

Effect of problem solving technique on chemistry students

by Science Domain

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Effect of Problem-solving Technique on Chemistry students' Academic Performance in Stoichiometry in Senior Secondary Schools in Nigeria

ABSTRACT

Aims: This study addressed the effect of problem-solving technique on students' academic performance in stoichiometry in Senior Secondary Schools in Port Harcourt, Rivers State Nigeria.

Study design: Quasi-experimental design specifically pre-test post-test control groups non-randomized design was adopted.

Place and Duration of Study: Senior Secondary Schools in Port Harcourt Local Government Area of Rivers State located at the South-South Geopolitical Zone of Nigeria and lasted for four weeks.

Methodology: 105 SS3 chemistry students from intact classes of selected schools formed the sample of the study. The instrument was Stoichiometry Achievement Test developed by the researcher and reliability coefficient calculated to be 0.79. Three research questions and three hypotheses were used in the study. Mean and standard deviation were used to answer the research questions while the hypotheses were tested using Analysis of Variance at .05 level of significance.

Results: Findings of the study revealed a significant difference in performance between students taught stoichiometry using problem-solving technique (experimental) and those taught using conventional lecture method (control). Students exposed to problem-solving technique obtained higher score in performance test than those in conventional lecture method. Furthermore, there was a significant difference in students' performance based on gender (male and female) and school type (private and public).

Conclusion: The study therefore, concludes that problem-solving technique is more effective and enhance students understanding than traditional lecture method. The study recommended that chemistry teachers should incorporate problem-solving in teaching stoichiometry and related concepts and present curriculum should be reviewed to recommend problem-solving technique.

Keywords: Problem-solving technique, stoichiometry, chemistry students, academic performance

16 **1. INTRODUCTION**

17

18 Chemistry occupy a central position in the field of science and provides basic concepts for
19 understanding complex chemical reactions utilized in industries for production of numerous
20 products for the benefit of man and technological development mostly in developing
21 countries like Nigeria. Other sciences, medicine, engineering, and related courses depend
22 on the knowledge of chemistry for effective functioning of their profession. Stoichiometry is a
23 concept in chemistry that has wide range of industrial applications because it establishes the
24 relationship between the amount of reactants and the products in a given reaction. It entails
25 the use of mathematical expressions to determine the amount of reactants and products in a
26 known reaction which is usually represented as mass or volumes and expressed in moles.
27 The amount in moles can be converted to grammes or volumes depending on the state of
28 the reactants and the products. The concept of stoichiometry though challenging to
29 students, plays an indispensable role in providing basis for proper understanding of related
30 concepts in chemistry. Adequate understanding of reaction stoichiometry is fundamental to
31 improved performance of students in practical chemistry, particularly quantitative or
32 volumetric analysis which involves calculation of masses and volumes. Stoichiometry
33 according to [1] is the study of quantitative aspect of mass-mole number relationship,
34 chemical formulae and reactions which involves mole concepts and balancing of chemical
35 equations. By implication, the relationship between the amount of reactants and products
36 represents the stoichiometry of the reaction and is usually expressed in moles in a given
37 reaction.

38 Concepts in stoichiometry contains mathematical expressions which require problem-solving
39 and high-level thinking skills to enhance understanding of facts because of the mathematical
40 calculations involved in determining the amount of substance. Problem solving can be
41 defined as a process whereby someone applies previously learned rules to a novel situation

42 in order to arrive at a solution [2]. It requires application of both tacit and explicit knowledge
43 to manipulate information for understanding of requirements of given problem. The
44 knowledge possessed by students should be relevant to the problem at hand and well-
45 structured or organized and transferable to the problem situation. Consequently, teachers
46 need to understand how and which knowledge is used to arrive at a particular answer or
47 even when correct answer is not attained, assessment of process applied should lead to
48 understanding student's processes. Students' understanding of problem is achieved when
49 the student's knowledge has coherence and cohesion to recognize and prevent use of
50 different and conflicting elements of knowledge [3]. This occurs when students are able to
51 bring together parts of their prior knowledge about the new situation and make sense of what
52 it entails. Problem-solving instruction is a constructivist-based student-centered instruction
53 founded on the principle of learning by doing and by experiencing which emphasizes on
54 learners' construction of knowledge for meaningful learning. The process of knowledge
55 construction by students facilitates proper understanding and retention of information
56 because the information learned is a product of their personal construction. This is opposed
57 to the traditional lecture method where the process of acquiring knowledge involves rote
58 memorization of chemical formulae and specific reaction. In this case knowledge is not
59 applicable to the knowledge already learned which constitute a problem to leading to
60 cognitive dissonance where facts are separated entities with no relationships. Cognitive
61 dissonance which can be described as having knowledge without being able to use it. The
62 constructivist learning theory provides basis for this study and describe knowledge as the
63 basis on which new learning is constructed. That is, knowledge is considered as the tool that
64 the learning object uses to construct new meanings in the process of 'knowing' [2].

