

Learning Styles and Academic Learning Time as Predictors of Secondary School Students' Achievement in Chemistry

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Abstract

The study investigated learning styles and academic learning time as predictors of secondary students' achievement in chemistry. Using an ex-post facto research type, four research hypotheses were tested. Two instruments - Learning styles ($r=0.76$) and academic learning time ($r=0.78$) questionnaire (LSALTQ) and Chemistry Achievement Test (EAT) ($r=0.81$) were used to gather data. Two hundred and forty chemistry students were randomly selected from four Local Government Areas of Oyo State, Nigeria. Multiple regression analysis was used to analyse the data. The results showed that there was a significant composite contribution of learning styles (lesson structure, sociological, auditory and tactile) and chemistry academic learning time available (allocated, instructional, engaged) to students' achievement in chemistry. Lesson structure had relative significant contribution to determine the achievement of students in chemistry. Teacher instructional time had highest contribution followed by students' engaged time. Chemistry teachers need to adapt their instructional delivery to the different learning styles of the students. Sufficient instructional and students' engaged times should be available for teaching, learning and laboratory practical activities. More time is to be devoted to students' learning while non-academic-related activity times that consume the learning time should be drastically reduced.

Keywords: Learning styles, academic learning time, engaged time, achievement, chemistry, secondary school

The importance of science education in developed and developing countries cannot be overemphasised. Science processes and products are universal

knowledge which no citizen can deny. Nigeria as a developing country needs to lay much emphasis on science education to enable her cope with technological development of the nation particularly at the secondary school level where solid foundation is indispensable. Science generally in Nigeria has been existing in its primitive form even before the introduction of Western education which brought modern science. Fafunwa (1987) advocated that science should be introduced as a compulsory subject at both elementary and secondary levels. He further explained that a mass science education campaign should be embarked upon amongst adults in order to allow Africa move from the static role of spectator to that of an actor in this computer age. This led to the introduction of biology as one of the secondary school core subjects into the 6-3-3-4 educational programme and emphasising more effective way of teaching and learning of science generally. Other physical sciences like physics and chemistry were also given attention by increasing numbers of teachers and laboratory facilities in schools.

The performance of secondary school students in science-based subjects has not been encouraging in spite of government's efforts to boost performance. The results of chemistry students in WAEC and NECO in the recent times showed low and fluctuating performance (Tables 1 and 2).

Table 1: Chemistry Students' Entries and Results for the May/June WAEC/ SSCE (2004-2009)

Year	Total Entry	Total Sat	Total Credit (A1-C6) (%)	Total Pass (D7-E8) (%)	Total Failed (%)
2004	345078	340774	128133 (37.60)	95404 (28.00)	117237 (34.40)
2005	338307	327225	135544 (41.42)	84267 (25.75)	107414 (32.83)
2006	389315	375285	140263 (37.38)	89998 (23.98)	123204 (38.64)
2007	432230	422681	194284 (45.96)	104680 (24.76)	111322 (26.33)
2008	428513	418423	185949 (44.44)	114697 (27.41)	110417 (26.38)
2009	478235	468546 . Km tannh;	204725 , (43.69)	114020 (24.33)	119260 (25.45)

Source: West African Examination Council Test Development Division

Table 2: Chemistry Students' Entries and Results for the May/June NECO/ SSCE (2004-2009)

Year	Total	Total Sat	Total	Total Pass	Total
	Entry		Credit (A1-C6)	(D7-E8)	Failed (%)
2004	286900	277393	(52.02) 134405	(28.00) 84267	(34.40) 117237
2005	281648	270628	(49.66) 135253	(25.75) 89998	(32.83) 123204
2006	304890	291344	(46.42) 176691	(23.98) 104680	(38.64) 111322
2007	340281	333303	(53.01) 258835	(24.76) 114697	(26.33) 110417
2008	388996	344766	(75.08) 169216	(27.41) 114020	(26.38) 119260
2009	415497	402785	(42.01)	(24.33)	(25.45)

Source: National Examinations Council Test Development Division

From Tables 2 and 3, students' performance in SSCE Chemistry over the six years reviewed has been low from the WAEC results where the percentages of those with D7 to E8 and Failure grades were higher than those who obtained A1 to C6 grades. From the NECO result, students' performance seemed to be better than WAEC but fluctuating in which the best NECO result was obtained in 2008. The inconsistency in performance trends might be due to learning styles of the students or academic learning time that is available for the students.

