Chapter Eight

Navigating the Maze of Students' Underachievement in Science: Does Science Education Research Provide a Road Map?

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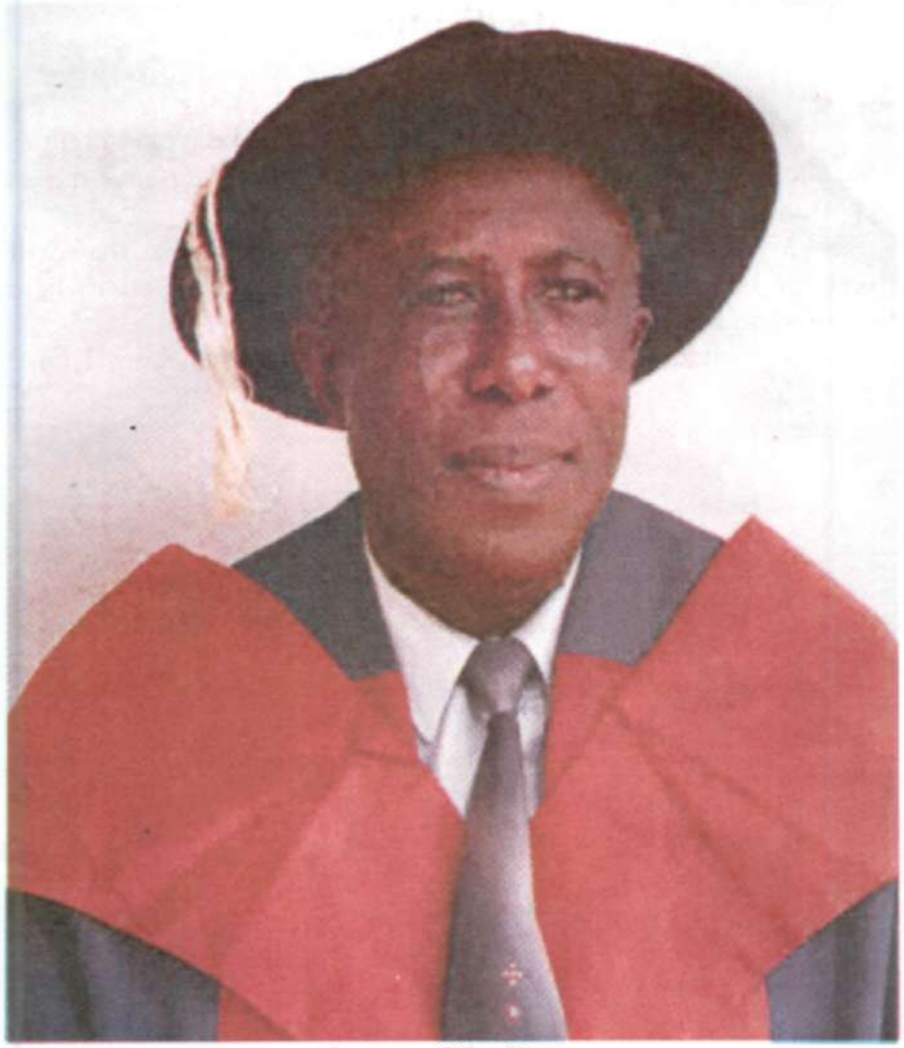

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Dedication

To:

The memory of my late parents who toiled day and night to send me to school and stood by me all the way. They gave me an opportunity they themselves never had.

My children and grand children in the hope that they will excel far beyond whatever achievements it pleased God to here bestowed on me.

My students who taught me a lot and from whom I have learnt a lot.

Acknowledgement

To God be the glory great things He had done. My profound gratitude and appreciation go, first and foremost, to the Almighty God maker of all things, both seen and unseen. He has been the one who has provided me solace, support and sustenance. He has stood with me and by me in thick and thin, rain and sunshine and at every turn and bend. To Him be honour, glory and adoration forever and ever more.

My thanks go to my late parents who dedicated themselves and all they had to send me to school and saw me through my school days. Though they have gone the way of all flesh, but their sweet memory remains indelible in my mind and consciousness. I pray for them, as always that their soul will continue to rest in perfect peace.

I want to thank the successive Vice Chancellors especially the incumbent, Prof. Mustapha Abdullahi and University management since 1976 that I joined Ahmadu Bello University as staff for opportunities I have had to study, teach and research. I wish also, in the same vein to thank the university organized lecture committee for giving me this unique opportunity, to give account of my academic and professional endeavours and stewardship.

I do thank, most sincerely the Dean of my Faculty, Professor Tijjani Abubakar for the immense logistic support he gave me in the course of preparing for this lecture. I found him extremely friendly and understanding. I also thank my Head of Department Dr. Mamman Musa for his encouragement and understanding. I also extend my thanks to my colleagues and friends in Faculty of Education, and especially in the Department of Science Education, most of whom had been my former postgraduate students. We have lived and worked together as brothers and sisters. That experience had been most encouraging and rewarding.

At an occasion like this, I remember with nostalgia and profound gratitude to my teachers at all levels of my educational pursuit – primary to university. May God bless them all, and may the soul of those amongst them that have passed on rest in perfect peace (Amen).

I remember with profound appreciation, individuals who have played key roles along my life's journey. Though too many to mention exhaustively a few of them are: Mr. D. J. K Farrar, my principal in secondary school, Okene who offered and paid my school fees just before and after I lost my father in 1971. Mr and Mrs Alvan Whitehead who cared for me and my family while I was studying as a PhD student in England. Prof. Adamu Baikie who gave me my first vacation job in 1973 as an undergraduate student. Engr. and Mrs. S. O. Akaiku who gave me enormous support when I was a secondary school student. To them I say thank you very much.

And to my numerous and hardworking students, I don't know where to begin from and where to end, but let it be known that I love you all and I do sincerely appreciate you all. I wish to put some emphasis on my postgraduate students both present and past, most of whom are here and most of whom have become my very close and personal friends. I learnt a lot from you too. God bless you all. And to all other great ABU students here, I thank you for keeping the flag of ABU flying and God bless you too,

I specially thank all the members of my family who have shown me love, care and kindness all along. I appreciate you. And to my relations: Mr. Reuben Jigah, Ali Bello, Dr. Edwin Konto and others. I appreciate our (Bassan-Nge) traditional ruler in Zaria and environs Chief Daniel Menegbe and his wife, Rt Revd (Prof) C. S. S. Bello, Bishop of Zaria Dioceses my brother and friend and his wife. I thank you and I love you all.

My sincere thanks also go to Mal. Saidu Shehu Adamu who typed the manuscript and the corrected drafts at every stage. I found him most efficient and professional. And to the audience, I thank and appreciate you very much for coming for without you this occasion could not have taken place. Do accept my gratitude and God bless you richly.

Thank you all for your attention and patience.

God Bless!

1.1 Preamble

I consider it a great honour and singular privilege to stand before this distinguished body of academic community to deliver this inaugural lecture. It is the 3rd from Faculty of Education, 1st from the department of science education and first to be delivered by a Professor in the field of science education. Traditionally, inaugural lectures are seen as ceremonial occasions during which the academic community of universities formally induct professors into exalted academic and professional office. But in more recent times, this emphasis tended to have broadened to include provision for an opportunity for the professor to pinpoint, analyze and hopefully shed light on the way forward regarding burning issues within the domain of the field in which he/she is a practitioner. For me, this translates amongst other things to the following:

a) To shed light into the academic and research enterprise in which I have had the privilege to practice for, at least, the last three decades.

b) To pinpoint, analyze, discuss and proffer functional recommendations to issues of academic and public interest that are germane to holistic and national development.

c) To bear my mind and consequently expound to this august assembly, and eventually the larger world, my thoughts, academic endeavours and contributions to the field of science education alongside the inherent implications and applications.

1.2 My Journey into the Teaching Profession

Before I attempt to focus attention on the kernel of the lecture, permit me Mr. Chairman, to open a little window, for the purpose of this occasion, to afford a glimpse of my adventure into the teaching profession. It was never in my thought, nor was it my intention least my plan to be a teacher, let alone a professor in the field of teacher – education. I had wanted to, and indeed planned to be a quality – control chemist. Thus when I was admitted, as an undergraduate student into Ahmadu Bello University in 1972, I registered to read Biochemistry. And to put me in a good stead for realizing my dream of becoming a quality-control chemist, I changed in part II of my programme from B.Sc Biochemistry to B.Sc Chemistry. At least, so I thought. I remember, for instance that in my parts II and III of the programme, some of the chemistry laboratory attendants, especially during our practical classes would throw jokes at me and say, "the way we see you, you may become a teacher…." I usually got angry at such jokes and wished I could throw some acid at them in response! Little did I know that they were being prophetic as you can see to day.

