EFFECTS OF STUDENT TEAMS-ACHIEVEMENT DIVISIONS STRATEGY AND MATHEMATICS KNOWLEGDE ON LEARNING OUTCOMES IN CHEMICAL KINETICS

Dr. Francis A. ADESOJI

Dr. Tunde L. IBRAHEEM

Abstract

The study investigated effects of Student Teams-Achievement Divisions strategy and mathematics ability on senior secondary school chemistry students' learning outcome in chemical kinetics. A pretest, posttest control group quasi experimental design was adopted for the study. Data were collected from a sample of 300 students made up of 110 males and 190 females from six senior secondary schools in Epe division of Lagos State, Nigeria. Analysis of covariance (ANCOVA) was used to analyze the data with pre-test scores as covariates in order to adjust for the initial differences in the sample. Multiple classification analysis (MCA) was also used to examine the magnitude of the differences among the groups. The findings revealed that there were significant main effects of treatment on students achievement and attitude ($F=190.58$; $P <0.05$) and ($F=379.275$, $P<0.05$) respectively. Mathematics ability had significant main effects on achievement ($F=12.971$; $P <0.05$) and on attitude ($F=3.678$; $P <0.\ 05$). The interaction effects of treatment and mathematics ability was significant for achievement ($F=8.146$; $P <0.05$) and also for attitude ($F=7.578$; $P <0.05$). Based on the findings, it was recommended that mathematical background of students should be taken into consideration before allowing them to enrol for chemistry at the senior secondary level. Students with very low mathematical ability should not be allowed to enrol for chemistry. Students Teams-Achievement Divisions strategy should also be used to teach chemistry at this level.

Key Words: Effects of student teams, mathematics knowledge, chemicel kinetics

INTRODUCTION

Within the last two decades, much has been written on the difficulties pupils of varying age at the secondary school level are having in coping with certain chemistry concepts. Such studies have revealed among other things that inability to handle mathematics concepts needed to solve chemistry problems seems to be the most worrisome (Astudillo and Naiz, 1996;Huddle, 1996 and Schmidt, 2000).

Science education had emphasized the importance of mathematics in science teaching and learning (Iroegbu, (1997). Abdullahi (1982) said, concerning science and mathematics.

> *Although mathematics and science are taught as separate subjects in schools from instructional point of view, science activity in the classroom has mathematical implications as working mathematical problems has scientific imports* p. 30

There are certain mathematical abilities, which are tied to success in chemistry and these mathematical concepts are cognitive entry characteristics for success in chemistry. The ability to manipulate symbols and the ability to use and maneuver algebraic symbols is necessary for success in chemistry. Comprehending basic geometry is particularly important for chemistry achievement. The ability to process numerical data shows no relationship to chemistry achievement (Fisher, 1996). This means that students' Computational skills do not influence student achievement, but students must be able to use algebra to solve problems and understand simple geometrical relationships. Additionally, Chandran (1985) compared cognitive factors and chemistry achievement and found that greater formal reasoning ability was correlated with greater achievement.

There are wide varieties of factors influencing student's success in chemistry aside from mathematical ability. Students with the intellectual ability have a greater chance of succeeding in chemistry than those without intellectual ability. However, a student's understanding of the content can be divided into two separate categories: Conceptual understanding and algorithms understanding. Neither seems to be entirely responsible for low test achievement.

Success or failure in chemistry is therefore dependent on more factors than simply knowledge of the subject. However, it has been shown that comprehending basic geometry is important for success in chemistry, and a good score in high school algebra is an indication of success in chemistry (Spencer, 1996).This study is therefore interested in finding out the effects of mathematics ability of students on their achievement particularly in chemical kinetics, a concept in chemistry which secondary school students often find difficult to understand.

