

**IFE JOURNAL OF THEORY AND  
RESEARCH IN EDUCATION**

ISSN: 0794-6754

**IJOTRE**

**Journal of the Institute of Education  
Obafemi Awolowo University,  
Ile – Ife.**

**Bi-Annual  
Vol. 25, No. 2, 2024**

**CALL FOR PAPERS**  
**IFE JOURNAL OF THEORY AND RESEARCH IN EDUCATION**  
**(IJOTRE)**

**NOTE TO CONTRIBUTOR**

The Institute of Education Journal of Theory and Research in Education (IJOTRE) disseminates information derived from research findings and theoretical topics in the areas of Nursery, Primary, Secondary and Higher Education for practitioners, educators, educationist, academia, researchers, curriculum planners and policy - makers with the main goal of improving educational status. IJOTRE is a annual and peer - reviewed Journal.

**Articles are expected to focus on any of the following topics:**

1. Contribution on theoretical, methodological and practical teaching aspects of education.
2. Research notes and project reports
3. Articles representing scholarly opinions on contemporary issues and trends stemming from any aspects of education.
4. Book reviews that are significant in the field of education.

**Guidelines for Papers Submission**

- \* Articles should not be longer than 15 A4 - sized pages using Times New Roman, font size of 12. Longer articles will attract additional publication fee.
- \* Reference style should conform to the America Psychological Association format (6th Edition). This should be arranged in alphabetical order according to the surname of the authors.
- \* Footnotes are not allowed.
- \* Manuscripts' cover should include the title of the paper, author(s) name(s), institution affiliation and E-mail address.
- \* Abstract should not be more than 250 words.
- \* Two hard copies of the manuscripts should be submitted for review. Articles can also be submitted by post to The Managing Editor, IJOTRE, Institute of Education, Obafemi Awolowo University, Ile-Ife. Nigeria or electronically via e-mail to [iedijotre@2022](mailto:iedijotre@2022).
- \* Assessment fee of ₦5,000 shall be paid before any paper shall be reviewed.
- \* Publication fee of ₦40,000 (\$50), is a condition for publication that a manuscript submitted to Ife Journal of Theory and Research in Education (IJOTRE) has not been published and will not be simultaneously submitted or published elsewhere. All fees must be paid into the Institute Books and Journals, Account Number 1013534137 Zenith Bank

Submissions are published at the editor's exclusive discretion. Submission that do not conform to these guidelines may not be considered for publication.

Bi-Annual

IJOTRE, Vol. 25 No. 1, 2024

iv

### **EDITORIAL BOARD**

Prof. H. O. Ajayi	(Editor – in – Chief)
Prof. P. O. Jegede	Member
Prof. C. O. Odejobi	Member
Prof. T. O. Bello	Member
Prof. O. E. Ojedokun	Member
Prof. B. A. Adeyemi	(Managing Editor)
Prof. O. S. Agboola	Member
Dr. O. O. Bakare	Secretary
Dr. Okewole	Member
Dr. S. O. Olajide	Member

### **EDITORIAL CONSULTANTS**

Prof. D. Adeyemo –	Dept of Local Government Studies, Obafemi Awolowo University, Ile – Ife.
Prof. O. O. Obilade –	Dept. of Adult Education and Life Long Learning, Obafemi Awolowo University, Ile – Ife
Prof. B. I. Popoola –	Dept. Of Educational Foundations and Counselling, Obafemi Awolowo University, Ile – Ife.
Prof. B. A. Omoteso -	Dept. of Educational Foundations and Counselling, Obafemi Awolowo University, Ile – Ife.
Prof. M. A. Adeleke -	Dept. of Science and Technology Education, Obafemi Awolowo University, Ile – Ife.
Prof. O. A. Sofowora -	Dept. of Educational Technology and Library Studies, Obafemi Awolowo University, Ile – Ife
Prof. A. T. Akande-	Dept. of English, Obafemi Awolowo University, Ile – Ife
Prof. E. T. O. Babalola -	Dept. of English, Obafemi Awolowo University, Ile – Ife.
Prof. M. A. Ajayi -	Dept. of Human Kinetics and Health Education, University of Ibadan, Ibadan.
Prof. J. B. Bilesanmi-	Dept. of Curriculum Studies and Instruction Technology, Olabisi Onabanjo University, Ago-Iwoye, Ogun State.
Prof. J. A. Adegbile -	Institute of Education, University of Ibadan.
Prof. E. F. Bamidele -	Dept. of Science and Technology Education, Obafemi Awolowo University, Ile-Ife.
Prof. A. A. Adediwura -	Dept. of Educational Foundations and Counselling, Obafemi Awolowo University, Ile-Ife.
Pro. O. A. Ogunfowokan-	Dept. of Chemistry, Obafemi Awolowo University, Ile-Ife.
Prof. A. Akinlua -	Dept. of Chemistry, Obafemi Awolowo University, Ile-Ife.
Prof. O. I. Orimoogunje -	Dept. of Geography, Obafemi Awolowo University, Ile-Ife.
Prof. O. A. Ajala -	Dept. of Geography, Obafemi Awolowo University, Ile-Ife.
Prof. T. O. Akinbobola -	Dept. of Economics, Obafemi Awolowo University, Ile-Ife.
Prof. M. A. Fatiregun -	Dept. of Kinetic and Human Recreation, Obafemi Awolowo University, Ile-Ife.

