

**PERSONALITY TYPE AND LEARNING STYLE
PREFERENCES AS DETERMINANTS OF STUDENTS'
ACHIEVEMENT IN SENIOR SECONDARY SCHOOL
BIOLOGY IN OSUN STATE, NIGERIA**

BY

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**A THESIS SUBMITTED TO THE INTERNATIONAL CENTRE
FOR EDUCATIONAL EVALUATION (ICEE)
INSTITUTE OF EDUCATION**

**IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR
THE DEGREE OF**

**DOCTOR OF PHILOSOPHY
OF THE
UNIVERSITY OF IBADAN.**

2014

ABSTRACT

Poor performance of students in biology at the senior secondary school level over the years has raised a serious concern among stakeholders particularly in Osun State. This trend has been attributed generally to factors relating to the home, school and the students themselves. Previous studies have neglected personality type and learning style preferences in relation to students' achievement in Biology. Therefore, this study examined through path linkages how personality type and learning style preferences determine students' achievement in biology at the senior secondary school (SSS) level in Osun State, Nigeria.

The study adopted the survey research design. This study was based on the Myers-Briggs, and Dun and Dun models that characterised personality type on: Extroversion, Sensing, Thinking, Judging (ESTJ), and learning style on: Visual, Auditory, Kinesthetic (VAK) respectively. The multistage sampling technique was used to select 1,480 SSS II students from 74 senior secondary schools in 15 selected local government areas. Three instruments were used: Cognitive Type Inventory ($r=0.52$), VAK Learning Style Indicators ($r=0.65$), Biology Achievement Test ($r=0.75$). Four research questions were answered. Pearson product moment, Path analysis, and Multiple regression were used to establish and estimate direct and indirect hypothesised linkages at 0.05 level of significance.

The percentage of respondents with different personality type preferences were: extroversion (62.3%), sensing (66.3%), thinking (63.3%), judging (63.1%), and that of learning style preferences were: visual (63.0%), auditory (78.1%), kinesthetic (35.8%). The predictor variables had significant correlations with students' achievement as: student gender (-0.074), extroversion (-0.269), sensing (-0.417), thinking (0.376), judging (0.327), visual (-0.430), auditory (-0.408), Kinesthetic (-0.438). The discrepancy between hypothesised and reproduced correlations in the model was minimal (26.7%). Five hypothesised predictor variables [student age (-0.058), extroversion (-0.113), sensing (-0.284), thinking (0.109), and kinesthetic (-0.347)] had direct effects on biology achievement. On the other hand, only three hypothesised predictor variables [student gender (-0.017), student age (0.011), and thinking (0.064)] had indirect effects on biology achievement. The percentages of direct and indirect paths were 15.4% and 84.6% respectively. About 27.9% of the variance observed in biology achievement was accounted for by age, extroversion, sensing, thinking, and kinesthetic.

Sensing and kinesthetic preferences were the most significant in determining students' achievement in biology at the sampled senior secondary schools in Osun State. Students should be encouraged to develop, improve and exhibit sensing and kinesthetic preferences when learning biology.

Keywords: Personality type, Learning style preferences, Students' achievement in biology, Senior secondary school in Osun State.

Word count: 382

ACKNOWLEDGMENTS

I give glory to Al-Mighty ALLAH, the creator of heaven and earth, the Maker of life, the All-Wise for giving me the grace to start and complete this programme. I thank HIM for extending His hands of mercy, protection, blessing, and possibility to me and my household. In fact, HE has never let me down. I shall forever praise and adore HIM; believe and trust in HIM.

My special gratitude goes to my supervisor Prof. E. Adenike Emeke for the care, guidance, and support given me during the course of this programme. I am particularly indebted to her for giving quality attention to my work at all the time and at different stages. I am equally thankful to daddy, her husband for giving me free access to their home. I am sincerely grateful to Dr. B.A. Adegoke whose unique assistance had made me to come out with a good work.

My gratitude goes to all my lecturers in the Institute of Education, University of Ibadan most especially Pro. F.I. Ibeagha (Former Head of the International Centre for Educational Evaluation), Prof. C.O. Onocha, Drs. C.V. Abe, J.A. Adegbile, J.G. Adewale, Ifeoma M. Isiugo- Abanihe, Modupe M. Osokoya, Monica N. Odinko, and J.O. Adeleke for their various contributions towards the successful completion of this programme.

I am grateful to the principals, biology teachers, and students of the schools used for this study, for the opportunity and co-operation given me during the period of data collection. I also appreciate the assistance rendered by Latifat Oyetoro, Laide Bangbola, and Ukwu Alex for marking the Biology Achievement Test (BAT) used for collecting data. I am sincerely grateful to Prof. A.A. Amusan (Department of Soil Science, Obafemi Awolowo University, Ile-Ife) whose advice and words of encouragement stimulated me to register for this programme. I am equally grateful to my kins and kiths: Messrs. I.M. Anibire, O.A Adeleke, Taofeek Abdulhammed, L.A Adebisi, M.O. Olaniyan, O. Onigbinde, Ayo Odelami, F.T Iyanda, Dr. O.G. Adeyemo, Dr. W.A. Babawale, and Dr. Rachael Ojelabi for their unflinching support and unalloyed co-operation.

Finally, I am sincerely grateful to my wife- Mrs. Sanni Fasilat Yetunde, and my children- Oluwatosin, Opeyemi, and Titilope for their priceless co-operation. I thank them for always being by my side.

DEDICATION

This work is dedicated

To

My Beloved Father and Mother:

Late (Chief) Jimoh Anibire Sanni,

and

Late Mrs Sabitiyu Atoke Sanni

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CERTIFICATION

I certify that this work was carried out by Mr. SANNI Kamorudeen Taiwo in the International Centre for Educational Evaluation, Institute of Education, University of Ibadan, Ibadan.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Biology is a fundamental science subject which serves as the basis for understanding the complexities of how the body parts of human beings function, and the ways by which these parts can be taken care of in order for man to live a healthy life. Also, Biology is one of the subjects which a student requires before he or she can pursue a career in such disciplines as medicine, pharmacy, genetic engineering, biotechnology, and nursing. Many students wish to pursue these courses especially now when the demand for the services of experts in these fields is on the increase globally.

Ezeazor (2003) observed that Biology as a science subject is as important to life and life processes, as it is interesting. Ezeazor remarked that Biology exposes the students to the world of self-knowledge and knowledge of the immediate and distant environment. This implies that, if students are equipped with adequate knowledge of their environment, it may go a long way in making them aware of the benefits they could derive from it. Thus, they will endeavour to make efforts to protect, improve, and sustain such environment. It was as a result of the importance of Biology in the development of individuals and the nation that its teaching is made compulsory for science students at the senior secondary school level of education as contained in the Nigerian National Policy on Education (NPE) (Federal Republic of Nigeria, 2009). Also, the popularity of Biology among Nigerian senior secondary school students is likely to be associated with the popular assumption that Biology is the easiest of all the three core science subjects.

Despite the importance of science in general and Biology in particular, students still perform poorly in the subject in examinations conducted by the West African Examination Council (WAEC). Olatoye (2004) found that, in Nigeria, student performance in science, both at the internal and external examinations, has been consistently poor. This is confirmed by studies of Okwilagwe, (1999); Obemeata, (2001); Emeke, Adeoye and Torubeli (2006) that showed continuous poor academic achievement in many school subjects. Incidentally, WAEC Chief Examiners' report regrettably affirmed that candidates' performance in Biology were poorer by the year 2010 [WAEC Chief Examiners' Reports (Nigeria), 2011]. A close look at the WASSCE results of ten years (2004 to 2013) in Biology portrays the same poor achievement. Table 1.1 showed the level of students' performance in Biology.

Table 1.1: Distribution of Students' Performance in Senior Secondary Certificate Examination (SSCE) in Biology from 2004 – 2013

Year	Total Entry	Total SAT	NUMBER AND PERCENTAGE OBTAINING GRADE								
			CREDIT AND ABOVE						Total Credit	PASS	FAIL
			A1	B2	B3	C4	C5	C6	1 – 6	7 – 8	9
2004	1027938	1005894 97.85	164 0.01	1074 0.10	24492 2.43	46378 4.61	48682 4.83	177765 17.67	298555 29.68	326092 32.41	348890 34.68
2005	1072607	1051557 98.03	241 0.02	970 0.09	36820 3.50	35655 3.39	75404 7.17	226760 21.56	375850 35.74	313827 29.84	338491 32.18
2006	1162046	1137181 97.86	1872 0.16	7466 0.65	100324 8.82	84625 7.44	109380 9.61	256187 22.52	559854 49.23	292317 25.70	261200 22.96
2007	1261971	1238163 98.11	106 0.01	969 0.08	31560 2.55	43439 3.51	77387 6.25	259750 20.98	413211 33.37	397353 32.09	402148 32.48
2008	1285048	1259965 98.05	549 0.04	2278 0.18	42608 3.38	38123 3.03	81990 6.51	262096 20.80	427644 33.94	329961 26.19	484071 38.42
2009	1364655	1340206 98.21	207 0.02	1179 0.09	26168 1.95	34038 2.54	65049 4.85	256471 19.14	383112 28.59	413014 30.82	471312 35.17
2010	1325408	1300418 98.11	1515 0.12	8702 0.67	121451 9.34	74113 5.70	128342 9.87	311510 23.95	645633 49.65	318486 24.4	297228 22.86
2011	1532770	1505199 98.20	128 0.01	1067 0.07	51247 3.40	49683 3.30	110823 7.36	366484 24.35	579432 38.56	458338 30.45	441720 29.35
2012	1687213	1645577 97.53	396 0.02	2235 0.13	58357 3.54	52115 3.16	110817 5.73	362972 22.05	586892 35.66	465078 28.26	555796 33.77
2013	1679249	1647823 98.12	233 0.01	2977 0.18	100531 6.10	87495 5.30	179792 10.91	480388 29.15	851416 51.66	442687 26.86	313104 19.00

Source: West African Examination Council (WAEC) Test Development Division Ogba (2014).