Learning styles are various approaches or ways of learning. Most people prefer an identifiable method of interacting with, taking in, and processing stimuli or information. Based on this concept, the idea of individualised learning styles originated in 1970 and acquired enormous popularity. One

style does not fit all. Effective teachers try to understand how individual child takes in and processes information. They realise that not all children learn the same way. Learning styles describe the ways in which individual children acquire information, evaluate it, and then examine their findings. Learning styles are applicable to all content areas and settings. An effective teacher tries to present materials in ways that will interest children and their them to absorb information. Understanding a child's learning style helps to accomplish this even in developing study materials for students in open and distance learning. Ipaye (2005) argued that an understanding of learners learning style could be much helpful both to the course writers and to the learners themselves.

Literature Review

Many research studies have revealed major learning difficulties in chemistry and identified correlate of these difficulties as inadequate relevant textbooks, insufficient qualified teachers, ill-equipped laboratories and poor students study culture (Hewson, Beeth and Thorley, 1998). Although, Treagust, Dur and Nieswandt (2000) concluded their research report by asserting that mar.; difficulties in learning and understanding chemistry appear to be caused or how chemistry instruction is passed to the students, yet mode of testing the students' knowledge on the chemistry content goes a long way to affect the- performance. Several methods of teaching, such as discussion, enquiry problem-solving and practical observations have been employed to engender chemistry instructions to students (Bowen, 2000). Other strategies have been researched into in order to bring about effectiveness in chemistry teaching and learning. Madukwe (1987) employed mastery learning, Raimi (2001) used problem solving and laboratory teaching modes and Igwe (2002) examined framing and team- assisted instruction strategy among others to teach chemistry topics in the curriculum. Many factors tend to affect the performance of students. These include school location, gender, age and class size (Ogunleye, 2002), students' ability (Afuwape, 2002), availability of facility (Osokoya, 1998), students' home background (Apara, 2005) and test anxiety (Boyinbode, 1988). Learning styles and academic learning time have not been given consideration as factors that could influence student achievement in chemistry.

Most theories of learning styles focus on personality and motivation to learn. Silver, Strong and Perini (1997) categorise learners into four in their learning style model as mastery style learners (sensing-thinking), understanding style learners (intuitive-thinking), self-expressive learners (intuitive-feeling) and interpersonal learners (sensing-feeling). Kolb (1984) in his experiential learning theory came up with a model of learning styles in which four approaches towards grasping experience were concrete experience, abstract conceptualisation and active experimentation. According to Kolb model, the ideal learning process engages all four of these modes in responding to situational demands. The resulting learning styles are combinations of the individual's preferred approaches. These learning styles saw learners as converger, diverger, assimilator and accommodator. Honey and Mumford's model when building on Kolb's model also identified four learning stages which include having an experience, reviewing the experience, concluding from experience and planning the next steps (Honey and Mumford, 2006).

Flemming's VARK (Visual, Aural, Write/Read and Kinesthetic) is one of the most common and widely used categorisations of the various types of learning styles. This model grouped learners into visual, auditory, kinesthetic or tactile. Flemming and Mills (1992) claimed that visual learners have a preference for seeing (think in pictures, visual aids such as diagrams, overhead slides, diagram, handouts etc.). Auditory learners' best learn through listening (lectures, discussions, tapes etc.). Tactile/kinesthetic learners prefer to learn via experience (active exploration of the world, science projects, and experiments). Its utilisation allows a teacher to prepare classes that address each of these areas. Cognitive approach to learning styles analyse the attitudes of students and how they approach things. This model was developed by Grasha (1996) who identified concepts of various learning styles as avoidant, participative, competitive, collaborative, dependent and independent. The model provided teachers with insight on how to approach instructional plans.