Bi-Annual

IJOTRE, Vol. 25 No. 1, 2024

## EFFECTS OF DIMENSIONAL ANALYSIS AND ADVANCE ORGANISER ON STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMICAL STOICHIOMETRY

**ADEOYE, Ikeoluwa Folasade Ph.D**

Faculty of Science Education

Department of Biology and Integrated Science Education

Emmanuel Alayande University of Education, Oyo,

Oyo State, Nigeria.

Email: [ikeoluboye@yahoo.com](mailto:ikeoluboye@yahoo.com), [adeoyeif@eauedoyo.edu.ng](mailto:adeoyeif@eauedoyo.edu.ng)

Mobile: + 2348038235302

### **Abstract**

*The study examined the effects of Advance Organiser and Dimensional Analysis on the Senior Secondary School Form Two (SS2) Chemistry students in stoichiometry. The pre-test-post-test experimental research design was used to investigate the effect of the treatment on the students' achievement in stoichiometric concepts. Six public schools were randomly selected. The schools were randomly assigned to three groups of Conventional Lecture, Advance Organiser and Dimensional Analysis treatment groups. The responses of one hundred and seventeen students who participated in the treatment and wrote pre-test-post-test stoichiometric tests were analysed for the study. There were two validated instruments; the treatment packages and the stoichiometric test. The treatment packages and stoichiometric test were pilot-tested in a school that was not part of the sampled schools for the study. The instruments were positively correlated with stoichiometric test correlation coefficient value of 0.76 using Pearson Product Moment. The inter-rater reliability of the instructional packages using Scout  $n$  values for Conventional Lecture, Advance Organiser, Dimensional Analysis were 0.72, 0.74 and 0.75, respectively. The results of analysis of the treatment using Analysis of Covariance (ANCOVA) indicate significant difference in the achievement of the students by treatment. The results of pairwise comparisons among the teaching methods show that the Advance Organiser and Dimensional Analysis are more effective in enhancing the achievement of stoichiometry than the Conventional Lecture method. However no significant difference between Advance Organiser and Dimensional Analysis on the students' achievement. The implication of the finding is that Advance Organiser and Dimensional Analysis promote students' knowledge of stoichiometry. The study recommends the methods for teaching of Chemistry concepts that are mathematical oriented.*

**Keywords:** Stoichiometry, Dimensional analysis, problem-solving, achievement, Advance Organiser, Conventional Lecture.

## **Introduction**

Stoichiometry in Chemistry involves mass, mole and volume relationships in chemical reactions. It deals with qualitative and quantitative determination of compositions in chemical reactions. The qualitative aspect is the conceptual knowledge of stoichiometry which involves recall and comprehension of concepts while the quantitative aspect involves calculations of chemical compositions of mass in gram, mass in mole, molar mass, percentage and molar volume (gas) in chemical reactions. It is the method by which quantitative comparison is made between reactants and products in chemical reaction. Skills of application, analysis and synthesising (Bloom 1969) are needed for solving quantitative problems in stoichiometry. The conceptual knowledge of stoichiometric is necessary to meaningfully solve the quantitative problems. This fact was established in Adeoye (2012) that conceptual knowledge promoted students' computational knowledge in Chemistry.