The turning point was during my national youth service which started at the Jimeta secondary school, Yola in 1975, but later in the service year; moved to Government Secondary School (GSS), Hong, both of which are in the present Adamawa State of Nigeria. It was while I was in Hong that the form III chemistry class assigned to me to teach made so much "noise" about the Youth Corper called Mr. Shaibu whom, according to them, simplified for them the learning of chemistry (which they had earlier considered impossible to understand) thereby making it easy and interesting for them to learn. The students formed what I might to-day describe as a "campaign group" who went to the Principal (Mr. Wilbeforce Juta) to ensure that he retained me in the school as a chemistry teacher. After my completion of the Youth service. Indeed, Mr. Juta did all he could to retain me in GSS Hong, first by securing teaching appointment and car loan from the Ministry of education, even before completion of my service period.

It was within this context that the thought began to flow across my mind, for the first time, to consider teaching as a profession since I probably might prove to be an effective one after all. This was then the scenario in which the seed of becoming a teacher was sown in my mind. The seed germinated, gradually grew and eventually choked out my initial thought and dream of becoming a quality – control chemist. It was with this background that I eventually sought employment into Ahmadu Bello University on completion of my Youth Service. I was offered employment as Graduate Assistant after I was considered successful at the interview scheduled for the purpose. I assumed duty at the defunct School of Basic Studies (SBS) in 1976. It was within the years I was in SBS that I gradually moved my career from the field of chemistry to that of science education. And when SBS folded up in 1988, I naturally transferred my services to the science education section of the then department of education. This has been the very brief summary of my career and professional journey into the teaching profession and specifically into the field of science teacher-education.

1.3 The Structure of my Lecture

This inaugural lecture is organized around the following themes or topics:

1.0 Introduction
2.0 Description of basic concepts: Science, Education and Science Education.
3.0 The maze of students' underachievement in science: Fact of Fiction?
4.0 Does science education research provide a road map to show the way out of the maze?
5.0 Discernible Road maps from Science Education Research Studies.
6.0 Conclusion and Recommendations
7.0 References
8.0 Acknowledgment.

2.0 Science Education: Meaning and Scope

In considering this segment of the lecture it is appropriate, to first focus on each part of the major concepts before we attempt to view them holistically vis-à-vis their relevance to the topic of the lecture. Thus, we should briefly consider; Science, Education and Science Education.

2.1 Science:

Science has been defined by many scholars and science philosophers too many to mention exhaustively. A few examples here will probably suffice. Aliyu (1982) defined science form three perspectives. To a scientist, it is an intellectual activity through which man seeks to understand nature. To the science teacher, science comprise organized and systematized body of knowledge in form of concepts theories and laws. To a layman, science is more-or-less everything, in form of machinery and gadgets that have made life more comfortable for him. He noted that none of these views by themselves represent a holistic definition of science. He thus concluded by giving what he considered a more broad-based definition which regards science as activities that culminate into testable, falsifiable and verifiable body of knowledge. Bassey (2005) observed that science is both a system of knowledge and the methodological process by which new knowledge is unravelled, thus ensuring the dynamics and growth of science. Furthermore, he conceives of science as a tool for probing and exploring the unknown. Shaibu (1992) defined science as a complex human activity that leads to the production of a body of universe statements called laws and theories which serve to explain the observable behaviour of the universe or some aspects of it.

Science can then be viewed as both an intellectual tool and an organized body of knowledge which carries with it a characteristic way of thinking, attitude, disposition and action. Infact it can be said that there is a scientific way of thinking, a scientific attitude and a scientific way of behaviour and action. There is, therefore a sense in which science can be seen as a culture which influences and even moulds the attitude and behaviour of individuals, communities and indeed nations exposed to that culture. In summary, therefore, science can be viewed as a human enterprise conceived by human mind to enable man explore or investigate, in a controlled and systematic manner his environment with a view to understanding it and thus manage and control it to his advantage ultimately. Indeed, this broad definition of science represents a major philosophical basis for contemporary global emphasis on teaching/learning science to attain scientific literacy for all.

2.2 Education

"Education is a house-hold word which, as we probably know, comes from the Latin word "Educare" which in its literary sense means to lead or to rear. Thus education refers to the process of dissemination, transmission and imparting of ideas, facts, information, culture, social ethos and ethics through a designed process of communication. It is a process of giving, exchanging or sharing of facts, information, ideas, skills, behaviour and attitudes that ultimately leads to noticeable, desirable and enduring behavioural changes in the individual (Gagne, 1986). Therefore, education can be viewed as a complex process of leading or raising individuals along life-long learning experiences. As a life-long process, it is aimed at preparation for life and indeed living. Of course, life or living means much more than mere existence. Fundamentally it consists in leading a happy, productive and fruitful life. Thus, we can qualify our earlier definition of education to give a more value-oriented one, namely that education is preparation for a happy, productive and fruitful life. This kind of "education for good life" should, in my opinion, focus on and emphasize the following imperatives amongst others, namely social responsibility, job/vocational re-orientation for self-reliance, political and social responsibility and regeneration that breed fair play, justice, equity, responsible citizenship, respect for the dignity, views and values of fellow human beings and commitment to moral and spiritual issues.

From the foregoing, I consider that education for good life as I have so far described constitute a veritable parameter for happy, productive and fruitful living of individuals, communities and nations, indeed developing nations such as ours-Nigeria. I also consider that we, in all probability, now have a functional barometer, from our description, by which we can assess ourselves and perhaps others as to whether or not we, as individuals, communities and a nation (Nigeria), have acquired or in the process of acquiring "education for the good life" I wish to conclude this segment by indicating that our description of the concept of education so far in this lecture provide us with a reliable and veritable instrument by which we can evaluate whether we are passing on to the present generation just any kind of stuff in the name of education or whether we are consciously and deliberately inculcating into them "Education for good life". This may probably be considered as food for thought.

2.3 Science Education

2.3.1 Definition

Science Education can be conceptualized as an integrated field of study comprising such knowledge domains as natural sciences, technology, philosophy, psychology, sociology and history. Basically it is a relevant combination of science, technology, educational theory and practice. According to Ahiakwo (2006), science education cuts across many fields of human endeavour namely, the natural sciences, sociology, philosophy, history, e.t.c He further explained that science education can also be described as "Education in science". Furthermore, Okeke (2007) described science education as an integrated field of study which considers both the subject matter of science disciplines such as biology, chemistry physics etc. alongside the processes involved in the teaching and learning of science. According to her, there actually exists a thin line between the concepts of science education and education in science. She posited that while the latter basically refers to the understanding and application of scientific concepts and principles, the former deals with the acquisition and development of processes and procedures required in helping others acquire necessary scientific and technological knowledge and the skills required for everyday living in a scientific and technological society.

2.3.2 Perspectives of Science Education

Science education can therefore be viewed from a number of stand-points which include the following perspectives.

a) **Perspective of Curriculum and instruction:** which deals with theories, principles and practices of curriculum design and implementation.
b) **Philosophical perspective:** This considers science education to have idealistic or pragmatic characteristics.
c) **Perspective of Pedagogy:** This involves all the processes and procedures for teaching and learning of science in the classroom situation. This lecture is predominantly located within this perspective.
d) **Perspective of the Society:** This perspective moves science education beyond the classroom environment to the larger society. This essentially involves the application of scientific knowledge for the improvement of the living conditions of humankind.

Thus, science education has a multi-dimentional character, relatively extensive and complex in nature and also of high utilitarian value and importance. Shaibu (1993), and Shaibu (2002) among others, have in many ways described the all encompassing nature of science education. Operationally therefore, science education can be considered to largely reside at two major levels, namely, at the level of educational institutions and at the level of the larger society. In all cases, it involves a dynamic and interactive equilibrium among humans, environment and materials.

2.3.3 Scope of Science Education

The scope of science education can largely be described by its core aims and goals. Oriafor (1997) listed a number of the aims and objectives of science education. These include the following:

a) Relevance and importance of the domains of educational endeavour which covers the cognitive, physco-motor and affective.
b) To inculcate and facilitate critical and flexible thinking process and familiarization with the spirit of science.
c) To prepare individuals for vocations in science.
d) To serve as springboard for generating empirical evidence for rational judgment on socio-political and economic issues that are germane to national growth and development.

2.3.4 Delineation

Mr. Chairman, this lecture is focused on the pedagogic perspective earlier highlight and this is in alignment with the first aim of science education listed above namely, the domains of educational endeavours covering the cognitive, psychomotor and affective aspects of knowledge, with particular emphasis on the cognitive domain. The lecture is furthermore focused on the secondary level of education. This is primarily because most of my research interest and efforts have been at this level of education. Additionally, most of the studies herein reported, are for reasons of specialization, in science education studies as they relate to teaching and learning of chemistry in particular.

3.0 The Maze of Students' Academic Underachievement in Science: Fact or Fiction?

Background

The Nigerian educational system has passed through many changes and curricular invocations in the last few decades. These include, for example, introduction of the Universal Primary Education (UPE) in 1976. This brought about unprecedented enrolment of pupils into primary schools. Okebukola (1984) observed that the liberalization of secondary school education, beginning especially from 1979 sharply increased student's enrolment into this level of education.

