IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 6, Issue 5 Ver. II (Sep. - Oct. 2016), PP 36-41
www.iosrjournals.org

Problem-Based Learning and Students' Academic Achievement on Thermodynamics (A case study of University of Uyo, Akwa - Ibom state, Nigeria)

Rebecca U. Etiubon[1], Anthonia N. Ugwu[2]
[1]*Science Education Department, University of Uyo, Uyo. Akwa Ibom State*
[2]*Science Education Department, Michael Okpara University of Agriculture Umudike, Abia State*

Abstract: *This study was designed to determine the effect of problem based learning on the academic achievement of first year science education undergraduate students of University of Uyo, Akwa Ibom State, Nigeria on thermodynamics. The study adopted quasi experimental pretest posttest non randomized group control design. Two research questions and two hypotheses formulated guided the study. Using purposive sampling technique, all the 104 science education students in 2015/2016 academic session formed the sample size. The instrument used for data collection was Thermodynamic Achievement Test (TAT) developed by the researchers. This was validated by 4 lecturers in science education and test and measurement. Using kuder Richardson formular 21, the reliability of the instrument was .83. The research questions were answered using mean and standard deviation while the hypotheses were tested using t test. The findings of the study showed that students taught with problem based learning approach had higher mean achievement scores than their counterparts taught with expository approach. Results also showed that gender had no significant effect on the students' mean achievement scores when taught with problem based learning approach. One of the recommendations was that teachers should endeavour to employ activity based teaching methods like PBL approach in teaching science.*

Keywords: *Academic Achievement, expository, Problem-based learning (PBL) Approach and Thermodynamics*

I. Introduction

Science and its applications are part of daily activities that make life better and understandable and as such scientists and non-scientists alike need to be well grounded on the basic scientific knowledge and principles. Hence, the inclusion of the development of an individual's understanding of science and its applications as one of the objectives of science instruction [1]. Scientific knowledge is important in understanding some day to day activities of human beings and is strongly related to the active notion of teaching science [2]. Science is investigative in nature and practical oriented and therefore needs activity based teaching strategies that can bring its processes to clearer understanding to its learners.

The teaching and understanding of science and its concepts have become important now more than ever. Consequently, various teaching approaches have been employed by science teachers in this regard to make the teaching and learning more meaningful and effective. Conceptual understanding of science concepts requires the use of new strategies by teachers for better learning and teaching of science. These new strategies need to be defined, understood, experienced and adopted by the teachers of science. Exploring the use of new strategies improves teaching pedagogy.

Chemistry is one of the science subjects that the knowledge is applied in most human endeavours. Chemistry as an essential tool for survival in exciting world globalization needs to be taught using innovative activity-based teaching methods and approaches that can enhance optimum performance and interest [3]. Chemistry is made up of topics which require complex mental processes that involve visualizing, manipulating, analyzing, abstracting and associating ideas [4]. The study of chemistry helps the learners acquire and learn skills that enable them draw intelligent conclusions from careful observations particularly on concepts like thermodynamics that is considered difficult by many students.

Thermodynamics is one of the chemistry topics that is found difficult to both teachers and students of chemistry due to its abstract nature. It also deals with the dynamics and behaviour of energy and its manifestations [5]. Thermodynamics should be an exciting topic to teach if teachers know what to teach and how to teach it. Thermodynamics is not the study of heat and work alone. It involves other variables related to temperature.

Most studies focus on impediments on most chemistry concepts considered abstract especially thermodynamics. Thermodynamics is a subject that involves multivariable problems and obvious difficulties that make the concept very abstract to the students as pointed out by [6]. For instance, students find topics like temperature, energy transfer during physical changes, heat of combustion, laws governing thermodynamics and

calculations involving problem-solving as it relates to heat capacities and bond energies of solution difficult to understand. The researchers are of the opinion that the use of Problem based learning (PBL) approach will reduce such difficulties to the barest minimum. Basic concepts such as increase in temperature can be demonstrated to learners using thermometer in a boiling liquid; increase in pressure by inflating a balloon bit by bit, increase in volume by filling a container with any liquid bit by bit and understood using other teaching approaches but may be better understood using PBL approach. Also different types of thermodynamic systems - an open system, closed system, and an isolated system and the activities therefore can be better understood using PBL approach. The same idea should be applied to concepts like exothermic and endothermic reactions that tries to demonstrate how heat is given out to the surroundings and how heat is absorbed by the surroundings. By these means, students gain indepth understanding of thermodynamics and are able to build connections between abstract and concrete experiences.

