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*Full Length Research*

# Heterogeneous catalysis: Efficacy of curriculum and item-teaching techniques on students' conceptual understanding of heat and vapours among senior secondary schools in Zamfara State

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**ABSTRACT:** The study sought to find out the relative effect of curriculum and item-teaching techniques on students' conceptual understanding in heat and vapours in senior secondary school in Zamfara State. Three research questions and three null hypotheses guided the study. The study adopted a quasi-experimental research design, precisely non-equivalent control group design. Simple random and Purposive sampling techniques were used to select a sample of 157 SS2 physics students for the study. Thermal Conceptual and Traditional Physics Exercises (TCTPE), which has twenty (20) items, was used to collect data for the study. Three experts in Department of Science Education, University of Nigeria, Nsukka, validated the instrument. Two reliability estimates confirmed the reliability of the instrument (TCTPE). The first tested the temporal stability and the second, the internal consistency of the TCTPE. The estimated values of 0.76 and 0.82 were obtained. The data obtained for the study were analyzed using frequencies, percentages, mean and standard deviation. Also, Analysis of covariance (ANCOVA) and Chi-square were used to test the null hypotheses at 0.05 level of significance. Findings of the study revealed that item-teaching technique increase students' achievement (or test) score in Traditional Physics Exercises in Heat and Vapour. However, there is no statistically significant difference in the mean achievement score of students given traditional physics exercises in heat and vapours under curriculum and item-teaching techniques. Meanwhile, students under curriculum teaching techniques had higher Conceptual Understanding mean score in heat and vapours, compared to their counterpart under item-teaching techniques. Finally, it was revealed that majority of students under curriculum teaching techniques were on scientific/conceptual understanding level, compared to their counterpart under item-teaching techniques where a very small number of students were on Scientific/Conceptual Understanding level. The study therefore, recommends that Physics teachers should teach to the curriculum for scientific/conceptual understanding of Senior Secondary School Students.

**Keywords:** Conceptual understanding, curriculum teaching techniques, item-teaching techniques, students' heat and vapours.

## INTRODUCTION

It is obvious that physics knowledge cannot be communicated effectively to students without appropriate pedagogical techniques. Evidence from many physics classrooms confirmed that knowledge of physics instructions is described in quantitative terms such as how much scientific vocabulary and how many formulas have been memorized (Ogundeji *et al*., 2019). And, lack of conceptual understanding usually goes unnoticed because students can solve many standard problems in spite of the difficulties (Antwi *et al*., 2016). To this extent, evidence from recent research in physics teaching revealed that many students still hold the foundational conceptual problems, even after instruction (Madu *et al.*, 2020; Nwankwo *et al*.,, 2018; Nworgu and Ugwuanyi, 2014; Orji, 2013). The implication is that not all pedagogy used by physics teachers promotes students' conceptual understanding.

The techniques which permit constant solving of traditional physics problems will not help students overcome their conceptual difficulties (Kim and Pak, 2001). Though the solution to traditional physics exercises and problems, presented mostly in quantitative terms, is an important component of studying to understand physics concepts, however, some aspects of conceptual understanding might require other approaches like: the use of conceptual change instructional model (Iloputaife, 2001; Asabe, 2014); constructivist instructional models (Nworgu, 1996; Agomuoh, 2010); conceptual change pedagogies (Stofflett and Stoddart, 1994; Madu and Nworgu, 2004; Orji, 2013); cognitive conflict process model (Lee and Kwon, 2001; Orji, 2013); spending time on conceptual activities (Lubienski, 2006) and having students discuss the reasons behind their answers to questions (Gales and Yan, 2001).

All these practices highlighted above are active instructional practices, structured toward student-oriented learning (OECD, 2009). The approaches also proved to have promoted, in practice, curriculum teaching i.e. in-depth teaching and learning as well as instructional content aligning with curriculum content. It implies therefore that, students taught under teaching techniques that focused on curricula might have some effect on their scores when exposed to traditional physics exercises and conceptual probing exercises.

Besides, literature has also identified "item-teaching technique" as one of the fast-growing practices introduced to the education system to cope with the demand of the 21st century. Item-teaching technique is the type of technique that engage students in item practices using actual items or items so similar to the actual test items. According to Rees (2001), item-teaching technique entails teaching students how to fill correctly the greatest number of items not minding if such a skill applies to situations outside the testing environment. According to Mehmet (2005), item-teaching technique only provides limited opportunity for in-depth and quality learning. Finding of Chinyani *et al*., as cited in Sama *et al*. (2021) revealed that students learning depth were limited because the Item-teaching practice gave opportunities to teachers to do selective teaching (i.e. by picking some items in the physics traditional exercises and problems to solve) thus, neglecting some areas of the curriculum content, which adversely affected students learning and learning depth. According to Phelps (2017), drilling in test format (whether actual or cloned test- items) does not promote learning but reduces it. Because it diverts the attention of the class from the subject matter instruction and consumes the time meant for instructional delivery.

Although the item-teaching approach might promote students' test scores, but might not be an appropriate classroom instruction practice (Suleiman *et al.*, 2022). Evidence provided by Amrein and Berliner (2002) revealed that student learning generally stayed the same or decreased after high-stakes tests were implemented. Findings of Amrein and Berlin (2002) indicated further that student academic achievement as measured by test scores does not necessarily reflect gains in student understanding in America, and probably in Nigeria as well. Because, Nigerian teachers also are under pressure to generate high test scores to the centralized power structure and to their students (Suleiman *et al*., 2022). The implication is that the item-teaching technique might have some effect on students' scores when given traditional and conceptual understanding exercises. Hence, the term "heterogeneous catalysis". Since, both techniques "curriculum and item-teaching techniques" in the literature reviewed is expected to have different effect on traditional physics exercises and conceptual understanding test. That is, curriculum teaching technique may have higher effect on students test score in traditional physics exercises compared to their counterpart on item-teaching techniques and vice-verse. As well as, curriculum teaching technique may have higher effect on students test score in conceptual understanding exercises compared to their counterpart on item-teaching techniques and vice-verse.

