



Research Article

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X Received: 19 October 2024 / Accepted: 6 March 2025 / Published: 10 March 2025

Effect of Integrating Practical Work in the Teaching of Advanced Level Chemistry on Students' Achievement in Stoichiometry: The Case of Gweru District Public High Schools

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DOI: <https://doi.org/10.36941/mjss-2025-0014>

Abstract

The study examined the impact of integrating practical work in the chemistry classroom on the achievement of Advanced level learners in stoichiometry. The researcher utilized the pre-test and post-test quasi-experimental design with non-equivalent comparison groups. The 56 participating learners who made up the study sample were drawn from 2 public high schools in Gweru district, Midlands Province, Zimbabwe. Data was collected using standardized achievement tests in stoichiometry. In the experimental school, practical work was integrated with theory during teaching while in the control school, learners were taught using the conventional method where theory aspects of the topic were completed first then a related practical activity was done on a later date. The researcher utilized the independent samples t-test to analyze quantitative data from the achievement tests. Findings from the study indicated that the difference between the mean scores of the learners in the control group and those in the experimental group was big enough to be statistically significant. Learners taught with practical, and theory integrated in the same lesson had a bigger mean gain than those taught theory preceding practical when the pre-test and post-test mean scores were compared. Teachers are therefore recommended to incorporate practical activities when delivering instruction to improve students' achievement in chemistry.

Keywords: integrating, practical work, teaching, achievement, stoichiometry

1. Introduction

The academic performance of learners is a key aspect of the teaching and learning process (Rono, Onderi & Owino, 2014) and one of its important goals (Narad & Abdullah, 2016). Achievement of learners in any subject area indicates the quality and effectiveness of learning (Adeyemo, 2001). This can be used to measure how well educational objectives are being attained (Adesoji, Omilani & Dada, 2017). Chemistry, as a science subject, has an important role to play in the development of any nation. According to Okafor (2000), the way in which chemistry is taught in schools has an impact on national scientific development. Chemistry is one of the pure science subjects studied at Advanced level in Zimbabwean public schools which is highly important to many manufacturing industries

which include but not limited to pharmaceutical, agricultural and textiles (Gongden, 2016). Recognizing the important role played by chemistry, there is a need to come up with various strategies which will improve and promote the teaching and learning of the subject in schools (Argaw, Haile, Ayalew, & Kuma, 2017). Integrating practical work with theory in the chemistry classroom is not only crucial for enhancing students' understanding of concepts but also for fostering critical thinking and problem-solving skills in the learners (Bennett, 2013). This study is timely and essential in supporting the advancement of chemistry teaching and equipping students with skills and knowledge required for the ever-evolving scientific landscape.

Due to the complexity of chemistry and that it is a conceptually difficult subject, it becomes important for educators to identify appropriate instructional strategies that can be employed to address challenges faced by students during learning (Gegios, Salta & Koinis 2017). Taber (2015) for example suggested that practical activities may be carried out to reinforce theory learnt or to prove ideas; however, the link between theory and the practical itself is not always obvious to students because teachers tend to separate the two when teaching. The current study puts an emphasis on teaching science laboratory work as an integral part of classroom instruction with pre-laboratory and post-laboratory discussions. On the contrary, Kazembe and Musarandega, (2012) and Mandina (2012) in their respective research studies on the teaching and learning of chemistry in Zimbabwean high schools show that teacher-led instruction still dominates classroom activities, method which has proved to be ineffective in promoting science learning. Chief examiners' reports from the Zimbabwe School Examinations Council for November 2013 Advanced level chemistry Examination indicate poor students' performance which they attributed to inadequate exposure to practical work and exercises before the examinations (ZIMSEC, 2013).

Baraya, Abdulrahman, and Yusuf (2019) noted that chemistry teachers in Nigerian schools do not start the practical aspect early; alongside the theoretical aspect, a practice which is likely to impede students' ability to link the theory aspect with the practical aspects thereby contributing to their poor performance in the theory of practical questions and qualitative analysis questions. According to Ekpo (1999), even the slightest effort teachers put in to separate science into practical and theory lessons contributes towards perpetuating dichotomy and is the direct opposite of what science is. The Advanced level chemistry curriculum syllabus objectives (MoPSE Curriculum Framework, 2015-2022) places emphasis on the student-centred process approach whose one of the requirements is that the students should participate actively during the learning process by engaging in adequate and meaningful hands-on activities during every classroom instruction. However, reports from the West African Examinations Council for 2003 show that science teachers still split theory and practical work when teaching; and worse still they never attend to the practical aspect until the second term of the final year or few weeks to public examinations (WAEC, 2003).