Science education students at the introductory level in higher institutions of learning often have difficulty in understanding thermodynamic concepts possibly because of the strategies employed in teaching it. It has been reported that one of the most effective approaches in addressing these difficulties is to understand chemistry concepts through Problem-Based Learning which is a scientifically accurate model [7].

II. Problem-Based Strategy and Students' Learning

Problem-Based Learning (PBL) is a natural way of learning that uses problem to motivate, focus and initiate students' learning. It is an approach that enables students to become active participants in solving problems and answering questions [8]. Problem-based learning is a teaching strategy where students are confronted with problems that require critical thinking and analysis of ill structured problems through development of hypotheses and analysis of data linking the new knowledge into their thinking and decision making. It is one of the innovative teaching strategies that can help students understand difficult concepts. PBL according to [8] is a student-centred teaching approach that enables students to become active participants in solving problems, answering questions and doing more to explore knowledge. It helps students to become familiar with a scientific reasoning process that facilitates critical thinking as it provides answers to fill gaps in students' knowledge. According to [9, 10] PBL approach encourages students to think about the way they do things. [11, 12] opined that PBL increases higher – level thinking skills of students by requiring them to think about a problem critically and analyse data to find solutions; on the other hand, problem stimulates students to carry out investigations to satisfy their needs to know, then link the new knowledge into their thinking and decision making processes.

PBL contributes to students' learning of specific ideas and skills used for simplifying abstract concepts such as thermodynamics by providing multiple ways for creating a classroom climate where all students are involved in problem-solving. This approach places greater emphasis on procedures that engage the mind, psychology and creativity of the students as they are directly involved in exploring the situation being probed through inquiry method [13, 14]. According to [15] students working with ill structured problems are more likely to develop a significant body of content knowledge, regulate their own thinking, and make meaningful use of it when necessary using PBL. [16] also posited that PBL enables students to develop active learning, problem solving skills and field knowledge based on understanding. This makes learners take responsibility for their learning and become independent learners who can continue to learn in their own lifetime. PBL as an instructional strategy may have a deepening effect and good quality content on its learners in addressing aspects considered difficult in the teaching of thermodynamics.

III. Expository Teaching Strategy and Students' Learning

Expository teaching method focuses on transmission of knowledge from the expert teacher to the novice [17]. This type of teaching strategy assumes that a teacher guides the students and offers them new information. This strategy is rather passive than active as it merely transfers information from the teacher to the students. This strategy does not give room for pedagogical skills that enhance effective learning of science. In this method, the teacher cannot facilitate the integration of life experiences and positive values into the teaching. Students listen and watch and most part of the teaching time is spent talking without obvious interaction with the students. In chemistry instruction, this method has failed to impart deep conceptual understanding of the contents [18]. [19] opined that expository teaching strategy gives little or no room for exchange of ideas and resources which are relevant to achieving lesson objectives and as such are rarely used to make information and ideas clear to students. Although teaching strategies are known to have great impact on the students' academic achievement, the influence of some other factors like gender on students' academic achievement cannot be ruled out.

IV. Gender and Students' Academic Achievement

The findings of some researches on the influence of gender on students' academic achievement remains inconclusive. [20] opined that male students show high academic performance when they are engaged in learning activities involving practicals and calculations than their female counterparts. [19] also found that there is male superiority in cognitive achievements in chemistry while [21] found that female students find it difficult to plot graphs and carry out problems involving calculations. He opined that this might be as a result of the abstract nature of some chemistry concepts. [22] found that there is no significant difference between male and female students' academic performance and retention in chemistry. [22] also submitted that in modern science curriculum programme, male and female students need to be encouraged to learn not only through eyes or ears, but should be able to use their hands-on and heads-on senses as it is the case with problem-based learning strategy. It is against this backdrop that this study did not only stop at determining the effect of problem-based learning strategy on chemistry students' academic performance on the concept of thermodynamics but went further to include that of gender as well.

V. Statement of the Problem

Science students at the introductory level often find it difficult to understand some science concepts. One of these concepts is thermodynamics. Thermodynamics is a concept in both chemistry and physics that is found difficult to both teachers and students alike due to its abstract nature. Consequently chemistry students' performance specifically on the concept in examinations has been persistently poor. This has lowered students' interest and knowledge acquisition on the concept. For conceptual understanding of thermodynamics, the researchers are of the opinion that teachers need to try the use of some innovative teaching strategies like problem based learning, process based approach and other activity based approaches to see how they can help the students understand the concept better. It is against this background that the researchers want to determine the effect of PBL on students' academic performance on thermodynamics in chemistry.