65 Teachers play an essential role in promoting students' understanding of stoichiometry which
66 prevent them from perceiving the concepts as a difficult. This can be achieved by adopting
67 teaching methods that encourage active engagement of the learner, focusing on the learner
68 rather than teacher, and acknowledging as well as challenging learners'

69 understanding/intellectual development and the interaction among these domains [4].
70 Students' difficulties in solving stoichiometric problems must be explored to enable teachers
71 design appropriate instructional strategies that will address students' difficulties and enhance
72 understanding of the concept. There are useful pedagogical strategies that can facilitate
73 meaningful learning of reaction stoichiometry of which problem-solving technique is one of
74 them. [1] appraising his experiences while teaching stoichiometry to students in grade 10
75 and 11 in Mid-Western Urban School District in United States of America with qualitative
76 narrative approach and face to face interview opined that teachers should adapt their
77 instructional strategies and modes of delivery to reflect students' individual learning styles
78 and be knowledgeable, creative, and resourceful in their subject area to help students learn
79 stoichiometry. There are several approaches for teaching science concepts, but the
80 suitability of a given or combination of methods depends on the topic because the method
81 suitable for one topic may not necessarily be suitable if applied to another topic. Therefore,
82 each method is unique in its ability to solve academic problem. There are various models of
83 problems solving based teaching strategies in chemistry. These models are very useful in
84 improving students' problem-solving abilities. A good example is the model developed by [5]
85 which involves the following stages:

- 86 • Defining the goal of the problem
- 87 • Selecting information from problem statement
- 88 • Selecting information from the memory
- 89 • Reasoning; and
- 90 • Error in computation

91 Furthermore, [6] developed a four-stage model for solving chemistry problems based on the
92 heuristic for easy application by students to alleviate the burdens of memorizing different
93 relationship or formulae relating to different topics by providing the key- relations chart. The
94 four stage- model otherwise known as WISE include:

- 95 • What is happening?
- 96 • Isolation of unknown
- 97 • Substitute given values
- 98 • Evaluate.

99 [7] developed a model which consist of four steps:

- 100 • Understanding the problem (recognizing what is asked for). For instance, asking
- 101 yourself what am I looking for? or what information is given in the problem?
- 102 • Devising a plan for solving the problem (responding to what is asked for). For
- 103 instance, ask questions such as do I know a similar problem? can I state the
- 104 problem?
- 105 • Carrying out the problem (developing the results of the response) and,
- 106 • Looking g back (checking. What does the results tell me?).

107 Another model is the dimensional analysis devised to solve problems in stoichiometry which
108 utilizes conversion factor in the stoichiometric calculations and set up a joined relationship
109 for solution. These conversion factors are provided by mole concept for problem-solving.
110 The equations or conversion factors are set up in fraction form and lined up sequentially
111 such that the units on top and bottom of neighbouring fractions are alternated for the units
112 cancel. On the other hand, the mole method involves step by step calculation of amounts
113 from the given quantity through the moles to amount of the unknown. In a given reaction,
114 chemical equations are represented in moles not in masses. Therefore, the moles must be
115 converted to mass to calculate the mass of product from a known mass of the reactant by
116 comparing the given ³⁹ number of moles of reactants to the number of moles of the product
117 and finally converting moles to mass of product. The dimensional analysis and mole method
118 obtain results from the quantity through the mole of the given and unknown substance. The
119 expression below shows the sequence in the conversion form mole to mass.