The teaching method employed by a teacher has been shown to reflect on students' understanding of the subject (Akinlaye, 1998). On this, Ajelabi (1998) was of the opinion that the teaching method adopted by the teacher in order to promote learning is of topmost importance. Hence, he concluded that there is the need to introduce, adopt, and adapt the latest instructional techniques that are capable of sustaining the interest of the learners. Cooperative learning techniques have been shown to enhance students' learning and social relations relative to traditional whole class methods of teaching (Okebukola, 1984; Ojo, 1989; Alebiosu, 1998; Fuyunyu, 1998; Esan, 1999; Adeyemi 2002; Omosehin, 2004; and Akinbode, 2006). The present study therefore adopted Students Teams-Achievement Divisions (STAD) cooperative learning strategy to teach the participants with a view to finding out its efficacy in the teaching of chemical kinetics.

Chemical Kinetics is an important concept in chemistry and it refers to the rates of chemical reaction. This concept has long being identified by researchers (Ahiakwo, 1984; 1991; Akinmade and Adisa, 1984; Osborne 2001) to be a dreaded one by secondary school students. West African Examination Council Chief Examiner's report of 1999 to 2004 had also indicated that Senior Secondary School chemistry students found chemical kinetics difficult to understand. The present study is therefore interested in finding out if the treatment condition will enhance students understanding of the concept.

Problem statement

The study seeks to determine the effects of STAD strategy and students mathematics knowledge (ability) on their learning outcomes (Achievement and attitude) in chemical kinetics.

Hypotheses

The following hypotheses were tested at 0 .05 level of significance.

Ho1 There is no significant main effect of treatment on

(a) Students' achievement in chemical kinetics

(b)Attitude towards chemical kinetics

Ho2 There is no significant main effect of mathematics ability on students

(a)Achievement in chemical kinetics

(b)Attitude towards chemical kinetics

Ho3 There is no significant interaction effect of treatment and mathematical ability on students.

(a)Achievement in chemical kinetics

(b)Attitude towards chemical kinetics.

Research methodology

Design: - A pretest post-test control group quasi experimental design using 2 x 3 factoral matrix was used

$O_1\ x_1\ O_2$ (E)

$O_3\ x_2\ O_4$(C)

Where O_1 and O_3 are pretest for the experimental and control groups respectively. O_2 and O_4 are posttest for experimental and control groups respectively.

X_1 = STAD

X_2 = conventional lecture method.

Variables in the study

(a) Independent variable

(i) Student Teams - Achievement Divisions strategy

(ii) Conventional lecture method (control)

(b) Dependent variables

(i) Cognitive achievement in chemical kinetics

(ii) Attitude to chemical kinetics

(c) Moderator variables

(i) Mathematical ability at three levels

High, medium and low.

Population

All the senior secondary two chemistry students in Epe division of Lagos State, Nigeria constituted the target population for the study.

Schools and subjects

Six grade 1 senior secondary schools in this division were selected for the study based on purposive sampling technique. The six schools were selected based on the facts that the subjects have been taught basic and prerequisite concepts such as energy changes in chemical reaction and chemical equilibrium necessary for understanding of chemical kinetics. All the 300 (110 males and 190 females) chemistry students in senior secondary two class in the six schools were participants in the study. Intact classes were however used.

Research instruments

Five instruments were used for the study. They are:

1. ***The cooperative learning guide***

This contains the roles of the teacher and the students in a cooperative learning situation. Experts in the field of educational psychology that are knowledgeable in cooperative learning techniques did the face validity while experts in English education did the language editing of the guide.

2. ***Achievement test on chemical kinetics***

This was made up of two sections. Section A was made up of 30 multiple choice items with four options. Section B was made up of 10 short answered questions. All the questions were to be answered by the participants in 1 hour 15 minutes. The reliability coefficient of the instrument was determined to be 0.84 using Kuder – Richardson formula 20 (KR20). The difficulty and discriminating indices of each of the test items were computed to further validate the instrument. The difficulty level ranged between 0.44 and 0.54 while the discrimination index ranged between 0.40 and 0.64.