5.1 Purpose of the study

The objective of the study is to determine the effect of using PBL approach on students' academic achievement in chemistry on the concept of thermodynamics. The following research questions guided the study

5.2. Research Questions

1. What is the mean achievement scores of chemistry students taught the concept of thermodynamics with PBL approach and those taught with expository approach?
2. What is the mean achievement scores of male and female chemistry students taught the concept of thermodynamics using PBL approach?

5.3 Research Hypotheses

1. There is no significant difference between the mean achievement scores of chemistry students taught the concept of thermodynamics using PBL approach and those taught using expository approach.
2. There is no significant difference between the mean achievement scores of male and female chemistry students taught the concept of thermodynamics using PBL approach.

5.4 Research Method

The study adopted a quasi-experimental pretest posttest non randomized control group design as intact classes were used. Two research questions and two hypotheses guided the study. All the first year undergraduate students of science education Department of the University of Uyo in 2015/2016 academic session formed the population of the study. Using purposive sampling technique, all the one hundred and four (104) chemistry students of the Department formed the sample size for the study. Thermodynamics Achievement Test (TAT) was the instrument used to collect data for the study. This was developed by the researchers using test blue print. TAT consisted of twenty multiple-choice test items. Each question had 5- options with 5-point score for each correct answer. Hence, 100 was the maximum score and the zero (0) for each incorrect answer. Treatment lasted for 3 weeks. Instrument validation was done by two lecturers of Science Education Department, University of Uyo and two measurement and evaluation experts from the same department. The instrument was developed from the curriculum content on the concept of thermodynamics with test blue print. The instrument was subjected to Kuder-Richardson 21 formulae for reliability and a reliability coefficient of .83 was obtained. Data collected from both experimental and control groups were analyzed using mean and standard deviation to answer the research questions while t test was used in testing the hypotheses formulated at .05 level of significance.

5.5 Results

The results of the study are presented below

Research Question 1

What is the mean achievement scores of chemistry students taught the concept of thermodynamics with PBL approach and those taught with expository approach?

Table 1: Mean achievement scores of students taught thermodynamics using Problem based learning and those taught using expository strategy.

Group	N	$\bar{x}$	SD
Problem-based learning	52	64.62	9.54
Expository strategy	52	57.02	11.93

Data in table 1 showed that mean achievement score of students taught with problem-based learning is 64.62 while those taught with expository strategy is 57.02. This implies that students taught using PBL strategy performed better than those taught using expository strategy. In order to ascertain whether the difference is significant or not, the data were further subjected to t test.

Hypothesis 1: There is no significant difference between the mean achievement scores of chemistry students taught the concept of thermodynamics using PBL approach and those taught using expository approach.

Table 2: t test analysis between the mean achievement scores of students taught using Problem based learning and those taught using expository strategy

Group	N	$\bar{x}$	SD	Df	t-cal	t-crit	Decision at P< .05
Pbl	52	64.62	9.54				
				102	3.58	1.96	Significant
Expo	52	57.02	17.20				

Table 2 showed that at .05 level of significance, tcal (3.58) is greater than the tcrit 1.96. Therefore, the null hypothesis is rejected. Hence, a significant difference exist between the achievement of students taught with problem based learning and those taught with expository strategy.

Research Question 2: What is the mean achievement scores of male and female chemistry students taught the concept of thermodynamics using PBL approach?

Table 3: Mean achievement scores of male and female students taught thermodynamics using Problem based learning approach.

Group	N	$\bar{x}$	SD
Male	29	63.11	11.04
Female	23	59.07	11.46

Data in table 3 showed that mean achievement score of male students taught with problem-based learning is 63.11 while those of female students was 59. 07. This implies that there was no significant difference between male and female students' mean achievement score that were taught with PBL approach.

Hypothesis 2

There is no significant difference between the mean achievement scores of male and female chemistry students taught the concept of thermodynamics using PBL approach.

Table 4: t test analysis between the mean achievement scores of male and female students taught using Problem based learning.

Group	N	$\bar{x}$	SD	df	t-cal	t-crit	Decision at P< .05
Male	29	63.11	11.04				
				50	1.81	2.01	Not Significant
Female	23	59.07	11.46				

Table 4 showed that at .05 level of significance, t-cal (1.81) is greater than the t-crit 2.01. Therefore, the null hypothesis is accepted. Hence, no significant difference exist between male and female students taught using problem-based learning.

VI. Discussion of Findings

The finding of the study in Table 1 showed that students gained better understanding of thermodynamics concept using PBL than with expository teaching strategy considering the fact that they had high mean achievement score of 64.62 as against their counterpart with 57.02. This showed that PBL facilitated students' understanding of the concept of thermodynamics. This may be due to the highly-interactive stimulating way that questions were used to challenge students' critical thinking on assigned tasks.