120

121

122	Mass				mass
123	Given volume	→	given moles	→	wanted moles → wanted volume
124	Number				number

125 **Figure 1:** Outline for dimensional analysis and mole method

126

127 The last strategy is the proportion or algorithmic method which compares the given
 128 amounts to the unknown amount and set up a relation between these amounts. This method²³
 129 emphasizes basic scientific principles through application during the process of solving
 130 problems which in turn promotes students' understanding of these principles by constantly
 131 reinforcing basic concepts

132

133 Several researches have been carried out to investigate the effectiveness of problem-solving³
 134 method in enhancing students' understanding of the concept of stoichiometry. For instance,
 135 [8] Mandina & Ochonogor (2017) attempted to remedy the difficulties encountered by high⁹
 136 school chemistry students when solving stoichiometric problems by using problem-solving
 137 approach on 485 advanced level learners high school students in Gweru District of
 138 Zimbabwe. Results of the study showed that, the use of problem-solving instruction was an⁹
 139 effective strategy in remedying the identified difficulties in comparison to the conventional
 140 lecture method. There was a significant difference between the mean score of students²
 141 exposed to problem solving models and those in the conventional lecture method. The
 142 instrument was Stoichiometry Achievement Test (SAT). [9] investigated the effect of¹⁴
 143 enhanced problem-solving technique on students' competence in tackling chemical
 144 problems. Quasi experimental design was adopted and 120 senior secondary 2 students of¹⁴
 145 Ekiti state used as sample. Result of the study showed that students exposed to enhanced
 146 problem-solving technique performed better than those exposed to lecture method. Further
 147 findings of this study revealed that it is better for students to learn the art of solving problem
 148 in a relaxed atmosphere by providing them with formulae and equations required. To

149 guarantee this, students should be made to understand the relationship between the
150 physical quantities that make up the atmosphere.

151 Apart from stoichiometry, the effectiveness of problem-solving instruction in enhancing
152 students' performance in chemistry have also been validated. For instance, [10] explored the
153 ³ effects of problem-solving instructional strategy, three modes of instruction and gender on
154 learning outcomes in chemistry. The sample was 210 SS2 chemistry students of Ekiti State,
155 Nigeria and the model was ³ Seven Step Chemistry Problem-Solving Model (SSCPSM)
156 ³ suggested by [11] and [3]. Findings of the study revealed that students in experimental group
157 (i.e problem-solving coupled with remediation) had the highest scores in chemistry
158 achievement test compared to ³⁸ the conventional lecture method. There was no significant
159 difference in students' performance based on gender.

160 [12] investigated the relative effectiveness of two problem-solving models ([13]-[11] and [5])
161 programmed student learning model in facilitating students' learning outcomes in chemistry
162 using 275 college of education students in Oyo and Ogun State, Nigeria as the sample. The
163 ¹¹ findings of the study revealed that students who were taught with problem-solving models
164 either teachers'-directed or students'-directed, performed significantly better than their
165 counterparts in control group that were taught with formula method. Gender was found to
166 affect students' cognitive achievement and attitude towards learning chemistry. Insignificant
167 interaction effect of treatment and gender at effective level was also established.

168 ⁵ [14] investigated the effects of problem-solving instructional strategy and numerical ability on
169 students' learning outcomes using Seven Step Chemistry Problem-Solving Model
170 (SSCPSM) and 201 chemistry students selected by multi-stage random sampling technique
171 ¹¹ from secondary schools in three local Government Areas of Ekiti State of Nigeria. Findings
172 ⁵ of the study revealed that problem-solving instructional strategy as well as students'
173 numerical ability improves students' performance in chemistry confirming that problem-
174 solving approach was ³ more effective and reliable method of teaching than conventional

175 ⁵ lecture method. The study also showed that students with high numerical ability performed
176 better than their counterparts with low numerical ability. ⁵ Male and female students of high
177 and low ability levels did not differ in their performance in chemistry at group levels.

178 Other researchers focused on the effect of other methods of teaching on students'
179 performance in stoichiometry. In this regards, [15] explored the ⁸ influence of process oriented
180 guided inquiry learning (POGIL) on science foundation students' achievement in
181 stoichiometry problems at university of Namibia and found that The POGIL group student
182 also recorded the highest improvement on questions related to stoichiometry and limiting
183 agents and ⁸ were able to give correct reasons for their answers obtained through numerical
184 calculations or multiple choice while demonstrating enhanced understanding of the linking
185 stoichiometry concepts compared to the traditional group. ¹⁵ There was a significant statistical
186 difference in achievement between the POGIL group and lecture group of students.