Stoichiometry is one of the difficult concepts in Chemistry that both the students and teachers have challenge in its learning and teaching (Bridges, 2015 and Shadack and Enunuwe, 2018). Kimberlin and Yeziarski (2016) and Shadack and Enunuwe (2018) had identified major areas of difficulties in chemical stoichiometry as understanding of mole concept, inability to balance chemical equation, determination of theoretical yields, identification of substance in excess, the use of inconsistent stoichiometric relationship and identifying the limiting factor in chemical reactions. Adeoye (2023) found that Chemistry students had difficulties in applying thermodynamic concepts in determination of heat change in chemical reactions.

Researchers have tried to alleviate most of the identifiable learning difficulties in Chemistry using various teaching methods. Mohafa, Qhobela and George (2022) evaluated the effect of interactive stimulation and found that the students taught with interactive stimulation had a higher mean score for retention in stoichiometry than the students in the control group taught using conventional method. The study also established significant difference between the groups. Kimberlin and Yeziarski (2016) engaged the students using inquiry-based lessons and Mamombe, Mathabathe and Gaigher (2022) with Process-Oriented Guided Inquiry Learning (POGIL), found that inquiry-based lessons were effective in building accurate stoichiometric concepts and the POGIL improved physical sciences learners' competency in solving stoichiometry problems. Gulacar, Mann, Man and Vernoy (2022) determined the influence of the problem construction on undergraduates' success with stoichiometry problems. The study found that the students who practiced the problem-construction method outperformed their counterparts in the control group who followed a traditional approach in the lessons of stoichiometry. The teaching methods were found to improve students' stoichiometry problem solving skill and conceptual understanding.

Ausubel (1960) proposed the using of advance organisers for meaningful learning. To Ausubel, advance organiser is any learning material that is previously given to students, that is related to the new learning materials that students are about to learn. Advance organiser serves as an anchor in the learner's cognition to meaningfully organise, store and establish connections between the prior knowledge and the new learning materials. Ausubel, was of the opinion that, advance organiser would promote meaningful learning and boost students' achievement and retention.

Ojobola and Ogunjobi (2021) found that Advancer Organiser in teaching improved senior secondary school performance and retentive memory which led to the students' substantial gain in the learning outcomes. Sabitu, Ayodeji and Olarewaju (2022) examined the use of incorporating advance organisers in teaching redox reactions at the secondary school level. The study showed that the method incorporated with Advance Organisers significantly affect the learning of redox reactions. The students in the experimental group achieved higher than the peers in the control group.

Lausin and Kijai (2020) investigated the effect of using particulate diagrams on high school students' conceptual understanding of stoichiometry in Thailand. The study indicated that the systematic use of particulate diagrams in the instruction of stoichiometry a significant positive effect on the students' conceptual understanding of stoichiometry and the students in the group had favourable attitude towards the chemistry topic. Vula and Berisha (2022) examined the effect of algebraic manipulations and analogical transformations to teaching problem-solving of contextual chemistry problems. The findings showed the students in the experimental group had better results in solving problems in Mathematics for Chemistry compared to the counterparts who did not receive the instruction. The effect of the method was more significant on students' chemistry achievement than in mathematics. Furthermore, Opara and Lami (2020) evaluated the effect of graphic organisers on students' achievement in Physics and Chemistry. The result showed that the students taught using graphic organisers had significant higher achievement in Physics and Chemistry than those taught with conventional method.

Dimensional Analysis in this context is the study of relationships between physical quantities such mass, mole, volume and their units of measurement by adding or equating these quantities in the same terms in calculation in stoichiometry. This involves conversions of mass to mass, mass to mole, mole to mass step conversion, and mole to mole in chemical reactions in solid states. In gas state reactions, the conversions are mole-volume or volume-mole, mass-volume or volume-mass and volume-volume. Probably, if Dimensional Analysis is systematically and effectively incorporated into teaching of stoichiometry would boost the understanding and problem-solving skill of Chemistry students in stoichiometry.

The research aims comparing the achievement of the Chemistry students in solving quantitative problems in chemical stoichiometry using dimensional analysis and advance organiser.

### **Purpose**

The purpose of this research was to determine the effects of Dimensional Analysis and Advance Organiser teaching strategies on the achievement of the Chemistry students in Chemical stoichiometry.