Secondly and equally importantly, the introduction of the Universal Basic Education (UBE) in September 1999 further prompted high level of pupils enrolment into the secondary schools across the country. These fundamental changes brought along with them phenomenal challenges of resources, logistics and implementations which many scholars and educationists regard as major contributor to the problem of students' academic underachievement which has aroused nagging national problem and concern. Bonnie (2003) for example, observed that inadequate planning of the UPE and UBE resulted in an astronomical increase in pupils' enrolment into the primary schools and cumulatively into the secondary schools with passage of time. Furthermore, Aliyu (1999) reported that poor planning and implementation led to inadequate and in some cases, lack of instructional materials, overcrowded classrooms, poor physical facilities, unsuitable psycho-social environment for learning in the schools. The overall effects of these ultimately resulted, willy-nilly, into unquantifiable stress and strain in academic activities in the schools. And these consequently made significant contributions to students' poor academic achievement which generally manifest as high level of failures in secondary school examinations conducted by West African Examination Council (WAEC) and National Examination Council (NECO). From the foregoing, the issue of students' under achievement in science and the factors that prompt and sustain them have been both historical and systemic. It will be a reasonable scientific conjecture to suggest that if the Government of Nigeria at the various levels have had the political and leadership will to tackle the antecedent problems that brought about students' academic underachievement alongside provision of appropriate public psychological orientation, the Nigerian educational system would have been put on the right track in the same manner that were done in developed and developing countries like India, Malaysia, Japan, etc.

Many science education scholars and curriculum specialists including this lecturer, have shown a great deal of interest and concern about the high level of students' underachievement in science. They further showed interest in finding out such factors that might be responsible for or contribute to the observed consistent pattern of low students' achievement which is detrimental to education generally and the desired move towards scientific literacy for all and technological breakthrough for sustainable national development. Some of the factors identified include the following:

i. Large class size-Ivowi etal (1992);

ii. Overload curriculum – Adeyegbe (1993)
iii. Use of inappropriate instructional strategies – Ajeyalemi (1983)
iv. Gender-related factors – Shaibu and Mari (1997)
v. Quality of pre and in-service teacher training. Shaibu and Usman (2002)
vi. Motivational support by parents and teachers. Shaibu and Iroegbu (2002)
vii. Lack of teaching and learning materials/facilities. Awolade (2005).

In an attempt to further provide emperical evidence to highlight the fact that students underachievement in science is a consistent reality that is living with us, I now refer you to the following statistics showing the profile of students' academic achievement in the Senior Secondary School Certificate Examination conducted by the West African Examination Council (WAEC) for the period of time covering 2005-2012 in science subjects as shown in Tables 3.1-3.6. Tables 3.1-3.3 show the profile of the national results covering the whole country while Tables 3.4-3.6 cover Kaduna State alone for the same period of time.

Statistics of Candidates Performance in Biology, Chemistry and Physics in the May June 2005-2012 WASSCE in Nigeria

Table 3.1: Students' Academic Achievement in Biology, Nation Wide (2005-2012)

Year	Total No of Cands that Entered	Total No of Cands that Sat	No Absent	No of Cands With C6 and Above	% of Cands with C6 and above	Letter Grade
2005	1072607	1051557 98.04	21050 1.96	375850	35.74	F
2006	1162046	1137131 97.86	24865 2.14	559854	49.23	D
2007	1261971	1238163 98.11	23808 1.89	4132211	33.37	F
2008	1285048	1259965 98.05	25083 1.95	427644	33.94	F
2009	1364655	1340206 98.21	24449 1.79	383112	28.58	F
2010	1325408	1300418 98.11	24990 1.89	645633	49.64	D

2011	1532770	1505199 98.20	27571 1.8	579432	38.49	F
2012	1687788	1646150 97.53	41638 2.47	587044	35.66	F

Source: WAEC Office, Lagos.
Note: The letter grades were added by the Author.

Table 3.2: Students' Academic Achievement in Chemistry Nationwide (2005-2012)

Year	Total No of Cands that Entered	Total No of Cands that Sat	No Absent	No of Cands with C6 and Above	% Of Cands With C6 and Above	Letter Grade
2005	357658	349936 97.84	7722 2.16	178274	50.94	C
2006	389462	380104 97.60	9358 2.40	170670	44.90	E
2007	432230	422681 97.79	9549 2.21	194284	45.96	D
2008	428513	418423 97.65	10090 2.35	185949	44.44	E
2009	478235	468546 97.97	9689 2.03	204725	43.69	E
2010	477573	465643 97.50	11930 2.5	236059	50.69	C
2011	575757	565692 98.25	10065 1.75	280250	49.54	D
2012	641622	627302 97.77	14320 2.23	270570	43.13	E

Source: WAEC Office, Lagos
Note: The letter grades were added by the author

Table 3.3: Students' Academic Achievement in Physics Nationwide (2005-2012)

Year	Total No of Cands that Entered	Total No of Cands that Sat	No Absent	No of Cands with C6 and Above	% of Cands with C6 and Above	Letter Grade
2005	351778	344411 97.91	7367 2.09	142943	41.50	E
2006	384477	375824 97.94	8653 2.25	218199	58.05	C

2007	427398	418593 97 94	8805 2.06	180797	43.19	E
2008	424893	415113 97.70	9780 2.30	200345	48.26	D
2009	474887	465636 98.05	9251 1.95	222722	47.83	D
2010	475414	463755 97.55	11659 2.45	237756	51.27	C
2011	573043	563161 98.28	9882 1.72	360096	63.94	B
2012	638834	624658 97.78	14176 2.22	429415	68.74	B

Source: WAEC Office, Lagos
Note: The letter grades were added by the author

Table 3.4: Students' Academic Achievement in Biology Kaduna State only (2005-2012)

Year	Total No of Cands that Entered	Total No of Cands that Sat	No Absent	No of Cands With C6 And Above	% Of Cands with C6 and Above	Letter Grade
2005	38330	37594 98.08	736 1.92	11340	30.16	F
2006	45312	44331 97.84	981 2.16	18340	41.37	E
2007	52699	51539 97.80	1160 2.20	15387	29.85	F
2008	55015	53946 98.06	1069 1.94	17378	32.21	F
2009	55776	54729 98.12	1047 1.88	16765	30.63	F
2010	64379	63361 98.42	1018 1.58	33015	52.10	C
2011	79885	78616 98.41	1269 1.59	32474	41.31	E
2012	93360	91646 98.16	1714 1.83	33549	36.60	F

Source: WAEC Office, Lagos
Note: The letter grades were added by the author

Table 3.5: Students' Academic Achievement in Chemistry Kaduna State only (2005-2012)

Year	Total No of Cands that Entered	Total No of Cands that Sat	No Absent	No of Cands with C6 and Above	% of Cands with C6 and Above	Letter Grade
2005	12645	12426 98.27	219 1.73	5571	44.83	E
2006	15023	14734 98.08	289 1.92	6869	46.62	D
2007	17735	17420 98.22	315 1.78	7811	44.84	E
2008	18386	18039 98.11	347 1.89	6493	35.99	F
2009	19461	19129 98.29	332 1.72	9522	49.77	D
2010	23725	23190 97.74	535 2.26	14188	61.18	B
2011	31414	30933 98.74	481 1.53	17752	57.38	D
2012	37875	37347 98.61	528 1.39	17062	45.68	D

Source: WAEC Office, Lagos

Note: The letter grades were added by the author

Table 3.6: Students' Academic Achievement in Physics Kaduna State only (2005-2012)

Year	Total No of Candidates that Entered	Total No: of Candidates that Sat	No: Absent	No: of Candidates With C6 and Above	% of Candidates with C6 and Above	Letter Grade
2005	12496	12285 98.31	211 1.69	4437	36.11	F
2006	14883	14618 98.22	265 1.78	9070	62.04	B
2007	17593	17323 98.47	270 1.53	5899	34.05	F
2008	18296	17954 98.13	342 1.87	8122	45.23	D
2009	19461	19129 98.29	332 1.71	9522	49.77	C
2010	23621	23116 97.86	505 2.14	15077	65.22	B
2011	31325	30810 98.36	515 1.64	12902	41.87	E
2012	37772	37257 98.64	515 1.36	27460	73.70	A

4.0 Does Science Education Research Provide a Road Map to Show the Way Out of the Maze?

4.1 Introduction

In choosing the topic of this lecture, I have used two metaphoric expressions "Maze and Road Map". The first i.e. "Maze" is purposively used to describe the phenomenon of students' underachievement in science. This is because the situation of underachievement, its existence and the factors that both prompt and support its prevalence are complex, complicated, pervasive and interwoven. The second, namely "Road map" is used to indicate that there have been a great deal of research efforts including those by this lecturer that are carried out towards ameliorating the nagging problem of students' underachievement in science.

No single lecture or presentation can claim to deal with the issues comprehensively or exhaustively. I have thus chosen some categories of factors that have been seen to play significant roles in arousing and sustaining students' underachievement in science and the research efforts that attempt to provide the way forward in the circumstances. These are as follows:

1. Teacher and student factors
2. Gender – related factors
3. Parents' and Teachers' factors
4. Curriculum-related factors
5. Instructional Strategy-related factors.