187 [16] in his comparative study of the effectiveness of flipped classroom and traditional
188 classroom instruction and found that flipped classroom instruction was effective in teaching
189 stoichiometry compared to traditional lecture method. Significant difference between the
190 flipped classroom and traditional classroom instruction on students' conceptual change on
191 stoichiometry was established. Students response to the flipped classroom instruction was
192 largely positive indicating it to be worthy approach for teaching stoichiometry. [17] developed
193 ¹⁷ a theoretical framework based on history and philosophy of chemistry to facilitate high
194 school grade 10 students' understanding of stoichiometry in Venezuela using dialectic
195 ¹⁶ constructivist strategy based on the presentation of hypothetical experimental data and
196 ¹⁶ found that students in the experimental group performed better than those in the control
197 group, not only on algorithmic items but also items requiring conceptual understanding.
198 ¹⁵ There was a statistically significant difference in students' performance between the
199 experimental and control group. History and philosophy of chemistry ¹⁷ perspective developed

200 in this study led to a critical evaluation of laws of definite proportion and their role in
201 chemistry education.

202 [18] explored approaches to dealing with difficulties undergraduate students experience with⁸
203 stoichiometry in Tshwane University of Technology South Africa using 456 first year
204 chemistry students of Taiwanese University of Technology (TUT) and worksheet intervention
205 model designed based on research. Findings of the study showed that structured worksheet
206 together with tactile models showed a remarkable improvement in undergraduates'
207 understanding of the concept of stoichiometry. [19] studied the effects of mathematical¹⁰
208 reasoning skills on students' achievement in chemical stoichiometry using 400 senior
209 secondary school students of Oshimili South Local Government area of Delta State Nigeria³³
210 as sample and Chemistry Achievement Test. Results of the study showed that there was a¹⁵
211 significant difference in achievement in stoichiometry as a result of mathematics instruction,¹⁰
212 entering mathematics skills and achievement in chemical stoichiometry. Furthermore,
213 mathematics skills correlated significantly with achievement in chemical stoichiometry. There
214 was significant gender difference in students' achievement in mathematics and chemical
215 stoichiometry. A significant improvement in chemical stoichiometry was recorded after
216 remediation.

217 Science subjects and related courses are usually dominated by the male students' and many
218 assertions tends to establish difference or no difference in gender performance in sciences
219 mostly those that involves mathematical and related disciplines like engineering. In this
220 regard, [20] investigated the differences between male and female students' performances in⁷
221 Biology, Chemistry and Physics among pre-degree students of Federal University Dutsin-
222 ma, Katsina State-Nigeria. The results of the study showed that there were no significant⁷
223 differences in the performance of male and female students in biology, chemistry and
224 physics. [21] compared male and female senior secondary school students' learning¹
225 outcomes in science in Katsina State, Nigeria using 204 students randomly selected from¹

226 the three geopolitical zones of the state. The findings of the research showed that there were
227 no significant difference between male and female students in overall science achievement
228 attitude to science and also biology, chemistry and physics achievements. [22] in their
229 research to find out if sex differences exist in calculating reacting masses from a set of
230 chemical equations among secondary school students in Makurdi metropolis found that
231 boys performed better than girls on the achievement test.

232

233 1.1 Statement of the Problem

234 Stoichiometry contains numerical problems which entails the use of mathematical
235 expressions to determine link between two or more parameters and find solution to chemical
236 problems. Unfortunately, concept difficulty in stoichiometry and students' poor performance
237 in certificate examinations has been established. In support of this, [23] reported students'
238 poor performance in stoichiometry and chemical reactions in May/June Senior Secondary
239 School Certificate Examination. The observed poor performance of students could be
240 attributed to factors which are either teacher or student related. The use of appropriate
241 teaching method enhances students' understanding of concepts which results in good
242 performance while use of wrong method lead to difficulty in understanding and cause poor
243 performance. The question therefore is, which teaching method will be effective to address
244 students' concept difficulty and poor performance in stoichiometry? In providing answer to
245 this question, several teaching approaches have been adopted but models of problem-
246 solving approach have not been fully explored leaving a gap in knowledge. This study
247 therefore, intends to bridge the gap by investigating the effect of problem-solving technique
248 (WISE model) on students' academic performance in stoichiometry in senior Secondary
249 School in Rivers State.