Learning style theories faced a lot of criticisms from various authors. Some psychologists and neuroscientists have questioned the scientific bases for theories on which they are based. Greenfield (2000) considered the issue of learning styles as nonsense from neuroscientific point of view. He emphasised that humans have evolved to build a picture of the world through

our senses working in unison, exploiting the immense interconnectivity that exists in the brain. Most educational psychologists believe that there is little evidence for the efficacy of most learning style models, and furthermore, that the models often rest on dubious theoretical grounds. Stahl (2002) posited that there has been an utter failure to find that assessing children's learning styles and matching it to instructional methods has any effect on their learning. Claxton (2006) has questioned the extent that learning styles such as VARK are helpful, particularly as they can have a tendency to label children and therefore restrict learning.

Although learning styles will inevitably differ among students in the classroom, teachers should try to make changes in their classroom that will be beneficial to every learning style. Some of these changes include room redesign, the development of small-group techniques (Dunn and Dunn, 1984). Sprenger (2003) also asserted that learning styles had effect on the classroom by basing her work on the three premises: teachers can be learners and learners can be teachers, everyone can learn under right circumstances and learning is fun, make it appealing. By using a variety of teaching methods from each of these categories, teachers offer different learning styles at once, and improve learning by challenging students in different ways. Coefferd, Moseley, Hall and Ecclestone (2004) found that none of the most popular learning style theories had been adequately validated through independent research, leading to conclusion that idea of a learning cycle, the consistency of visual, auditory, and kinesthetic preferences and value of matching teaching and learning styles were all highly questionable.

Many psychologists believe that there is little evidence for efficacy of most of the learning style models and that the models often rest on dubious theoretical grounds. According to Stahl (2002) there has been an utter failure to find that assessing children's learning styles and matching to instructional methods has effect on their learning. Massa and Mayer (2006) also questioned the extent that learning styles such as VARK are helpful as they can have tendency to label children and therefore restrict learning. It was concluded from their study that if the learning hypothesis is correct, visual learner should learn better with visual method, and auditory learners should learn better with auditory method.

Academic learning time (ALT) is the amount of time a student spends

attending to relevant academic tasks while performing tasks with high rate of success. If learners spend more time and use that time effectively, then they will learn more effectively. Academic learning time (*ALT*) is the amount of time and the quality of education time a student spends attending to relevant academic tasks while performing those tasks with a high rate of success (*Caldwell, Huitt and Berliner, 1981*). *ALT* is that precise period when an instructional activity is perfectly aligned with the student's readiness and learning occurs. The more time one spends on a task, the more one learns. Research has verified that this relationship exists for academic activities (*Hollowood, Salisbury, Rainforth and Palombaro, 1995*). Effective instruction maximises the amount of time a student is both focussed on learning at an appropriate difficulty level, and experiencing a high level of success. Not all students will spend the time allocated to a task actively engaged in appropriate activities. While a teacher is passing instruction, learners engage in different activities such as day dreaming, singing, tapping, playing, sleeping, making noise etc.

Learning time is engaging in appropriate activities that are closely related to improve academic performance. The schedule time and allocated time merely set the upper limit for engaged time. The value of engaged time is emphasized by the large number of studies that have had as their goal to increase the active engagement of the learner. For engaged time to be really useful, the student must be participating in useful activities at a high rate of success.

ALT is the portion of engaged time during which students are not only actively learning, but are learning successfully. “*ALT*” is that part of allocated time in any subject-matter area in which a student is engaged successfully in the activities or with the materials to which he/she is exposed and in which those activities and materials are related to educational outcomes.

