

2.3. Research instruments

2.3.1. Instruments for data collection

a. Chemistry achievement test

The chemistry achievement test (CAT) consists of two components. Section A focuses on students' biographical information, whereas Section B consists of 50 things derived from past questions. Section B used questions from past West Africa examination council (WAEC) examinations. Section B comprises multiple-choice questions that have one correct answer and four distracters. Each question in Section B has a unique answer.

b. Chemistry learning style questionnaire (CLSQ)

The measure utilised was the Kirton [41] adoption-innovation inventory (KIA), adapted and adjusted to assess cognitive preferences. The instrument was modified to accommodate the Section A portion. The learning style questionnaire for chemistry students consists of two sections: Sections A and B. Section A collects data on students' personal information such as their name, school name, gender, and school type. Section B consists of 33 statements that students need to rate on a four-point scale ranging from very difficulty (VD), difficulty (D), very easy (VE), and easy (E). Students are required to choose the option that best reflects their degree of applicability. The instrument was utilised to classify the pupils into several groups based on their learning styles.

2.3.2. Scoring of the items in the instruments of data collection

For the CAT, each correct answer given by the students in Section B was scored 1 (one), while wrong answers were scored zero (0). The maximum mark for this section is 50. In answering the research questions and testing the hypotheses, only the summation of the scores of the correct answers in Section B of the CAT was used. For the CLSQ, the students scoring 66 and below were regarded as field dependent learners, and those scoring 67 and above were considered field-independent.

2.4. Validity of CAT

Expert judgement and a table of specifications were employed to determine the validity. Content validity was determined using a Bloom taxonomy-based table of specifications. The table of specifications was a two-dimensional table that displayed the information to be evaluated and the test objectives. This is to correctly represent content categories. The purpose of validating the items was to verify their alignment with the table of specifications and to guarantee that they addressed the subject matter.

2.4.1. Treatment procedure

Step 1: training of the teachers for used for the puzzle instructional strategy and lecture method groups

The puzzle instructional strategy group: the puzzle instructional strategy group teachers were trained for three days. For day one, the teachers were trained on the concepts of puzzles, a brief history of puzzles, types of puzzles, puzzle solving, and the value of puzzles in the classroom for 1 hr: 30 mins using the treatment package for puzzle instructional strategy. On day 2, the teachers were trained on how to teach using the puzzle instructional strategy for 2 hrs and were asked to practice under the researcher's supervision. On day 3, the teachers were made to continue practicing how to use the puzzle instructional strategy in the classroom by following the steps. The session ended only when the researcher was convinced that the teachers could effectively apply the methodology after evaluating their practices. Table 1 shows the table of specification on 50-item CAT.

Table 1. Table of specification on 50-item CAT

Content	Knowledge 15%	Comprehension 25%	Application 60%	Total % of items
Periodic table and chemical equation 50%	5	5	20	30
Nomenclature of compounds 30%	5	5	6	16
Chemical Reaction 20%	1	1	2	4
Total	11	11	28	50

Step II: pre-testing of the groups

A week before the treatment's commencement, the students used the puzzle instructional strategy, and the lecture groups were pre-tested using the CAT and the CLSQ. The CAT scores were used as a pre-test, while the CAT questionnaire scores were used to classify the students into various learning style groups. The pre-test scores were used to determine the equivalence of the groups. Immediately after the pretest, the investigator distributed the plans for the use of puzzle instructional strategy and lecture method to the teachers (research assistants). They were instructed to follow the guide strictly and apply the recommended instructional methods in their respective classes.