It is on this basis that the researchers seek to find out, the heterogeneous catalysis of the effect of curriculum and item-teaching techniques on students' conceptual understanding of heat and vapours in Zamfara State, Nigeria.

## REVIEW OF RELATED LITERATURE

### Students' conceptual understanding

Conceptual understanding according to Hiebert and Lefevre (1986) refers to a person's representation of the major concepts in a system. This representation cannot be attained by rote memorization, it must be learned through thoughtful and reflective learning. It involves students' ability to see the connections between concepts and procedures, and explains why some facts are consequences of others. Hiebert and Grouws, as cited in O'Dwyer *et al*. (2015) students' conceptual understanding develops when given the chance to struggle with a problem, and discuss the conceptual relationships explicitly. According to the National Assessment of Educational Progress (NAEP) (2005), conceptual understanding in physics is the understanding of the core principles of science, especially the physics concepts used to explain and predict observations of the natural world, and knowing how to apply this understanding efficiently in the design and execution of scientific investigations and in practical reasoning. It is the students' application of sound scientific concepts to explain specific phenomena relating to physics concepts (Lawson and Verah, in Saleh, 2011).

The implication is that conceptual understanding of students can be expressed in measurement terms in scientific research. Yeo and Zadnik (2001) used a scoring rubric for assessing students understanding in an introductory thermal concept evaluation classroom. Madu and Nworgu (2004) developed a scoring rubric for conceptual understanding namely: sound (or scientific conception) conception (SC), partial conception (PC), alternative conception (AC) and no conception (NC). Each item was arranged and scored in four-point scale respectively (i.e. SC = 2, PC = 1, AC = 0 and NC = 0). This is in agreement with Orji (2013) who opined that students may either have scientific (sound) conception (SC) or partial understanding (PU) or alternative conception (AC) or no conception (NC) about a concept, but the scoring of Orji differs from that of Madu and Nworgu study (i.e. SC = 3, PC = 2, AC = 1 and NC = 0).

However, both studies agreed that scientific conception indicates complete and correct response statements that explains a particular concept. Partial conception is typified by an incomplete response to a concept. Alternative conception represents a response that is illogical and contrary to statements or ideas currently accepted by the scientific community about a particular concept. No conception is typified by an irrelevant response or no response at all.

Findings of Iloputaife and Nworgu (2002), Madu and Nworgu (2004), and Agomuoh (2010) revealed that the conceptual instructional model promotes students conceptual change, achievement, and retention; since, the majority of the students move from alternative and partial conceptions to scientific conceptions. As well, Orji (2013) found that cognitive conflict instructional strategy promoted students’ conceptual change and attention. Since, conceptual change and understanding are intertwined (Ugwuanyi, 2012) and all the studies revealed were carried out in physics; it could be concluded therefore that, students’ conceptual understanding, academic achievement, and retention, among others, will be enhanced if appropriate pedagogy is correctly used in a physics classroom.

Also, the result of the study conducted by Antwi *et al*. (2016) revealed that students from the experimental group (i.e. peer instructional approach) have a better conceptual understanding of Mechanics than the students from the control group (i.e. traditional lecture method). Gaigher *et al*., (2007) found that students who had been exposed to the structured problem-solving strategy demonstrated better conceptual understanding of physics and tended to adopt a conceptual approach to problem-solving. Findings of Kola (2017) who investigated students’ conceptual understanding of physics through an interactive lecture-engagement, revealed that there was a significant interaction between the students’ scores in the conceptual physics and the teaching method employed (i.e. interactive lecture-engagement). Phage (2018) studied undergraduate physics students’ conceptual understanding in the learning of kinematics using a blended approach, and found improved performance and competence of over 85% due to understanding the concept than learning to pass. Findings of Mills (2019) revealed that teaching for conceptual understanding is promoted when teachers used manipulatives word problems related to the students live during group discussion.

## Curriculum versus item-teaching on students learning

Curriculum teaching according to Popham (2001), is the teaching technique that is directed at the curricular content knowledge or skills represented by a given test. Here, the target of the teacher instruction is on test-represented contents rather than on test items. And, if it is effective, Popham, (2001) will elevate students’ scores on high-stakes tests and, more importantly, will elevate students’ mastery of the knowledge or skills on which the test items are based. However, Rees (2001) advised that teachers must concentrate on teaching the curriculum chosen by test-designers. They further emphasized that curriculum teaching techniques will promote critical thinking rather than rote memorization.

On the other hand, teaching-to-the-test is a new issue that has just emerge within the education system (Styron and Styron, 2012). Simply put, teaching-to the-test is known as item-teaching (Popham, 2001). It is a personal belief as well as teaching strategy that educators have adopted to compensate for high-stake and high-testing assessment practice in this era (Styron and Styron, 2012), which forces teachers to address content that can be measured in standardized tests and avoid more analytical material hinders learning. Although many unintended consequences of high-stakes testing have been noted (Rees, 2001), one of the most prevalent, is the negative effect it has on teaching practices and, consequently, students learning.

