Effects of Personalised System of Instruction on Students' Academic Achievement in Chemistry

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Abstract: This study evaluated the effects of personalised system of instruction on students' academic achievement in Chemistry. The study also investigated the moderating effect of gender on the students' academic achievement. One hundred and nine senior Secondary School One (SS 1) students randomly selected from three co-educational secondary schools in Oro, Kwara State, Nigeria participated in the study. The study adopted a pretest, posttest, control group experimental design with a 3×2 factorial matrix. There were two experimental groups in which one received personalised instruction with target dates and the other without target dates. The control group received conventional teaching. Treatment lasted six weeks. Four hypotheses were tested at the .05 level of significance. The results of the analysis done using ANCOVA and Fisher's LSD test indicated that students in the PSI group had more significant improvement in their academic performance in chemistry than those taught with conventional method. Also there was no significant interaction of treatment and gender on the dependent measure. Implications of the findings for counselling and educational practices and preparation of teachers on the use of PSI for improving students' learning were discussed.

INTRODUCTION

Research evidence in Nigeria[1-4] indicate low science (especially chemistry) attainment of secondary school students. This situation is amplified by the few number of students pursuing science related courses in higher educational institutions compared with the art and social science students. This has in turn, led to the failure of the science programmes in the developing countries and Nigeria in particular to initiate and sustain the base for technological development[5]. Traditional methods of teaching science at the secondary school level have been widely criticised[1,5-8] as being responsible for the undesirable state of science education in Nigeria. Ajiboye,[9] reported that lecture method is still popular in most developing countries including Nigeria in spite of its obvious and serious limitations. The attention of many science educators has continued to be directed at searching for appropriate methods of science instruction.

Recent researchers have focused on several dynamic and pragamatic teaching methods and strategies such as problem-solving, project, field trip, concept mapping[10] and computer instruction[11,12]. Furthermore, individualized programmed instruction or self-learning or personalised system of instruction[13-16] and mastery learning strategy[4] among others have been used by researchers in their bid to improve students' achievement in different subjects. Good as these teaching methods are, they have their limitations.

However, it is evident that mastery learning strategy and related approaches especially the self-learning or individualized instruction method is more effective in teaching some difficult concepts or topics in science especially secondary school chemistry than the conventional teaching methods. Therefore, there is need for further investigations into the use of various forms of mastery learning approach in teaching some difficult topics in secondary school chemistry such as stoichiometry, mole concepts and other related concepts. The mastery learning method adopted in this study was the Personalised System of Instruction (PSI) propounded by Keller[17]. The PSI emphasized selection of responses, alteration of the responses and specification of a contingency between the response and a reinforcer.

A number of studies have shown PSI to be superior to traditional methods of teaching chemistry[6], social studies[3], computer science[18].

It has also been shown that students who take PSI and similarly designed courses improved their higher-order cognitive abilities in physics, engineering and other sciences[19,20].

Although, PSI has been reported to be superior to conventional teaching methods in USA and Europe, it has not been widely utilised in Nigeria in teaching chemistry among the secondary school students. Also, most of the cited studies used PSI among college or university students in USA. Given the poor performance of secondary school students in science subjects and low enrolment in science-related courses in higher educational institutions and obvious advantages of PSI in improving students' achievement and interests in science as well as paucity of research in the use of PSI in Nigeria, it is necessary to find out whether secondary school students taught with PSI method are able to improve in their academic achievement in chemistry. This study used PSI among the senior secondary school students in chemistry. The PSI has a self-pacing feature which allows the student to progress through the course at his own pace. However, in this study, a modification to the PSI was introduced by giving a target date for each lesson unit to be completed by the students. This was to prevent the frequent incompleteness or postponement of work by students reported by earlier researchers.

Purpose of the study: The purpose of this study was to:

- Investigate whether PSI with target dates will be more effective than PSI without dates in improving he academic achievement of students in chemistry.
- Investigate whether PSI with target dates will be more effective in improving the academic achievement of students in chemistry.
- Investigate whether PSI without target dates will be more effective than conventional method of teaching in improving the academic achievement of students in chemistry.
- Investigate whether gender has effect on the academic achievement of students taught with PSI.

Hypotheses: The following Null Hypotheses were tested at the 0.05 level in this study:

- There is no significant difference between the academic achievement of students who received PSI with or without target dates and those who received instruction by conventional method of teaching chemistry after treatment.