Examining Table 1.1, it is well established that from 2004 to 2013 the population of students who passed Biology at credit level in WASSCE was below 39%, except in 2006, 2010, and 2013 when the number of credit passes in the subject rose to 49.23%, 49.65% and 51.66% respectively. From Table 1.1, it can be inferred that, over the years, the percentage of students qualified to pursue science based courses in the Universities is below 39%. If this low achievement of students in Biology and other science subjects is not given prompt attention, it may affect the level of scientific and technological development of Nigeria. It

may equally affect the Nigerian vision of scientific society and working towards a 40:60 art to science ratio.

Many factors have been associated with students' poor performance. These factors include: teaching methodology (Adeyemi, 2002); type of text used (Keeve, 1995); locus of control (Emeke, Adeoye and Torubeli, 2006); teacher quality (labo-Popoola, 2003); school quality (Obemeata 2001). Edeh and Vikoo, (2013) identified other factors influencing students' performance as: teachers' expectancy, parental involvement, study style, previous knowledge and attitude/interest. Wabuke (2013) gave a summary of student-related factors that influence performance in Biology as: students' interest in Biology, students' interest in practical lessons, students' ambition, students' attitude towards Biology, students' ability to do practical, students' indiscipline, students' absenteeism, freedom to choose subjects, and students' having study timetables and planning. Considering the factors associated with poor academic achievement as identified by these scholars one can categorise them into: parent factor, government factor, teacher factor, and learner factor.

Despite the fact that the factors associated with students' poor academic performance are multi-dimensional, it is the students that directly continue to be at the receiving end of the outcome of both internal and external examinations. Another concern is that, these students have little or no control over the major stakeholders of education (parents, government, and the teacher). This implies that if parents, government, and teacher fail to perform their duties as expected in the education of the children, there is little or nothing the children could do to these stakeholders. However, these students have reasonable control over themselves. In the view of this, there may be need to pay special attention to learner personal variables such as student personality type and student learning style preferences which may have influence on their learning outcomes.

Teaching and learning are activities which involve the teacher, the learner and the learning environment. For a teacher to teach effectively, he/she should be able to have an indepth understanding of the personality type and the learning style which individual student tends to exhibit in any teaching-learning situation. This belief, as far back as the late 1990s, was confirmed by McKeachie (1994) who said that, if teachers really want to get their message across, they need to present "the material" in a multi-faceted way across the range of student personality type and learning style preferences. Also, Felder and Brent (2000) found that students learn more if they are aware of how they learn and how to use their strengths and develop their weak areas.

Similarly, Romanelli, Bird, and Ryan, (2009) observed that students with knowledge of their own preferences are empowered to use various techniques to enhance learning, which in turn may impact overall educational satisfaction. Therefore, for a student to learn effectively, he/she may need to be aware of his/her personality type and learning style preferences. Also, he/she may need to develop and exhibit the expected personality type and learning styles which the effective learning of a particular subject or topic requires.

In addition, Leonard (1997) found that students not only have a learning style but they also tend to have a preferred learning style (the result of being an individual and being unique). From literature, it seems clear that students have a preferred learning style under which they learn better. For instance, Felder, Felder & Dietz, (2002) reported that students who were classified as extroverts on the Myers-Briggs Type indicators seem to learn better in learning environment that allows for group work and interactive activities. On the other hand, according to them, sensors like to work with concrete ideas and processes, thinkers prefer objective conclusions based on concrete evidence while judgers like planned and organised information. However, the type of learning styles a student exhibits may depend on the type of topic or subject he/ she is being exposed to.

The above assertion is supported by Leonard (1997), who observed that the demands placed upon the student determine the style of learning the student chooses. Thus, for a student to learn Biology effectively, he/she may need to exhibit learning styles that would allow for group work and interactive activities, working with concrete ideas and processes, preferring objective conclusions based on concrete evidence, planning and organization of information. This implies that such a student may need to exhibit personality type – that comprises extroversion, sensing, thinking, and judging preferences. With the context of the reviews made so far, it seems that personality type may influence learning styles which may in-turn determine the level at which students learn.

Emeke (2012) said that, the characteristic patterns of thoughts, feelings and behaviours that make a person unique define that person's personality. Personality type, which has been under consideration for many years back constitutes a fairly stable phenomenon in the life of an individual. Personality type according to Jung (1976) referred to the characteristic way in which an individual approaches life's experiences. Phares (1991) is of the opinion that personality type is that pattern of characteristic thoughts, feelings and behaviours that distinguish one person from another and that which persists over time and situation. Also, John (2006) viewed personality type as a comfort zone where thinking occurs with less effort and with the greatest trust. Personality type preferences are the characteristic thoughts,

feelings and behaviours which learners tend to exhibit in a learning situation and that which take a discontinuous approach. Personality types are sometimes distinguished from personality traits, with the latter embodying a smaller grouping of behavioural tendencies (Berstein, Penner, Clark- Stewart, & Roy. 2008). According to type theories, for example, extroverts and introverts are two fundamentally different categories of people. According to trait theories, extroversion and introversion are part of a continuous dimension, with many people in the middle (Furnham and Crump, 2005). This means that type theories do not give room for continuous variation in an individual. It is either an individual belongs to one personality type or the other. There is no in-between. In the other hand, trait theories accommodate continuous variation. Several models of personality type have been developed and used to measure personality. Some of these models, are – Myers-Briggs personality model, the Big Five Factor Personality model, Cattell's 16PF model, Saville and Holdsworth's OPQ (Occupational Personality Questionnaire) model, and Belbin 'team role' personality model. Myers and Caulley (1986) confirmed that the only commonly used among these models to measure personality type is Myers-Briggs Personality Model. Other personality models measure personality traits.

According to Myers and Caulley (1986), Myers-Briggs Personality Model was developed in the early 1950's by Isabel Briggs Myers and Katherine Cooks Briggs. In the Myers-Briggs Personality Model, it is proposed that an individual's personality profile can be factored into four dimensions. These dimensions are Orientation to life (Extroversion/Introversion), Perception (Sensing/Intuition), Decision making (Thinking/Feeling), and Attitude to the outside world (Judging/Perception).

Considering the four dimensions of personality, it implies that an individual's personality can be described by two major personality types. They are; personality type – ESTJ (Extroversion, Sensing, Thinking, Judging) and personality type – INFP (Introversion, iNtuition, Feeling, Perception).

John (2006) identified the characteristics that students exhibit for Myers-Briggs Personality Type-ESTJ (Extroversion, Sensing, Thinking, and Judging) as:

Extroversion Preference: Students who have extroversion preference learn best through interacting with people, action and things. They have an easier and more effective learning experience when they verbalise their learning as it is happening.

Sensing Preference: Sensing types tend to trust information that is perceived directly by the senses, i.e. vision, audio, touch (manipulation), taste, and smell. They learn best through

concrete experience, moving step by step with known things to the abstract. Sensors like to attend to concrete reality and focus on things that are tangible, practical and observable.

Thinking Preference: Thinkers tend to trust their logic to evaluate the facts and possibilities. They are impersonal and objective in their analysis. Thinking types draw attention to the “correctness” of relationship and the clarity of thinking when studying in a group. They learn best through clear logical material, analysing experiences to find objective truth.

Judging Preference: Students who have judging preference tend to organise their time around a plan. They learn best through instruction that is organised and which moves in predictable ways, toward closure. They tend to sacrifice learning additional information if that learning will prevent them from completing their schedule. When studying in a group, they keep the group on task and help it to be more efficient. Examining the four preferences of Myers – Briggs Personality Type-ESTJ and the characteristics that students tend to exhibit for each of them , it seems that they are relevant to teaching –learning situation in the field of Biology. In view of this, Myers-Biggs Personality type-ESTJ was considered in this study.

Considering learning styles, Giles, Pitre and Womack (2003), said that the term “learning Styles” is commonly used throughout various educational fields and therefore, has many connotations. In general, learning style refers to the uniqueness of how each learner receives and processes new information through his/her senses. Li, Chen and Tsal, (2008) defined learning style as an individual’s preferential focus on different type of information, the different ways of perceiving the information, and understanding the information. In his own contribution, Milgram and Price (2003) referred to learning style as the unique complex of conditions under which an individual concentrates on, obtains, processes, retains and applies new and difficult information. Therefore, in sum, one may say that all stable learner personal characteristic conditions under which an individual learns best make up what is referred to as learning style.

However, James and Gardener, (1995) defined learning style preferences as the manner in which, and the conditions under which, learners most efficiently and effectively perceive, process, store, and recall what they are attempting to learn. This implies that, the ways and manner in which learners learn best when being exposed to any learning situation describe learning style preferences. Several models of learning styles have been developed and used by researchers to explain learning style. Some of these learning style models are: David Kolb’s Learning Style Model, Felder-Silverman Learning Style Model, Grasha–Riechmann Learning Style Model, Anthony Gregorc’s Learning Style Model, Gardener’s Multiple Intelligences and VAK Learning Style Model.

VAK learning style model was developed by Dunn and Dunn (Dunn and Griggs, 2003). According to Chislett and Chapman, (2005), the original VAK concepts were first developed by psychologists and teaching (of children) specialists, like Fernald, Keller, Orton, Gillingham, Stillman and Montessori. In VAK learning styles model, three learning styles were identified by Dunn, and Dunn (Dunn and Griggs, 2003). These learning styles are:- Visual learning style, Auditory learning style, and Kinesthetic learning style.

Visual Learning Style:- It involves the use of seeing to observe things, including pictures, diagrams, demonstrations, displays, handouts, films, flip-chart, etc.

Auditory Learning Style:- This involves the transfer of information through listening: to the spoken word, of self or others, of sounds and noises.