Bond (2005) defines both extremes of item-teaching with one side, “examining state objectives and designing curriculum around those objectives to improve understanding,” and the other side, “drilling students on actual test items that will appear on the tests to improve scores”. It implies that, teaching-to the-test could be in two ways (Popham, 2001). Firstly, it is the classroom instruction that incorporates the actual items on the high-stakes tests. Secondly, is the classroom instruction that gives practice exercises showing “clone items” i.e. items so similar to the test’s actual items.

In a domain such as physics, a student may learn correctly the steps for solving certain types of problems (e.g. heat and vapours) but still retain misconceptions of the basic underlying concepts (such as temperature, change of state, heat and specific heat capacity and so on). In heat and vapour, a block of ice at $-10^0$C is placed inside a container which is gradually supplied with heat.

The test-taker must choose from four choices the statement that best describes what will happen to the ice block. Suppose the teacher had earlier revised this item slightly using a hot cylindrical container and an ice block of -5$^0$C. Here, only the temperature of ice and structure of the initial question was altered. The cognitive demand is unchanged in this type of cloned item. Popham further expatiated that, any classroom instruction that is focused directly on item teaching is engaging in a very different kind of teaching different from the curricular.

However, literature have reported that teacher focuses on examination-related activities to assist students to score better and such practices may increase test scores without necessarily increasing students' understanding. The findings of Safa and Jafari (2016) revealed that the final exam adversely affected English as a Foreign Language (EFL) teachers' teaching methodology and promote item-teaching practices as teachers taught according to the test's content and format. Asma *et al*. (2014) shared a similar view after examining the washback effects of the Pakistan intermediate English examination. Phelps (2017) reported the same and concluded that drilling students on the actual test format does not promote learning but reduces it, because it diverts the attention of the class from the subject matter instruction and consumes the time meant for instructional delivery. He further emphasized that money spent on test preparation services is money wasted if the service consists primarily of test-taking strategies, format familiarity, and practice test-taking. To this extent, Popham (2001) recommends deterrence procedures to help reduce the amount of item-teaching techniques found in the education sector.

## Objective of the study

The main purpose of this study is to find out the relative effect of curriculum and item-teaching techniques on students' conceptual understanding of heat and vapours in Zamfara State, Nigeria. Specifically, the researcher intends to determine the:

1. effect of curriculum and item-teaching techniques on students' academic achievement of heat and vapours.
2. effect of curriculum and item-teaching techniques on students' conceptual understanding of heat and vapours.
3. students' conceptual understanding levels of heat and vapours when exposed to curriculum and item-teaching techniques.

## Research questions

1. What are the mean academic achievement scores of students taught heat and vapours under curriculum and item-teaching techniques?
2. What is the conceptual understanding mean scores of students' taught heat and vapours under curriculum and item-teaching techniques?
3. What are the students' conceptual understanding levels of heat and vapours when taught using curriculum and item-teaching techniques?

## Hypotheses

**$H_{01}$:** There is no statistically significant difference in the mean academic achievement score of students taught heat and vapours when exposed to curriculum and item-teaching techniques.
**$H_{02}$:** There is no statistically significant difference in the conceptual understanding mean scores of students taught heat and vapours when exposed to curriculum and item-teaching techniques.
**$H_{03}$:** There is no statistically significant difference in the students' conceptual understanding level of heat and vapours when taught using curriculum and item-teaching techniques.

## METHODOLOGY

The study adopted a quasi-experimental research design, specifically, a pretest-posttest non-equivalent control group research design. In this type of design, the random assignment of subjects to experimental and control groups are not possible (Nworgu, 2015). The population for this study was 2,237 senior secondary students' class II of the 8 science and technical schools in Zamfara State, Nigeria. Simple random and Purposive sampling techniques were used to select a sample of 157 SS2 physics students for the study. While simple random sampling technique was used to select four (4) out of the eight (8) schools, purposive sampling was used to choose one class each from the selected schools. The choice of purposive sampling technique was to enable the researcher to select four intact classes whose class size is not more than 40. Thermal Conceptual and Traditional Physics Exercises (TCTPE) was used to collect data for the study. TCTPE is a combination of Thermal Conceptual Exercise (TCE) and Traditional Physics Exercise (TPE). Two experts in the Department of Science Education and one expert from Measurement and Evaluation, in University of Nigeria, Nsukka validated the instrument. Content validity of TCTPE was determined using a well-constructed table of specification. The TCTPE contains (20) multiple choice questions having 10 TCE which probe students' conceptual understanding of heat and vapour since students were ask to explain reasons for their answers; and 10 TPE which was used for measure students' academic achievement of heat and vapour. The TCE was mixed with the TPE. TCE rubric takes after Madu and Nworgu (2004); as well as Orji (2013) scoring format of 2, 1, 0 and 3, 2, 1, 0 respectively. 2 (SC), 1 (PU), 0 (AC & NC) were used in getting the Whole Test Score (WTS), while, 3 (SU), 2 (PU), 1 (AC), 0 (NC) were used in classifying students understanding into levels. Two reliability estimates confirmed the reliability of the instrument (TCTPE). The first is estimate of temporal stability because the instrument was used for both pretest and posttest, and was done by administering the TCTPE on a sample of 20 students that was not part of the study. Two weeks after the first administration, the same TCTPE was administered on the same sample again. The two scores were correlated using Pearson product moment correlation coefficient and the correlation coefficient (r) was 0.76. The second reliability estimate was estimate of internal consistency. This was computed using Cronbach Alpha formula and the internal consistency index of 0.82 was obtained. The choice of this reliability estimate is because the instrument is polychotomously scored items. The instrument for collection of relevant data was administered to physics students in the sampled schools before the commencement of the experiment which serves as pretest score. After the pretest, the actual experiment began which started with the training of the physics teachers' teaching the students in their normal classroom. By this, the newness effect of strange teacher is controlled. Also, lesson note produced by the researchers were used by teachers which help to control instructional situation variable. The experiment lasted for two weeks after which the instrument was administered again for another score called posttest score. In the experiment, two instructional techniques (curriculum and Item-teaching) were used and they both acted as a control for each other. The teachings were carried out according to the detailed lesson notes made for the two groups. The data obtained for the study was analyzed using mean and standard deviation to answer the research questions 1 and 2, but frequency and percentage was used to answer research question 3. Analysis of Covariance (ANCOVA) and Chi-square were used to test the null hypotheses 1-2 and 3 respectively at 0.05 level of significance. ANCOVA was used to bridge the gap of non-randomisation effect of quasi-experiment.