Academic Learning Time = f (allocated time, instructional time and engaged time)

$$ALT = f(AT,IT,ET)$$

Allocated time is that which the state, the district, school, or teacher provides

the student for instruction. Sometimes, it is called scheduled time. *Instructional time* is actual time spent on instruction. School administration determines the allocated time. Huitt, Caldwell, Traver and Graeber (1981) found that student unengaged behaviours could be classified as: **management/transition, socialising, discipline, unoccupied/observing, and out of the room.** Idle time activities in schools are *daily, routine classroom activities or "in-between" activities*, distributing, setting up, or gathering equipment, supplies, materials etc., taking roll, students standing in line, waiting for teacher's help, listening to nonacademic directions and waiting for next activity to begin.

Total Allocated Time (set) = Time On-task + Time Off-task

Engaged time is the time that students appear to be paying attention to materials/presentations that have instructional goals. A synonym for engaged time is "attention." This implies a mental attitude in which concentration is given voluntarily and steadily by all during the entire instruction. ALT is a combination of three separate variables: Content overlap, involvement, and success. Content overlap is defined as "the percentage of the content covered on the test actually covered by students in the classroom" and is sometimes referred to as "Time on Target" (Felder and Brent, 2005). Involvement is the "amount of time students are actively involved in the learning process" and is often referred to as "Time on Task." Success is defined as the "extent to which students accurately complete the assignments they have been given" (Felder and Spurlin, 2005). A high level of academic learning time means that students are covering important (tested/evaluated) content; students are "on-task" most of the class period; and students are successful on most of the assignments they complete. Hollywood, Salisbury, Rainforth and Palombaro (1995) identified six categories of sources of lost instructional time which werestudent interruptions (disruptive behaviour, leaving the room, changing seats, peer conflicts), teacher interruptions (disciplinary actions, collecting or distributing materials, calling the office); visitors to the class; loudspeaker announcements; transitions and other sources (late starts, early dismissal, fire drills).

The Problem

Chemistry as one of the science subjects at senior secondary school level is suffering from ineffective learning styles and hence low performance by the students offering chemistry. The difficulty observed in students' learning of chemistry is as a result of chemistry teachers focusing solely on teaching rather than involve students in effective and active learning by tailoring their instructions to take care of various learning styles of the students. Learners are meant to play active role in teaching and learning in which both the teacher and learners contribute positively. Since students learn in different ways, it therefore means that their performance depends on the type of learning modes they embrace both in the class and outside.

Also, the time available for serious academic activities in schools is affected by meetings, teachers' poor attendance in classroom, sporting activities, social events, holidays and other unforeseen programmes which reduce students' learning time and thereby could affect their achievement in chemistry. This study focuses on the learning styles and academic learning times as predictors of students' performance in chemistry.

Research Hypotheses

1. There is no significant composite contribution of learning styles to students' cognitive achievement in chemistry.
2. There is no significant relative contribution of learning styles to students' cognitive achievement in chemistry.
3. There is no significant composite of chemistry learning available time to students' achievement in chemistry.
4. There is no significant relative contribution of chemistry learning time to students' cognitive achievement in chemistry.

Methodology

Research Design

The study employed an ex-post facto research design in which none of the variables used in study was manipulated but were used as they occur.

Population and Sampling Procedure

The population used for the study consisted of all SSS3 chemistry students in both public and private secondary schools in Ibadan metropolitan city, Oyo state. Four local government areas were randomly selected. Four schools were also randomly selected (two public and two private) from each of the local governments. Fifteen SSS3 chemistry students were randomly selected from each of the schools to make a total of two hundred and forty (240) students sample used for the study. The SS3 students were used because they have relatively high knowledge in chemistry, have developed specific learning styles and also have understood the time they were engaged in learning chemistry over the years of senior secondary experience.