Kinesthetic Learning Style:- It involves physical experience- touching, feeling, holding, doing, practical hands- on experiences. The word “kinesthetic” describes the sense of using muscular movement – physical sense. Kinesthetic therefore describes a learning style which involves the stimulation of nerves in the body’s muscles, joints and tendons

According to Chislett and Chapman (2005), student preferences identified for each of the VAK learning styles are:

Visual: - Visual learners have preferences for seeing, for reading diagrams and maps, for expressing their feelings and moods through art, for thinking and imagination. They remember much of what they read. They prefer instructions to be written.

Auditory: - Auditory learners have preferences for listening, for verbal explanation, for talking over their notes, for discussions, for repeating words and key points in their head. They remember things they hear. They are good listeners.

Kinesthetic: - Kinesthetic learners have preferences for making things, for learning by trial and error, for demonstration, for sport activities, for practical work. They remember best through their own experiences.

Looking critically at VAK learning styles model, the indicators (visual, auditory, kinesthetic) seem relevant to the explanation of student learning styles in the teaching and learning of the sciences especially Biology. Also, Chislett and Chapman (2005) reported that the Visual-Auditory-Kinesthetic Learning Styles Model or ‘Inventory’, usually abbreviated to VAK, provide a simple way of explaining and understanding individual learning styles. They confirmed that VAK learning style model is widely used in schools in the United States, and 177 articles have been published in peer-reviewed journals. In view of this, VAK learning styles was used in this study.

Apart from personality type and learning style preferences, students' gender and age were also considered in this study. The gender influence on personality type is well documented in literature. For instance, Feingold (1994) reported that women score lower than men on assertiveness and higher on extroversion, anxiety, trust, and tender-mindedness. Archana (2007), however observed that female students had a significantly higher attribute of feeling preference than their male counterparts for whom thinking attribute was high. Considering the influence of gender on student' learning styles, Cavanaugh (2002) found that boys tend to be kinesthetic and visual. Also, Marcus (1999) and Pizzo (2000) declared that males tend to learn less by listening. Girls, more than boys, tend to be auditory-oriented.

Similarly, influence of gender on students' achievement has continuously been a thing of concern to researchers. For instance, Butler (2000); Chanlin (2001) were of the opinion that there were gender differences in academic achievement. Also, Jegede and Inyang (1990) found that boys performed better than girls in integrated science. However, Adepoju (1998) did not find any difference in achievement in science learning between boys and girls. Therefore, investigation into the relationship between gender and achievement still needs the attention of researchers because, from available literature, researchers have reported mixed findings on the influence of gender on students' achievement.

The influence of age on student learning styles continues to be a variable that deserves researchers' attention. For instance, Milgram and Price (2003), and Cavanaugh (2002) said that such factors as age, achievement level, gender, and culture can influence an individual's learning style and his/her achievements in learning. Similarly, Grasha (1996) reported consistent relationship between students' age, achievement and learning style. Also, Raven, Cano, Garton and Shelhamer (1993) found that age has negligible association with student learning styles.

1.2 Statement of the Problem

Students' poor performance in science generally and Biology in particular has been considered a serious problem in senior secondary school education by major stakeholders (e.g teachers, parents and researchers). This poor performance in Biology has been confirmed by low level of performance of students in examinations conducted by external body like the West African Examinations Council (WAEC) over the years.

From the available literature, several authors concentrated on finding the factors which bear on relationship among students' poor performance, government factor, parent factor, school factor, and teacher factor. Indeed, a few of the authors looked at factors that are

exclusive to students. Few studies have been conducted with regards to student personality type, student learning styles and students' achievement in the field of Biology at secondary school level. Apart from this, learning is a unique activity which nobody can do for the learner irrespective of the learner's gender or age. Therefore, there is need for continuous research on factors that are exclusive to students in order to see how such factors relate to their learning as well as how the factors can be harnessed to improve their performance.

In view of the foregoing, this study developed a causal model involving students' gender, age, extroversion, sensing, thinking, judging, visual, auditory, kinesthetic, and achievement in senior secondary school Biology.

1.3 Research Questions

Based on the stated problem, the study provided answers to the following questions.

1. What is the pattern of students' responses to measurement items on extroversion, sensing, thinking, judging, visual, auditory, kinesthetic, and Biology achievement?
2. What is the pattern of correlations in the model consisting of gender, age, extroversion, sensing, thinking, judging, visual, auditory, kinesthetic, and Biology achievement?
3. Is the model which describes the causal effect among the variables (gender, age, extroversion, sensing, thinking, judging, visual, auditory, kinesthetic, and Biology achievement) consistent with the observed correlations among these variables?
4. If the model is consistent, what are the estimated direct, indirect, and total causal effects among the variables?

1.4 Scope of the Study

This study was limited to the causal-effect relationships among students' gender, age, extroversion, sensing, thinking, judging, visual, auditory, kinesthetic and Biology achievement. The study focused on SSS 2 Biology students in Osun-State. Generalisation from the findings of the study was restricted to the variables and the population of the study.

1.5 Significance of the study

The results of this study will provide the government, policy makers, curriculum developers, civil society organisations, classroom teachers, and students the empirical information needed in relation to the contributions of the nine predictor variables of this study to the achievement of students in Biology with a view to bringing sustainable improvement to

their performance. Apart from the above mentioned categories of people, the findings of the study will be useful to human psychologists who require empirical information to confirm the existing assertions about the correlations that exist among the psychology variables and students' achievement that were considered in this study. The information will afford the human psychologists the opportunity to better guide students' thought, feelings and behaviours towards the improvement of their achievement in school subjects.

Finally, the data base will help provide further illumination into behavioural research

1.6 Definition of Terms

Operational Definition of Terms:

Age:- It refers to SSS 2 students that fall into age range of between 15years and 16years, and between 17years and 18years.

Exogenous Variables: - These variables are gender and age which are merely correlated but their causal relations are not explained by the model.

Endogenous Variables: - These variables are extroversion, sensing, thinking, judging, visual, auditory, kinesthetic and Biology achievement which have their variability explained by the model.

Personality Type: - It explains the personality type which SSS 2 Biology students exhibited in relation to personality type -ESTJ (Extroversion, Sensing, Thinking, Judging).

Personality Profile: - It describes the personality of SSS 2 Biology students in relation to personality type- ESTJ.

Extroversion:- This is the pattern of responses of SSS 2 Biology students to measurement items on extroversion.

Sensing:- It is the pattern of responses of SSS 2 Biology students to measurement items on sensing.

Thinking:- This is the pattern of responses of SSS 2 Biology students to measurement items on thinking.

Judging:- It is the pattern of responses of SSS 2 Biology students to measurement items on judging.

Learning Style: - This explains the learning style which SSS 2 Biology students exhibited in relation to VAK (Visual Auditory Kinesthetic)

Visual:- It is the pattern of responses of SSS 2 Biology students to measurement items on visual.

Auditory:- This is the pattern of responses of SSS 2 Biology students to measurement items on auditory.

Kinesthetic:- It is the pattern of responses of SSS 2 Biology students to measurement items on kinesthetic.

Achievement:- This is the performance of SSS 2 students as shown by their scores in Biology Achievement Test.

Personality Type Preference:- This is the pattern of responses of SSS 2 Biology students to measurement items on extroversion, sensing, thinking, and judging.

Learning Style Preference:- It refers to the pattern of responses of SSS 2 Biology students to measurement items on visual, auditory, and kinesthetic.

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CHAPTER TWO

LITERATURE REVIEW

Introduction

Literature related to the study in terms of their theoretical and empirical studies was reviewed under the following headings:

- 2.1 Theoretical Background.
- 2.2 Personality and Personality Theories.
- 2.3 Learning and Learning Theories.
- 2.4 Personality Type Preferences and Personality Models.
- 2.5 Learning Style Preferences and Learning Style Models.
- 2.6 Personality Type and Learning Style Preferences.
- 2.7 Personality Type Preferences and Achievement.
- 2.8 Learning Style Preferences and Achievement.
- 2.9 Gender and Personality Type Preferences
- 2.10 Gender and Learning Style Preferences.
- 2.11 Gender and Achievement.
- 2.12 Age, Personality Type Preferences, Learning Style Preferences, and Achievement.
- 2.13 Research Gap.
- 2.14 Appraisal of Literature Review.

2.1 Theoretical Background

The theoretical background of personality type lies in **holistic learning theory**. The basic premise of this theory is that the individual's personality consists of many elements, specifically, the intellect, emotions, the body impulse (or desire), intuition and imagination (Burns, 1995). Therefore, effective learning requires the activation of all personality elements. To activate personality elements, Carver and Scheier (2000) suggested that there should be interaction between the individual and the environment. This is explained by other personality theories such as behavioural theory, psychodynamic theory, and humanist theory. All these theories have been discussed under Personality and Personality Theories (see 2.3).

On the other hand, learning styles centre round **sensory stimulation theory**. According to Burns (1985), traditional sensory stimulation theory has as its basic premise that effective learning occurs when the senses are stimulated. He finds that 75% of the knowledge held by adults is learned through seeing. Hearing is the next most effective (about 13%) and the other senses – touch, smell and taste account for 12% of what we know. In a similar way,

effective learning requires the stimulation of multi-senses. Senses can only be stimulated in individuals through their interactions with the environment. Other theories that have to do with learning styles are: behaviourism, cognitivism, and constructivism (see 2.4)

2.2 Personality and Personality Theories

Personality

Different definitions of personality have been given by different researchers. For instance, Jung (1934) referred to personality as the supreme realisation of the innate idiosyncrasy of a living being. Oxford Dictionary, third edition defines idiosyncrasy as a person's particular way of thinking, behaving and feeling that is clearly different from that of others. Similarly, Carver and Scheier (2000) define personality as a dynamic organisation, inside the person of psychophysical systems that create a person's characteristic patterns of behaviour, thoughts and feelings.