## RESULTS

**Research Question 1: What are the mean academic achievement scores of students taught heat and vapours under curriculum and item-teaching techniques?**

From Table 1, both groups (i.e. students taught curriculum teaching techniques and those taught item-teaching techniques) had approximately the same pretest mean academic achievement scores of 1.04 and 0.99 respectively, which revealed that they have same baseline of prior knowledge. However, after instruction, the group under curriculum teaching had a mean score and standard deviation value of 1.63 and 0.24, while, the group under item-teaching had a mean score and standard deviation value of 1.66 and 0.24. Students' under item-teaching group had higher mean gain of 0.67 compared with those under curriculum teaching group with a mean gain of 0.59. This is an indication that item-teaching technique better increase students' achievement (or test) score.

**Hypothesis 1: There is no statistically significant difference in the mean academic achievement score of students taught heat and vapours when exposed to curriculum and item-teaching techniques.**

The result in Table 2 shows an F-ratio of 0.61 with associated exact probability value of 0.43. The null hypothesis ($H_{01}$) is not rejected, since the associated probability value 0.43 is greater than 0.05 set as alpha level for testing the hypothesis. Inference drawn is that there is no statistically significant difference in the mean achievement score of students taught heat and vapours under curriculum and item-teaching techniques. i.e. any difference in the mean gain as observed in table 1 is due to chance.

**Research Question 2: What is the conceptual understanding mean scores of students' taught heat and vapours under curriculum and item-teaching techniques?**

From Table 3, both groups (i.e. students taught curriculum teaching techniques and those taught item-teaching techniques) had approximately the same pretest mean conceptual understanding scores of 0.65 and 0.63 which revealed that the two groups are on the same preconception baseline prior to instructions. However, after instruction, the group under curriculum teaching had a mean score and standard deviation value of 1.70 and 0.23, against the group under item-teaching which had a mean score and standard deviation value of 0.68 and 0.32. The difference in students' conceptual understanding mean score revealed that the group under curriculum teaching techniques had higher conceptual mean gain (valued at 1.05) than the group under item-teaching techniques with a lower mean gain of 0.05. This is an indication that students' conceptual understanding of heat and vapour shifted from Naïve or No conception to Alternative Conception, and from Alternative Conception to Partial Conceptual Understanding and finally to Sound or Scientific Understanding.

**Hypothesis 2: There is no statistically significant difference in the conceptual understanding mean scores of students taught heat and vapours when exposed to curriculum and item-teaching techniques**

The result in Table 4 shows an F-ratio of 672.091 with associated exact probability value of 0.000. The null

**Table 1.** Pre-test and post-test Mean academic achievement scores of students taught heat and vapours under curriculum and item-teaching techniques.

| Techniques | Pre-test | | | Post-test | | Mean gain |
|---|---|---|---|---|---|---|
| | N | x̄ | SD | x̄ | SD | |
| Curriculum teaching group | 79 | 1.04 | 0.44 | 1.63 | 0.24 | 0.59 |
| Item-teaching group | 78 | 0.99 | 0.42 | 1.66 | 0.24 | 0.67 |

**x̄ =** Mean; **SD** = Standard deviation; **N =** Number of students.

**Table 2.** Analysis of Covariance (ANCOVA) results showing the effect of curriculum and item-teaching techniques on academic achievement of students taught heat and vapours.

| Source | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 0.035[a] | 2 | 0.018 | 0.309 | 0.735 |
| Intercept | 64.920 | 1 | 64.920 | 1139.147 | 0.000 |
| Pretest | 0.000 | 1 | 0.000 | 0.002 | 0.966 |
| Techniques | .035 | 1 | 0.035 | 0.610 | 0.436 |
| Error | 8.777 | 154 | 0.057 | | |
| Total | 435.090 | 157 | | | |
| Corrected Total | 8.812 | 156 | | | |

Key: df = degree of freedom; F= F-value; Sig.= Probability or significant value.