Research Instruments

Two instruments were employed to collect data for the study. They were (i) Learning styles and academic learning time questionnaire (LSALTQ) and (ii) Chemistry Achievement Test (EAT). A validated 35-item structured learning styles and academic learning time questionnaire (LSALTQ) was divided to two sections A and B. Section A elicited the personal background information of the students. Section B contained seven subscales: Subscales B to E had 20 items that related to learning styles of students and subscales F to H contained academic learning time on four-point Likert scale of Strongly agree (SA)-4, Agree (A)-3, Disagree(D)-2 and Strongly Disagree (SD)-1. The scores were reversed for negatively written items. The questionnaire was validated by experts from the International Centre for Educational Evaluation (ICEE), University of Ibadan, Ibadan, Nigeria. The internal consistency of items of each scale was ascertained by pilot testing the questionnaire to 50 chemistry students who did not participate in the study. Cronbach Alpha reliability coefficients were indices of the learning styles subscale was 0.76 while that of the academic learning time was 0.78. The chemistry achievement test contained 50 multiple choice items taken from five topics of SSS1 to 3 chemistry. The topics were particulate theory of matter, acids bases and salts, periodicity, electrochemistry and hydrocarbons. Kuder Richardson (KR-20) was employed to find the internal consistency of the Chemistry Achievement Test and coefficient of 0.81 was obtained.

Data Collection

The researcher with two other research assistants visited the sampled schools to administer the questionnaires to the chemistry students used for the study. The chemistry teachers in the schools also assisted in the process of data collection which lasted two weeks. Both the learning styles and academic learning time questionnaire and chemistry achievement test were administered one after the other. The chemistry achievement test was scored for each student by the researcher over a total mark of 50.

Data Analysis Procedure

Data collected were analysed using multiple regression analysis to test the hypotheses generated for the study.

Results and Discussion

In order to test hypothesis one, the result is as shown on Table 3.

Table 3: Regression Summary and ANOVA of Chemistry Students' Achievement by Learning Styles

R	=	.346
R Square	=	.120
Adjusted R Square	=	.105
Standard Error	=	11.108

Model	Sum of Squares	Df	Mean square	F	P	Remark
Regression	3940.971	4	985.243			
Residual	28997.429	235	123.393	7.985	.000	Significant
Total	32928.400	239				

Table 3 elicits that the R-value, R-square and adjusted R square were .346, .120 and .105 respectively. There is a positive correlation between the learning styles of chemistry students and their achievement in chemistry. Results also showed that learning styles contributed 10.5% to the variation observed in chemistry achievement. It is also revealed from Table 1 that the

contributions of the learning styles to chemistry achievement was significant [$F(4,235) = 7.985, P < 0.05$]. Therefore, there was a significant composite prediction of learning styles (lesson structure, sociological, auditory and tactile) to students' achievement in chemistry. This result corroborated the findings of Pasher, McDaniel, Rohrer and Bjork (2009) who reported that the learning styles of engineering students determine their achievement and attitudes. It is at variance with Uzuntiryaki (2007) who found that there was no significant influence of matching students' learning styles on students' chemistry achievement. The joint contribution of chemistry students' learning styles implies that the way children learn determines the level of understanding and assimilation which in turn generally affected their achievement in chemistry.

Table 4: Multiple Regression Coefficients of Learning Styles on Students' Chemistry Achievement

Model	Unstandardised Coefficients		Standardised Coefficients	T	Sig	Remark
	B	Std. Error	Beta			
Constant	78.898	3.390		23.275	.000	
Lesson Structure	-9.599	2.123	-.401	-4.523	.000	Significant
Sociological Learning Style	-3.138	2.331	-.133	-1.346	.179	Not Significant
Auditory Learning Style	-1.223	1.593	-.052	-.768	.444	Not Significant
Tactile Learning Style	4.360	3.050	.186	1.430	.154	Not Significant

Table 4 shows the relative contribution of each of the learning styles to students' achievement in chemistry. From the Table, structure of chemistry lesson had significant contribution to students' achievement in chemistry ($P = -.401, t = -4.523, P < 0.05$) while sociological ($P = -.133, t = -1.346, P > 0.05$), auditory ($P = -.052, t = -.768, P > 0.05$), and tactile ($P = .186, t = 1.430,$

$P > 0.05$) learning styles had no significant contributions to students' achievement in chemistry. Lesson structure goes a long way to determine the achievement of students especially in chemistry. Felder (2010) found that good instruction which is tailored towards students' learning style assists them to learn better than instructions that are at variance with the learning styles of the students. He further emphasised that teaching should address all categories of learning styles and that opportunities are to be provided in class for both active and reflective learners.