3. ***Student's mathematics knowledge test (SMKT)***

This was made up of thirty (30) multiple choice items with four options. The questions are on prerequisite Mathematics concepts for the understanding of chemical kinetics. The concepts are integration, differentiation, surds, factorization, indices and logarithms. Five experts in the field of mathematics education and test construction subjected the SMKT to face and content validity. The reliability coefficient of the instrument was determined to be 0.80 using Kuder – Richardson formula 20 (KR20). The difficulty and discriminating indices of each test item were computed to further validate the instrument. The difficulty levels ranged between 0.40 and 0.50 and the discrimination index ranged between 0.45 and 0.60. The scores of the participants in the instrument was used to classify the them into high medium and low mathematical achievers

4. ***Students attitude to chemical kinetics questionnaire (SACKQ)***

This was a twenty-item questionnaire rated on a four-point likert type intervals scale ranging from strongly agreed (SA) to strongly disagreed (SD). This instrument, which was developed by the researcher, was validated by four secondary school teachers and four science education lecturers in tertiary institutions. The reliability coefficient was calculated to be 0.76 using Cronbach alpha after the administration of the instrument to a selected sample of SS II chemistry students in Ijebu-Ode Ogun state, Nigeria.

5. ***Lesson notes on Chemical Kinetics***

There were six lesson notes, which were prepared on weekly basis for the six weeks of treatment for the study. The duration for each lesson was 80 minutes (Double period)

Procedure for data collection

The procedure for data collection was in three main phases and it lasted for eight weeks. The phases were:

Pre-test for the first one week

Treatment for the next six weeks

Post- test for the last one week of the eight weeks

Prior to the collection of data, the participating teachers and students were trained. The training programme lasted for two weeks. The training of the teachers focused on the use of (STAD) cooperative learning techniques and the different treatment conditions. The teachers of the students in the control group were not given any special training.

The participants for the study were subjected to orientation activities on cooperative learning guide. The students were taught the social skills and principles of intra-team cooperation in cooperative learning.

Pretest

The instrument were administered in the following order; students' attitude to chemical kinetics questionnaire, followed by the achievement test on chemical kinetics and finally student's mathematics knowledge test. The attitude questionnaire was administered first in order to avoid the influence of the chemistry achievement test on students' attitude.

Treatment

(I) Experimental group

Treatment in this group involved the following steps.

- Teacher presented the topic in form of lecture, demonstration and discussion

- Students in five member heterogeneous academic teams within the group engaged themselves in intensive cooperative study of the learnt materials by studying, workshops and drilling each other.

- Teacher gave questions on the topic to the students in form of quiz.

- Students answered the questions individually without assistance from their team mate.

- The average score of members of each team is calculated to find the team's mark.

- The teacher recognized and rewards the best three teams.

- Teacher gave assignment.

Control group

Here students sat individually and not in group throughout the lesson.

The treatment for each lesson involved the following steps:

- The teacher presented the lesson in form of lecture and demonstrations.

- Students listened to the teacher and wrote down chalkboard summary.

- Students asked the teacher questions on areas of the topic that is not clear to them.

- The teacher asks the students questions and the students answered individually.

Post test

After six weeks of treatment, post-test was administered on the experimental and the control groups. The SACKQ and the ATCK were re-administered again.

Data analysis

Analysis of Covariance (ANCOVA) was used to Analyse the data. Scheffe's Pairwise comparison was also used to establish the variation due to treatment and to locate for the source of significance.

Table 1: Summary of ANCOVA of post-test achievement scores of students' by treatment and mathematical ability.

Source of Variance	Hierarchical Method				
	Sum of Squares	df	Mean Square	F	Sig.
Covariates	1267.081	1	1267.081	17.161	.000
Main effects (combined)	30197.93	5	6039.589	81.800	.000
Treatment	28133.26	2	14066.63	190.518	.000*
Math ability	1915.360	2	957.680	12.971	.000*
2 – way interaction combined	3088.156	8	386.019	5.228	.000
Treatment / mathematical ability	2405.801	4	601.450	8.146	.000*
Model	34899.69	18	1938.872	26.260	.000
Residual	20747.28	287	73.834		
Total	55646.97	299	186.110		

* P <. 05 Significant result

The result of the main effect of treatment in table 1 revealed that the effect of treatment on students' achievement in chemical kinetics was significant at .05 alpha level (F = 190.516; P< 0.05). This implies that the post-test scores of students in

chemical kinetics differ significantly in the experimental and control groups. Hypothesis 1a is therefore rejected.