**Table 3.** Pre-test and post-test mean scores of students conceptual understanding of heat and vapours under curriculum and item-teaching techniques using Whole-Test Analysis.

| Techniques | N | Pre-test | | Post-test | | Mean gain |
|---|---|---|---|---|---|---|
| | | x̄ | SD | x̄ | SD | |
| Curriculum teaching group | 79 | 0.65 | 0.35 | 1.70 | 0.23 | 1.05 |
| Item-teaching group | 78 | 0.63 | 0.31 | 0.68 | 0.32 | 0.05 |

**x̄ =** Mean; **SD** = Standard Deviation; **N =** Number of students.

**Table 4.** Analysis of Covariance (ANCOVA) results showing the effect of curriculum and item-teaching techniques on students' conceptual understanding of heat and vapours.

| Source | Type III Sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 43.103[a] | 2 | 21.552 | 367.171 | 0.000 |
| Intercept | 28.044 | 1 | 28.044 | 477.788 | 0.000 |
| Pretest | 2.838 | 1 | 2.838 | 48.350 | 0.000 |
| Techniques | 39.449 | 1 | 39.449 | 672.091 | 0.000 |
| Error | 9.039 | 154 | 0.059 | | |
| Total | 275.590 | 157 | | | |
| Corrected Total | 52.142 | 156 | | | |

Key: df = degree of freedom; F= F-value; Sig. = Probability or significant value.

hypothesis ($H_{02}$) is rejected, since the associated probability value 0.000 is less than 0.05 set as level of significance for testing the hypothesis. Inference drawn is that there is statistically significant difference in the conceptual understanding mean score of students taught heat and vapours under curriculum and item-teaching techniques. It implies that, instructional technique is significant in students' conceptual understanding favouring curriculum teaching technique.

**Research Question 3: What are the students' conceptual understanding levels of heat and vapours when taught using curriculum and item-teaching techniques?**

Table 5 shows the item analysis of students conceptual understanding levels in heat and vapours under curriculum and item teaching techniques are presented in frequencies and percentages. On the overall, students' conceptual

**Table 5.** Frequency and Percentage of students' conceptual understanding levels in heat and vapours under curriculum and item-teaching techniques.

| Item No. | Curriculum teaching techniques (n = 79) | | | | Item-teaching techniques (n=78) | | | |
|---|---|---|---|---|---|---|---|---|
| | SU [f (%)] | PU [f (%)] | AC [f (%)] | NC [f (%)] | SU [f (%)] | PU [f (%)] | AC [f (%)] | NC [f (%)] |
| 1 | 61(38.9) | 5(3.2) | 7(4.5) | 6(3.8) | 15(9.6) | 26(16.6) | 12(7.6) | 25(15.9) |
| 2 | 58(36.9) | 14(8.9) | 4(2.5) | 3(1.9) | 16(10.2) | 27(17.2) | 17(10.8) | 18(11.5) |
| 3 | 65(41.4) | 9(5.7) | 4(2.5) | 1(0.6) | 18(11.5) | 18(11.5) | 20(12.7) | 22(14.0) |
| 4 | 59(37.6) | 14(8.9) | 5(3.2) | 1(0.6) | 21(13.4) | 20(12.7) | 11(7.0) | 26(16.6) |
| 5 | 63(40.1) | 9(5.7) | 4(2.5) | 3(1.9) | 11(7.0) | 22(14.0) | 18(11.5) | 27(17.2) |
| 6 | 71(45.2) | 4(2.5) | 2(1.3) | 2(1.3) | 9(5.7) | 26(16.6) | 18(11.5) | 25(15.9) |
| 7 | 69(43.9) | 4(2.5) | 5(3.2) | 1(0.6) | 18(11.5) | 14(8.9) | 15(9.6) | 31(19.7) |
| 8 | 52(33.1) | 13(8.3) | 7(4.5) | 7(4.5) | 15(9.6) | 21(13.4) | 5(3.2) | 37(23.6) |
| 9 | 60(38.2) | 9(5.7) | 6(3.8) | 4(2.5) | 18(11.5) | 13(8.3) | 15(9.6) | 32(20.4) |
| 10 | 67(42.7) | 8(5.1) | 3(1.9) | 1(0.6) | 19(12.1) | 18(11.5) | 16(10.2) | 25(15.9) |
| O/No. | 62(39.8) | 9(5.7) | 5(3.0) | 3(1.8) | 16(10.2) | 20(13.1) | 15(9.4) | 27(17.1) |

O/No. of Stdts: Overall number of students. n = No. of Respondents; NC= No Conception; AC = Alternative Conception; PU = Partial Understanding; SU = Scientific Understanding; F = frequency; % = Percentage.

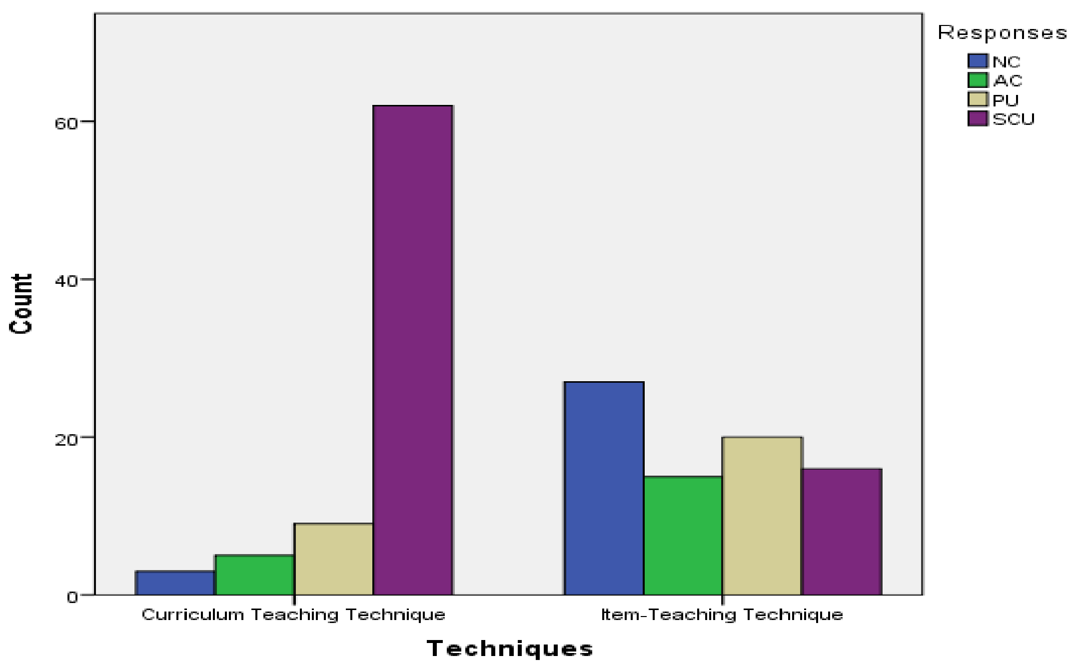


**Figure 1.** Histogram showing the distribution of location on overall students' conceptual understanding levels of heat and vapours.