Table 5: Regression Summary and ANOVA of Chemistry Students' Achievement by Academic Learning Time

R = .260
 R Square = .068
 Adjusted R Square = .056
 Standard Error = 11.408

Model	Sum Squares	of Df	Mean square	F	P	Remark
Regression	2226.965	3	742.322			
Residual	30711.435	236	130.133	5.704	.001	Significant
Total	32938.400	239				

Table 5 shows that there was a positive relationship ($R = 0.260$) between academic learning time available for chemistry learning and students' achievement in chemistry. Adjusted R square of 0.056 implies that the chemistry academic learning time jointly accounted for 5.6% of the variance observed in students' achievement in chemistry. The ANOVA result of the regression also shows that there was a significant composite contribution of chemistry academic learning time available to students' achievement in chemistry [$F(3,236)=5.704$, $P < 0.05$]. This result is in consonance with Fisher and Berliner (1985) that discovered that academic learning time is a strong determinant of academic achievement. Some students simply require more time for mastering content than others. Therefore a discrepancy between amount of time allocated and amount of time needed for learning contributes to low achievement (Gettinger, 1991). Maximising academic success and productivity depends to a great extent on teachers' ability to match learning tasks to individual learner needs in terms of knowledge,

skills, and interests within the academic time available for the school.

Table 6: Multiple Regression Coefficients of Learning Styles on Students' Chemistry Achievement

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig	Remark
	B	Std. Error	Beta			
Constant	78.733	4.699	-.026	16.756	.000	Not Significant
School Allocated Time	-.623	1.622		-.384	.701	
Students' Engaged Time	-3.867	1.582	-.156	-2.445	.015	
Teacher Instructional Time	-4.962	1.639	-.207	-3.033	.003	Significant

Table 6 shows the relative contribution of each category of academic learning time to students' achievement in chemistry. Teacher instructional time and students' engaged time had relative significant contributions to students' achievement in chemistry with ($t = -3.033$, $(3 = -.207, P < 0.05)$) and ($t = -2.445$, $p = -.156, P < 0.05$) to students' achievement respectively. School allocated time had no significant relative contribution ($t = -.384$, $(3 = -.026, P < 0.05)$) to students' achievement in chemistry. The result also showed that teacher instructional time had highest contribution followed by students' engaged time. Greenwood, Terry, Marquis and Walker (1994) also discovered that although the amount of time teachers allocate and use for instruction as well as the time during which students are engaged are all positively correlated with learning (achievement), it is the proportion of engaged time that is productive and actively successful that relates strongly to achievement.

Conclusion

The study examined the students' learning styles and academic learning time as predictors of students' achievement in chemistry. Learning styles of the

students in general and chemistry in particular was found to contribute significantly to the level of performance in chemistry. Chemistry teachers' instruction should therefore be geared towards meeting learning styles of the students so as to make them learn effectively. When the learning styles of the students are taken into consideration in the class, they tend to concentrate, participate and are more readily active in the discussion. Also, academic learning time is another factor that significantly predicted students' achievement in chemistry. ALT depends not only on students' procedural involvement with their school work but also on the nature and quality of school work in which they invest themselves. If students are required to engage in tasks that are not well-matched to their individual characteristics and interest, ability level, background knowledge then ALT is minimised because substantive engagement is likely to be low.