The multiple classification analysis (MCA) in table 2 showed the magnitude of post test, mean achievement scores of the experimental and the control group.

Table 2: Multiple classification analysis of post-test achievement scores. According to treatment and mathematical ability.

Grand mean=53.49

Treatment + Category	N	Unadjusted Mean	Adjusted for factors & covariates Mean	Unadjusted Deviation	Eta	Adjusted for factors and covariates Deviation	Beta

Treatment 1. Cooperation 2. Control	 210 90	 60.1636 59.3889	 61.16 60.23	 6.67 5.89	 0.657	 7.67 6.74	 0.754
Mathematics ability 1. Low 2. Medium 3. High	 78 126 96	 50.3462 54.6984 54.4583	 49.83 53.32 56.68	 -3.14 1.20 0.96	 0.137	 -3.66 -1.70 3.19	 0.191
Multiple R R^2							0.752 0.565

From Table 2 students in STAD cooperative group obtained a higher achievement score of (x = 61.16) compared to that of the control (x = 60.23).

From Table 1 the main effect of mathematical ability on Students' achievement in chemical kinetics is significant (F = 12.971; P <.05). This means that there is a significant difference in the post test achievement scores of the students of low, medium and high mathematical ability levels. Hence, hypothesis 2a is rejected. Table 2 also revealed that students of high mathematical ability obtained the highest achievement score (x = 56.68) followed by those of medium mathematical ability (x = 53.32) while the student of low mathematical ability obtained the least achievement score (x = 49.83).

From Table 1, the 2 way interaction effect of treatment and mathematical ability on

Student's achievement in chemical kinetics is significant (F = 8.146; P <.05).

Hypothesis 3a is thus rejected.

Table 3 revealed that there was a significant main effect of treatment on students' attitude to chemical kinetics F = 379.275; P <.05). The result implied that the post – test attitude scores of the students exposed to the different treatment conditions were significantly different. Thus the null hypothesis (Ho1b) was rejected.

Table 3: Summary of ANCOVA of post-test attitude scores of students according to treatment and mathematical ability

SOURCES OF VARIANCE	HIERARCHICAL METHOD				
	Sum of squares	df	Mean Square	F	Sig.
Covariates	7713.561	1	7713.561	111.294	.000
Main Effects (combined)	53404.05	5	10680.81	154.106	.000
Treatment	52573.69	2	26286.84	379.275	.000*

Math ability	509.849	2	254.925	3.678	.026*
2 - way interaction Combined Treatment / Math Ability	 2341.253 2100.788	 8 4	 292.657 525.197	 4.223 7.578	 .000 .000*
Model Residual Total	63566.09 19475.58 8304.67	18 281 299	353.449 69.308 277.731	50.953	.000

* Significant at P <0.05)

To find the magnitude of the post – test mean attitude scores of subjects exposed to treatment and control the multiple classification Analysis (M.C.A.) presented in Table 4 was computed

Table 4: Multiple classification Analysis of post – test Attitude scores by treatment and Mathematical Ability.

Grand mean=33.03

Treatment + Category	N	Unadjusted Mean	Adjusted for factors & covariates Mean	Unadjusted Deviation	Eta	Adjusted for factors and covariates Deviation	Beta
Treatment 1. Cooperation 2. Control	 210 90	 52.3800 21.0000	 52.06 21.41	 19.34 - 12.03	 .829	 19.03 - 11.62	 .814
Mathematics ability 1. Low 2. Medium 3. High	 78 126 96	 32.4231 30.9603 36.2500	 34.16 33.70 31.23	 - .61 - 2.07 3.21	.137	 1.12 .67 - .80	0.75
Multiple R R^2							.858 .736

From Table 4, students in the STAD group had the highest mean attitude score (x = 52.06) while the Control group had (x = 21.41).