understanding levels under curriculum teaching techniques were 62(39.8%) on SU; 9(5.7%) on PU; 5(3.0%) on AC and 3(1.8%) on NC; out of 79. The result indicates that, majority of students were on Scientific Understanding (SU) while, very few students were on Alternative Conception (AU) and No Conception (NC). On the other hand, students' conceptual understanding levels under item-teaching techniques were 16(10.2%) on SU; 20(13.1%) on PU; 15(9.4%) on AC and 27(17.1%) on NC; out of 78. The result indicates that, very few students were on Scientific Understanding (SU) while, large number of students were on No Conception (NC). There is much difference in students conceptual understanding levels of heat and vapours on the basis of techniques. This is clearly showed in the histogram chart (Figure 1).

However, the chart above (Figure 1) revealed how students' response with categorizes been distributed among techniques (i.e. curriculum teaching and item teaching). The chart showed clearly that large number of students under curriculum teaching techniques are on

**Table 6.** Overall trace analysis of students' conceptual understanding in heat and vapours on the basis of curriculum and item-teaching techniques.

| Techniques | Respondents | | | | Total | $x^2$ | df | p-value | Decision |
|---|---|---|---|---|---|---|---|---|---|
| | SU | PU | AC | NC | | | | | |
| Curriculum Teaching | 62 | 9 | 5 | 3 | 79 | | | | |
| Item -Teaching | 16 | 20 | 15 | 27 | 78 | 55.49 | 3 | 0.00 | S |
| Total | 78 | 29 | 20 | 30 | 157 | | | | |

$x^2$ = Chi-square Value; df = degree of freedom; NC= No Conception; AC = Alternative Conception; PU = Partial Understanding; SU = Scientific Understanding; F = frequency; P-value = Probability or Sig. Value; S = Significant.

scientific understanding against item-teaching techniques where large number of students are on No or Naïve Conception. Nevertheless, the difference on students' conceptual understanding level of heat and vapour was further confirmed by testing the hypothesis below.

**Hypothesis 3: There is no statistically significant difference in students' conceptual understanding levels of heat and vapours when taught using curriculum and item-teaching techniques**

The result presented in Table 6, revealed the result on students' conceptual understanding of Heat and Vapours under Curriculum and Item-Teaching Techniques. The probability value of 0.00 which is less than the level of significance 0.05, informed the decision that the hypothesis is S (Significant). To this effect, the null hypothesis was rejected by the researcher. Thus, differences in students' conceptual understanding levels of heat and vapours under curriculum and item-teaching techniques is significant.

## DISCUSSION

The study sought to find out the relative effect of curriculum and item-teaching techniques on students' conceptual understanding of heat and vapours in Zamfara State. Findings of the study showed that students taught heat and vapour under item-teaching group had higher mean gain compared with those under curriculum teaching group. This was an indication that item-teaching technique increase students' achievement (or test) score given traditional physics exercises in heat and vapours. Inference drawn was that there was no statistically significant difference in the mean achievement score of students given traditional physics exercise in heat and vapours under curriculum and item-teaching techniques. Therefore, any difference in the mean gain as observed in table 1 was due to chance. It was further revealed that students under curriculum teaching technique had higher conceptual understanding mean score, against, their counterpart under item-teaching technique who had lower conceptual understanding mean gain. This was an indication that students conceptual understanding of heat and vapour had shifted. Inference drawn was that there was statistically significant difference in the conceptual understanding mean score of students taught heat and vapours under curriculum and item-teaching techniques. It implies that, instructional technique was significant in students' conceptual understanding in favour of curriculum teaching technique. Finally, it was also revealed that majority of students under curriculum teaching techniques were on scientific understanding level while, few were on Alternative Conception (AC) and No Conception (NC). On the contrary, a very small number of students under item-teaching techniques were on Scientific Understanding (SU) while, large number of students were on No Conception (NC). There is much difference in students conceptual understanding levels of heat and vapours on the basis of techniques as shown in the chart. However, the hypothesis confirmed the differences in students' conceptual understanding levels of heat and vapours under curriculum and item-teaching techniques to be significant. These findings are in agreement with the findings of the following studies: Popham (2001), Styron and Styron (2012), Phelps (2017), Amrein and Berliner (2002), Mehmet (2005), Chinyani *et al*. (2013), Iloputaife and Nworgu (2002), Madu and Nworgu (2004), Agomuoh (2010), Orji (2013), Antwi, et al. (2016), Gaigher *et al*. (2007), and Kola (2017).