The current research focuses on one topic, stoichiometry to determine the effectiveness of integrating practical work with theory in chemistry classes. Stoichiometry is among the topics that students find difficult (Booi, 2023; Izunwanne, Ahuchaogu & Amanze, 2017; Uchegbu, Oguoma, Elenwoke, & Ogbuagu, 2016). The researcher identified the mole concept, stoichiometric calculations, volumetric analysis and titration analysis as difficult topics that students struggle with. From the experience the researcher has in teaching chemistry, students experience difficulties with quantitative chemistry problems which are a major obstacle in chemistry learning. Several research studies have been carried out to improve the performance of students in stoichiometry (Opara, 2014; Mandina & Ochonogor, 2018; Etokeren, Ibemenji & Alamina, 2019) but students still report difficulties in the topic. Generally, there is a paucity of research information on the effectiveness of incorporating practical work with classroom instruction in science compared to the traditional theory before practical. The focus of this study, therefore, is finding plausible answers to the question: What difference exists in students' performance when practical work and theory are taught together versus when practical is taught separately from the theoretical aspect?

2. Statement of the Problem

The traditional way of teaching chemistry in secondary schools involves teaching theory in the classroom while the practical component is done later in the laboratory. However, this conventional method prioritizes the theory aspect, which makes it difficult for students to link the knowledge they obtain from the theoretical class to the practical class and vice versa. For proper understanding, it is imperative that teachers integrate practical work with theory when teaching chemistry, which is the focus of the current study.

2.1 Aim of the Study

The aim of this study is to establish the effect of integrating practical work with theory on the achievement of Advanced Level chemistry students in Gweru district in Zimbabwe.

2.2 Objectives of the Study

To researcher identified the following objectives to achieve the aim of the study:

- (i) To determine how integrating practical work into teaching of chemistry enhances the achievement of students.
- (ii) To compare the mean scores of students taught theory and practical integrated in one lesson and those taught theory first then practical later.

2.3 Hypotheses of the Study

The following hypotheses were generated and tested at 0.05 level of significance.

- H_0 : The difference between the mean achievement scores of students taught when practical is integrated with theory and those taught with theory and practical separated is not statistically significant.
- H_1 : The difference between the mean achievement scores of students taught when practical is integrated with theory and those taught with theory and practical separated is statistically significant.

3. Research Methodology

The study made use of quasi-experimental research design which utilized pre and post-test comparison groups which were non-randomized and non-equivalent. The rationale behind choosing this design was that it is impossible to conduct a true experiment on human beings. Furthermore, Fatade, Mogari, and Arigbabu (2013) noted that quasi-experimental design is associated with causal-effect relationships and is therefore easier to set up when compared to true experiments. By adopting the quasi-experimental design, the researcher as able to use intact classes during the implementation of the intervention thus minimizing disruption of other school programmes during the period of study. The use of intact classes also allowed the researcher to administer the intervention on one group while the other group acted as a control group (Mandina & Ochonogor, 2018). The methodology used in this study agrees with what was suggested by Arzi and White, (2005) who opined that it is impossible to apply random selection of participants in educational research, while Cook (2002) observed that assigning subjects randomly to control and experimental groups in research involving the effectiveness of teaching strategies to improve student achievement is rare. Since it was not possible for the researcher to conduct a true experiment, a non-equivalent group design was used (Johnson & Christenson, 2012).

3.1 Participants of the Study

The sample of the study was made up of 56 Advanced level chemistry learners drawn from two co-educational high schools in Gweru district. The researcher conducted a pre-test in 11 of the 14 public high schools in the district and used post-hoc tests with ANOVA to determine two schools whose mean scores difference was statistically insignificant. The p-value was found to be 0 as shown in table 1, indicating that the probability of a type 1 error (rejecting a correct null hypothesis) is small (0%). A smaller p-value rejects the null hypothesis and strongly supports the alternate hypothesis (H_1) implying that some of the groups' averages are considered not to be equal. After the ANOVA, post hoc tests were done to find any pairs of groups with similar means. This analysis identified two schools which the researcher assigned randomly into the experimental and control groups by flipping a coin (McLeod & Guy-Evans, 2023).