250 1.2 Purpose of the Study

251 This research was carried out to evaluate the effect of problem-solving technique on
252 students' academic performance in stoichiometry in senior secondary schools in Rivers
253 State. Specifically, the study tends to determine the:

- 254 1. performance of students taught stoichiometry with problem-solving technique and
255 those with conventional lecture method in Senior Secondary School in Rivers State.
- 256 2. performance of male and female students taught stoichiometry with problem-solving
257 technique and those taught with conventional lecture method in Senior Secondary
258 School in Rivers State?
- 259 3. performance of public and private school students taught stoichiometry with
260 problem-solving technique and those taught with conventional lecture method in
261 Senior Secondary School in Rivers State?

262 1.3 Hypotheses

263 HO₁. There is no significant difference in performance between students taught
264 stoichiometry with problem-solving technique and those taught with conventional
265 lecture method in Senior Secondary School in Rivers State.

266 HO₂. There is no significant difference in performance between male and female students
267 taught stoichiometry with problem-solving technique in Senior Secondary School in
268 Rivers State?

269 HO₃. There is no significant difference in performance between public and private school
270 students taught stoichiometry with problem-solving technique in Senior Secondary
271 School in Rivers State.

272 2. MATERIAL AND METHODS

273

274 ³⁰ Quasi-experimental experimental design using pre-test post – test control group was
275 adopted. The population of this study was 520 senior secondary 3 chemistry students from
276 57 private and 48 public ²⁵ schools in Port Harcourt Local Government Area of Rivers State.
277 ³ 105 SS2 chemistry students consisting of 61 males and 44 females from intact classes of
278 selected schools formed the sample. The two intact classes in each selected school were
279 used for the study and randomly assigned ¹¹ experimental and control groups. The total
280 number of students in the experimental groups were 53 and control group 52. The
281 instrument was a 20-item multiple choice Stoichiometry Achievement Test (SAT) developed
282 by the researcher. Test items were selected from past question papers of WAEC Senior
283 Secondary School Certificate Examination (SSCE) and subjected to face and content
284 validation by two lecturers in Science Education Department and one lecture in
285 ⁴ Measurement and Evaluation. The reliability coefficient was determined by test–retest
286 method and coefficient found to be 0.70. ¹¹ Mean and standard deviation were statistical tools
287 used to answer research questions while Analysis of Variance was used to test the
288 hypotheses at .05 level of significance. Students in the ³⁴ experimental group were taught
289 using problem-solving instruction and those in the control group with conventional traditional
290 lecture method. The instrument was administered as pre-test before treatment and post-test
291 after treatment and data used for analysis.

292

293 3. RESULTS

294

295 Research Question 1.

296 ² What is the performance of students taught stoichiometry with problem-solving technique
297 and those with conventional lecture method in Senior Secondary Schools in Rivers State?

298

299 Table1 showed that the pre-test mean performance scores of students taught stoichiometry
 300 with problem solving-technique and those taught with conventional lecture method were
 301 38.17 and 40.67 respectively with standard deviations of 12.36 and 9.56. Also, the post-test
 302 mean performance score of students taught stoichiometry with problem solving-technique
 303 and those taught with conventional lecture method were 54.43 and 42.81 respectively with
 304 standard deviations of 17.46 and 17.36. Students in the problem-solving technique recorded
 305 higher mean performance score and higher standard deviation than those in the
 306 conventional lecture method after treatment.

307
 308 Table 1. Mean and standard deviation analysis of performance of students taught

Group	N	Mean			Standard Deviation		
		Pre-test	Posttest	Diff.	Pre-test	Post-test	Diff.
Experimental	53	38.17	54.32	16.15	12.30	17.36	10.01
Control	52	40.67	42.81	2.14	9.56	18.27	6.03
Diff. between		2.50	1.51	4.01	2.74	0.91	3.98

309 stoichiometry with problem-solving technique and those taught with conventional lecture
 310 method.