Carver and Scheier gave the explanation of their definition of personality as follows:

- * Dynamic Organisation: This suggests ongoing readjustments, adaptation to experience, continual upgrading and maintaining. Personality doesn't lie there. It has process and it is organised.
- * Inside the person: It suggests internal storage of patterns, supporting the notion that, personality influences behaviours, thoughts and feelings.
- * Psychophysical systems: This suggests that the physical is also involved in who we are.
- * Behaviour, Thoughts, and Feelings: This indicates that personality includes a wide range of psychological experience/manifestation. That personality is displayed in MANY ways.

Also, Carver and Scheier (2000) suggested that the word personality conveys a sense of consistency, internal causality, and personal distinctiveness. They are of the belief that issue of personal distinctiveness is very important. Although, there are certain universal characteristics of the human race and particular features of individuals. For example, we all experience stress and the elevated cortisol that goes with it, and we all suffer the immune suppressive effects thereof. But, each of us is unique too.

Examining the definitions of personality as given and explained by the above scholars, one may consider personality as the function and the unique expression of an individual's mind based on the way he/she thinks, feels and behaves.

However, psychologists identify some fundamental characteristics of personality.

They are:

- i. **Consistency:** - There is generally recognisable order and regularity to behaviour. Essentially people act in the same ways or similar ways in a variety of situations. For instance, students who are told of their success in any examination, be it internal or external will behave in a similar way. What will be similar in their behaviours is that, they will all feel happy and encouraged. So also, the unsuccessful ones will feel unhappy and discouraged.
- ii. **Psychological and Physiological:-** Personality is a psychological construct, but researcher suggests that it is also influenced by physiological processes and needs. For example, a child that is raised in an environment that is characterised by immorality may not be upright in character. This is because, children are not only docile listeners but they are actively watching what goes on in their environment and this may have influence on their behaviours.
- iii. **It Impacts behaviour and action:-** Personality does not just influence how we move and respond in our environment, it also causes us to act in certain ways. For instance, an extrovert tends to behave in a different way from an introvert. Extrovert feels deprived when cut-off from group interaction while introverts feels comfortable staying alone.
- iv. **Multiple expressions:-** Personality is displayed in more than just one way. It can also be seen in our thoughts, feeling, close relationships, and other social interaction. This implies that personality is the function of how an individual thinks, feels, and behaves.

Personality Theories

There are dozens of personality theories. For clarity, these dozens of personality theories can be confined to three broad perspectives: (1) Psychoanalytic Theory, which focuses on the inner workings of personality, especially internal conflicts and struggles, (2) Behaviouristic Theory, which places greater importance on the external environment and on the effects of conditioning and learning, and (3) Humanistic Theory, which stresses subjective experience and personal growth (Nevid and Rathus, 2005).

- i. **Psychoanalytic Theory:-** Sigmund Freud was the founder of this theory. Freud drew on physics of his day (thermodynamics) to coin the term psychodynamics. Based on the idea of

converting heat into mechanical energy. He proposed that psychic energy could be converted into behaviour. Freud's theory places central importance on dynamic, unconscious psychological conflicts. He divides human personality into three significant components:- the **id**, **ego** and **super-ego**.

The **id** is the innate biological instincts and urges present at birth. It is self-serving, irrational, impulsive, and totally unconscious. It operates on the pleasure principle. It demands immediate gratification of its need regardless of external environment. Examples of such innate biological instincts and urges are:

Libido:- This is the energy which promotes survival that underlies sexual desire, and is expressed whenever we seek pleasure.

Thanatos:- This one is responsible for aggressive and destruction urges (the long history of wars and violence as evidence of such urges).

The **ego** (The "executive") is guided by the reality principle. It delays action until it is practical or appropriate. It is the system of thinking, planning, problem solving, and deciding. It is a conscious control of the personality. It directs energies supplied by the **id**. The **id** is like a blind king or queen whose power is awesome but who must rely on others to carry out orders. The **id** can only form mental images of things it desires ("Primary process Thinking"). The **ego** wins power to direct behaviour by relating the desires of the **id** to external reality.

The **super-ego** acts as a judge or censor for the thoughts and actions of the **ego** to bring behaviours under control. A person with a weak **super-ego** will be a delinquent, criminal, or antisocial personality. In contrast, an overly strict or harsh **super-ego** may cause inhibition, rigidity, or unbearable guilt. Freud refers to **conscience** as part of the **super-ego**. It reflects all actions for which a person has been punished. When the standards of the conscience are not met, you are punished internally by guilt feelings. However, **Ego** ideal reflects all behaviours for which a person has been rewarded. The ego ideal is a source of goals and aspirations. When its standards are met, pride is felt. According to Freud, personality is based on the dynamic interaction of these three components. Also, he is of the opinion that childhood experiences are important to development, and believed birth order may influence personality development.

- ii **Behaviouristic Theory:-** This explains any model of personality that emphasises observable behaviour, the relationship between stimuli and responses, and the impact of learning. The behaviourist position is that personality is no more (or less) than a collection of learned behaviour pattern. **Personality**, like other learned behaviour, is acquired through classical

and operant conditioning, observational learning, reinforcement, extinction, generalization, and discrimination. Children can learn things like kindness, hostility, generosity, or destructiveness. The belief of behaviourist was a radical shift away from Freudian philosophy.

This school of thought was developed by B.F. Skinner who put forth a model which emphasised the mutual interaction of the person or “the organism” with its environment. Skinner believed children do bad things because the behaviour obtains attention that serves as a reinforce. For example:- a child cries because the child’s crying in the past has led to attention. These are the response and consequences. The response is the child crying, and the attention that child gets is the reinforcing consequence. According to this theory, people’s behaviour is formed by processes such as operant.

However, the impact of learning on personality cannot be undermined. Learning theorists are interested in the ways that learning principles shapes and explain personality. They reject the idea that personality is made up of consistent traits. Their argument was that immediate conditions (for example rewards and punishments) in a given situation determine what behaviour **is likely** to occur, independent of **the actor’s personality trait**. Nevid and Rathus, (2005) agrees that some situations strongly affect behaviour. Other situations are trivial and have little impact. Thus, external events interact with each person’s unique learning history to produce behaviour in any given situation.

iii Humanistic theory:- Humanists view human nature as inherently good and they seek ways to allow our positive potentials to emerge. They reject the Freudian view of personality as a battleground for biological instincts and unconscious forces, and they oppose the mechanical “thing-like” overtones of the behaviourist viewpoint. We are not, they say, merely a bundle of moldable responses; rather, we are creative beings capable of free choice. To a humanist, the person you are today is largely the product of all of your previous choices. The humanistic viewpoint also places greater emphasis on immediate subjective experience, rather than on prior learning. Humanists believe that there are as many “real world” as there are people. So, to understand behaviour, we must learn how a person subjectively views the world-what is “real” for him or her.

According to Nevid, and Rathus, (2005), much human behaviour can be understood as an attempt to maintain consistence between one’s self-image and one’s actions. He maintains that experiences that match the self-image are symbolised (admitted to consciousness) and contribute to gradual changes on the self. Information or feelings

inconsistent with the self-image are said to be incongruent. It is incongruent, for example; to think of yourself as a considerate person if others frequently mention your rudeness. Experiences seriously incongruent with the self-image can be threatening, and they often distorted or denied conscious recognition. Blocking, denying, or distorting experiences prevents the self from changing and create a gulf between the self-image and reality. As the self-image grows more unrealistic, the incongruent person becomes confused, vulnerable, dissatisfied, or seriously maladjusted.

But, when your self-image is consistent with what you really thinks, feel, do, and experience, you are best able to actualize your potentials. Rogers also considered it essential to have congruence between the self-image and the ideal self. The greater the gap between the way you would like to be – the greater the tension and anxiety experienced. The Rogerian view of personality can therefore be summarised as a process of maximising potentials by accepting information about oneself as realistically and honestly as possible. In accord with Rogers' thinking, researchers have found that people with a close match between their self-image and ideal self tend to be socially poised, confident, and resourceful. Those with a poor match tend to be anxious, insecure, and lacking in social skills.

2.3 Learning and Learning Theories

Learning

Burns (1995) 'conceived of learning as a relatively permanent change in behaviour with behaviour including both observable activity and internal processes such as thinking, attitudes and emotions'. Burns considers that learning might not manifest itself in observable behaviour until some time after the educational programme has taken place. Also, Ileris (2001) said, in psychology and education, learning is commonly defined as a process that brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values and world views. Learning as a process focuses on what happens when the learning takes place. Explanations of what happens constitute **learning theories**.

Learning Theories

A learning theory is an attempt to describe how people and animals learn; thereby helping us understands the inherently complex process of learning. According to Schunk, (2000), learning theories have two chief values. One is in providing us with vocabulary and a conceptual framework for interpreting the examples of learning that we observe. The other is

in suggesting where to look for solutions to practical problems. The theories do not give us solutions, but they do direct our attentions to those variables that are crucial in finding solutions.

Schunk classified learning theories into three main categories or philosophical frameworks: behaviourism, cognitivism, and constructivism. Behaviourism focuses only on the objective aspects of learning. Cognitive theories look beyond behaviour to explain brain-based learning. And constructivism views learning as a process in which the learner actively constructs or builds new ideas or concepts.

Behaviourism

Behaviourism as a theory was primarily developed by B.F. Skinner. It loosely encompasses the work of people like Edward Thorndike, Tolman, Guthrie, and Hull. What characterise these investigators are their underlying learning. In essence, three basic assumptions are held to be true. First, learning is manifested by a change in behaviour. Second, the environment shapes behaviour. And third, the principles of contiguity, (how close in time two events must be for a bond to be formed) and reinforcement (any means of increasing the likelihood that an event will be repeated) are central to explaining the learning process Kim and Axelrod, (2005). For behaviourism, learning is the acquisition of new behaviour through conditioning.