Table 3 showed that mathematical ability of students had a significant effect on their attitude (F = 3.678; P <.05). This implied that students differ significantly in their attitude towards chemical kinetics across the experimental group and the control. Hypothesis 2b is therefore rejected. MCA result of Table 4 showed that the low mathematical ability students as having the highest post – test mean attitude score (x

= 34.16) followed by the medium mathematical ability (x = 33.70) while the high mathematical ability students had the lowest mean attitude score (x = 31.23).

Scheffe post – hoc analysis Table 5 revealed that each of the three possible pairs of groups was significantly different from each other. This accounts for the observed significant effect.

Table 5. Scheffe post – Hoc Analysis of Effect of Mathematical Ability on students' Attitude to Chemical Kinetics according to mathematical ability.

Mathematical Ability	X	1. Low	2. Medium	3. High
1. Low	34.16		*	*
2. Medium	33.70			
3. High	31.23	*	*	

*Pair of groups significantly different at P < .05

The result of 2 way interaction effects in Table 3 showed that there was a significant interaction effect of treatment and mathematical ability on students' attitude towards chemical kinetics (F = 7.578; P < .05). Based on this finding hypothesis 3b is rejected.

Discussion of findings

The result that treatment has significant effect on students' achievement and attitude towards chemical kinetics showed that the treatment condition in this study i.e. STAD cooperative learning strategy had the potentials to improve students' learning outcome in secondary school chemistry. This finding provided empirical support to earlier findings: Johnson and colleagues, (1981); Fu-yun-yu, 1998; Udousoro (2000); Popoola, (2002) and Omoshehin (2004) that established that cooperative learning strategy promoted better achievement and productivity than the conventional lecture method.

The study also revealed that there was statistically significanct main effect of mathematical ability on students' achievement in chemical kinetics. Students of high mathematical ability performed better than those of medium ability that also performed better than those of low ability. This trend is the same in both the experimental and the control groups. This result is in agreement with that of Spencer (1996) who found that the more mathematical background a student has while taking chemistry the better the student will perform in chemistry examination.

The study also showed that low mathematical ability students developed more positive attitude than those of medium and high mathematical abilities. This can be

explained from the point of view that weaker students improve their performance when grouped with higher achieving students in a cooperative learning environment (Cohen, 1994). This improved performance leads to interest in the subject and positive attitude.

Conclusion and Recommendation

The findings of this study provides support for the efficacy of the STAD cooperative learning strategy in the teaching of science as claimed by researchers (Johnson and Jhonson, 1994, 1999; Alebiosu 1998; Ojo, 1989; Fuyunyu, 1998; Esan, 1999; Adeyemi, 2002 and Omoshehin, 2004). The superiority of STAD cooperative learning strategy over the conventional technique could be attributed to the fact that it makes students develop more positive attitudes toward self, peer, adults and learning in general (Omoshehin, 2004).

The significant main effect of mathematical ability on students' achievement and attitude to chemical kinetics implies that only students with sound mathematical background will perform well in quantitative aspect of chemistry. It is imperative therefore that mathematical ability of students should be taken into consideration before allowing students to offer chemistry at the senior secondary school level. It is therefore recommended that students with very low mathematical ability should not be allowed to enroll for chemistry at the senior secondary school level. It is also strongly recommended that workshops and seminars on cooperative learning strategies should be planned for chemistry teachers in secondary schools.

References

Abdullah, A. 1982. *Teaching Science in Nigeria*. Ilorin. Atolo press.

Adeyemi, S. B. 2002. Relative effects of cooperative and individualistic learning strategies on students' declarative and procedural knowledge in Map work in Osun state, Ph.D. Thesis. Dept. of Teacher Education University of Ibadan, Ibadan.

Ahiakwo, M. L. 1984. Topic: Difficulties in chemistry. M.Ed. Thesis. Dept. of Teacher Education, University of Ibadan, Ibadan.

Ahiakwo, M. L. 1991. Cognitive styles and students' problem solving competence in

chemistry, *Journal of Science Teachers Association of Nigeria.* 27 . 1 : 31 – 39.