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 320

321 **Research Question 2.**

322 What is the performance of male and female students taught stoichiometry with problem-
323 solving technique in Senior Secondary School in Rivers State?

324

325 Table 2 showed that the post-test mean performance score of male and female students
326 taught stoichiometry with problem solving-technique were 53.08 and 40.30 respectively with
327 standard deviations of 19.15 and 15.96. Male students taught stoichiometry using problem
328 solving technique recorded higher mean performance score and higher standard deviation
329 than female students.

330 **Table 2.** Mean and standard deviation analysis of performance of male and female students
331 taught stoichiometry with problem-solving technique in Senior Secondary Schools in Rivers
332 State.

Gender	N	Mean	Std. Deviation
Male	31	53.08	19.15
Female	22	40.30	15.96
Difference		12.78	3.19

333

334

335 **Research Question 3**

336 What is the mean performance of public and private school students taught stoichiometry
337 with problem-solving technique in Senior Secondary School in Rivers State?

338

339 Table 3 showed that the post-test mean performance score of private and public school
340 students taught stoichiometry with problem solving-technique were 54.86 and 42.23
341 respectively with standard deviations of 18.16 and 15.14. Private secondary school students
342 taught with problem-solving technique recorded higher mean performance score and higher
343 standard deviation than public secondary school students.

344

345 **Table 3.** Mean and standard deviation analysis of performance of public and private school
 346 students taught stoichiometry with problem-solving technique in Senior Secondary Schools
 347 in Rivers State.

School Type	N	Mean	Std. Deviation
Private	57	54.86	18.16
Public	48	42.23	15.14
Difference		12.63	3.02

348

349 **3.2 Hypothesis 1**

350 ² There is no significant difference in performance between students taught stoichiometry with
 351 problem-solving technique and those with conventional lecture method in Senior Secondary
 352 School in Rivers State.

353 From Table 4, the calculate value of F-ratio = 11.477 is greater than the table value ($p = .05$).
 354 Therefore, the null hypothesis which states that ¹³ there is no significant difference in
 355 performance between students taught stoichiometry using problem-solving technique and
 356 traditional lecture method in senior secondary school ² rejected. This infers that there is a
 357 significant difference in performance between students taught stoichiometry using problem-
 358 solving technique and conventional lecture method in senior secondary schools in Rivers
 359 State.

360 **Table4.** ANOVA of the post-test experimental and control mean ² performance of
 361 students taught stoichiometry using problem-solving technique and those taught with
 362 lecture method in senior secondary schools in Rivers State.

	²⁹ Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3479.138	1	3479.138	11.477	.001
Within Groups	31223.624	103	303.142		
Total	34702.762	104			

363

364 3.3 Hypothesis 2

365 There is no significant difference in performance between male and female students taught
366 stoichiometry with problem-solving technique in Senior Secondary School in Rivers State.

367

368 From Table 5, the calculate value of F-ratio = 13.061 is greater than the table value ($p =$
369 0.05). Therefore, the null hypothesis which states that there is no significant difference in
370 performance between male and female students taught stoichiometry with problem-solving
371 technique in Senior Secondary Schools in Rivers State is rejected. This infers that there is a
372 significant difference in performance between male and female students taught
373 stoichiometry with problem-solving technique in Senior Secondary Schools in Rivers State.

374

375 **Table 5:** ANOVA of the post-test mean score of male and female students taught
376 stoichiometry using problem-solving technique in senior secondary schools in Rivers State.

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4179.241	1	4179.241	13.061	.000
Within Groups	32957.749	103	319.978		
Total	37136.990	104			

377

378 3.4 Hypothesis

379 There is no significant difference in performance between public and private school students
380 taught stoichiometry with problem-solving technique in Senior Secondary School in Rivers
381 State?

382

383 From Table 6, the calculated value of F-ratio = 14.641 is greater than the table value ($p =$
384 .05). Therefore, the null hypothesis which states that there is no significant difference in

performance between public and private school students taught stoichiometry with problem-solving technique in Senior Secondary School is rejected. This infers that there is a significant difference in performance between public and private school students taught stoichiometry with problem-solving technique in Senior Secondary School in Rivers State.