There are two types of possible conditioning:

Classical conditioning: This is a type of conditioning where the behaviour becomes a reflex response to stimulus as in the case of Pavlov's Dogs. Pavlov was interested in studying reflexes, when he saw that the dogs drooled without the proper stimulus. Although no food was in sight, their saliva still dribbled. It turned out that the dogs were reacting to lab coats. Every time the dogs were served food, the person who served the food was wearing a lab coat. Therefore, the dogs reacted as if food was on the way wherever they saw a lab coat. In a series of experiments, Pavlov then tried to figure out how these phenomena were linked. For example, he struck a bell when the dogs were fed. If the bell was rang in close association with their meal, the dogs learned to associate the sound of the bell with food. After a while, at the mere sound of the bell, they responded by drooling.

Operant conditioning; It is a conditioning where there is reinforcement at the behaviour by a reward or a punishment. The theory of operant conditioning was developed by B.F. Skinner and is known as Radical Behaviourism. The word "operant" refers to the way in which behaviour

'operates on the environment'. Briefly, a behaviour may result either in reinforcement, which increases the likelihood of the behaviour recurring, or punishment, which decreases the likelihood of the behaviour recurring. It is important to note that, a punishment is not considered to be applicable if it does not result in the reduction of the behaviour, and so the terms punishment and reinforcement are determined as a result of the actions. Within this framework, behaviourists are particularly interested in measurable changes in behaviour.

Sincere behaviourists view the learning process as a change in behaviour; educators arrange the environment to elicit desired responses through such devices as behavioural objectives, competency-based education and skill development and training (Smith, 2002). Educational approaches such as applied behaviour analysis, curriculum based measurement, and direct instruction have emerged from this model (Kim and Axelrod, 2005).

Cognitivism

The earliest challenge to the behaviourists came in a publication in 1929 by Bode, a gestalt psychologist, (Bode, 1929). He criticized behaviourists for being too dependent on overt behaviour to explain learning. Gestalt psychologists proposed looking at the patterns rather than isolated events. Gestalt views of learning have been incorporated into what have come to be labeled cognitive theories. Two key assumptions underline this cognitive approach: (1) that the memory system is an active organised processor of information and (2) that prior knowledge plays an important role in learning. Cognitive theories look beyond behaviour to explain brain-based learning. Cognitivists consider how human memory works to promote learning. For example, according to Lilienfeld et al. (2010), the physiological processes of sorting and encoding information and events into short term memory and long term memory are important to educators working under the cognitive theory.

The memory theories that were established as a theoretical framework in cognitive are Atkinson-Shiffrin memory model and Baddeley's working memory model. New cognitive framework of learning began to emerge during the 1970s, 80s, and 90s. Today, researchers are concentrating on topics like cognitive load and information processing theory. deJong (2010) asserted that these theories of learning play a role in influencing instructional design. He further affirmed that aspects of cognitivism can be found in learning how to learn, social role acquisition, intelligence, learning, and memory as related to age. Smith (2002) stated that educators employing a cognitivist approach to learning would view learning as internal mental process (including, insight, information processing, memory, perception) employed in order to develop learner capacity and skills to improve learning. The educator structures

content of learning activities to focus on building intelligence, cognitive, and mental cognitive development.

Constructivism

Gibbons (2004) reported that the learning theories of Jean Piaget, Jerome Bruner, Lav Vygotsky and John Dewey serve as the foundation of constructivist learning theory. Constructivism views learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge or experience. In other words, “learning involves constructing one’s own knowledge from one’s own experiences.” Constructivist learning, therefore, is a very personal endeavour, whereby internalised concepts, rules, and general principles may consequently be applied in a practical real-world context.

This is also known as social constructivism. According to Driver, Asoko, Learch, Scott, and Mortimer, (1994), social constructivists posited that knowledge is constructed when individuals engage socially in talk and activity about shared problems or tasks. Learning is seen as the process by which individuals are introduced to a culture by more skilled members. Constructivism itself has many variations, such as active learning, discovery learning and knowledge building. Regardless of the variety, constructivism promotes a student’s free exploration within a given framework or structure, Devries and Zan (2003). They went further to say that, teacher acts as facilitator who encourages students to discover principles for themselves and to construct knowledge by working to solve realistic problems. Aspect of constructivism can be found in self-directed learning, transformational learning, experiential learning, and religious practice.

However, other learning theories are: **Transformative learning theory and Neuro education learning theory.**

Transformative Learning Theory

Transformative learning theory explains the process of constructing and appropriating new and revised interpretations of the meaning of an experience in the world, Taylor (2008). Also, Mezirow (1997) opined that transformative learning is the cognitive process of effecting change in a frame of reference. Ileris (2001) added that, it is recognised that important emotional changes are often involved in transformative learning. Mezirow maintained that these frames of reference define our view of the world and we have a tendency as adults to reject or deem unworthy any ideals that do not ascribe to our particular

values, associations, and concept. Our frames of reference are composed of two dimensions: habits of mind, such as ethnocentrism, which are more fixed and influence our point of view and the resulting thoughts of feelings associated with them. These points of view may change over time as a result of influences such as reflection, appropriation and feedback.

According to Ileris (2001), transformative learners utilise discourse as a means of critical examination and reflection devoted to assessing reasons presented in support of competing interpretations. This can be achieved by critically examining evidence, arguments, and alternative point of view. When circumstances permit, transformative learners move towards a frame of reference that is more inclusive, discriminating, self-reflective and integrative of experience. Also, Mezirow (1997) reiterated that transformative learning leads to autonomous and responsible thinking which is essential for full citizenship in democracy and for moral decision making in situations of rapid change.

Neuroeducation Learning Theory

Neuroeducation is an emerging new learning theory. Prestigious universities such as Harvard, Johns Hopkins, USC and others are now offering programmes dedicated to neuroeducation and are developing majors and degrees in the field. Wolf (2010) referred to neuroeducation as a learning theory that is founded on connecting what we know about how the brain processes and stores information with classroom instruction and experiences. He explained that neuroeducation analysed the biological change in the brain as new information is processed and looks at what environmental, emotional, social situations are best in order for the new information to be processed. It further analyses under what conditions the brain stores information and links it to other neurons versus simply determining that the information is non-essential to store and hence reabsorbs the dendrite and dismisses the information.

Radin (2009) pointed out that the examination of the art and science of teaching was further accelerated by President G.H Bush when he declared the 1990s as the Decade of the Brain. The integration and application of what we know about the brain was strengthened in 2000 when the American federation of teachers stated, it is vital that we identify what science tells us about how people learn in order to improve the education curriculum Radin (2009). Also, Rowland (2010) discussed that what is exciting about this new field in education is that, the way modern brain imagine techniques now make it possible, in some sense, to watch the brain as it learns. Rowland said, as academic language and learning (ALL) educators often work with students on improving their approaches to learning, the question then arises: can

the results of neuroscientific studies of brains as they are learning usefully inform practice in this area? Although the field of neuroscience is young, it is expected that with observing learning, the paradigms of what students need and how students learn best will be further refined with actual scientific evidence. In particular, students who may have learning disabilities will be taught with strategies that engage their brain and makes the connections needed.

2.4 Personality Type and Personality Models

Personality Types

An understanding of student personality type at the classroom level will expose the teacher to the personality type preferences which an individual student like to exhibit during teaching-learning process. This may facilitate the creation of educational activities that can accommodate the student's various personality type preferences with a view to improving learning outcomes.

Several models have been developed by researchers to measure personality but the most widely used model that measures personality types is Myers-Briggs Type Indicator (MBTI), Myers and Caulley (1980). However, other personality models, such as, the Big five factors, Cattels 16 PF, and Saville Holdworth's 'OPQ', measure personality traits.

According to Reinhold (2006), Myers Briggs proposes that an individual personality type can be described along four dimensions. These dimensions are:

- I. Orientation to life
- II. Perception
- III. Decision making
- IV. Attitude to the outside world.

Reinhold (2006) gave the detailed of the four dimensions of Myers Briggs Personality Types as:

i. **Orientation to life:** Orientation to life has to do with a person's most natural energy orientation. He maintains that every person has two faces. One is directed towards the outer world of activities, excitement, people, and things. The other is directed inward to the inner world of thoughts, interest, ideas, and imagination. While these are two different but complementary sides of our nature, most people have an innate preference toward energy from either the OUTER or the INNER world. Thus, one of their faces, either the Extraverted (E) or Introverted (I), takes the lead in their personality development and plays a more dominant role in their behaviour.

ii. **Perception:** It has to do with a person's most natural way of perceiving or understanding issues. The Sensing(S) side of our brain notices the sights, sounds, smells and all the sensory details of the present. It categorises, records and stores the specifics from the here and now. It is reality based, dealing with 'what is'. It also provides the specific details of memory and recollections from past events. The iNtuitive (N) side of our brain seeks to understand, interpret and form overall patterns of all the information that is collected and records these patterns and relationships. It speculates on possibilities, including looking into and forecasting the future. It is imaginative and conceptual.

iii. **Decision making:** The decision making dimension explains a person's most natural way of forming judgments and making choices. The Thinking (T) side of our brain analyses information in a detached, objective fashion. It operates from factual principles, deduces and forms conclusions systematically. It is our logical nature. The Feeling (F) side of our brain forms conclusions in an attached and somewhat global manner, based on likes/dislikes, impact on others, and human and aesthetic values. It is our subjective nature. Although everyone uses both means to form conclusions, each person has a natural bias towards one over the other. Even, when they give us conflicting directions, one side will still be the natural trump card or tiebreaker.

iv. **Attitude to the outside world:** It has to do with a person's "action orientation" towards the outside world. All people use both Judging (Thinking and Feeling) and Perceiving (Sensing and Intuition) processes to store information, organise our thoughts, make decisions, take actions and manage our lives. Yet one of these processes (Judging or Perceiving) tends to take the lead in our relationship with the outside world while the other governs our inner world. A Judging (J) style approaches the outside world with a plan and is oriented towards organising one's surroundings, being prepared, making decisions and reaching closure and completion. A Perceiving (P) style takes the outside world as it comes and is adopting and adapting, flexible, open-ended and receptive to new opportunities and changing game plans.