Table 1: ANOVA test for the Baseline Equivalence Test (Pretest)

Source	DF	Sum of squares	Mean square	F statistic	P-value
Groups (between groups)	10	2851.8539	285.1854	23.6092	0
Error (within groups)	252	3044.0167	12.0794		
Total	262	5895.8706	22.5033		

The schools that were randomly selected were deemed to have similar laboratory facilities and socio-economic background. While Argaw et al. (2017) identifies the non-equivalent control group design as the most employed quasi-experimental design in educational research, the design has its own limitations which the researcher overcame by matching the experimental and comparison groups prior to the start of the intervention to make the two groups more comparable. Before carrying out the experiment, the researcher administered a pretest to all the 14 public high schools in Gweru district. Based on the results obtained, 2 of those schools that were found to have scored and obtained nearly the same mean score were selected. A distance of approximately 30 km separated the control and experimental school. The teacher in the control school (comparison group) taught the theory aspect first and then did the practical with the students after the three-week study period. On the other hand, the learners in the experimental school were taught by their teacher theory and practical activities in the same lesson (integrated approach) after receiving a two-hour training on how to integrate practical work with theory when teaching.

3.2 Instruments for Data Collection

Data for the study was collected using two standardized chemistry achievement tests (CAT) on the stoichiometry topic. The tests comprised of 25 multiple choice items. The tests were validated by experts in chemistry education who included 3 ZIMSEC examiners and the research supervisor. Before the instruments were used in the actual study, the researcher administered the same tests in the pilot as well as in the actual study. Using the split half method, the internal consistency of the pre-test 0.85 was while that of the post-test was 0.78. Downing (2004) considers any value of the Pearson correlation coefficient above 0.7 as acceptable for research tools. For Brown (2002) this tool was 0.79 reliable while for Bano, Khan and Khan (2021), the value was also 0.79. Hence these chemistry tests used in this study may be referred to as sufficiently reliable.

3.3 Method of Data Analysis

Data was analyzed using descriptive statistics (mean, standard deviation) and inferential statistics (independent samples t-test) using Statistical Package for Social Sciences (SPSS) version 20.0 to compare the achievement of students in the control and experimental groups after the intervention.

A p-value of less than 0.05 would imply that the difference between the mean scores of the two schools was big enough to be statistically significant.

4. Study Findings

Prior to performing the two-sample t-test, the researcher had to test the assumption that the variances of the two groups were homogeneous. In this case the Levene's test for equality of variances was conducted to test the null hypothesis that the variances are equal amongst the two groups (Jackson, 2012). If $p < 0.05$ the Levene's test is positive meaning that the variances are not the same, hence, the groups are significantly different that is the homogeneity of variances assumption has been violated (Dhlamini, 2012). The researcher formulated a Null Hypothesis (H_0), which stated that the variances of the population were equal and an alternate Hypothesis (H_1) which indicated that the variances of the population were not equal.

Table 2: Results of Levene's Test to Determine Equality of Variance

Source	DF	Sum of squares	Mean square	F statistic	P-value
Groups (between groups)	1	10.4867	10.4867	3.1395	0.08277
Error (within groups)	48	160.3333	3.3403		
Total	49	170.82	3.4861		

Results from table 2 show that the p-value is 0.08277 and is greater than α (0.05), therefore H_0 is accepted. The averages of the control and experimental groups were assumed to be equal. In other words, the difference between the sample variances of these two groups is not big enough to be statistically significant. The researcher cannot therefore reject the null hypothesis that the variances are equal. Thus, the assumption of homogeneity of variances for and that data is normally distributed were satisfied. Having satisfied the assumption of homogeneity therefore, the researcher proceeded to test the hypotheses with the independent sample t-test (pooled variance).