4.2 My Contributions to Research Efforts that Attempt to Show the Way Out of the Maze

4.2.1 Teacher and Student Factors

The teacher and the central role that he/she plays in the education industry is pertinently driven home by the declaration contained in a position paper (NERDC, 1980) which observed interalia that:

> ..... teachers are the main determinants of quality in education. If they are apathetic, uncommitted, uninspired, lazy, unmotivated, anti-social, the whole nation is

doomed. If they are ignorant and impart wrong knowledge, they become not only useless, but dangerous. The kind of teachers trained and posted to schools may well determine what the next generation may be.

Topics Difficulty in Chemistry: Students' and Teachers' Perception

In this study, (Shaibu, 1988) investigated the level of conceptual difficulty at which science students perceive/estimate chemistry topics presented to them. The same topics were also given to their teachers to estimate their respective conceptual difficulty from the "Eye" of their students.

The sample comprised 150 chemistry students of the defunct School of Basic Studies, Ahmadu Bello University. Average age of the sample, which was obtained by simple random selection was 18 years. Data were collected using two instruments, namely students' and teachers' questionnaire each with reliability coefficient of r = 0.75 and 0.78 respectively.

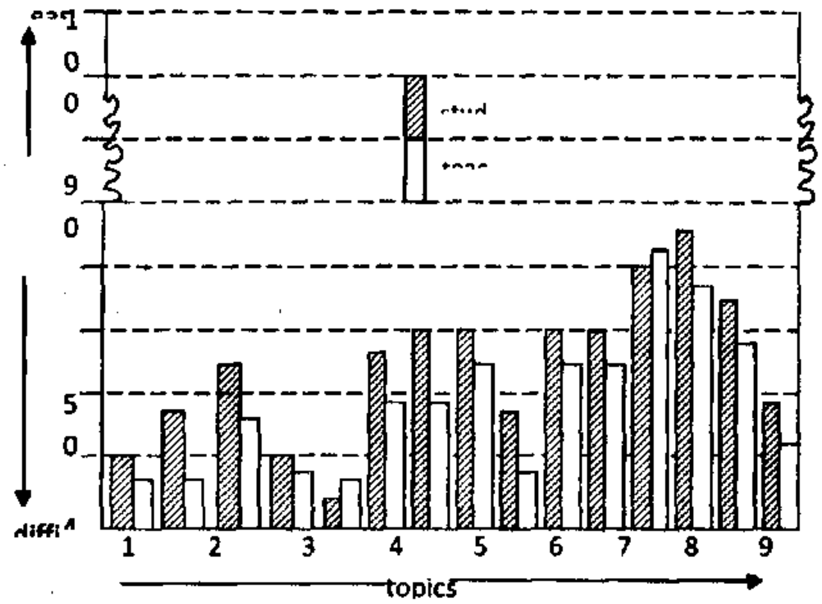
The results are shown in Tables 4.1(a) and 4.2(b).

Table 4.1(a) Distribution of Students and Teachers' Responses in % Teachers Responses in Parenthesis.

S/N	Topics	Difficult	Moderate	Easy
1	Names of organic compounds (nomenclature): generally, the IUPAC system	10.0 (4.7)	28.0 (24.6)	62.0 (70.7)
2	Structure of molecules: arrangement of atoms in molecules leading to the concept of structural isomerism	14.6 (4.7)	45.4 (41.3)	40.0 (54.0)
3	Conformations of organic molecules: rotation about single C-C bonds, eg eclipsed and staggered conformation is ethane	25.3 (18.8)	30.4 (34.9)	44.3 (46.3)
4	Functional groups: recognition and naming of functional groups, eg >C = O carbonyl group, NH_2 amino group	10.7 (9.4)	29.0 (24.3)	60.3 (66.3)
5	Atomic structure: electronic configuration of atoms underlying an understanding of organic reactions	5.3 (9.4)	40.7 (36.3)	54.0 (54.3)

6	Symbolisms, eg resonance, curved arrows, partial and full charges	25.3 (18.8)	39.3 (41.3)	35.4 (40.0)
7	Bonding in organic molecules: electronic concept of covalent bonding, (Lewis theory)	30.0 (18.8)	24.8 (37.0)	45.2 (44.2)
8	Stereochemistry, eg hexagonal, triangular and planar molecules-	30.0 (23.5)	40.0 (38.3)	30.0 (36.2)
9	Rules and principles, eg Markownikov's rule transition state theory	16.0 (9.4)	37.4 (28.9)	46.6 (60.7)
10	Reaction of organic compounds, eg reactions of alcohols, hydrocarbons, amines, esters, etc	30.0 (23.5)	48.0 (48.9)	22.0 (27.6)
11	Named organic reactions, eg Wurtz reaction, Cannizzaro reaction, Hofmann reaction	30.0 (23.5)	28.3 (31.0)	41.7 (45.5)
12	Reaction mechanisms; description of bond-breaking and bond-making processes involved in organic reactions	40.0 (42.3)	42.0 (39.4)	18.0 (18.3)
13	Organic synthetic pathways interconversion of organic compounds, eg oxidation of alcohols to carboxylic acids; reduction of carbonyl group to hydrocarbons	45.3 (37.6)	44.4 (45.0)	10.3 (17.4)
14	Energetics of organic reactions; explanation of energy profile of organic reactions, eg the concepts of free energy change (ΔG) enthaphy change (ΔH), chemical equilibria (K)	35.2 (28.5)	46.0 (51.9)	18.8 (19.6)
15	Calculations involving organic compounds, eg calculating empirical and molecular formulae from numerical data	20.0 (14.3)	45.0 (35.9)	35.0 (49.8)

Table 4.1(b): Barchart Distribution of Students' and Teachers' Responses



The results show, among other things that:

(i) The students found more than half of the topics conceptual difficult (Table 4.1a)

(ii) The teachers tend to consistently underestimate the conceptual difficulties experienced by their students (Table 4.1b).

(iii) The teachers tend to estimate the level of conceptual difficulties of the topics from a teaching, rather than from a learning perspective.

A Chi-square test of the response distribution ($\chi2$ = 5.42) showed that the students'/teachers' perception disparity is statistically significant ($P \leq 0.05$).

Educational Implications

A major implication of these findings for efficient teaching and learning science and to mitigate students' underachievement in science is that science teachers should develop the capability and empathy to operate at similar or possibly the same conceptual frequency with their students. Earlier studies, for example, Arzi et al

(1984), and Bojezuk (1982) also showed that teachers in non – African settings also have similar tendencies of not having enough grasp of the conceptual difficulties that their students experience in the process of teaching and learning science.

Achievement of Senior Secondary School Students in Savoy's Concepts as a Correlate of their Achievement in Balancing Chemical Equations

Chemical equations can be described as symbolic and quantitative representations of the changes that occur in the process of chemical reactions based on the principle that matter is neither created nor destroyed during chemical reactions. For example, the chemical equation: $xA+yB \rightarrow pC+qD$ shows that A and B are the reactants while C and D are the end products. Also x,y,p and q represent the relative numbers of moles of reactants and products i.e. the stoicheometric coefficients.

Studies have shown that the ability required to write chemical equations correctly is not a simple one (Suderji, 1983, Savoy, 1988). Schmidt (1984) and Bello (1988) reported that students' persistent difficulties in solving stoicheometric problems are partly associated with their inability to write chemical formulae and present chemical equations correctly.

Savoy (1988) identified 8 concepts which he considered to serve as the relevant subordinate concepts which underline the understanding of and thus the ability to balance chemical equations correctly.

They are the following:

(1) Atoms and atomicity
(2) Molecules and molecular formulae
(3) Atomic structure and bonding
(4) Valency
(5) Use of brackets
(6) Radicals
(7) Subscripts and coefficients
(8) Molar ratio

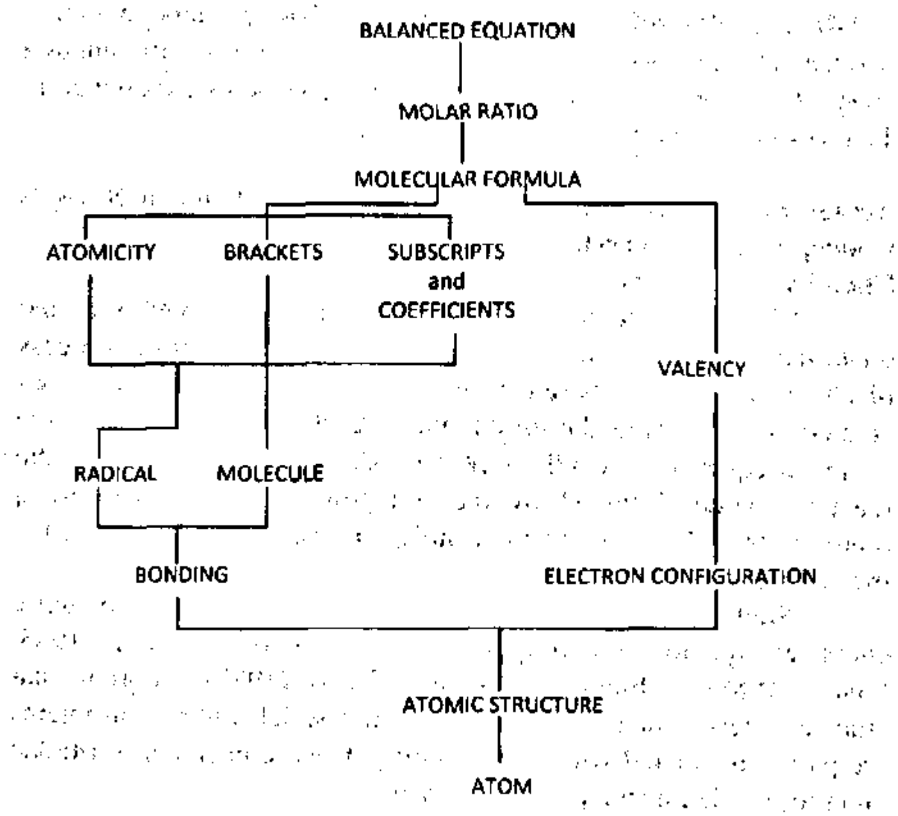


Fig 1. Savoy's Conceptual Hierarchy of Concepts needed to balance chemical equations
Source: Savoy (1988)