Step III: application of the strategies in teaching

During the treatment, which lasted six (6) weeks, for each lesson, the lecture method group students were made to solve puzzles, followed by the chemistry teacher teaching the concepts using the following steps:

- Step I: gaining attention: to gain students' attention, the teacher first asks students what they know about puzzles and their types and presents the puzzle sheet to the students before introducing the concepts to be studied. Students will be asked to explain the concept to be explored.
- Step II: informing learner of the objective(s): students were told to achieve the objectives at the end of the lesson.
- Step III: stimulating recall of prerequisite learning: students were asked to solve the puzzles from the puzzle sheet given to them in groups. The puzzle activity proceeded as follows: first, the students solved and completed the empty boxes on the puzzle sheet and generated the words that matched each answer. After that, with the provided words representing each solved figure, they make a complete sentence that makes sense or has meaning.
- Step IV: presenting the stimulus material: students were asked to bring out all the concepts they could generate while solving their puzzles. The aim is to encourage participation.
- Step V: providing learning guidance: from the generated concepts by the students, the teacher selects and brings out a problem for the students to solve in groups. The aim is to encourage participation and critical thinking.
- Step VI: eliciting the performance: the teacher looks to see if the students' workings are correct. The aim is to encourage participation and foster understanding.
- Step VII: providing feedback about performance: the teacher corrects the students based on what they discovered in step VI. The aim is to foster understanding.
- Step VIII: assessing performance: learners were asked to solve more of the problems individually as a result of the feedback. This was done by giving students homework, classwork from the textbooks, and puzzle sheets. The work is assessed, and feedback is provided.
- Step IX: enhancing retention and transfer/drawing of conclusion: the teacher explains all the necessary procedures required to solve the problems, considering all the mistakes made by learners at all the other stages. Also, the teacher will ask the students to relate what they have learned to real-life situations.

2.4.2. Post testing

For the post-test, the CAT instrument was again administered on the puzzle instructional strategy and lecture group students to get their achievement scores. After six (6) weeks of treatment or experimentation, the posttest was administered. The CAT scores were used at posttest, while the CAT questionnaire scores were used to classify the students into various learning style groups. The posttest scores were used to determine the equivalence of the groups and used to assess the academic performance of the students.

3. RESULTS AND DISCUSSION

The study was conducted to ascertain if learning styles and corresponding teaching methods are factors that influence effective learning. This section presents and elucidates the study results, accompanied by a thorough discussion. The data were presented in tables and other elements that are easily comprehensible to readers. The findings of the study were examined in the subsections.

- RQ1: is there a disparity in the average achievement scores among chemistry students with identical learning styles who are instructed using the puzzle instructional technique against those instructed using the lecture method?

Table 2 shows that the puzzle instructional strategy group students had a mean of 28.278 and a mean of 21.008 for the control group. The average disparity between the two scores was 7.270, with a preference towards the students in the experimental group. This indicates the presence of a discrepancy between the groups in terms of their chemistry scores.

Table 2. Descriptive statistics comparing puzzle instructional strategy and lecture group students' chemistry achievement scores

Groups	Learning styles	N	Mean	Mean diff.	SD
Puzzle instructional strategy	Dependent	119	28.278	7.270	8.074
Lecture method group	Independent	243	21.008		8.038

H01: there is no significant difference in the mean achievement scores between chemistry students with the same learning styles instructed with puzzle instructional strategy and lecture method.

The data in Table 3 demonstrates a significant difference between the puzzle instructional approach group and control groups at the post-test, as indicated by the calculated significance value. The value of 0.000 is lower than the critical significance level. 0.05 is the numerical value. Therefore, H_{01}, which states that there is no significant difference in the accomplishment scores of chemistry students taught using a puzzle instructional strategy based on their learning styles compared to those trained with the lecture technique based on their learning style, is rejected.

Table 3. Independent t-test statistics comparing the difference in mean between puzzle instructional strategy and lecture group students' achievement at post-test

Groups	Learning styles	N	Mean	Mean diff.	SD	Sig (2-tail)
Puzzle instructional strategy	Dependent	119	28.278	7.270	8.074	0.00
Lecture method group	Independent	243	21.008		8.038	

- RQ2: is there any difference in the mean achievement between male and female chemistry students with the same learning styles instructed with puzzle instructional strategy and those instructed with lecture method?