Recommendations

Based on the findings of this study, the following recommendations are made to improve chemistry students' learning styles and enhance the academic learning time:

- (i) learning styles of each chemistry student should be taken into consideration when teachers are planning their mode of instructions
- (ii) teachers should structure lessons to match learning tasks of the individual student in order to maximise chemistry students' academic success and productivity
- (iii) chemistry teaching should be student-centred in which they are fully engaged and active in both the classroom and practical activities
- (iv) education policy makers should look into the academic time schedule for teaching chemistry to ensure its adequacy for chemistry curriculum completion and assessment
- (v) school administrators should monitor the instructional time of chemistry teachers to ascertain their regular attendance, punctuality and instructional engagement in class.

References

- Apara, S.A. (2005). *Effects of Programmed Instruction and Peer-Tutoring Instructional Strategies on Students' Learning Outcomes in Secondary School Social Studies*. ICEE, Institute of Education : University of Ibadan.
- Berliner, D. (1991). What's all the fuss about instructional time? In : M. Ben-Peretz & R. Bromme (Eds.). *The Nature of Time in Schools: Theoretical Concepts, Practitioner Perceptions*. New York: Teachers College Press. Retrieved March 2006, from <http://courses.ed.asu.edu/berliner/readings/fuss/fuss.htm>
- Bowen, C.W. (2000). A Qualitative Literature Review of Cooperative Learning Effects on High School and College Chemistry Achievement. *Journal of Chemical Education*, 77(1): 116—119.
- Oyinbode, E.R.I. (1988). *Personality Correlates of Item Response Changing Behaviour in Two Objective Test Formats*. ICEE, Institute of Education. University of Ibadan.
- Caldwell, J., Huitt, W., & Berliner V. (1981). *Leader's Guide for Student Engaged Time*. Philadelphia. Research for Better Schools, Inc.
- Claxton, G. (2006). *Building Learning Power*. Bristol: TLO Ltd.
- Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). *Learning Styles and Pedagogy in Post-16 Learning. A Systematic and Critical Review*. London: Learning and Skills Research Centre.
- Dunn, R., Dunn, K., & Price, G.E. (1984). *Learning Style Inventory*. Lawrence, KS, USA: Price Systems.
- Fafunwa, A.B. (1987). *New Perspective in African Education*. Lagos: Macmillan (Nigeria) Publishers.
- Felder, R.M. (2010). Are Learning Styles invalid? (Hint: No). *On-Course*

Newsletter. Retrieved April, 2012 from
<http://www.oncourseworkshop.com/Leaming046.htm>

- Feldel, R.M. & Brent, R.E. (2005). Understanding Student Differences. *Journal of Engineering Education*, 94(1), 57-72.
- Feldel, R.M. & Spurlin, J. (2005). Applications, Reliability, and Validity of the Index of Learning Styles. *International Journal of Engineering Education*, 96(4), 309-319.
- Fisher, C.W.,& Berliner, D.C. (1985). *Perspectives on Instructional Time*. New York: Longman.
- Fisher, C., Filby, N., Marliave, R., Cahen, L., Dishaw, M., Moore, J., & Berliner, D. (1978). *Teaching behaviors: Academic Learning Time and Student Achievement: Final Report of Phase III-B, Beginning Teacher Evaluation Study*. San Francisco: Far West Laboratory for Educational Research and Development.
- Fleming, N.D., & Mills, C.E. (1992). Not Another Inventory, Rather a Catalyst for Reflection to Improve the Academy, 11,137.
- Gettinger, M. (1991). Learning Time and Retention Differences between Nondisabled Students and Students with Learning Disabilities. *Learning Disability Quarterly*, 14,179-189.
- Grasha, A. (1996). *Teachingwith Style*. Pittsburg, PA: Alliance Publishers.
- Greenfield, S. (2000). *The Private Life of the Brain*. London: John Willey & Sons Inc.
- Greenwood, C.R., Terry, B., & Walker, D. (1994). Confirming a Performance-based Instructional Model. *School Psychology Review*, 23,652-668.
- Hewson, P.W., Beeth. M.E. & Thorley, N.R. (1998). Teaching for Conceptual Change. In : B.J. Fraser. *International Handbook of Science Education. The Science Teacher*, 58.6:52 - 57.