### **Hypothesis**

The null hypothesis raised for the study is:

There is no significant difference effect of Conventional Lecture, Advance Organiser and Dimensional Analysis methods on students' achievement in stoichiometric chemistry.

### **Methodology**

The research design for the study was quasi experimental of pre-test post-test experimental control design. The population for the study was Senior Secondary School Students in Form Two (SS2). A purposive sampling technique was used to select a Local Government in Oyo State, Nigeria, for effective research and easy monitoring by the researcher. Six public Senior Secondary Schools in the Local Government Area were randomly selected for the study. The Chemistry students in their intact classes, which constituted the samples for the study, were randomly selected for the research. The total number of Chemistry students in the randomly sampled schools was one hundred and thirty-eight (138) students. Some of the students who did not actively participate, who had no 90% treatment attendance and who did not participate in either pre-test or post-test were removed. Hence, the total number of sampled students for the study was one hundred and seventeen (117).

The sampled schools were designated as Advance Organiser, Dimensional Analysis and Conventional Lecture groups and the students in the schools were taught using the teaching methods. The students in all the treatment groups were taught the same stoichiometric concepts of balance of chemical equations, determinations of relative molar mass, percentage composition, mole, mass, atoms and volume relationships in chemical reactions.

The students in the control group were taught these stoichiometric concepts using the Conventional Lecture method. The students in Advance Organiser treatment group were first taught the mathematical concepts like addition, multiplication, percentage, proportionality, significant figures and standard form that as related to the stoichiometric concepts before the commencement of each lesson of the stoichiometric concepts. The Dimensional Analysis made use of the available data instead of formulae, relating the data to different units like in mole, mass, atoms and volume (reactions involve gas) from chemical reactions to solve stoichiometric problems with active participation of student's analysis of the data, and synthesis and applying the information to the solve problems. Both the Conventional Lecture and Advance Organiser treatment groups made use of chemical formulae: Amount,  $n$  (mole) = Mass,  $m$  (g) ÷ Molar mass,  $M$  ( $\text{gmol}^{-1}$ ); Avogadro constant,  $L = \text{Number of atoms, } N \div \text{Amount, } n$  (mole); Avogadro constant,

L = Molar volume,  $V = 22.4 \text{ dm}^3$  at s. t. p. in solving stoichiometric problems. In the three treatment groups, conceptual aspects of stoichiometry like what are mole, molar mass, molar volume and so on, were taught. The stoichiometric problems for the treatment and questions in the stoichiometric test were adapted from the Outline of Chemistry for Schools & Colleges and the Understanding Chemistry for Schools and Colleges authored by Ojiodu (2008), and Ojokuku (2017), respectively. The treatment of the students with the teaching methods was for four weeks and two weeks for pre-test and post-test administration of the stoichiometric test.

The instructional packages for treatment in the teaching methods and the stoichiometric quantitative test were validated by two veteran chemistry educators and one mathematics educator to determine their face, construct and content validities. The instructional packages were pilot tested in schools different from the sampled schools for the study. The reliability of the stoichiometric quantitative test was determined using pre-test and post-test method and the scores of the students were found to be positively correlated with high correlation coefficient value of 0.76 before used for the study. The inter-rater reliability that measure the internal consistency of the instructional packages were 0.72, 0.72 and 0.75 for Conventional Lecture, Advance Organiser and Dimensional Analysis using Scott's

## Results

**Table 1 Descriptive Statistics of the Students' Pre-Test Post-Test Scores in the Lecture, Advance Organiser and Dimensional Analysis**

Method	Mean	Mean Diff	N	Std. Dev.	Std. Dev. Mean
Conventional Lecture Pre-Test	8.9429	3.800	35	2.3632	.3995
Conventional Lecture Post-Test	12.7429		35	3.7128	.6276
Advance Organiser Pre-Test	9.6923	10.872	39	2.1662	.3469
Advance Organiser Post-Test	20.5641	12.907	39	3.8443	.6156
Dimensional Analysis Pre-Test	8.7674		43	3.4629	.5281
Dimensional Analysis Post-Test	21.6744		43	5.2767	.8047

The mean differences of the treatment show Dimensional Analysis > Advance Organiser > Conventioal Lecture.