Ajelabi, P. A. 1998. The relative effectiveness of computer assisted and text – assisted programmed Instruction on students' learning outcomes in social studies. Ph. D. Thesis. Dept. of Teacher Education, University of Ibadan.

Akinbode, M. B. 2006. The relative effect of two instructional strategies on senior secondary school students' learning outcome in Islamic studies. Ph. D. Thesis. Institute of Education. University of Ibadan, Ibadan.

Akinlaye, F. A. 1998. Teacher Directed Inquiry, guided discussion and students' learning outcomes in some aspects of social studies. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan, Ibadan.

Akinmade, C. T. and Adisa, J. 1984. A study of students' areas of difficulties.

Curriculum Studies. 2.2 : 84 – 96

Alebiosu, K. A. 1998. Effects of two cooperative learning models on senior secondary school students' learning outcomes in chemistry. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan, Ibadan.

Astudilo, L. and Naiz, M. 1996. Reasoning strategies used by students to solve stoichoimetry problems and its relationship to alternative concepts, prior knowledge and cognitive variables. *Journal of Research in Science Teaching*. 21.2 : 172 – 184.

Chandran, S. 1985. *The role of cognitive factors in chemistry achievement*.

Western Australian Institute of Technology. Persh

Cohan, E. G. 1994. Restructuring the classroom conditions for productive small groups. *Review of Educational Research* Spring 64.1 : 1 – 35.

Esan, A. O. 1999. Effects of cooperative and individualistic problem-solving strategies on students' learning outcomes in secondary school mathematics. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan, Ibadan.

Fisher, G. 1996. The validity of pre-calculus. Multiple choice and performance based testing as a predictor of under graduate mathematics and chemistry achievement. M.Sc. Thesis. Dept. of chemistry. University of California, Santa.

Fu-yun-yu. Y. 1998. The effects of cooperation with inter-group competition on performance and attitudes in a computer assisted science instruction. *Journal of Computers in Mathematics and Science Teaching.* 17.4 : 381 – 395.

Huddle, P. A. and Pillary, A. 1996. An-depth study of misconception in stoichiometry and chemical equilibrium at a South African University. *Journal of Research in Science.* 33:65 – 78.

Iroegbu, T. O. 1997. Problems Based Learning Numerical Application and Gender as Determinants of Achievement in Problem Solving and Line Graphing skills in Senior Secondary Physics in Ibadan. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan, Ibadan.

Johnson, D. W.; Johnson, R. T.; and Zaindman, B. 1981. Oral interaction in cooperative learning groups: speaking, listening and nature statements made by high, medium and low achieving students. *Journal of Psychology* 119: 303 – 321.

Ojo, O. M. 1989. The differential effectiveness of cooperative, competitive and individualistic goal structures on students' performance in chemistry. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan, Ibadan.

Okebukola, P. A. O. 1984. Effects of cooperative, competitive and individualistic laboratory interaction patterns on students performance in Biology. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan.

Omoshehin, M. F. 2004. Effects of a training programme in cooperative learning of pre-service teachers' classroom practice and pupils learning outcomes in social studies. Ph.D. Thesis. Dept. of Teacher Education. University of Ibadan, Ibadan.

Popoola, A. A. 2002. Effect of heuristic problem-solving and programmed instructional strategies on senior secondary school students' learning outcome in mathematics in Ekiti State, Nigeria. Ph.D. Thesis. Dept. of Techer Education. University of Ibadan, Ibadan.

Osborne, J. F. 2001. Science Education for Contemporary Society: Problems Issues and Dilemmas in O. Dejong, E. R. Science Bergy, A. Alblas (eds). *Teaching for Scientific Literacy.* Utrech; The Master Land.

Schmidt, H. J. 2000. In the Maze of Chemical Nomenclature. How students name oxo-sarts. *International Journal of Science Education.* 3 : 86 – 97.

Spencer, H. E. 1996. Mathematics SAT Test scores and college chemistry grade. *Journal of chemical Education.* 73.2 : 1050 – 1153.