This finding is in agreement with the findings of [9] who opined that PBL is a student-centred teaching approach that enable students to become active participants in solving problems, answering questions and doing much more to explore knowledge; [13] also posited that PBL enable students to develop active learning, problem-solving skills and field knowledge based on understanding. According to them, it makes learners take responsibility for their own learning and become independent learners who can continue to learn in their whole lifetime. This outstanding effect may be attributed to the submission of [11, 12] who revealed that students working with ill-structured problems are more likely to develop a significant body of content knowledge, regulate their own thinking, and make meaningful use of it when necessary. This may have been the case with the students taught thermodynamics with PBL strategy. There is a wide margin in knowledge acquisition between expository method of teaching and PBL method.

The finding is also in agreement with [15] and[16] who found out that PBL increases higher – level thinking skills of students by requiring them to think about a problem critically and analyse data to find solutions; on the other hand, problem stimulates students to carry out investigations to satisfy their needs to know, then link the new knowledge into their thinking and decision making processes.

Table 2 showed that male students taught using PBL did not achieve significantly higher than their female counterparts. This finding is in agreement with [22] who submitted that there is no significant difference between male and female in the level of creativity and academic achievement respectively when taught with PBL strategy if they are exposed to the same teaching methods and learning environments. If exposed to right learning environment and opportunities that stimulate knowledge, male and female students will achieve equally.

VII. Recommendations

Based on the findings of the study, the following recommendations were made;

1. Teachers should try and employ PBL approach in the teaching learning situations to enhance students understanding.
2. Chemistry teachers should encourage students to use questions critically to explore, brainstorm and widen their knowledge in science concepts especially difficult chemistry concepts.
3. Curriculum planners, examination agencies and government agencies responsible for designing and revising the curriculum should incorporate problem-based learning strategy in teaching chemistry.

7.2 Conclusion

Consequent upon the findings of this study, it can be concluded that the use of Problem-based learning approach in the teaching of thermodynamics engages students in critical thinking, facilitates problem-solving skills and helps them to perform better generally too. From the findings, students' achievement to a great extent rely on the strategy used by the teacher in teaching thermodynamics concepts particularly when exposed to practical questionings. Chemistry teachers should therefore, employ innovative and activity-based teaching strategies like problem-based learning to improve students' performance in difficult and abstract concepts like thermodynamics.

References

[1] T Adiguzel, Use of audio modification in science vocabulary assessment. *The Eurasia Journal of mathematics, science and technology Education**, 7(4), 2011, 215-225.***

[2] Kavsut, G. (2010). Investigation of Science and Technology textbook in terms of the factors that may lead to misconceptions. *Journal of Procedia Social and behavioural Sciences*, 2(2), 2010, 2088-2091.

[3] E. J. Obiekwe, C. B. Njelita, Teaching Gas Laws, Boyle's, Charles, General Gas Laws using Activity-Based Method and Step-by-Step Approach. 9(Katsina: *Science Teachers Association of Nigeria Chemistry panel Series, 2013) 16-21.*

[4] T. M. Udofia, Problem-Solving: An appropriate strategy for teaching calculations in electrochemistry, *in G. Ojokuku (Ed.),Handbook for Chemistry Teachers, 6(Kano: Science Teachers Association of Nigeria Chemistry Panel Series, 2010) 33-37.*

[5] M S Aziz, A. N. Md Zain, and M. A. B. Samsudin, The impact of PBL on undergraduate Physics students understanding of Thermodynamics. *International Journal of Academic Research in Economics and Management Sciences, 3(1),* 2014, *126-137.*

[6] G. M. Hobold, (2014). What are some interesting applications of thermodynamics in our daily lives? Retrieved online on 12 February 2016 from http//www.quora.com/what-are-some-interesting-applications-of-thermodynamics-in-our daily life?.