Shaibu (2002) investigated senior secondary school students' (SS II) achievements in Savoy's concepts and the relationship between these and their achievements in balancing chemical equations. The sample, obtained through stratified random selection was 180 comprising 115 male and 65 female students. Their average chronological age was 17 years. Two instruments were used for data collection. These were Chemical Concepts Achievement Test (CCAT and Chemical Equation Achievement Test (CEAT). While CCAT measured the students' achievement in Savoy's identified 8 concepts CEAT measured their achievements in balancing chemical equations that require the knowledge of the underlying Savoy's concepts. Using the method of split – half, adjusted by the

Spearman–Brown prophecy formula, the reability coefficient of CCAT was found to be r = 0.82 while that of CEAT was r = 0.78. CCAT was rendered in the multiple choice (MC) format, comprising 30 items while CEAT was in free – responses (F.R) format comprising a total of 17 items. The data collected were computer – analyzed using the SPSS statistical package.

Results

The results are shown in Tables 4.2(a) – 4.2(c)

Table 4.2(a) Students' Achievement in Savoy's Chemical Concepts

S/N	Chemical Concepts	N	No. of Subjects Scoring 50% or above of the maximum score	%
1	Atoms and Molecules	180	125	70.3
2	Atomicity	180	90	50.0
3	Valency	180	70	38.8
4	Subscript	180	55	30.6
5	Brackets	180	50	27.8
6	Coefficients	180	45	25.0
7	Radicals	180	35	19.3
8	Molar Ratio	180	30	16.6

Table 4.2(b) Students' Achievement in Balancing the Chemical Equations

Task	N	No. that Achieved 40% or above of the maximum score	%
Balancing of the given chemical Equation	180	18	10.0

Table 4.2(c) Correlation Between Students' Achievement in CCAT and CEAT.

Test	N	$\bar{X}$	Std Dev	r	r^2	df	p
CCAT	180	17.10	15.12	0.70*	0.49	178	0.035
CEAT	180	19.66	18.20				

***Significant** $P \leq 0.05$

Table 4.2(a) shows that out of the eight (8) concepts, it was only in two that 50% or more of the students scored up to 50% or above of the maximum score. This is indicative of students' poor understanding of Savoy's concepts which are basic and supportive of the ability to balance chemical equations.

Hines (1990) also reported that secondary school students in Botswana in South Africa had a low – level understanding of Savoy's concepts. Additionally, Schmidt (1984) found that secondary school students in Germany had conceptual difficulties with quantitative relationships in chemistry and this tended to affect their achievement in balancing chemical equations.

Table 4.2(b) shows that only 18 students (10%) were able to attain 40% or more of the maximum score given in the task of balancing chemical equations they were given in the study. This poor achievement tended to have logically derived from their poor understanding of the underlying pre-requisite Savoy's concepts as indicated in Table 4.2(a).

Table 4.2(c) shows the Pearson's Product Moment Correlation coefficient between the students' achievement in Savoy's concepts and their achievement in balancing the chemical equations. The correlation, $r = 0.70$, indicates a strong and significant relationship between understanding of Savoy's concepts and ability to balance chemical equations. Further analysis shows that the coefficient of determination $r^2 = 0.49$. This shows that 49% of the variance in the ability to balance chemical equations is accounted for by students' functional understanding of stipulated Savoy's concepts.

Findings

1. The students achieved properly in the tasks involving Savoy's chemical Concepts.
2. The students also achieved poorly in the tasks involving balancing of chemical equations.
3. There is statistically significant relationship between achievement in Savoy's chemical concepts and achievement in balancing chemical equations.
4. Forty nine percent (49%) of the variance in balancing chemical equations is accounted for by the students' functional understanding of Savoy's chemical concepts as pre-requisite knowledge base.

Implications for Education

The assumption, often made implicitly by science teachers that students will along the line of instruction develop required skills and ability to perform target tasks needs a re-examination as such assumption is not supported by this empirical finding.

Relationship between Conceptual Knowledge and Problem – Solving Proficiency of Science Students: Pedagogic Implications

The development in students of the ability to solve problems is major goal in science teaching and learning (Gagne, 1985). Two types of knowledge have been identified to underline problem – solving proficiency. These are conceptual and procedural or strategic knowledge. The former refers to knowledge of concepts, laws and theories of a particular domain presented to students in the course of instruction while the latter refers to the knowledge of general heuristics that underline the ability to solve problems using acquired conceptual knowledge. Problem–solving facility is enhanced where the *structure* and *hierarchy* of acquired conceptual knowledge is both adequate and relevant.

Shaibu, (1992) investigated the relationship between science students' possession of conceptual knowledge and their ability to utilize such to solve related problems. The theoretical framework of the study was based on Ausubel's (1968) theory of meaningful learning. A major plank of the theory is that where students do not possess requisite subsumers, they resort to learning by rote.

The structure and hierarchy of concepts (knowledge) acquired in that way is found to be, often most unhelpful for students to solve problems. The study attempted to identify the relationship if any between the conceptual knowledge of science students in Nigeria and their ability to solve problems based on such knowledge as necessary pre-requisites. Specifically the study sought to:

(a.) find out if the students possessed the relevant conceptual knowledge they were previously exposed to in their course of instruction.

(b.) find out, based on (a) above, if the students were successful in solving the related problems.

(c.) determine the relationship, if any between students' conceptual knowledge and their problem-solving proficiency.

The sample which was obtained across the country (Nigeria) through simple random sampling comprised a total of 190 science students offering chemistry as one of their three main subjects. They were selected from five schools of the defunct Schools of Basic Studies equivalent to the current SS3 secondary school students. Two tests, multiple choice and free-response formats (labeled tests A and B respectively) were used to collect data. Test B was structured on test A, meaning that test B required the knowledge of test A to solve the problems contained therein.

The maximum score obtainable in test A = 40 while the maximum score for test B = 43 which depended on the total number of operational steps required to solve the five problems. The data collected were analyzed using the MINITAB statistical package.

Results

The results are shown in Table's 4.3(a)-4.3(f).

Table 4.3(a) Some Statistical Properties of Tests A and B

Statistical Properties	**Test**	
	A	**B**
Sample size (N)	190	190
Sum of Scores ($\sum x$)	3695	1643
Mean Score (x)	19.45	8.65
Std. Dev (s)	5.05	3.95

Test A (Max Score = 40) Test B (Max Score = 43)

Tables 4.3(b) and 4.3(c). Facility Indices of Items in Tests A and B respectively

Table 4.3(b) Facility Indices of Items in Test A		**Table 4.3(c) Facility Indices of Items in Test B**	
> 0.50	20	1	0.44
> 0.30 ≤ 0.49	15	2	0.41
		3	0.52
< .30	05	4	0.70
Total	40	5	

Table 4.3 (c) Comparison Between Students' Achievement in Tests A and B

Tests	N	$\bar{X}$	Sd	SEd	t-value	df	P-value
A	190	19.45	5.09				
B	190	8.65	3.95	0.47	22.98*	378	0.02

*Significant at $P \leq 0.05$

Table 4.3 (d) Relationship Between the Students' Academic Achievement in Tests A and B

Tests	N	$\bar{X}$	Sd	r	r^2
A	190	19.45	5.05		
B	190	8.65	3.95	0.45	0.20

Table 4.3 (f) Simple Regression Analysis of the Students Scores in Tests A and B

Tests	N	$\bar{X}$	Sd	No reaching Predicted score	% reaching predicted score	Coefficient of Regression
A	190	19.45	5.05			
B	190	8.65	3.95	80.	42.0	0.35

The following comprise the major findings of the study:

(i) The students possessed most of the conceptual knowledge required to solve the problems they were confronted with.

(ii) The students were unsuccessful in solving the problems, not withstanding that they possessed the relevant conceptual knowledge.

(iii) There is a weak connection between the students' possession of conceptual knowledge and their problem-solving proficiency. The variance of the latter accounted for by the former is 20% only.