- Hollywood, T.M., Salisbury, C.L., Rainforth, B., & Palombaro (1995). Use of instructional Time in Classrooms Serving Students with and without Severe Disabilities. *Exceptional Children*, 61,242-252.
- Honey, P. & Mumford, A. (2006). *The Learning Styles Questionnaire, 80-item Version*. Maidenhead, UK: Peter Honey Publications.
- Huitt, W., Caldwell, J., Traver, P., & Graeber, A. (1981). Collecting Information on Student Engaged Time. In: D. Helms, A. Graeber, J. Caldwell, & W. Huitt (Eds.). *Leader's Guide for Student Engaged Time*. Philadelphia: Research for Better Schools, Inc.
- Igwe, I.O. (2002). *Relative Effect of Framing and Team -Assisted Instructional Strategies on Students Learning Outcomes in Selected Chemistry Concepts in Parts of Ibadan*. ICEE, Institute of Education. University of Ibadan.
- Ipaye, Babatunde (2005). *Study Guides and Learning Strategies in Open and Distance Learning*. Lagos: Chayoobi Publishers.
- Kolb, D.A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice-Hall.
- Madukwe, E.A. (1987). *Effect of Supplement Mastery Learning Strategy with Preparatory Review on the Students' Achievement in Chemistry*. ICEE, Institute of Education. University of Ibadan.
- Massa, L.J., & Mayer, R.E. (2006). Testing the ATI Hypothesis: Should Multimedia Instruction Accommodate Verbaliser-visualiser Cognitive Style. *Learning and Individual Differences*, 16,321-336.
- Ogunleye, B.O. (2002). Evaluation of the Environmental Aspect of the Senior Secondary School Chemistry Curriculum in Ibadan, Nigeria. An Unpublished Ph. D. Dissertation. University of Ibadan. Ibadan.
- Osokoya, M.M. (1998). Some Determinants of Secondary School Students Academic Achievement in Chemistry in Oyo State. An Unpublished Ph. D. Dissertation. University of Ibadan. Ibadan.

- Pashler, H., McDaniel, M., Rohrer, D. & Bjork, R (2009). Learning Styles: Concepts and Evidence. *Psychological Science in the Public Interest*, 9(3), 105-119.
- Raimi, S.M. (2002). Problem Solving Technique and Laboratory Skills as Supplement to Laboratory Teaching in Senior Secondary School Students Learning Outcomes of Volumetric Analysis. An Unpublished Ph. D. Thesis. University of Ibadan. Ibadan.
- Silver, H.F., Strong, R.W., & Perini, M.J. (1997). Integrating Learning Styles and Multiple Intelligences. *Educational Leadership*, 55(1), 22-27.
- Sprenger, M. (2003). *Differentiation through Learning Styles and Memory*. Thousand Oaks, CA: Corwin Press.
- Spoon, J.C., & Schell, J.W. (1998). Aligning Student Learning Styles with Instructor Teaching Styles. *Journal of Industrial Teacher Education*, 35,41-56.
- Stahl, S.A. (2002). Different Strokes for different Folks? In: L. Abbeduto (Ed.). *Taking Sides: Clashing on Controversial Issues in Educational Psychology*. Guilford, CT, USA: McGraw-Hill.
- Stallings, J., & Kaskowitz, D. (1974). *Follow through classroom observation evaluation, 1972-1973*. Menlo Park, CA: Stanford Research Institute.
- Treagust, D., Duit, R. & Nieswandt, M. (2000). *Sources of Students' Difficulties in Learning Chemistry*. New York. Teacher College Press.
- Uzuntiryaki, E. (2007). Learning Styles and High School Students' Chemistry Achievement. *Science Education International*, 25-37.