4.1 Hypotheses Testing

Null hypotheses (H_0): There is no significant difference between the achievement of students who were taught when practical is integrated with theory in chemistry lessons with the achievement of students where theory and practical were taught separately.

Alternate Hypotheses (H_1): There is a significant difference between the achievement of students taught when practical is integrated with theory in chemistry lessons with the achievement of students where theory and practical were taught separately.

Table 3: Mean Scores and Standard Deviation (SD) of Students in the Posttest

Group	N	$\bar{x}$	Std dev	P
Control posttest	26	18.115385	2.643133	0.000013
Experimental posttest	24	21.75	2.64164	

Data presented in table 3 shows that students in the experimental group (mean score of 21.75) performed better in the post-test as compared to the students in the control group (mean score of 18.115385). The P-value was found to be 0.000013 which is less than the alpha (0.05), therefore researcher rejected the null hypotheses (H_0). In other words, the findings of this study showed that students taught with practical, and theory integrated performed better in the posttest than those taught with theory and practical separated assuming pooled variance of the two groups before the intervention. The implication is that students who were taught with practical and theory combined in

one lesson mastered the strategies of answering stoichiometry questions better than those taught using the conventional method where theory and practical work were separated.

4.2 Descriptive Statistics

To determine the effect of integrating practical work into teaching on the achievement of students and to compare the achievement of students taught with theory and practical integrated in one lesson and those taught theory first then practical later, the researcher managed to answer the objectives of the study. The pre-test scores of students' mean and standard deviation and post-test for both experimental and control groups were presented. As shown in table 4, before intervention the pre-test mean score for the control group was 15.03846 while the pre-test mean score of the experimental group was 15.00. The pre-test means in both groups were relatively the same. As highlighted by Argaw, Haile, Ayalew and Kuma (2017) this enabled the researcher to infer the effect of the treatment (integrating practical work with theory) after the intervention. A higher mean score on the post-test from the experimental group than the control group can then be attributed to the treatment, on the basis that confounding variables would have been controlled. From the data presented in table 4, the mean gain for the experimental group (6.75) was greater than the mean gain for the control group (3.076925). The conclusion based on the mean gain is that integrating practical work is more effective when compared to the conventional method.

Table 4: Summary of Mean Scores of Students in Pretest and Posttest.

Group	N	Pretest $\bar{x}$	Posttest $\bar{x}$	Mean gain
Control	26	15.03846	18.115385	3.076925
Experimental	24	15.00	21.75	6.75

5. Discussion

The study investigated and compared the effects of two instructional methods namely: integrating practical work with theory in the chemistry classroom and the conventional method where practical and theory are taught separately on the achievement of Advanced level chemistry students in Gweru district. The results from the pre-test scores proved that the two groups under investigation were homogeneous in relation to their performance in the stoichiometry test. The participants were then subjected to a post-test at the end of the three-week treatment programme to see if there was a change in their performance. Data collected from the study was analysed using the two samples t-test. The findings of the study revealed a better and improved performance for participants in the experimental group in comparison to those in the control group. The results of the study revealed that there was a statistically significant difference ($p < 0.05$) in the mean scores of students exposed to the two different methods of instruction. Out of the two teaching methods, inferential statistics indicated that students taught with practical, and theory integrated produced a higher achievement than students taught practical and theory in different lessons.

6. Conclusion

In this study, the researcher developed a model teaching strategy and established its effect on students' achievement in Gweru district in the Midlands province of Zimbabwe. The researcher is familiar with the setting having been an Advanced level chemistry teacher in the province for more than a decade, therefore is aware of the way of teaching in the setting under study. The study gathered evidence indicating that integrating practical work with theory lessons has a greater effect on students' performance than teaching practical work separately from theory. Based on these findings, the researcher concluded that instructional strategies that teachers employ in teaching have

a significant effect on students' performance.

7. Recommendations

Based on the study findings, the following recommendations were made: Practical work should not be taught as a separate entity from theory but instead as an integral part of teaching and learning of chemistry. Students must be challenged by teachers to design and carry out practical work under their watch. Teachers must carry out adequate practical lessons involving scientific reports written by students. Students must be made to present or communicate findings during lessons. It is evident from the results of the study that integrating practical work with theory when teaching chemistry is an effective teaching method which has the potential to improve students' achievement in the subject. Therefore, the researcher strongly recommends chemistry teachers to use this instructional method in their lessons. Furthermore, in-service training through symposiums and workshops should be organized and made compulsory for practicing chemistry teachers so that they can embrace the skills of teaching for life and not just for examinations.