Pedagogic Implication

The view, often held by science teachers that students would develop desired problem -- solving skills and capabilities if only exposed to instructions in relevant conceptual knowledge should be approached cautiously, especially that such tacit professional assumption is found, from this study, not to be viable or tenable as a meaningful instructional strategy.

A structured Text Approach to Remediating Difficult Concepts in the Teaching and Learning of Science in Schools

Remediation of problem – solving difficulties is shown, from literature to have been undertaken by a number of approaches. Examples include: -

(a) Specific teaching of problem – solving skills (Reif et al, 1986)
(b) Guidance and counseling method (Herron, 1984)
(c) Classroom interactive approach (Adeyegbe, 1985)
(d) Structured text approach (Shaibu, 1998)

These are generally aimed towards promotion of students' understanding of the difficult concepts. The assumption is that improved understanding of science concepts enhances the ability to command knowledge (Ebel and Frisbie, 1986) which in turn brings about proficiency in students' problem-solving capabilities.

Shaibu (1998) investigated the efficacy of printed structured text in remediating learning and problem – solving difficulties of science students. It involved printed texts in modules (topics) each addressing specific conceptual difficulties that have been previously identified through application of diagnostic tests. The choice of the approach is based on such considerations as its, simplicity, flexibility and adaptability. The study was based on the constructivist paradigm, the thrust of which is that learners process information verbal, symbolic or sensory in order to find meaning, explain natural phenomena and thus construct their knowledge (Drive and Bell, 1986; Osborne and Wittrock, 1983). The immediate implication of this model of learning for instruction in science is that:

(a) the learner is an active participant in the learning process rather than a passive recipient of information or knowledge.
(b) it serves to explain, at least in part, sources of pre-conceptions that students bring to science class, how misconceptions develop and why they are sometimes difficult to correct.

(c) it gives insight into how and why students often find some science concepts difficult to understand and hence incapable of applying them in appropriate situations.

The sample comprised a total of 50 science students of senior secondary school (Year II) Zaria Metropolis. Their average chronological age was 16 years. The remedial package (i.e. the printed structured text) which comprised ten topics were administered to the sample, who had participated in an earlier diagnostic study that showed they were deficient in dealing with chemical problem-solving tasks they were previously exposed to. The conceptual difficulties they haboured were diagnosed using paper – and – pencil tests and also from analysis of protocols collected from the students. The remedial treatment lasted 5 weeks i.e. two topics of the remedial package per week. The design of the study was quasi-experimental involving pre-posttest/matched group design.

Results

Table 4.4(a) Some Statistical Properties of the Results

Variables	Pretest		Posttest	
	EG	CG	EG	CG
Sample Size (N)	25	25	25	25
Sum of Scores ($\sum X$)	219.00	231.00	409.00	261.00
Mean Score (X)	8.76	9.24	16.36	10.44
Standard Deviation (Sd)	4.10	3.28	6.78	4.74

Table 4.4 (b) Comparison of the Pre and Post test Scores of the Experimental and Control Groups

Variables	Pretest		Post test		SEd	t-value	df	P-value
	X	Sd	$\bar{X}$	Sd				
EG	8.7	6.78	16.36	6.50				
CG	9.24	4.44	10.43	4.20	1.08	3.46*	48	0.01
SEd	1.02		1.67					
t-value	0.94**		3.55*		*Significant at $P \leq 0.05$			
df	48		48		(Between Groups Comparison)			
P-value	0.13		0.03					

* **Significant** at $P \leq 0.05$ (EG vs EG)

** **Not Significant** at $P \leq 0.05$ (CG vs CG)

(Within Groups Comparison)

Findings

(a) The Academic achievement of both the experimental group (EG) and the control group (CG) generally improved from pre-to post test.

(b) The academic achievement of the EG at the posttest level using within-group comparison, was found to be statistically significant at $P \leq 0.05$ and df = 48 while that of the CG under the same conditions was found not to be statistically significant. It should be noted that both groups were equivalent before the treatment intervention.

(c) The posttest academic achievement of the EG was found to be statistically superior to their achievement at the pretest level while for the CG, their academic achievement at the posttest level (though improved) was not statistically higher than that of their pretest.

Implications of the findings for Education (Teaching and learning)

The totality of the findings (a-c) strongly suggest that science students' conceptual difficulty that often manifest as observable underachievements can be remediated to a tolerable level if the appropriate psycho-social, professional expertise and teacher-motivation are in place.

4.2.2 Gender–related Factors in Students' Academic Achievement

Introduction

There are many studies reported in literature which show that gender, as a reality of life and gender–related differences as variables have exerted significant influence on teaching and learning of science, and thus academic achievement in science. While the concept of sex and gender tend generally to be used interchangeably, they do not refer to the same thing. For example, while sex refers to the fact of being either male or female in a biological sense, gender refers to qualities of masculinity or feminity which are most often used within traditional or cultural contexts.

Studies in science education have shown that gender issues and practices tended to have negatively affected the female students in terms of access, participation and achievement in science. Okeke (2000) reported that females are under-represented, indirectly made to lose interest and thus underachieve in science. Two major categories of factors have been fingered to be at play, namely out-of-school and within – school factors. Out of school factors include methods of upbringing that tend to make females feel their role is in the kitchen and that they are to be seen and not heard. Within-school factors include the following:

(a) Public perception of science which, willy–nilly portrays science as a masculine discipline dominated by the male human kind.

(b) Gender bias in curricular materials: In most instances when examples/illustrations are given in text books it's mostly men that are used. (Erinosho, 1997). Other studies outside Nigeria indicate similar trends, for example (Biachini, 1993).

(c) Science teaching strategies: Studies, for example Njoku (2006) have shown that both the overt and covert pedagogic behaviour of teachers tend to favour the boys more often, than the girls. The general effect of these is to dampen the interest of girls and possibly decrease their academic potentials and ultimately their achievement; and that removal of gender biases in science curriculum and instruction helps to improve academic achievement of girls. It was within this theoretical framework that Shaibu and Mari (1997) investigated gender–related differences of junior secondary school students' understanding of science process skills.

The Study was entitled **Gender–related Differences in the Understanding of Science Process Skills Amongst Junior Secondary School Students**

Science process skills are intellectual tools together with learned capability that scientists use as self-management procedure in carrying out their scientific activities (Gagne, 1986). During the last two decades or so, science educators have advocated that the processes of science should be taught as integral part of the science curriculum. They have argued that acquisition of science process–skills should be a major goal of science education. It has been found that the use of science process – skills as an instructional strategy is viable and help to improve academic achievement (Awodi, 1984).

Campbell (1979) identified two aspects of science process skills which are called the basic science process skills and integrated science process skills. These are listed below:

Basic Science Process Skills:

a) Observing
b) Classifying
c) Inferring
d) Measuring
e) Communicating
f) Predicting

Integrated Science Process Skills:

a) Making operational definitions
b) Formulating questions and hypotheses
c) Experimenting
d) Interpreting Data
e)
f) Formulating models and predictions.

Two instruments were used for data collection. These are the Inventory of Science Processes (IOSP) and the Test of Practicals Skills (TOPS). While IOSP was used to measure the subjects' understanding (achievement) in science process skills, TOPS was used to measure their ability to use the science process skills they possessed to solve given problems which rely on the understanding of science process skills. The two instruments IOSP and TOPS have reliability coefficients of 0.84 and 0.78 respectively. IOSP was adapted from Nay (1987) while TOPS was designed by the researchers.

The nine science process skills tested during the study are as follows:

a) Observing
b) Measuring
c) Classifying

d) Formulating hypotheses
e) Experimenting
f) Interpreting data
g) Communicating information
h) Making inferences
i) Predicting

The population comprised junior secondary school students, classes 1 – 3 in Zaria and Sabon Gari Local Government Areas of Kaduna State. A total of 5 co-educational, 3 male and 3 female school were selected purposively. Stratified random sampling was used to select samples from the co-educational schools, while simple random sampling was used to obtain samples from the single – sex schools. A total of 30 students (10 from JSS 1, 2 & 3 each) were selected from each of the 11 schools to give a total of 330 sample size. Their average chronological age was 13.5 years. The two instruments were administered to the subjects through face-to-face contact by the researchers. The data collected was analyzed using the Statistical Package for Social Sciences (SPSS) software. The study sought to find out:

(a) the level of understanding of science process skills amongst male and female students in the population covered by the study.
(b) if junior secondary school boys and girls exposed to NISP curriculum differ significantly in their understanding of science process skills.
(c) if junior secondary school boys and girls exposed to NISP curriculum differ significantly in their ability to use their understanding (knowledge) of science process skills to solve related problems in science.