Looking critically at the four dimensions that explain an individual personality types as given by Myers-Briggs, four bipolar personality type preferences can be identified. This is confirmed by Felder, Felder, Mauney, and Dretz (1995) who says that, the Myers-Briggs Type Indicator identifies preferences in four areas:

a. Extroversion vs. Introversion

Extroverts are usually energised by being with people, and interacting with them. They often think best if they can talk over their ideas with other people.

Introverts, on the other hand, think best by themselves and by processing ideas in their own minds.

b. Sensing vs. Intuition

Sensing types tend to take in information in a sequential way through the use of their five senses. They tend to be interested in the concrete and here & now. Intuition types are more interested in theories and possibilities. They often make good guesses without going through sequential steps of reasoning it out.

c. Thinking vs. Feeling

Thinking types tend to make decisions more objectively, on logical, impartial grounds. Feeling types, on the other hand, tend to come to a decision more subjectively on the basis of feelings as well as the effect of the decision on personal issues.

d. Judging vs. Perceiving

Judging types like things to be clear and settled. They are naturally closure-oriented. Perceiving types like matters to be open-ended for as long as possible.

Also, Myers-Briggs, according to Felder et.al, (1995) (2002), identified how people with the eight personality type preferences learn as:

- i. **Extroverts:** The extroverted learner learns more effectively through concrete experiences, contacts with the outside world, and relationships with others. They value group interaction and class work done together with other students. They are willing to take conversational risks, but are dependent on outside stimulation and interaction.
- ii. **Introverts:** The introverted learner learns more effectively in an independent situations that are more involved with ideas and concepts. Their strengths are their ability to concentrate on task in hand as well as their self-sufficiency. However, they need to process ideas before speaking which sometimes leads to avoidance of linguistic risk-taking in conversation.
- iii. **Sensing types:** The sensors learn more effectively from reports of observable facts and happenings. They prefer physical and sense based input. Their great assets are their willingness to work hard in a systematic way. They pay attention to details. However, they will be hindered should there be a lack of clear sequence, goals or structure in the language or language course.

- iv. **Intuitive types:** The intuitive learners learn more effectively from flashes of insight, using their imagination, and grasping the general concepts rather than all the details. Their strengths are their ability to guess from the context, structuring their own training, conceptualising and model-building. However, they can be hindered by inaccuracy and missing important details.
- v. **Thinking types:** The thinking learners learn more effectively from impersonal circumstances and logical consequences. Their strengths are in the ability to analyse and their self-discipline. However, they can suffer from performance anxiety because their self-esteem is attached to achievement.
- vi. **Feeling types:** The feeling learners learn best from personalized circumstances and social values. They have the advantage of their strong desire to bond with the teacher, resulting in good relations which lead to high self-esteem. However, they can become discouraged if not appreciated, and disrupted by lack of interpersonal harmony.
- vii. **Judging types:** The judging learners learn more effectively by reflection, analysis and processes that involve closure. They have the advantage of systematically working through a task and wanting to get the job done. However, they suffer from rigidity and intolerance of ambiguity.
- viii. **Perceiving types:** The perceiving learners learn best through negotiation feeling, and inductive processes that postpone closure. Their strong points are their openness, flexibility and adaptability to change, and new experiences. However, they may suffer from laziness and inconsistent pacing over the long haul.

Examining Myers-Biggs personality type's preferences, two possible personality types are identifiable. They are: personality types- ESTJ (Extroversion, Sensing, Thinking, Judging) and personality type-INFP (Introversion, iNtention, Feeling, Perception). However, the relationship among the personality type preferences for each of the four bi-polar dimensions provides additional possible personality types. This makes the total number of Myers-Biggs personality types to be 16.

This is confirmed by Archana (2007) who said that, Myers Biggs type indicator (MBTI) categorises people into 16. basic personality types. These personality types are :

- ESTJ (Extroversion, Sensing, Thinking, Judging)
- INFP (Introversion, iNtention, Feeling, Perception)
- ESTP (Extroversion, Sensing, Thinking, Perception)

ESFP (Extroversion, Sensing, Feeling, Perception)
ESFJ (Extroversion, Sensing, Feeling, Judging)
ENFP (Extroversion, iNtuition, Feeling, Perception)
ENTP (Extroversion, iNtuition, Thinking, Perception)
ENFJ (Extroversion, iNtuition, Feeling, Judging)
ENTJ (Extroversion, iNtution, Thinking, Judging)
INTJ (Introversion, iNtuition, Thinking, judging)
INTP (Introversion, iNtuition, Thinking, Perception)
INFJ (Introversion, iNtuition, Feeling, Judging)
ISTJ (Introversion, Sensing, Thinking, Judging)
ISTP (Introversion, Sensing, thinking, Perception)
ISFP (Introversion, Sensing, Feeling, Perception)
ISFJ (Introversion, Sensing, Feeling, Judging)

1. ESTJ

ESTJ (Extroversion, Sensing, Thinking, Judging) is an abbreviation used in the publications of the Myers-Briggs Type Indicator (MBTI) to refer to one of sixteen personality types. According to Bourne (2005), Myers-Briggs, describes ESTJs as individuals that direct their energy towards the outer world of actions and spoken words. They introduce a logical organisation and structure into the way things are done. They prefer dealing with facts and the present, and are likely to implement tried and trusted solutions to practical problems in a professional manner. The dominant function of ESTJs is the judging one of Thinking.

Characteristics of ESTJs

- * They like to make decisions on the basis of logic, using objective considerations.
- * They are concerned with truth, principles and justice.
- * They are analytical and critical, tending to see the flaws in situations.
- * They tend to organise life on a logical basis, classifying, ordering, and directing facts and situations.
- * They are comfortable with conflict as a way of resolving problems.
- * ESTJs like to think on practical decisions that lead to tried and trusted ways of organising or solving problems.
- * ESTJs like to work hard and efficiently to complete tasks by the deadlines set.

- * They focus too much on the current task at the expense of broader interpersonal issues
- * ESTJs do not pay enough attention to other's feelings and values.
- * They express appreciation towards others.
- * They take command, decide what needs to be done, and tell everyone what to do.
- * When ESTJs are under extreme stress, they withdraw and want to be alone.
- * Also, under stress, they have intense emotions, that may not be expressed.

2. INFP

INFPs direct their energy towards the inner world of thoughts and emotions. They give importance to particular ideas or beliefs; focusing on those things that they believe in strongly. They prefer dealing with patterns and possibilities, especially for people. They prefer to undertake work that has a meaningful purpose. The dominant function of INFPs is the judging one of feeling.

Characteristics of INFPs

Pearman, Lonbardo, and Eichinger, (2005) gave the characteristics of INFPs as follows;

- * INFPs make decisions on the basis of personal values.
- * They assess the impact of decisions on others, being sympathetic or compassionate.
- * They retain a strong sense of values, which are often not expressed.
- * They feel appreciation towards others but not express it.
- * INFPs look for meaningful relationship.
- * They generate team spirit through sensitive listening and a quite enthusiasm.
- * INFPs like to avoid conflict and not giving forthright criticism when it is needed.
- * They focus on impersonal details during discussions and when making decisions.
- * They contribute creative ideas, but overlook current realities.
- * When INFPs are under extreme stress, they tend to be critical and find fault with almost everything.

3. ESTPs

According to Myers, McCaulley, Quenk, and Hammer, (1998), ESTPs direct their energy towards the outer world of actions and spoken words. They solve problems, take action and actualize ideas and concepts-bringing them to function. They are therefore action oriented problem solvers. They often prefer to work with practical organisational issues. The dominant function of ESTPs is the perceptive one of sensing.

Characteristics of ESTPs.

- * ESTPs focus more on the here and now rather than possibilities for the future.
- * They like looking at information in terms of facts and details.
- * ESTPs seek to experience and enjoy the world as it is.
- * They tend to enjoy action and events for themselves rather than for the company of others.
- * ESTPs tend to apply a common sense approach to problem solving.
- * They like turning to a new problem before the last one has been fully completed.
- * They express appreciation to others for their qualities.
- * When under extreme stress, they have intense negative feelings towards others, which may be openly expressed.

4. ESFPs

Killian, (2007) gives the description and characteristics of ESFPs as follows:

ESFPs direct their energy towards the outer world of actions and spoken words. They get things done, and get them done quickly. They prefer doing things with and for people. They seek to live life to the full and create experiences for others as well. They enjoy solving urgent problems, such as fire-fighting or trouble shooting. Their dominant function is the perceptive one of Sensing.

Characteristics of ESFPs

- * ESFPs like looking at information in terms of facts and details.
- * They focus more on the here and now, rather than possibilities for the future.
- * They tend to enjoy action and events for the company of others rather than the events themselves.
- * They use a sense of humour to build a friendly atmosphere.
- * They maintain awareness of the factual information on which discussions are based.

- * They act too quickly, without appearing to think things through. ESFPs spend time to interpret facts – looking for subjective meaning, and for underlying patterns.
- * They fail to consider cost implications
- * When in extreme stress, ESFPs go quiet or withdraw from others.
- * They openly criticize other people.

5. ESFJ.

Bess, et.al, (2003) described ESFTs as individuals that direct their energy towards the outer world of actions and spoken words. They seek to build harmony in personal relationships, engendering team spirit and being an encouragement to others. They like dealing with people, and organise life on a personal basis. Their dominant function is the judging one of Feeling.

Characteristics of ESFJs

- * ESFJs make decisions on the basis of personal values.
- * They seek stable, harmonious relationships.
- * They tend to consider others' feeling before their own.
- * ESFJs view people subjectively, observing facts that support harmonious relationships.
- * They work hard and efficiently to complete tasks by the deadlines set.
- * They strive to ensure that people are happy with the service provided.
- * They like to avoid conflict, and not given criticism when it is needed.
- * They tend to talk too much.
- * They tend to neglect their own needs while being concerned for others.
- * When under extreme stress, ESFJs become very critical and find fault with almost everything.