Table 4 shows that the male students in puzzle instructional strategy groups had a mean score of 28.605 with a standard deviation of 8.132 and 28.124 for the female students with a standard deviation of 8.092. The mean/average difference between the two scores was 0.481, indicating that the males performed slightly better. The table reveals that male students in the lecture strategy group had an average score of 22.805, while female students had an average score of 21.988 with a standard deviation of 9.120 and 8.125, respectively. The average difference between the two sets of scores was 0.817, favoring the males.

Table 4. Descriptive statistics comparing the effect of puzzle instructional strategy and lecture strategy on male and female students' achievement

Sex	Methods	Learning styles	N	Mean	SD	Mean diff.
Male	Puzzle	Dependent	38	28.605	8.132	0.481
Female			81	28.124	8.092	
Male	Lecture	Independent	108	22.805	9.120	0.817
Female			135	21.988	8.125	

H02: there is no significant difference in the mean achievement between male and female chemistry students with the same learning styles instructed with puzzle instructional strategy and those lecture strategy.

Table 5 indicates that the disparity between male and female students in the puzzle instructional and lecture groups at the post-assessment stage is not statistically significant. This is because the computed significance values of 0.763 and 0.986 are more significant than the crucial significance value of 0.05. Therefore, H02, which states that there is no substantial disparity in the academic performance of male and female students instructed using dependent and autonomous learning styles, taught with puzzle instructional strategy and lecture method, respectively, is accepted.

Table 5. Independent t-test statistics comparing the difference in mean between male and female students at post-test in puzzle instructional strategy and lecture strategy

Sex	Methods	Learning styles	N	Mean	SD	Mean Diff.	df	t	2(tail)
Male	Puzzle	Dependent	38	28.605	8.132	0.481	117	0.302	0.763
Female			81	28.124	8.092				
Male	Lecture	Independent	108	22.805	9.120	0.817	241	0.602	0.986
Female			135	21.988	8.125				

The findings of hypothesis one in our study indicate a notable disparity in the academic achievement of students who were instructed using the puzzle instructional strategy compared to those taught using the lecture technique as confirmed by Yousof *et al.* [42] and Rezvanifard *et al.* [43], also based on their learning styles. This difference is in favour of those taught with a puzzle instructional strategy. Our finding may be because the students in the puzzle instructional strategy groups, who are field-dependent learners, were made to work in collaboration with their teachers during the teaching and learning process. These collaborative activities would have made them better understand the concept taught, reflected in their performances, unlike those in the lecture method groups, which are independent learners who get little or no assistance from their peers and limited assistance from their teachers. Our study aligns with the research conducted by Ajaja and Eravwoke [16], İlçin *et al.* [2], Enwerekowe *et al.* [44], Sehic and Khan [45], González-Gálvez *et al.* [46], and Muthu *et al.* [47], which demonstrates a notable disparity in the academic achievement of pupils who were taught via role play analogy compared to those who were taught using the lecture technique, and with the opinion of Almigbal [19] that students understanding of course content is associated with their learning styles and instructors teaching styles.

We found that learning styles in relation to teaching methods and sex do not significantly affect students' achievements. The observed outcome can be attributed to the equitable benefits experienced by all students, regardless of their gender and learning preferences, throughout the teaching and learning process. Additionally, the alignment between the teaching methods and the students' learning styles may have contributed to the students' maximum benefit during the teaching and learning process. Our study discovery aligns with the research conducted by Urhievwejire [15], Cheek and Cheek [48], and Ani *et al.* [49], who found no substantial correlation between the cognitive styles of chemistry students and their conceptual understanding based on gender.

4. CONCLUSION

According to the study's results, learning styles and pedagogical approaches are elements that impact successful learning. Additionally, there is no difference in student accomplishment based on students' sex cognitive types or the methods used to teach them. Therefore, it was suggested that teachers use approaches similar to their students' learning styles in the classroom based on the study's findings.

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