Results

The results obtained are shown in Tables 4.5 (a) – 4.5

Table 4.5 (a). Some Statistical Properties of IOSP Scores

Variables	JSS I	JSS II	JSS III
N	110	110	110
Range (%)	8 – 50	8 – 60	23 – 69
Mean Score (X)	29.4	30.60	38.10
Std Dev.	10.20	8.50	8.30

Table 4.5 (b). Some Statistical Properties of TOPS Scores

Variables	JSS I	JSS II	JSS III
N	36	36	36
Range (%)	6 – 31	10 – 29	5 – 44
Mean Score (X)	15.30	18.40	26.30
Std Dev.	5.60	4.80	8.70

Table 4.5 (c) t-test Analysis of Male and Female Mean Scores in IOSP

Variables	N	$\bar{X}$	SD	df	t-value	P
Male	185	30.50	10.50			
Female	145	33.80	9.30	328	3.71*	0.024

* significant at $P \leq 0.05$

Note Max. Score = 70

Table 4.5 (d) t-test Analysis of Male and Female Means Scores in TOPS

Variables	N	$\bar{X}$	SD	df	t-value	P
Male	65	19.40	7.30			
Female	43	20.60	8.60	106	0.59	0.56

t-value is <u>not</u> significant at $P \leq 0.05$

<u>Note</u>: Max. Score = 60, and a total of 108 subjects out of 330, randomly selected were used in this phase that involved practical activities.

Findings

The following comprise the major findings from this study:

(i) The students (both male and female) possessed low level understanding of science process skills as can be seen from their mean scores in IOSP (Table 4.5(a))

(ii) The female students had a significantly higher understanding of science process skills compared to their male counterparts (Table 4.5(c)).

(iii) Junior Secondary School male and female students exposed to science curriculum material (NISP) do not differ significantly in their ability to use possessed knowledge of science process skills to solve related problems.

Implications for Pedagogy

(i) The higher achievement of the girls over the boys in the Inventory of Science Processes test may be due to social and cultural influences which tend to make girls to be more careful, more observant, and also to make use of their eyes and ears (and less of their lips) in comparison to boys. Science teachers need to bring these sort of gender-related characteristics on board their instructional plan and behaviour.

(ii) Even though the female students had better understanding of the science process skills (Table 4.5(c) they were unable to use such knowledge to solve related problems and thus gain similar superiority over their male counterparts as was the case in IOSP. This portrays existence of weak connection between declarative and strategic knowledge of the students. Science teachers need to take appropriate pedagogic steps to close such undesirable gap between students' declarative and strategic knowledge. This calls for patience, experience and expertise on the part of science teachers.

(iii)The generally – held omnibus notion that boys achieve better than girls in science needs a re-appraisal, at least for purposes of pedagogy.

4.2.3 Parents' and Teachers Motivational Factors

Introduction

Studies have shown that parents' motivational support for their children/wards constitute a vital category of motivational factors in students' learning of science. For example, Igwue (1990) found from his studies carried out in Kano State that the background of parents, in terms of social, economic and cultural settings have substantial influence on the motivational level of their children/wards. Studies have also shown that science teachers serve as veritable source of motivation for their students (Skinner and Belmont, 1993). They reported that teachers' motivational support help to foster the fulfillment of some basic psychological needs of the students.

It was against this theoretical background that Shaibu and Iroegbu (2003) carried out a study entitled: **A Study of the**

Relationship Between Parents' and Teachers' Motivational Support and Secondary School Students' Achievement in Science. The study investigated the interaction, if any between parents' motivational support for their children/wards and the academic achievement of the latter. It also investigated the relationship, if any between science teachers' motivational support for their students and the academic achievement of such students in science. Two related null hypotheses were stated and tested.

A total of 360 senior secondary school III science students, obtained through simple random sampling comprised the subjects of the study. They comprised 210 boys and 150 girls drawn from three educational zones, namely, Abia, Afikpo and Umuhia educational zones in Abia State. Their average chronological age was 17 years. Two structured likert – type questionnaire constituted the instruments used for data collection. The reliability coefficient of the instruments, obtained through split-half method and adjusted by the Spearman – Brown prophecy formula were 0.75 and 0.78 respectively. The questionnaire were administered by the researchers to the subjects in their respective schools via face-to-face contact for all the three basic science subjects, Biology, Chemistry and Physics.

Results

The results from the study are shown in Tables 4.6(a) and 4.6.(b).

Table 4.6.(a) Correlation Between Parents' Motivational Support and Students' (their children) Academic Achievement in Science

S/N	Subject	N	r	r^2	r (critical)	df	P
1.	Biology	350	0.42	0.18	0.12	348	0.022
2.	Chemistry	350	0.44	0.19	0.12	348	0.024
3.	Physics	350	0.40	0.16	0.10	348	0.020

Table 4.6(b) Correlation Between Teachers Motivational Support and their Students' Academic Achievement in Science

S/N	Subject	N	r	r^2	r (critical)	df	P
1.	Biology	350	0.45	0.20	0.12	348	0.024
2.	Chemistry	350	0.46	0.21	0.14	348	0.024
3.	Physics	350	0.48	0.23	0.15	348	0.026

r is +vely correlated and significant at $P \leq 0.05$

Findings

The results show that:

(i) there is positive and significant correlation between parents' motivational support for their children/wards and the academic achievement of the latter in science.

(ii) there is positive and significant correlation between teachers' motivational support for their students and the academic achievement of the students.

(iii)the coefficient of determination (r^2) indicates that the variance in academic achievement accounted for by parents' motivational support ranges between 16% - 18% while those for teachers motivational support ranges from 20% - 23% in the three subjects under study.

Implications for Teaching and Learning of Science

(i) Students' academic achievement in science is influenced not only by factors prevalent in the school but also by the social and cultural home factors.

(ii) Science teachers should be sentive and receptive to socio-cultural backgrounds of their students and blend same to the process of teaching and learning as a way forward to improve academic achievement of their students in science.

4.2.4 Curriculum – Related Factors

Curriculum, both as a terminology and as a concept especially, is most often misunderstood and also misconstrued even by those within the education industry. It has been defined variously by many authors and scholars. A few example here will suffice. Onwuka (1981) defined curriculum as the process of determining and pursuing set social objectives through the instrumentality of the school. Tanner and Tanner (1985) defined it as the planned and guided learning experiences and intended outcomes formulated through the systemic and systematic construction of knowledge under the auspices of the school for learners continous and meaningful growth in personal, social and vocational competencies. Ben-Yunusa (2002) opined that curriculum is both the essence and product of the distilled thinking of the society.

Shaibu (2014) observed that the science curriculum in Nigerian schools are deficient philosophically and thus handicapped in helping to point the way forward for learners academic achievement and hence for national development. It was within this contextual background that Shaibu and Bichi (2003) investigated the efficacy of two models of curriculum packages with respect to their potency in promoting students' academic achievement in science. The study is entitled **Effect of Historically – Enriched Curriculum on Science Students' Academic Achievement in Evolution Concepts in Nigerian Secondary School.** It focused on the concept of evolution as one typical example of the science concepts that students often find difficult to understand and thus achieve poorly. The aim was to compare the relative effectiveness of the conventional biology curriculum with the historically – enriched one and to find out which of them would help to promote students' academic achievement in biology. Scholars, for example, Anderson, (1990) and Jensen and Finley (1995) reported the relative efficacy of an historically – enriched curriculum, and showed that it was moderately effective in enhancing students' academic achievement in the area of Darwinian evolution concepts. Furthermore, Jensen and Finley (1996) postulated that the instructional use of historically – enriched curriculum is based on the premise that its use meets the pedagogic requirements for conceptual change among science students and consequently enhanced their understanding and thus promoting academic achievement.

The focus of the study was to find out if historically – enriched curriculum would prove superior or otherwise over the conventional biology curriculum that have been generally in use. The population comprised SSS 3 biology students from Giwa Education Zone. A total of 104 of the students were obtained by simple random selection from the total 868 students. The quasi-experimental design involving the matched group, pre-posttest approach was used. The experimental and control groups, comprised 52 subjects each. The experimental group (EG) comprising 30 male and 22 female students, was treated with the historically – enriched curriculum while the control group (CG) comprising 34 males and 18 females students, was taught using the conventional curriculum. The treatment lasted six weeks of 2 hours instruction each day of the working week. Both groups were posttested at the end of the treatment period, using the Evolution Concept Test (ECT) as the main instrument ($r = 0.72$). Data collected was computer analyzed using the SPSS software.

The Results

The results obtained are presented in Tables 4.7(a) and 4.7(b).

Table 4.7(a) t-Test Analysis of the Pretest Mean Scores of the Experimental and Control Groups

Groups	N	$\bar{X}$	SD	t-value	df	P
EG	52	12.16	3.55	0.07*	102	0.49
CG	52	11.72	3.04			

t – not significant at $p \leq 0.05$

Table 4.7(b). t-Test Analysis of the Posttest Mean Scores of the Experimental and Control Groups

Groups	N	$\bar{X}$	SD	t-value	df	P
EG	52	18.55	6.70	3.22*	102	0.01
CG	52	14.16	4.76			

* **Significant** at $P \leq 0.05$

Findings

The following constitute some of the major findings from the study:

1. The subjects in the experimental group i.e. the group that was exposed to the historically– enriched curriculum achieved significantly higher than their counterpart in the control group.
2. The historical links and additives blended into the historically – enriched curriculum tended to humanize science teaching and helped the subjects exposed to it (EG) to achieve higher.
3. The humanization flavour blended into the historically – enriched curriculum tended to have positively affected conceptual and behavioural disposition of the subjects exposed to it (EG) in a manner that they saw the science concepts taught more as human ideas and human enterprise which can be meaningfully and successfully engaged in by human beings like them.