Item-teaching technique is capable of raising students' scores on high-stakes tests, as well as, elevate students' mastery of the knowledge or skills on which the test items are based (Popham, 2001) not minding the application of the skill to situations outside the testing environment. Styron and Styron (2012) found that item-teaching technique forces teachers to address content that can be measured in standardized tests and avoid more analytical material which hinders learning. Phelps (2017) found that, drilling students in test format does not promote learning but reduces it, and diverts the attention of the class from the subject matter instruction and consumes the time meant for instructional delivery. Also, finding of Amrein and Berliner (2002) revealed that student learning generally stayed the same or decreased after high-stakes tests were implemented. Mehmet (2005) found that item-teaching technique only provides limited opportunity for in-depth and quality learning. Similarly, findings of Chinyani *et al*.

as cited in Sama *et al*. (2021) confirmed that students learning depth were limited under item-teaching technique. And, further commented that the practice gave opportunities to teachers to do selective teaching, thereby, neglecting some areas of the curriculum content which adversely affected students learning and learning depth. Item-teaching techniques can only be used to support instruction and not the instruction itself (Baker, et al., 2001). The implication is that, the item-teaching technique might have some effect on students' scores and students conceptual understanding, but it is impact on students understanding is limited. Hence, the concept "heterogeneous catalysis" as revealed also in the finding of this study.

As for curriculum teaching technique; findings of Rees (2001) which emphasized that, curriculum teaching techniques will promote critical thinking rather than rote memorization buttressed the findings of this present study to support that, the teaching technique that teach to the Curriculum or guided by curriculum were proved to promote students' understanding. Findings of Iloputaife and Nworgu (2002), Madu and Nworgu (2004), and Agomuoh (2010) which revealed that, conceptual instructional model promotes students conceptual change, achievement, and retention buttressed the findings of the present study because they found that majority of the students move from alternative and partial conceptions to scientific conceptions which curriculum teaching technique also stresses. Orji (2013) found that cognitive conflict instructional strategy promoted students' conceptual change and attention. The study conducted by Antwi *et al*., (2016) revealed that students under peer instructional approach have a better conceptual understanding of Mechanics than the students under traditional lecture method. It was found that peer instruction has a significant impact on students' scores in both FCI and MBT than the traditional lecture methods. Gaigher *et al*. (2007) found that students exposed to the structured problem-solving strategy demonstrated better conceptual understanding of physics and tended to adopt a conceptual approach to problem-solving. Findings of Kola (2017) investigated the conceptual understanding of physics through an interactive lecture-engagement, revealed that there was a significant interaction between the students' scores in the conceptual physics and interactive lecture-engagement teaching method. Finally, findings of all the literature revealed hinges on the fact that, techniques had a significant effect on students score, but techniques which promote curriculum-teaching will have heterogeneous impact on students learning, since, it will promote both students conceptual understanding and academic achievement in secondary school physics.

## Conclusion

Based on the findings of this present study, the researchers suggested a curriculum-sensitive pedagogy during classroom interactions so as to avert pedagogical failure in the implementation of physics curriculum in secondary schools, especially in this era of high-stake testing which is strengthening daily by technological advancements.

## Recommendation

1. Physics teachers should teach to the curriculum as to promote students' scores in both traditional physics and conceptual understanding exercises among senior secondary schools.
2. Physics teachers should not direct instruction specifically towards the actual items on the test itself; rather he/she should endeavour to teach the content represented by the test as stipulated in the curriculum.
3. Physics teachers should teach students for scientific or conceptual understanding in senior secondary schools.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## REFERENCE


Agomuoh, P. C. (2010). Effects of PEDDA and the Learning Cycle (TLC) constructivist instructional models on students' conceptual change and retention in Physics. Unpublished Ph.D Thesis, UNN.

Amrein, A. L., & Berliner, D. C. (2002). High-stakes testing, Uncertainty, and Student learning. *Education Policy Analysis Archives, 10*(18), 1-74.

Antwi, V., Raheem, K., & Aboagye, K. (2016). The Impact of Peer Instruction on Students' Conceptual Understanding in Mechanics in Central Region of Ghana. *European Journal of Research and Reflection in Educational Sciences 4*(9), 54-69.

Asabe, M. B. (2014). Impact of conceptual instructional method on students' academic achievement in practical chemistry among secondary school students in Zaria Educational Zone Kaduna State Nigeria. *Journal of Education and Human Development*, *3*(2), 351-360.

Asma, A., Sabeen, Q., & Isabel, W. (2014). Investigating the Washback Effect of the Pakistani Intermediate English Examination. *International Journal of English and Literature, 5*(7), 149-154.

Bond, L. (2005). Teaching to the Test: The Carnegie Foundation to the Advancement of Teaching. Retrieved from http://www.carnegiefoundation.org/perspectives/teaching-test.

Gaigher, E., Rogan, J. M., & Braun, M. W. H. (2007). Exploring the development of conceptual understanding through structured problem-solving in Physics. *International Journal of Science Education*, *29*(9), 1089-1110.

Gales, M. J., & Yan, W. (2001). Relationship between constructivist teacher beliefs and instructional practices to students' mathematical achievement: Evidence from TIMSS (Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA).

Hiebert, J., & Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics: An introductory analysis. *Conceptual and procedural knowledge: The case of mathematics*. Taylor and Francis Group. 28p.

Iloputaife, E. C. (2001). Effects of analogy and conceptual instructional models on physics achievement of secondary school students. Unpublished Ph.D Thesis, UNN.

Iloputaife, E. C., & Nworgu, B. G. (2002). Analysis of restructuring alternative conceptions of physics students using analogy and a five-step conceptual instructional models. *Proceedings of the 43rd Annual Conference of STAN and Inaugural Conference of CASTME- Africa*. Pp. 405-408.

Kim, E., & Pak, S. J. (2002). Students do not overcome conceptual difficulties after solving 1000 traditional problems. *American Journal of Physics*, *70*(7), 759-765.