**Table 2: ANCOVA Results of Pre-post of the Students Achievement in Stochiometric Chemistry by Treatment**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta
Corrected Model	2040.272	3	680.09	38.01	.000	.502
Intercept	1753.12	1	1753.12	97.98	.000	.464
Preachievement	246.638	1	246.64	13.78	.000	.109
Treatment	1776.679	2	888.34	49.65	.000	.468
Error	2021.848	113	17.89			
Total	45017.000	117				
Corrected Total	4062.120	116				

$R^2 = .502$ , Adjusted  $R^2 = .489$  Alpha = .05

The results of ANCOVA on Table 2 indicate that  $F_{(2, 116)} = 49.65$ ,  $p < .05$ ), show significant difference in the treatment by Conventional Lecture, Advance Organiser, Dimensional Analysis and methods.

**Table 3: Bonferroni's Post Hoc Pairwise Comparisonsof the treatment by Advance Organiser, Dimentional Analysis and Conventional lecture methods**

(I) Treatment group	J Treatment Group	Mean Difference (I-J)	Std Error	Sig
Conventional Group	Advance Organiser	-7.700	.989	.000
	Dimensional	-9.070	.964	.000
Advance Organiser	Conventional	7.700	.989	.000
	Dimensional	-1.371	.945	.449
Dimensional	Conventional	9.070	.964	.000
	Advance Organiser	1.371	.945	.449

The mean difference is significant at the .05

The results on Bonferroni's Pairwise Comparisons indicate significant differences among the treatment groups. There is significant difference between Conventional and Advance Organiser and Dimensional Analysis methods. there is significant difference between Advance Organiser and Conventional Lecture method but not with Dimensional Analysis method and there is significant difference between Dimensional Analysis and Coventional Lecture method but not with Advance Organiser. Hence both Dimensional Analysis and Advance Organiser are more effective in the teaching of stochiometric in chemistry than the Conventional Lecture method

### **Discussion of Findings**

The pre-test means scores of the students under the three methods of teaching in Table 1 show that students' knowledge of stoichiometry was inadequate. This is because the scores of the students before treatment with the teaching methods were below fifty percent of the total mark. The students in the three groups show improvement in their knowledge of stoichiometry after the treatment with the teaching methods. The students in Advance Organiser and Dimensional Analysis groups, achieved slightly above fifty percent while the students in the conventional method have their achievement below fifty percent. This indicates that the Advance Organiser and Dimensional Analysis are more effective in improving students' knowledge of stoichiometry than the Conventional Lecture method. The effectiveness of the Advance Organiser and Dimensional Analysis over Conventional Lecture was further tested using ANCOVA and Bonferroni post hoc pairwise comparisons. The results show the effectiveness of Advance Organiser and Dimensional Analysis as being effective in the teaching of stoichiometry than Conventional Lecture but Dimensional Analysis was not more effective than Advance Organiser.

The effectiveness of Dimensional Analysis over the Conventional Lecture method, on students' understanding of stoichiometry may be as a result of the processes involved in the teaching method. There were step-by-step of analysing the data, systematic synthesising of information from the provided data and application of the information to solve stoichiometric problems involved in Dimensional Analysis. In addition to these, the Dimensional Analysis relates concepts of stoichiometry with one another, without the use of chemical formulae in solve stoichiometric problems. This finding is in line with Vula and Berisha (2022) who reported that algebraic manipulations and analogical transformations improved Chemistry students' knowledge of problem-solving in contextual Chemistry problems.

The Advance Organiser being more effective on the students' understanding of stoichiometry than the conventional method may be that the mathematical orientation in Advance Organiser served as anchor to the learning of stoichiometric concepts and thereby result into meaningful learning of the concepts. The finding is in support with Ojobola and Ogunjobi (2022) that found Advance Organiser in promoting students' performance and retention in Chemistry.

### **Conclusion and Recommendation**

The findings of the study show that chemistry students have difficulty in learning stoichiometry. Probably, the abstract nature of the subjects and the phobia that most students have for subjects that are mathematically oriented, may be the reasons. There is the need to stimulate students' interest in the subject via effective teaching methods like dimensional analysis and advance organiser for mathematical oriented science subjects.

## Recommendations

The study recommends the use of Dimensional Analysis and mathematical Advance Organiser in alleviate students' learning difficulties in stoichiometry. The training and retraining of Chemistry teachers in Chemistry contents and knowledge of pedagogies would enhance the teachers content knowledge and teaching skills that would promote effective teaching and learning of Chemistry.