- There is no significant difference between the academic achievement of students who received PSI with target dates and those who received PSI without target dates after treatment.
- There is no significant effect of gender on academic achievement of students taught with PSI.
- There is no significant interaction effect of treatment and gender on students' academic achievement.

MATERIALS AND METHODS

Research design: The study adopted a pretest, post-test control group experimental design with a 3×2 factorial matrix.

Sample: The participants for this study were 109 (male = 55, female = 54) Senior Secondary One (SS 1) chemistry students randomly selected from three co-educational secondary schools located in Oro environ, Kwara State. Three chemistry teachers involved in the study had a minimum of five years post qualification teaching experience as a graduate. They all have teaching qualifications not lower than the Post Graduate Diploma in Education (PGDE).

All the SS 1 chemistry students (N = 36) in one of the schools were randomly assigned to experimental group 1 (the PSI with target dates) and those in the second school constituted experimental group 2 (N = 36) (the PSI without target dates). The SS 1 chemistry students in the third school (N = 47) served as the control group 3. These students received conventional teaching from their regular chemistry teachers.

The research instruments: The instruments for this study consisted of 12 PSI course units and a fifty-item test. The PSI course units were written by the researcher. The materials in the units were presented in hierarchical or sequential order. The contents covered topics which include relative atomic mass, relative molecular mass, mole concept, oxidation state, and chemical equation all under the broad topic of stoichiometry at the secondary school level. Each unit had unit quiz made up of multiple choice items.

The test instrument contained 50 multiple choice based on the topic stoichiometry in the secondary school chemistry syllabus. The internal consistency reliability cronbach's alpha of the test instrument was 0.85.

Procedure: The study covered a period of six weeks for the PSI and the conventional teaching methods. Each week comprised four periods of 40 min. The SS I chemistry teachers in the three schools involved in this study were

briefed about their roles in this study before the commencement of the experiment. There were two experimental groups and a control group. One experimental group received PSI with target dates while the other received PSI without target dates. The control group received conventional teaching (lecture-demonstration method). Two science student-teachers of a College of Education served as proctors for each experimental group. All the students in the experimental and control groups were administered the test items before and after treatment.

For the PSI, the researcher broke down the topics (stoichiometry, relative atomic mass, relative molecular mass, mole concept etc.) into 12 units. Each unit had course materials written on the topic with a set of ten questions serving as unit quiz. Three sets of tests were written for each unit to serve as make-up quizzes. A student must obtain an 'A' grade (90% or more correct) on the first quizzes before he should move to a new unit. Students should take a make-up quiz any time their initial score fell below 90% correct. They could take as many make-up quizzes as necessary to reach the criterion (90%) by which time they would be considered to have completed the unit. Students must complete a prior lesson unit before taking quiz on the succeeding lesson.

A list of target dates was given to each student in the group that received PSI with target dates while no target dates were given to the PSI alone group. None was given to the students in the control group. Regarding target dates, each student was supposed to complete one unit in two lessons (i.e. 12 units in 6 weeks). The students were told that if they failed to pass any quiz by the stipulated target date two times consecutively, they would be given a warning; the third time, they would be told to either withdraw from the course or get an F.

The data obtained from the score of the students in the pre and post-test administration of the 50-item test instrument were analysed using a 3×2 factorial analysis of covariance (ANCOVA) and Fishers LSD test at 0.05 level of significance.

RESULTS

The results on Table 1 indicates an F-ratio value of 46.49 ($F_{(2,103)}$ = 46.49, p<0.05) which is statistically significant at the 0.05 level. It means that the three groups were statistical different from each other in their posttest scores after the experimental treatment. Hence hypothesis 1 is rejected. This demonstrates that PSI training had good impact on their achievement in chemistry.