Table 6. ANOVA of the mean score of public and private school students taught stoichiometry with problem-solving technique in senior secondary schools in Rivers State

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4156.872	1	4156.872	14.641	.000
Within Groups	29243.356	103	283.916		
Total	33400.229	104			

4. Discussion of Findings

Evidence from the findings of this study revealed a significant difference in performance between students taught stoichiometry with problem-solving technique and those taught with conventional lecture method (Table5). Students taught with problem-solving technique performed significantly better in the performance test than those taught with conventional lecture method. Results of this study corroborates the findings of other studies on the effect of problem-solving instruction on students' performance in stoichiometry by [19], [24] and [9] where significant differences in performance between students taught stoichiometry with problem-solving technique and conventional lecture method were established in their

405 independent studies. ¹³ Students in the experimental group where lesson was delivered by
406 problem-solving technique performed better because they achieved good reasoning and
407 process skills in calculations which enhance their mathematical skills and enable them to
408 solve algorithmic problems in stoichiometry. This validate, [19]'s claim that mathematics
409 ¹⁰ skills correlated significantly with achievement in chemical stoichiometry and [14] assertion
410 ²⁸ that students with high numerical ability performed better than their counterparts with low
411 numerical ability in chemistry and students' numerical ability improves students' performance
412 in chemistry. Furthermore, students in the problem-solving instruction classroom, utilized
413 both fact and explicit knowledge acquired in the process of problem-solving instruction to
414 ¹ manipulate information and understand what is required in the problem as they are exposed
415 to meaningful learning. According to [25], this is the knowledge that is ¹ responsible for
416 interactions involved in problem-solving or the process of knowing as students engage or
417 ¹⁶ attempt to solve chemical problems. In the control group, where students were exposed to
418 traditional lecture method, students were not involved in the process of knowledge
419 construction instead they played a passive role in the classroom depending on the teacher
420 as the source of information. Knowledge is not personalized but transferred by repeated act
421 of memorization resulting in poor retention and retrieval of information. The students attempt
422 to solve chemical problems through rote memorization and recall of information which
423 translates into difficulty in understanding and the low scores obtained in the stoichiometry
424 test.

425
426 ⁶ There was a significant difference in performance between male and female students taught
427 stoichiometry with problem solving technique. ⁷ Male students performed significantly better
428 than female students in the performance test. This results in agreement with that of [19] who
429 found a significant gender difference in students' performance in stoichiometry and further
430 gives credence to the assertion that males possess better mathematical skills and perform
431 better in concepts that involves calculations than the females. The results however, disagree

432 with the findings of [14] and [10] where no significant gender difference in students'
433 performance in stoichiometry was found. Finally, ¹⁵ there was a significant difference in
434 performance between private and public secondary school students in stoichiometry.
435 Private secondary school students performed significantly better in the performance test
436 than public secondary school students.

437

438 5. CONCLUSION

439

440 The outcome of this study confirms that Problem-solving technique is effective and enhance
441 students' understanding of concepts in stoichiometry than conventional lecture method.
442 There was ² a significant difference in performance between students taught stoichiometry
443 with problem-solving approach and those taught with conventional lecture method.
444 Students' taught with problem solving technique performed ²⁷ significantly better than those
445 taught with conventional lecture method. Furthermore, there was a significant difference in
446 performance of students based on gender (male and female) and school type (private and
447 public).

448

449 6. Recommendations

450

451 ¹² Based on the findings of this study the following recommendations were made.

- 452 1. chemistry teachers should in cooperate problem-solving learning to improve
453 student's understanding.
- 454 2. chemistry ³ curriculum should be reviewed to accommodate problem-solving and
455 activity oriented instructional strategies.
- 456 3. chemistry educators should understand students' difficulties and implement problem
457 solving pedagogies technique to address students' difficulties in solving problems on
458 stoichiometry.

459 **CONSENT**

460 As per international standards, or university standards, students' written consent has been
461 collected and preserved by authors.

462 **COMPETING INTERESTS**

463

464 Authors have declared that no competing interest

465

466

467

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561 **APPENDIX**

Effect of problem solving technique on chemistry students

ORIGINALITY REPORT

%**29**

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INTERNET SOURCES

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PUBLICATIONS

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