Kola, A. J. (2017). Investigating the conceptual understanding of physics through an interactive lecture-engagement. *Cumhuriyet International Journal of Education, 6*(1), 82-96.

Lee, G., & Kwon, J. (2001). What do you know about students' cognitive conflict in science education: A theoretical model of cognitive conflict process. In: *Proceedings of 2001 AETS Annual meeting, Costa Mesa*. Pp. 309-325.

Lubienski, S. T. (2006). Examining instruction, achievement, and equity with NAEP mathematics data. *Education Policy Analysis Archives, 14*(14), 1-33.

Madu, B. C., & Nworgu, B. G. (2004). Facilitating students' retention of some concepts in physics using a constructivist-based approach. *Journal of Research in Education, 1*(1), 66-70.

Madu, B. C., Ogundeji, O. M., & Okoye, N. E. (2020). Scientific explanation of phenomenon, imagination and concept formation as correlates of students' understanding of physics concepts. *Journal of Natural Sciences Research*, *11*(16), 17-28.

Mehmet, H. (2005). *Fundamental of research methodology*. London, United Kingdom: Paraclete Publisher.

Mills, J. (2019). Making multiplication meaningful: Teaching for conceptual understanding. *Teachers and Curriculum*, 19(1), 17-25.

National Assessment of Educational Progress (NAEP) (2005). *Science conceptual understanding*. Retrieved from https://nces.ed.gov/nationsreportcard/.

Nwankwo, M. C., Achufusi, N., & Offiah, F. C. (2018). Effect of metaconceptual teaching intervention on students' conceptual understanding in physics. *International Journal of Science and Research, 8*(5), 1484-1490.

Nworgu, B. G. (1996). Teaching for conceptual understanding: conceptual-change instructional model. *A Lead Paper Presented at the 37th Annual Conference of STAN held at Uyo from 12 to 17th August*.

Nworgu, B. G. (2015). *Educational research: Basics Issues and Methodology* (3rd edition) Nsukka: Wisdom Publisher Ltd.

Nworgu, B. G., & Ugwuanyi, C. S. (2014). Assessment of senior secondary students conceptual understanding on force and motion. *Journal of Science Teachers Association of Nigeria, 49*(1), 170-186.

O'Dwyer, L. M., Wang, Y., & Shields, K. A. (2015). Teaching for conceptual understanding: A cross-national comparison of the relationship between teachers' instructional practices and student achievement in mathematics. *Large-scale Assessments in Education*, *3,* Article number *1*.

Ogundeji, O. M., Madu, B. C., & Onuya, C. C. (2019). Scientific explanation of phenomena and concept formation as correlates of students' understanding of physics concepts. *European Journal of Physics Education*, 10(3), 10-19.

Organisation for Economic Co-operation and Development (OECD) (2009). Teaching practices, teachers' beliefs and attitudes in creating effective teaching and learning environment: First Results from TALIS. Retrieved from https://www.oecd.org.

Orji, E. I. (2013). Relative effects of cognitive conflict instructional strategy and conceptual change pedagogy on students' conceptual change and attention in temperature and heat. Unpublished Master in Education (Science Education) thesis, University of Nigeria, Nsukka.

Phage, I. (2018). Undergraduate physics students' conceptual understanding in the learning of kinematics using a blended approach. The *proceedings of SOCIOINT 2018- 5th International Conference on Education, Social Sciences and Humanities,* 2-4 july 2018. Dubai, U.A.E. Pp. 654-659.

Phelps, R. P. (2017). The "Teaching to the Test" family of fallacies. *Revista Iberoamericana de Evaluación Educativa, 10*(1), 33-49.

Popham, W. J. (2001). Teaching to the test? Helping all students achieve. *Educational Leadership, 58*(6), 16-20.

Rees, J. (2001). Frederick Taylor in the classroom: Standardized testing and scientific management. *Radical Pedagogy 3*(2), 10-12.

Safa, A. M., & Jafari, F. (2016). The Washback effects of high school third grade exam on EFL teachers' methodology, evaluation and attitude. *Applied Research in English Language, 5*(1), 77-98.

Saleh, S. (2011). The level of B.Sc.Ed students' conceptual understanding of Newtonian physics*. International Journal of Academic Research in Business and Social Sciences, 1*(3), 249-256*.*

Sama, R., Adegbuyi, J. Y., & Ani, M. I. (2021). Teaching to the curriculum or teaching to the test. *Journal of Social, Humanity, and Education, 1*(2), 103-116.

Stofflett, R. T., & Stoddart, T. (1994). The ability to understand and use conceptual change pedagogy as a function of prior content learning experience. *Journal of Research in Science Teaching*, *31*(1), 31-51.

Styron, J. L. & Styron, R. A. (2012). Teaching to the test: A controversial issue in quantitative measurement. *Systemics, Cybernetics and Informatics*, *10*(5), 22-25.

Suleiman, B., Ogundeji, O. M., & Bello, A. (2022). Curriculum teaching versus teaching-to-the-test: Towards an appropriate classroom instructional practice in Nigeria. *Journal of Educational Research on Children, Parents, and Teachers, 3*(1), 440-455.

Ugwuanyi, C. S. (2012). Assessment of senior secondary students conceptual understanding on force and motion. Unpublished M.ed thesis, University of Nigeria, Nsukka. Enugu. Nigeria.

Yeo, S., & Zadnik, M. (2001). Introductory thermal concept evaluation: Assessing students' understanding. *The Physics Teacher, 39*(8), 495-504.