Pairwise comparison of the posttest mean scores of the three groups were carried out using Fisher's protected LSD post hoc test since the F-ratio obtained in Table 1

Table 1: Analysis of covariance on the students' academic achievement scores in chemistry based on treatment

Source of variation	Sum of squares	Df	Mean squares	F	P
Between groups (PSIID, PSI and Control)	22298.46	2	11149.23	46.49	.05
Gender (Male, Female)	102.23	1	102.23	.42	NS
2-Way interaction treatment x gender	98.07	2	49.03	.20	NS
Within	24701.73	103	239.82		
Total	47200.49	108			

was statistically significant. The posttest mean scores (x) for groups 1, 2 and 3 were 68.75, 67.20 and 47.00 respectively. The result of Fisher's LSD post hoc test showed that significant differences in mean scores were found between Groups 1 (PSITD) and 3 (CT), (11.75) and between Groups 2, (PSI) and 3 (CT) (10.2) but not between Groups 1 (PSITD) and 2 (PSI) (1.55). The calculated LSD value was 6.51. Based on the post hoc tests no significant differences were found in the posttest mean scores of the students taught by PSI with target dates and those taught by PSI without target dates after treatment. This means Hypothesis 2 is accepted.

The result on Table 1 further indicated that there was no significant main effect of gender on the academic achievement of the students ($F_{(1,103)}$-0.42, NS). Hence Hypothesis 3 is accepted. The table also reveals that there was no significant interaction effect of treatment and gender on the academic achievement of the students ($F_{(2,103)}$ = 0.20, NS). Therefore, Hypothesis 4 is accepted.

DISCUSSION

The results from this study show that there was a statistically significant difference in posttest mean scores of the three groups (PSITD, PSI and CT) in their academic achievement in chemistry. The result rejected hypothesis 1 that states that there is no significant difference in the academic achievement in chemistry of the students in the three groups after treatment. The results indicate that the PSI taught group (with or without target dates) had more significant improvement in their academic achievement in chemistry than the conventional taught control group. The findings from this study supported those of other researchers[1,6,13,16,19,21] which showed that PSI significantly improved the students' academic achievement in various school subjects.

The effectiveness of the PSI is due to the self-pacing nature of it and the procedure of obtaining feedback through testing and applying corrective through instruction and retesting with other remediation. Also, the fact that students really understood the principles,

concepts and formulars involved in the topics and interacted with the proctors on lively interchange of ideas, interest and importance common to each other, fostered meaningful learning which accounted for the marked improvement of the academic achievement of the PSI taught group over the conventionally taught group.

The finding that the posttest mean scores of the group that received PSI with target dates did not differ significantly from those that received PSI without target dates is interesting and unexpected. It is expected that addition of target dates would have caused the PSITD group with target dates to complete all the task assigned and performed better on the test items than the group that had PSI without target dates. This finding indicates that achievement in chemistry especially the topics involved goes beyond merely completing the assigned work but involves actual understanding of the principles and their application to given situations. One also expected most students that received PSI without target dates not to complete all their units before the end of the experiment. However, on the contrary, very few of them did not complete their work by the end of the experiment. This might be because in the school system absence from classes and non-completion of assignment carried some stiff penalties.

Furthermore, this is related to the fact that continuous assessment, an important part of the final assessment, is always based on the marks scored on both tests and assignments. Hence, the students have to comply with the rules in order to obtain good grades for continuous assessment in their different subjects. Consequently, most of them could not afford to leave their work uncompleted.

This study also investigated the effect of gender on the academic achievement of students exposed to PSI. The results showed that the students' academic achievement was not affected by their gender. This indicates that PSI was effective in improving the academic achievement of the students regardless of their gender. The results also indicate that there was no significant interaction effect of treatment and gender on the students' academic achievement. This implies that the effectiveness of PSI in improving the students' academic achievement does not depend on their gender. Both male and female students showed marked improvement in academic achievement as a result of their exposure to PSI teaching method.

CONCLUSION AND IMPLICATIONS

In conclusion, students who received PSI with or without target dates scored significantly higher on the posttest items in chemistry than did students instructed by the conventional method. Furthermore, the group, taught by PSI with target dates, did not score significantly higher than those taught by PSI without target dates. However, almost all students taught by PSI with target dates completed their lessons before the end of the experiment while few of those taught by PSI without target dates could not complete their lessons.

The results of this study have implications for the teaching of chemistry in particular and science subjects in general. The PSI will be useful in teaching very abstract concepts and principles that are difficult for students. Chemistry teachers in particular and science teachers in general could be encouraged to use personalised system of instruction to help their students learn better. When PSI is combined with target dates, it will assist the students in studying and learning at their own pace and at the same time, prevent them from falling too far behind.

The PSI could be adopted with secondary school students where there are large students populations but grossly inadequate number of experienced teachers. The school counsellor in conjunction with the subject teachers could mount the PSI to improve the learning of students in difficult topics as part of the educational guidance programme in the schools.