6. ENFP

Georgia State University (2006) provided the following as the description and characteristics of ENFPs.

ENFPs are the types that direct their energy towards the outer world of actions and spoken words. They seek to develop new potential, explore new possibilities and create new situations that yield the expectation of something better. They often enjoy work that involves

experimentation and variety. The dominant function of ENFPs is the perceptive one of iNtuition.

Characteristics of ENFPs

- * ENFPs like looking at information from a global viewpoint, spotting patterns and relationships.
- * They change procedures to see if any improvement can be made, rather than just operate them.
- * ENFPs are interested in evolutionary development, but with an eye on the strategy.
- * They inwardly appreciate the contributions of others, though not expressing it that often.
- * ENFPs internally reject any options that clearly conflict with their values, though the rejection might not be expressed or seen to others.
- * When in a team environment, ENFPs act as catalyst for change, and encourage the team to change together.
- * They are being selective about starting projects, and producing plans to help identify which ones can be delivered.
- * When under stress, ENFPs involve people in brainstorming ideas.
- * They provide a lot of drive, but try to do too much.

7 ENTP

Falt (2004) described ENTPs as individuals that direct their energy towards the outer world of actions and spoken words. They try to create new potential, changing things to see if any improvement can be made. ENTPs generally work towards a better future. They are often trying challenging the status quo and instigating change. The dominant function of ENTPs is the perceptive one of iNtuition.

Characteristic of ENTPs

- * ENTPs try ideas out, to explore new possibilities and discover, by experience, which, ones work.
- * They focus more on possibilities for the future than the here-and-now.
- * They tend to look inward to spot the flaws in situations, people or ideas.
- * In a team environment, ENTPs challenge the status quo, and encourage other team members to achieve more than they thought they could.
- * They find ways to overcome apparently insurmountable difficulties.

- * They tend to initiate too many projects, and not being able to deliver on all of them.
- * On recognising stress, ENTPs provide a lot of diver, but try to do too much.
- * They also draft in people with proven skills to work on the problem.

8 ENFJ

ENFJs direct their energy towards the outer world of actions and spoken words. They try to build harmony in important personal relationships. Their lives are organised on a personal basis, seeking to develop and promote growth in people they values, Bourne, (2005) The dominant function of ENFJs is the judging one of feeling.

Characteristics of ENFJs

- * They make decisions on the basis of personal values
- * They tend to adapt to the environment, taking on board those values that are held as important by friends and family, or society as a whole.
- * They tend to consider other's feelings before their own.
- * When in a team environment, ENFJs seek to arrive at consensus decisions.
- * They focus on areas of agreement and building on other's proposals
- * They find an independent and objective means of verifying their insights about people.
- * They let others develop at their own pace.
- * On recognising stress, ENFJs contribute creative ideas, but overlook current realities
- * They fail to consider the cost implication.

9. ENTJ

ENTJs direct their energy towards the outer world of actions and spoken words. They organise and structure the word according to logical principles, tending to control life-organising systems and people to meet task oriented goals. They also try to improve the way things are done. The dominant function of ENTJ is the judging one of thinking.

Characteristic of ENTJs

Pearman and Albritton, (1996) gave characteristics of ENTJs as follows;

- * They like making decisions on the basis of logic, using objective considerations.
- * They are concerned with truth principles and justice.

- * ENTJs are comfortable with conflict as a way off resolving problems
- * They focus on creative decisions that lead to change and new possibilities.
- * In a team environment, ENTJs provide a drive to complete the task on time and to a high quality.
- * Also, they involve people who are competent in relevant skills and ensuring everyone knows what they have to do.
- * They sometimes issue directives without explaining the reasons why.
- * On recognising stress, ENTJs decide what needs to be done, and tell everyone what to do.
- * They make decisions quickly, and without considering the impact on people.

10. INTP

Pearman, et. al, (2005) described INTPs as individuals that direct their energy towards the inner world of thoughts and emotions. They structure and organise their ideas, coming up with theories and explanations to explain new areas of scientific research or experience. They often seek to understand the full complexity of any situation and enjoy solving difficult intellectual problems. The dominant function of INTP is the judging one of Thinking.

Characteristics of INTPs

- * INTPs like making decisions on the basis of logic, using objective considerations.
- * They are concerned with truth, principles and justice.
- * They think mostly about impersonal issues, focusing more on concepts, truths and systems rather than individuals' feeling.
- * INTPs perceive patterns in information to support the logical analysis.
- * In a term environment, the INTPs focus attention on central issue.
- * They view information objectively.
- * At times, INTPs cling to a principle at the expense of relationships and harmony.
- * On recognising stress, INTPs criticize others efforts and ignore their feelings.
- * They withdraw to think about the central issue that needs attention.
- * Under extreme stress, INTPs become preoccupied with details, without any logical basis.

11. INTJ

INTJs direct their energy towards the inner world of thoughts and emotions. Generally, INTJs use their imaginations to come up with new ideas, possibilities and perspectives. They often organise their lives on a logical basis, and produce plans and strategies to put their ideas into practice. The dominant function of INTJ is the perceptive one of iNtuition.

Characteristics of INTJs

Kilhan (2005) identified the characteristics of INTJs as follows:

- * INTJs focus more on possibilities for the future than the here-and-now.
- * They enjoy change, challenge and variety.
- * They seek to develop an understanding of how the world can be.
- * They seek to establish a clear vision but fail to involve others in the development of that vision.
- * INTJs apply logical analysis to perceive patterns and possibilities; this enables them to quickly see the underlying principles in a situation.
- * In a team environment, the INTJs develop and maintain a sense of direction in the teams work.
- * Also, they ensure that ideas and vision are translated into action.
- * They produce work to a high level of quality.
- * At times, INTJs express emotions in an intensive and uncontrolled way.

12. INFJ

INFJs direct their energy towards the inner world of thoughts and emotions. INFJs are described as individuals that use their imagination to come up with new ideas, possibilities and insights, especially in relation to people and important beliefs. Also, are often good at developing insight into people, thought, which can often remain unexpressed. The dominant function of INFJs is the perceptive one of iNtuition.

Characteristics of INFJs

According to Jung (1971), the following are the characteristics of INFJs:

- * They like looking at information from a global view point, spotting patterns and relationships that lead to an understanding of the key issues.
- * They seek to develop an understanding of how the world is, or can be.
- * INFJs express appreciation for the contributions of others, particularly where they have done or said something that supports their ideals

- * In a team environment, the INFJs seek to promote harmony and co-operation.
- * Also, they listen carefully to various viewpoints, and being able to identify potential areas of agreement to be used as a basis to move forward.
- * They tend to pursue ideas without fully thinking through the consequences in, say, cost terms.
- * On recognising stress, they tend to make errors of fact, or ignore routine matters that might nevertheless be essential.
- * Under extreme stress, INFJs act in a very materialistic and selfish way.

13. ISTJ

Hunsley, Lee, and Wood (2004) described ISTJs as individuals that direct their energy towards the inner world of ideas and information. They try to clarify concepts and information, seeking to have as clear a knowledge as possible. They often place a lot of trust in experience. They envisage future goals especially where there is a clear pathway to that goal. The dominant function of ISTJs is the perceptive one of Sensing.

Characteristics of ISTJs

Bess and Harvey, (2001) identified the characteristics of ISTJs as follows:

- * ISTJs like looking at information in terms of facts and details
- * They feel comfortable in areas of proven experience.
- * They like to be pragmatic in nature, constantly learning to adapt to the world as it is now
- * ISTJs make decisions on the basis of logical analysis that support their understanding of the world.
- * When in a team environment they sort ideas and identify those that are most practical.
- * Also they maintain team focus on the objective
- * They often focus too much on the current task at the expense of longer term or inter personal issues.
- * They develop a long term vision that avoids focusing on details.
- * On recognising stress, ISTJs find a place of solitude in which to think and work.
- * Under extreme stress, they act impulsively, and change things without any thought.

14. ISTP

Thomas (1992) identified the following as the general description of ISTP: They direct their energy towards the inner world of thoughts (and, may be, emotions). They analyse situations and come up with explanations of how things work. ISTPs prefer dealing with tangible problems and proven experience. They often enjoy solving organisational problems that need to be thought through. The dominant function of ISTPs is the judging one of Thinking.

Characteristics of ISTPs

Virgina (2004) provided the following as the characteristics of ISTPs.

- * They like making decisions on the basis of logic, using objective considerations.
- * They are concerned with truth, principles and justice.
- * ISTPs think mostly about impersonal issues, focusing more on concepts, truths and systems rather than individuals' feelings.
- * They focus their thinking on understanding practical problems.
- * When in a team environment, ISTPs like to be a source of information, or an 'expert' in some subjects.
- * They encourage the team to realistically assess the situation.
- * Focus too much on the current task at the expense of longer term or interpersonal issues.
- * They tend not to complete a task before moving into the next one.
- * On recognising stress, they withdraw from people, to think through possible solutions.
- * Under extreme stress, ISTPs attribute unrealistic negative meaning to others actions and statements.

15. ISFP

Myers (1980) gave the general description of ISFPs as: They direct their energy towards the inner world of thoughts and emotions. They give importance to particular beliefs or opinions, particularly those that relate to people that they know and current experiences. ISFPs tend to take a caring and sensitive approach to others. The dominant function of ISFPs is the judging one of Feeling.

Characteristics of ISFPs

Myers, Mary, Naomi and Allan, (1998) listed the following as the characteristics of

ISFPs:

- * They make decisions on the basis of personal values.
- * They assess the impact of decisions on others, by being sympathetic or compassionate.
- * ISFPs retain a strong sense of values, which are often not expressed.
- * They feel appreciation towards others, but not express it.
- * They focus their feeling on current relationships and people, e.g.; through one-to-one discussions and fact-based conversation.
- * They seek to enjoy the company of those they know, and being concerned, for their well-being and happiness.
- * In a team environment, ISFPs solve problems as they arise, especially ones concerning people.
- * They ensure the well-being of team members.
- * They are being considerate of others points of view and going with the majority.
- * ISFPs list options and undertake a formal process of evaluation against criteria, including a cost benefit analysis.
- * On recognising stress, they concentrate on what they see as important, and tend to work alone if possible.
- * When under extreme stress, they become bossy and ignore others' feelings.
- * They become very critical and finding fault with almost everything.