8. Suggestions For Future Research

The current study focused on only one topic from the ZIMSEC Advanced level chemistry syllabus and was restricted only to Advanced level chemistry learners. As such the impact or effect that the intervention had in this topic is also assumed to be appropriate to other levels and topics. The researcher recommends that in future other studies could focus on one topic each from the three sections of the syllabus namely: physical, inorganic and organic chemistry. Since the study could only use intact classes that have been assigned by the schools and not by the researcher, the future researchers can randomly assign students in one school, with the permission of the school administration to the control and experimental groups.

References

- Adesoji, F.A., Omilani, N.A. & Dada, S.O. (2017). A Comparison of Perceived and Actual Students' Learning Difficulties in Physical Chemistry, *International Journal of Brain, and Cognitive Sciences*, 6 (1), 1-8. <https://doi.org/10.5923/j.ijbcs.20170601.01>
- Adeyemo S. A. (2001). Imagery in Thinking and Problem Solving. *Perceptual and Motor Skills*, 92(2), 395-398. <https://doi.org/10.2466/pms.2001.92.2.395>
- Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, S. G. (2017). The Effect of Problem Based Learning (PBL) Instruction on Students' Motivation and Problem-Solving Skills of Physics. *EURASIA Journal of Mathematics, Science and Technology Education*, 13(3), 857-871. <https://doi.org/10.12973/eurasia.2017.00647a>
- Arzi, H. J., & White, R. T. (2005). Longitudinal Studies: Designs, Validity, Practicality, and Value. *Research in Science Education*, 35(1), 137-149. <https://doi.org/10.1007/s11165-004-3437-y>
- Bano, H., Khan, M.S., & Khan, S.I. (2021). Development of Valid and Reliable Mathematics Achievement Test. *Elementary Education Online*, 20(2), 1642-1658.
- Baraya, G. A., Abdulrahman, S. R., & Yusuf, S. (2019). Comparative Analysis of Students' Academic Achievement in Quantitative, Qualitative and Theory of Practical Chemistry in Senior Secondary Schools: A Pre-requisite to Quality University Education, in *Kastina State Metropolis*, 5(1), 79-84.
- Bennett, M.J. (2013). *Basic Concepts of Intercultural Communication*. 2nd Edition, Intercultural Press, Boston.
- Booi, K. (2023). Physical Science Educators' Teaching Approaches for Facilitating Conceptual
- Brown, J. D. (2002). The Cronbach Alpha Reliability Estimate. Shiken: JALT Testing & Evaluation, 6(1), 17-18. <https://hosted.jalt.org/test/PDF/Brown13.pdf>
- Cook, T. D. (2003). Why have educational evaluators chosen not to do randomized experiments? *The ANNALS of the American Academy of Political and Social Science*, 589(1), 114-149.
- Dhlamini, J.J. (2012). Investigating the Effect of Context-based Problem-Solving Instruction on the Performance of Learners. Unpublished Doctoral Dissertation. University of South Africa, Pretoria, South Africa. <http://hdl.handle.net/10500/9739>