[7] S Rosier, L. Viennot, Students' reasoning in thermodynamics. *International Journal of Science Education, 13(2),* 1991, *159-170.*

[8] O O Azu, A. A. Osinubi, A survey of Problem-Based Learning and traditional methods of teaching anatomy to 200 Level Pharmacy students of the University of Lagos, Nigeria. *African Journal of Pharmacy and Pharmacology, 5(2), 2011, 219-224.*

[9] O Ates, A. Eryilmax, Effectiveness of hands-on and minds-on activities on students' achievement and attitudes towards Physics. *Asia -Pacific Forum on Science learning and teaching, 12(1), 2011, 1-22.*

[10] G Watson, Using Technology to promote success in Problem-Based learning courses. *The technology source*, 8(2), 2002, 361-369.
[11] C E. Hmelo-Silver, Problem-Based Learning: What and How do Students learn? *Educational Psychology Review*, 16(3), 2004, 235-266.
[12] G L. Khun, F B Reiser, Students constructing and defending evidence-based scientific explanations. *National American Research Centre for Science and Technology, Northwestern University, 2005.*
[13] N Shin, S MaGee (2003). www.rfwp.com/pages/wp-content/uploads/2011/06/engaged-educated-keynote.pdf.
[14] C. G. Malinowski, J. Johnson, Moment. *Eurasia Journal of Mathematics Science and Technology Education, 3(1),* 2001, *71 -78.*
[15] S Bayraktar, Turkish preserving primary school teachers' science teaching efficiency, belief and attitudes towards science.The effect of primary teacher education programme, *School Science Mathematics, 1(1),* 2011 *83- 92.*
[16] T. H. Adeniji, Class-Discussion and Activity-Based Approaches to Teaching Boyle's, Charles' and General Gas Laws. 9 (Katsina: *Science Teachers Association of Nigeria Chemistry Panel Series, 2013) 23-28.*
[17] K B Krynock, L Robb, Is problem based learning for your curriculum? *Illinois School Research and Development Journal, 3(3),* 1996, *21 – 24.*
[18] P R Gordon, A.M. Rogers, M. Comfort, N. Gavul, and B.P. Mcgee, A taste of problem-based learning increases achievement of urban minority middle-school students. *Educational Horizons 79, 2001, 171 – 175.*
[19] O Olaoye, E.O. Adu, Problem-based learning strategies and gender as determinants of grade 9 students' academic achievement in algebra. *International Journal of Education Science. 8 (3), 2015, 485 – 492.*
[20] A Goldstein, Intelligent Quotient test: Gender differences small; Intelligent Quotient large. *Journal of Biosocial sciences, 2(30),* 2009, *541-553.*
[21] B Moronfolla, Effects of resources on the academic achievement of secondary school students, *M. Ed Research Thesis, University of Ilorin*, Kwara State, 2012.
[22] E. O. Omosewo, Physics teachers' education and National Education reforms : *Proceedings of the 41st annual conference of Science Teachers Association, University of Lagos, Nigeria, 2012, 48-52.*
[23] Goldstein, A. (2009). Intelligent Quotient test: Gender differences small; Intelligent Quotient large. *Journal of Biosocial sciences, 2(30), 541-553.*
[24] Gordon, P. R., Rogers, A. M. Comfort, M., Gavul, N. & Mcgee, B. P. (2001). A taste of problem-based learning increases achievement of urban minority middle-school students. *Educational Horizons 79, 171 – 175.*
[25] Krynock, K. B. & Robb L. (1996). Is problem – based learning for your curriculum? *Illinois School Research and Development Journal, 33 21 – 24*
[26] Malinowski, C. G. & Johnson, J. (2001). Moment. *Eurasia Journal of Mathematics Science and Technology Education, 3(1), 71 - 78.*
[27] Moronfolla, B. (2012). Effects of resources on the academic achievement of secondary school students in Ilorin Local Government Area of Kwara State. *Unpublished M. Ed Research Thesis, University of Ilorin.*
[28] Olaoye,O. & Adu, E. O. (2015). Problem-based learning strategies and gender as determinants of grade 9 students' academic achievement in algebra. *International Journal of Education Science. 8 (3): 485 – 492.*
[29] Omosewo, E. O. (2012). Physics teachers' education and National Education reforms. *Proceedings of the 41st annual conference of Science Teachers Association, University of Lagos, Nigeria.*
[30] Shin & McGee (2003). www.rfwp.com/pages/wp-content/uploads/2011/06/engaged-educated-keynote.pdf.

Delete These References Below

[31] Azu, O.O., & Osinubi, A. A. (2011). A survey of Problem-Based Learning and traditional methods of teaching anatomy to 200 Level Pharmacy students of the University of Lagos, Nigeria. *African Journal of Pharmacy and Pharmacology, 5(2), 219-224.*
[32] Aziz, M. S. Md Zain, A. N. & Samsudin, M. A. B. (2014). The impact of PBL on undergraduate Physics students understanding of Thermodynamics. *International Journal of Academic Research in Economics and Management Sciences, 3(1), 126-137.*
[33] Bayraktar, S. (2011). Turkish preserving primary school teachers' science teaching efficiency, belief and attitudes towards science.The effect of primary teacher education programme, *School Science Mathematics, 1(1), 83- 92*