The PSI could be used with students who are working and are at the same time engaged in distance learning programme. In this respect, the self-directed nature of the PSI method will help the students to cope with learning such that they could cover their course materials adequately before their examinations.

REFERENCES

1. Ajelabi, P.A., 1998. The relative effectiveness of computer assisted and text assisted programmed instruction on student learning outcomes in social studies. Unpublished Ph.D. Thesis, University of Ibadan.

2. Okebukola, P.A., 1997. The state of science education in Nigeria. Paper presented at the ELSSA British Council Primary Sci. Forum, Kaduna, pp: 5.

3. Olagunju, A.M., 2001. Increasing girls' interest, participation and achievement in science. A paper presented in 42nd STAN Annual Conference Proceedings, pp: 288.

4. Salami, S.O., 1991. Effects of mastery learning strategy and counselling on academic achievement of students in chemistry. The Nigerian Journal of Guidance and Counselling, pp: 4-97.

5. Okebukola, P.A., 2003. Development of a strategy plan for enhancing relevance of science and technology education for all in Africa. Science Education Intl., 14: 23-29.

6. Adesoji, F.A., 1991. A comparative analysis of problem-solving and self-learning technique in teaching electrolysis. Unpublished Ph.D. Thesis, Obafemi Awolowo University Ile-Ife.

7. Ezeliora, B., 2004. Innovative programmes to counter gender in science among primary school pupils. Proceedings of the 45th Annual Conference, 28: 148-152.

8. Osinubi, O., 2003. Constructivist methods of teaching and meta-cognitive strategy as determinants of learning outcomes in primary school science. Unpublished Ph.D. Thesis, Institute of Education, University of Ibadan, Ibadan.

9. Ajiboye, J.O., 2005. Effects of a training programme in cooperative learning on pre-service teachers' classroom practice in social studies. The African Symposium, 5: 42-49.

10. Orukotan, A.F., 1999. The relative effects of instructional strategies of framing and rehearsal on secondary school students' learning outcomes in some biology topics. Unpublished Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria.

11. Fajola, O.O., 2000. Effects of the three modes of computer based instructional strategies on students' learning outcomes in biology. Unpublished Ph.D. Thesis, University of Ibadan, Ibadan.

12. Jegede, O.J., P.A. Okebukola and G.A. Ajewole, 1992. Students' attitude to the use of the computer for learning and achievement in biological concepts. Journal of the Science Teachers' Association Nigeria, 27: 62-65.

13. Ajiboye, J.O., 1996. A self-learning programme, the modified lecture method and students' cognitive and affective outcomes in some population education concepts. Unpublished Ph.D. Thesis, University of Ibadan, Ibadan.

14. Eguabor, V.O. and O.F. Betiku, 1997. Self-Learning Module (SLM) or individualized programmed instruction as an innovation in learning STM in Nigeria in 40th Conference Proceedings of Science Teachers Association of Nigeria.

15. Egunjobi, A.O., 2002. The relative effectiveness of computer assisted instructional models on students' learning outcomes in geography. An unpublished Ph.D. Thesis, University of Ibadan, Ibadan.

16. Sotayo, M.A.O., 2002. Computer textual assisted programmed instruction and students' cognitive preference style as determinants of secondary school achievement in heat related concepts in Physics. An unpublished Ph.D. Thesis, University of Ibadan, Ibadan.

17. Keller, F.S., 1968. Goodbye, teacher. Journal of Applied Behaviour Analysis, 1: 79-89.

18. Hambleton, I.R., W.H. Foster and J.T.E. Richardson, 1998. Improving student learning using the personalised system of instruction. Higher Education, 35: 187-203.

19. Grant, L.K. and R.E. Spenser, 2003. The personalised system of instruction: Review and applications to distance education. The International Review of Research in Open and Distance Learning. Retrieved June 29, 2006 from http://www.irrodl.org/index.php/irrodl/article/view Article/152/233, 4: 1-18.

20. Allan, L.T., 1997. The Keller Plan at law school. Retrieved June 30, 2006, from htpp://austli.i.edu.au/~alan/j_leged.html

21. Udousoro, U.J., 2000. The relative effects of programmed instruction in mathematics. An unpublished Ph.D. Thesis, University of Ibadan, Ibadan.