- Downing, S. M. (2004). Reliability: On the Reproducibility of Assessment data. *Medical Education*, 38(9), 1006-1012. <https://doi.org/10.1111/j.1365-2929.2004.01932.x>
- Ekpo, J.U. (1999). Status of secondary school science practical work in Akwa Ibom state, Nigeria. *AJEIMA*, 2(1), 12-29.
- Etokeren, I., Ibemenji, K.G., & Alamina, J. (2019). Effect of Problem-solving Teaching Technique on Students' Stoichiometry Academic Performance in Senior Secondary School Chemistry in Nigeria. *Asian Journal of Advanced Research and Reports*, 4(3), 1-11. <http://dx.doi.org/10.9734/ajarr/2019/v4i330110>
- Fatade, A.O., Mogari, D., & Arigbabu, A.A. (2013). Effect of Problem-Based Learning on Senior Secondary School Students' Achievements in Further Mathematics. *Acta Didactica Napocensia*, 6(3), 27-44.
- Gegios, T., Salta, K., & Koinis, S. (2017). Investigating high-school chemical kinetics: the Greek chemistry textbook and students' difficulties. *Chemistry Education Research and Practice*, 18(1), 151-168. <https://doi.org/10.1039/C6RP00192K>
- Gongden, E. J. (2016). The Effects of Analogy on Male and Female Chemistry Students'. Problem-Solving Ability in Electrolysis. *International Journal of Scientific Research in Education*, 9(1), 1-6. [https://ijsre.com.ng/asets/vol.,-9\(1\)-ephraim-joel-gongden.pdf](https://ijsre.com.ng/asets/vol.,-9(1)-ephraim-joel-gongden.pdf)
- Izunwanne, U.R., Ahuchaogu, A., & Amanze, K.O. (2017). Tertiary Institution Students' Perception of Difficult Topics in Organic Chemistry Curriculum in Imo State. *American Association for Science and Technology*, 3(2), 9-15. <http://www.aascit.org/journal/education>
- Jackson, S. L. (2012). *Research methods and statistics: A critical thinking approach*. (4th Edition). Wardsworth, USA: Linda Shreiber-Ganste.
- Johnson, B., & Christenson, L. (2012). *Quantitative, Qualitative, and Mixed Approaches*. (4th Edition.). University of South Alabama: SAGE Publications, Inc.
- Kazembe, T. C., & Musarandega, A. (2012). Student Performance in A-level Chemistry Examinations in Makoni District, Zimbabwe. *Eurasian Journal of Physics and Chemistry Education*, 4(1), 2-29. <https://doi.org/10.12973/ejpce.2009.00048a>
- Mandina, S., & Ochonogor, C. (2018). Comparative Effect of Two Problem-solving Instructional Strategies on Students' Achievement in Stoichiometry. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(12), em1621. <https://doi.org/10.29333/ejmste/95125>
- Mcleod, S., & Guy-Evans, O. (2023). *Random Assignment in Psychology: Definition & Examples*. Psychology Research Methodology. Ministry of Primary and Secondary Education, Curriculum Framework for Primary and Secondary Education, Zimbabwe, (2015-2022).
- Narad, A., & Abdullah, B. (2016). Academic Performance of Senior Secondary School Students: Influence of Parental Encouragement and School Environment. *Rupkatha Journal on Interdisciplinary Studies in Humanities*, 8(2), 12-19. <http://dx.doi.org/10.21659/rupkatha.v8n2.02>
- Okafor, P. N. (2000). Laboratory Resources and Utilization as Correlates of Chemistry Students' Learning outcomes. *41st Annual Conference Proceedings of STAN*, 169 -173.
- Opara, M. (2014). Improving Students' Performance in Stoichiometry through the Implementation of Collaborative Learning. *Journal of Education and Vocational Research*, 5(3), 85-93. <http://dx.doi.org/10.22610/jevr.v5i3.156>
- Rono, K., Onderi, H., & Owino, J. (2014). Perceptions of causes of poor academic performance amongst selected secondary schools in Kericho Sub-County: Implications for school management. *Kenya Journal of Educational Planning, Economics & Management*, 7(2), 1-24.
- Taber, K.S. (2015). The role of practical work in teaching and learning chemistry. *The school science review*, 96, 75-83.
- Uchegbu, R. I., Oguoma, C. C., Elenwoke, U. E., & Ogbuagu, O. E. (2016). Perception of Difficult Topics in Chemistry Curriculum by Senior Secondary School (II) Students in Imo State. *AASCIT Journal of Education*, 2(3), 18-23. <http://article.aascit.org/file/pdf/9730743.pdf>
- Understanding of Stoichiometry. In *Proceedings of the 15th International Conference on Education and New Learning Technologies* (pp. 902-905). <https://doi.org/10.21125/edulearn.2023.0332>
- W.A.E.C (2003). Chief Examiner 's report for 2002. *May/June Senior School Certificate Examinations*. Lagos: West African Examinations Council.
- Zimbabwe Schools Examinations Council (2013). *Chief examiner's report*. Harare: ZIMSEC.