4. The blending of relevant science history into the curriculum tended to have minimized, if not totally remove the usual mystification and sacrosanct perception of science by science students, thus enhancing positive engagement that consequently resulted in improved academic achievement.

Pedagogic Implications

1. The humanistic model of science education, which conceives of, and presents science as a human activity constructed by human mind, and engaged in by human kind paves a way forward for effective instructional strategies in science and consequently improved academic achievement by the students exposed to such mode of instruction.
2. The hypothetico – deductive paradigm of science which places emphasis on the role of subjective conjectures as a basis for deriving testable scientific hypotheses has its foundation in the humanistic paradigm of science and is viable for enhancing academic achievement of students in science.
3. The constructivist model of science educational practice which stipulates that knowledge is not transferred from one head to another, but rather that individuals actively make meaning of external stimuli and thus construct their own knowledge is equally founded on the humanistic principles of science teaching and learning. Science teachers at all educational levels need to be acquainted with these and explore them to maximally enhance the academic achievements of their students.

4.2.5 Instructional Strategy – Related Factors

It has been reported in literature that the manner in which science subjects are taught in schools requires the majority of science teachers to use the traditional, talk – and – chalk method of teaching (Shaibu and Mari, 2003, Usman, 2000). The findings from these studies showed, for example that most science teachers do not encourage students' active participation in the teaching/learning process. Lack of such active participation of students has been identified as one of the major factors responsible for poor academic achievement of students in science subjects. This was found to have reflected in students' low academic achievement in the Senior School Certificate Examinations (SSCE) year after year. It is within the context of this that an investigation was carried out by Shaibu and Usman (2002) to identify possible instructional strategy that might be helpful in the search for students' improved academic achievement in science. It was entitled:

The Effects of NISTEP Mode of Teaching on Junior Secondary School Students' Academic Achievement in Integrated Science

NISTEP is an acronym which stands for Nigerian Integrated Science Teacher – Education Project. Its teaching approach derives from the psychological principle that students learn better through active participation in the teaching learning process that might often involve exposure to activity – based methods (Kempa, 1986). Goals of integrated science teaching is to develop in the learners the following skills:

(i) Active involvement in the teaching/learning process
(ii) Ability to learn with some degree of independent mind
(iii) Recall of information for use in relevant contexts
(iv) Devising of cognitive schemes for solving problems
(v) Classifying and using information flexibly
(vi) Interpreting data appropriately
(vii) Communicating results/findings effectively.

The population of the study comprised fifteen junior secondary schools located within Sabon Gari Local Government Area of Kaduna State. A total of two co-educational schools were purposively selected from the population and 100 students were randomly selected from the two schools i.e. 50 students from each school. Through the process of simple random selection one of the schools was used as the experimental group while the other was used as the control. Two topics – feeding in plants and energy conversion were used for treatment which lasted six weeks. The experimental and control groups were matched before the experiment. The instrument used for data collection was the Integrated Science Achievement Test (ISAT) which was adapted from Iyang (1988). The reliability coefficient was re-calculated and found to be 0.86. The NISTEP method of teaching (Appendix I) was used as instructional strategy for the experimental group (EG) while the traditional lecture method was used in the control group (CG) to teach the same topics as the experimental group. At the end of six weeks of treatment a posttest was administered to both groups. The data collected was computer – analyzed using the SPSS software.

Results

The results obtained from the study are shown in Tables 4.8(a) and 4.8(b).

Table 4.8(a). Comparison of the Pretest Mean Scores of the Experimental and Control Groups

Groups	N	$\bar{X}$	SD	t-value	df	P
EG	50	8.20	3.50	1.20	98	0.42
CG	50	6.02	3.10			

Not significant at $P \leq 0.05$

Table 4.8(b). Comparison of the Posttest Mean Scores of the Experimental and Control Groups

Groups	N	$\bar{X}$	SD	t-value	P
EG	50	15.01	3.90	11.78*	0.01
CG	50	7.85	4.02		

* Significant at $P \leq 0.05$

Findings

The following comprise the major findings from the study:

(i) The difference in the pretest mean scores of the subjects in the experimental and control groups was not significant statistically, meaning they were academically equivalent before the treatment intervention.

(ii) The academic achievement of the subjects in the experimental group was statistically superior to their counterparts in the control group. This can only be attributable to the use of the NITEP method of teaching which seemed to have proved more effective than the traditional lecture method used for the control group.

(iii)Exposure of science students to learner – centered and activity – based instructional strategies have viable potentials for improving the academic achievement of students in science.

Implications for Pedagogy

(i) The basic professional skills and expertise for engaging in the use of learner – centered instructional approach should begin to receive adequate attention.

(ii) The re-appraisal of science curriculum and pedagogic skills for effective activity – based instructional approach should receive the needed emphasis at all levels of education.

5.0 Discernible Road Maps from Science Education Research Studies

The following comprise some of the major signposts that have been identified from this lecture and which constitute potential and veritable road maps to help navigate us out of the maze of students' underachievement in science.

a. Science Teachers' Professional Skills

Teachers' professional skills to operate at the same or at least, similar conceptual levels with their students in the business of teaching and learning science in order to reduce students' conceptual bottlenecks is vital (study on Topic difficulties: 4.2.1(a))

b. Science Teachers' Expertise to perform conceptual task-analysis

Teachers' expertise to perform conceptual task-analysis of the subject matter they teach logically in order to guide teaching sequence from the known to the unknown is needed more than ever before to promote meaningful leaning (Students' Achievement in Savoy's concepts: 4.2.1(b))

c. Existence of gap between science students' conceptual and strategic knowledge

The existence of a wide gap between science students' conceptual knowledge and their problem solving proficiency calls for urgent attention of science teachers and curriculum planners in order to minimize significantly students' academic underachievement in science (Relationship between conceptual knowledge and problem-solving proficiency... 4.2.1 (c))

d. Remediation of Difficult Concepts

Science students' conceptual difficulties that often manifest as observable under-achievement can be remediated by the teacher to a tolerable level if appropriate psycho-social, professional, pedagogic expertise and teacher motivation are in place. (Structured text approach to remediating difficult concepts 4.2.1 (d))

e. Gender-related Differences

Gender-related differences, e.g societal expectations, cultural values and sex role stereotyping often have negative effects on science students' academic achievement (Gender-related differences... 4.2.2)

f. Parents' and Teachers' Motivational Support

Parents' and also teachers' motivational support for their children and their students respectively are direct functions of students' academic achievement in science (Parental and Teachers' motivational support: 4.2.3)

g. Philosophical and Psychological Orientation of Curriculum Materials

The philosophical and psychological assumptions that guide the design of science curriculum materials can either promote or hinder students' academic achievements in science (Effects of historically-enriched curriculum... 4.2.4)

h. Effectiveness of Teacher – Training Programmes

The kind and effectiveness of teacher-training programmes designed and implemented at all levels of education have direct influence on science students' academic achievement.

i. Instructional Models used by Science Teachers

The cooperative and humanistic models of science teaching and learning have laudable potentials for improving students' academic achievement in science.

6.0 Conclusion and Recommendations

6.1 Conclusions

a. Students' underachievement in science cannot be accounted for by a simple or single factor, but a multiplicity of complex interrelated factors.

b. Some of the categories of factors that militate against students' academic achievement in science include the following:

Teacher factors
Students factors
Societal factors
Curriculum-related factors
Cultural and belief factors
Gender-related factors
Political, Economic and national value system factors

c. The teaching and learning of science as a set of dogmas rather than a set of human activities designed by human mind to explore natural phenomena has negative effects on students' academic achievement in science.

d. The tacit societal endorsement of greed, graft and avarice that have bred and sustained debilitating corruption, thereby focusing our attention on materialism and diverting same away from hardwork and commensurate investment on education by private individuals, organizations and more importantly various tiers of government is a major source and cause of students' patent underachievement in science.

6.2 Recommendations

a. The teaching and learning of science should put greater premium on the humanistic model of instruction as this has potential for promoting students' academic achievement.

b. The national policy statement underlying the philosophical objectives of our educational system at all levels needs to be revised and refined to make it more pragmatic in a manner that is both practically implementable and empirically amenable for evaluation.

c. There is a great and urgent need to improve on the quality, effectiveness and flexibility of our teacher training systems at all educational levels thereby enhancing the professional skills and expertise of science teachers who are the key players in the search for improving students' underachievement in science.

d. The situation in which teachers at all educational levels are constrained to "fight" for their professional rights and conducive working conditions, using available and legitimate labour tools is extremely inimical to teachers' motivation and ultimately students' academic achievement in science. The Federal Government and other tiers of Government should as a matter of priority take necessary steps to provide the appropriate recognition, respect, conducive psycho-social atmosphere and patently commensurate and enhanced service conditions and reward mechanisms for teachers at all educational levels to stem the tide of students' underachievement in science

e. The hypothetico-deductive paradigm of science teaching and learning which also derive from humanistic principles should be given greater emphasis especially in its application for cooperative learning of science as opposed to competitive learning strategy.

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