## References

- Adeoye, I. F. (2012). Secondary School Students' Conceptual and Computational Knowledge in Electrochemistry. *Oyo State Journal of Mathematics Association*. 3(2), 96-106.
- Adeoye, I. F. (2023). *Strengthening Students' Knowledge of Basic Thermodynamic Concepts using Structured Inquiry-based Instruction*. Paper Presented at 7<sup>th</sup> Canadian International Conference on Advances in Education, Teaching & Technology 2023 (EDU Teach, 2023). June 17, 2023 – Online Session.
- Ausubel, D. P. (1960). The use of Advance Organisers in the learning in the Learning and Retention of Meaningful Verbal Material. *Journal of Educational Psychology*. 51(5), 267-273.
- Bloom, B. S. (1969). *Taxonomy of Educational Objectives: The Classification of Educational Goals: Hand book 1, Cognitive Domain*. New York: Mckay.
- Bridges, C. (2015). Experiences teaching stoichiometry to students in grades 10 and 11 Doctoral Dissertation, Walden University, United States. <https://scholarworks.walden.edu/cgi/viewcontent.cgi?article=1290&context=dissertations>.
- Gulacar, O., Mann, H. K., Man, S. S. and Vernoy, B. J. (2022). The influence of Problem Construction on Undergraduates' Success with Stoichiometry Problems. *Educ. Sci.* 12 (12), 867. <https://doi.org/10.3390/educsc112120868>.
- Kimberlin, S. and Yeziarski, E. (2016). Effectiveness of Inquiry-based Lessons using Particulate Level Models to Develop High School Students' Understanding of Conceptual Stoichiometry. *The American Chemical Society and Division of Chemical Education, Inc.* 93(6), 1002-1009.
- Lausin, F. and Kijai, J. (2020). The Effects of Using Particulate Diagrams on High School Students' Conceptual Understanding of Stoichiometry. *Human Behavior, Development and Society*. 21(1), 68-77.
- Mamombe, C. Mathabathe, K. C. and Gaigher, E. (2022). From the Familiar to the Abstract: Exploring Grade II Learners' Development in Stoichiometry Problem Solving Competency with Exposure to POGIL. *African Journal of Research in Mathematics, Science and Technology Education*. 26 (2), 166-180.
- Mohafa, L. G., Qhobela, M. and George, M. (2022). Evaluating the Influence of Interactive Stimulations on Learners' Academic Performance in Stoichiometry. *South African Journal of Chemistry*. 76, 1-8.
- Ojiodu, C. C. (2008). *Outline Chemistry for Schools & Colleges*. Lagos: New Wave

- Publishers. Pp 387-412.
- Ojobola, F. B. and Ogunjobi, A. O. (2021). Effect of Advance Organiser on Performance and Retention of Senior School Students in Chemistry in Lagos State, Nigeria. *Euro Afro Studies International Journal (EASIJ.COM)*, 10 (3). DOI: [www.doi.org/10.5281/zenodo.5997029](http://www.doi.org/10.5281/zenodo.5997029).
- Ojokuku, G. O. (2017). *Understanding Chemistry for Schools and Colleges*. Second Revised Edition. PRESS-ON CHEMBOOKS. Pp 62 – 82.
- Opara, M. F. and Lami A. (2020). Graphic Organizer and Students' Achievement in Physics and Chemistry: Integrating Technology in Science Classroom. *Global Scientific Journals*. 8 (3), 247-259. <https://www.globalscientificjournals.com>
- Sabitu, A., Ayodeji, I. R. and Olarewaju, L. Y. (2022). Advance Organisers and Secondary School Students' Performance in Redox Reactions. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*. 7(10), e001754. <https://doi.org/10.47405/mjssh.v7i10.1754>.
- Shadreck, N. and Enunuwe, O.C. (2018). Recurrent difficulties: Stoichiometry Problem-solving. *African Journals of Educational Studies in Mathematics and Sciences*. 24, 25-31.
- Vula, E. and Berisha, F. (2022). Using Algebraic manipulations and Analogical Transformations to Problem-Solving of Contextual Chemistry Problems. *European Journal of Educational Research*. 11 (3), 1781-1796.