16. ISFJ

ISFJs direct their energy towards the inner world of thoughts and emotions. The general description of ISFJs include: They try to clarify ideas and information, particularly when it relates to people and important relationships. They are quiet, serious observers of people. They are often both conscientious and loyal. The dominant function of ISFJs is the perceptive one of Sensing Borne (2005).

Characteristics of ISFJ

Bess, Harvey, and Jwartz, (2003) identified the characteristics of ISFJs as follows:

- * They like looking at information in terms of facts and details.
- * They focus more on the here and now rather than possibilities for the future.
- * They seek to develop a realistic understanding of the world as it is, in the light of what they observe.

- * They focus their sensing on ideas and possibilities that relate to people.
- * They reinforce the subjectivity of observation.
- * In a team environment, ISFJs work hard and efficiently to complete tasks by the deadlines set.
- * They ask for contributions from all team members, and seek to arrive at consensus decisions.
- * They maintain respect for established hierarchies and traditions.
- * They tend to avoid conflict, and not giving criticism when it is needed.
- * On recognising stress, ISFJs find a place to solitude in which to think and work.
- * They also value the efforts of others, and appreciate their encouragement.
- * However, under extreme stress or fatigue, ISFJs are being intolerant of others who do not act competently.
- * They are being argumentative

Personality Models

Some of the personality models that have been developed by researchers for understanding, explaining and measuring personality are Myers-Briggs Personality Model, Cattell's 16PF Model, Belbin 'team role' Model, and The Big-Five factor Model. From the available literature, it is only the Myers-Briggs Personality Model that describes and measures personality types. Other personality models describe and measure personality traits.

Cattell's 16PF Model

According to trait theory, human personality is composed of a number of broad traits or dispositions. Early theories attempted to describe every possible trait. For instance, Cattell (1957) reports that psychologist Gordon Allport identified more than 4,000 words in English language that could be used to describe personality traits. Later, Raymond Cattell analysed this list and whittled it down to 171 characteristics, mostly by eliminating terms that were redundant or uncommon. He was then able to use a statistical technique known as factor analysis to identify traits that are related to one another. By doing this, he was able to reduce his list to 16 key personality factors.

McCrae & Coasta (1996) affirmed that Raymond B. Cattell developed his 16PF in the 1940s. However, most sources indicate an original publication date of 1949. The opinion of Cattell was that each person contains all of these 16 traits to a certain degree, but they might

be high in some traits and low in others (Paul, 1992)). Zeisset (2006) reported that, the 16PF is one of the longest standing and most widely used personality testing systems of all.

Cattell identifies sixteen 16 personality traits with their code letters and preferences Zeisset (2006). They are:

- * Warmth (A): outgoing versus reserved
- * Reasoning (B): Abstract versus concrete
- * Emotional stability (C): Calm versus high strung
- * Dominance (E): Forceful versus submissive
- * Liveliness (F): Spontaneous versus restrained
- * Rule-consciousness (G): Conforming versus non-conforming
- * Social Boldness (H): Uninhibited versus shy
- * Sensitivity (I): Tender-hearted versus trusting
- * Vigilance (J): Unsuspecting versus suspicious.
- * Abstractedness (M): Imaginative versus practical
- * Privatness (N): Discreet versus open
- * Apprehension/Apprehensiveness (O): Worried versus confident
- * Openness to change (Q₁): Flexible versus attached to the familiar
- * Self-reliance (Q₂): Self-sufficiency versus dependent
- * Perfectionism (Q₃): Controlled versus undisciplined
- * Tension (Q₄): Impatient versus relaxed

Conn and Rieke, (1994) confirmed that Cattell also developed an assessment based on these 16 personality factors. The test is known as the 16PF Personality Questionnaire. Conn and Rieke maintain that the questionnaire is frequently used, especially in business for employee testing and selection, career counseling and marital counseling.

Belbin's Team Role Model

Zeisset (2006) reported that Belbin used Cattell 16PF Model in constructing his 'Belbin Team Roles' model and testing instruments. West (1994) claims that, based on research with over 200 teams conducting management business games at the Administrative Staff College, Henley, in the UK, Belbin identified nine team types. These nine team types with their characteristics are as follows:

- * **Coordinator:-** The co-ordinator is a person oriented leader. This person is trusting, accepting, dominant and is committed to team goals and objectives. The co-ordinator is a positive thinker who approves of goal attainment,

struggle and effort in others. The co-ordinator is someone tolerant enough to reject their advice. However, the co-ordinator may not stand out in a team and usually does not have a sharp intellect.

- * **Shaper:-** The shaper is a task-focused leader who abounds in nervous energy, who has a high motivation to achieve and for whom winning is the name of the game. The shaper is committed to achieving the aims of the team. He or she will challenge, argue or disagree and will display aggression in the pursuit of goal. According to Belbin, the presence of two or three shapers in a group can lead to conflict, aggravation and in-fighting.
- * **Plant:-** The plant is a specialist idea maker characterised by high IQ and introversion while also being dominant and original. The plant tends to take radical approaches to team functioning and problems. Plants are more concerned with major issues than with details. The weakness of a plant is the tendency to disregard practical details and argumentativeness.
- * **Resource Investigator:-** The resource investigator is the executive who is never in his room, and if he is, he is on the telephone. The resource investigator is someone who explores opportunities and develops contracts. Resource investigators are good negotiator who probe others for information and support and pick up other's ideas and develop them. They are characterised by sociability and enthusiasm and are good at liason work and exploring resources outside the group. Their weaknesses are a tendency to lose interest after initial fascination with an idea, and they are not usually the source of original ideas.
- * **Company worker/implementer:-** Implementers are aware of external obligations and are disciplined, conscientious and have a good self-image. They tend to be tough-minded and practical, trusting and tolerant, respecting established traditions. They are characterised by low anxiety and tend to work for the team in a practical, realistic way. Implementers figure prominently in positions of responsibilities in larger organisations. They tend to do the jobs that others do not want to do and do them well: for example, disciplining employees. However, implementers are conservative, inflexible and slow to respond to new possibilities.
- * **Monitor evaluator:-** According to the model, this is a judicious, prudent, intelligent person with a low need to achieve. Monitor evaluators contribute

particularly at times of crucial decision making because they are capable of evaluating competing proposals. The monitor evaluator is not deflected by emotional arguments, is serious

minded, tend to be slow in coming to a decision because of a need to think things over and takes pride in never being wrong. However, their weaknesses are that they may appear dry and boring or even over-critical. They are not good at inspiring others. Those in high level appointments are often monitor evaluators.

- * **Team worker:-** Team workers make helpful interventions to avert potential friction and enable difficult characters within the team to use their skills to positive ends. They tend to keep team spirit up and allow other members to contribute effectively. Their diplomatic skills together with their sense of humour are assets to a team. They tend to have skills in listening, coping with awkward people and to be sociable, sensitive and people oriented. However, they tend to be indecisive in moments of crisis and reluctant to do things that might hurt others.
- * **Completer finisher:-** The completer finisher dots the i's and cross the t's. He or she gives attention to detail, aims to complete and to do so thoroughly. They make steady effort and are consistent in their work. They are not so interested in the glamour of spectacular success. Their weakness, according to Belbin, are that they tend to be over anxious and have difficulty letting go and delegating work.
- * **Specialist:-** the specialist provides knowledge and technical skills which are in rare supply within the team. They are often highly introverted and anxious and often tend to be self-starting, dedicated and committed. Their weakness are single-mindedness and a lack of interest in other peoples' subjects.

The Big Five Factor Model

'The Big Five is the commonly used term for the model of personality which describes the five fundamental factors of our personality. The Big Five-Factor Model is comprised of five personality dimensions (OCEAN): Openness to Experience, Conscientiousness, Extroversion, Agreeableness, and Neuroticism. Paunonen and Jackson (2000) claim that each of the five personality factors represents a range between two extremes. For example, extroversion represents a continuum between extreme extroversion

and extreme introversion. In the real world, most people lie somewhere in between the two polar ends of each dimension. According to them, the major proponents of the Big Five-Factor Model are Norman, Smith, Goldberg, McCrae and Coasta, Brand and Egan, Goldman, and Sinclair.

McCrae and Coasta (1997) presented the Big Five-Factors and the behavioural elements associated with them as:

- * **Openness to experiences (vs. closeness to experiences).** Finds routines and systems constricting, enjoys challenging the status quo, and champions change. He is a creative thinker and problem solver, unconventional and intellectual. Thinks on feet, idealistic and has a broad range of interests.
- * **Conscientiousness (vs. lack of conscientiousness).** Reliable and efficient, persevering and dutiful, quality-conscious and detailed, keen to achieve goals.
- * **Extroversion (vs. introversion).** Open and talkative, competitive, enthusiastic and persuasive, enjoys a fast pace and variety at work. Socially active and energetic, can be impulsive or indiscreet, needs praise-enjoys attention. Can lack concentration in routine or long tasks.
- * **Agreeableness (vs. Disagreeableness).** Empathetic and consensus oriented, enjoys team participation, tolerant of others, seen as kind and generous, patient and democratic with others. Can find disciplining others difficult, can be seen as too soft or submissive.
- * **Neuroticism (vs. Emotional stability).** Prone to anxiety under pressure, dislikes making big/important decisions, not ambitious, and concerned by change or the unexpected. May be temperamental, nervous in presenting self or own ideas.

McCrae and Coasta (1997) considered that the Big Five as a very useful model for assessing non-managerial staff, but it lacks some of the rigor required for assessing people in or destined for managerial and executive roles. The Big Five Model gives us an accurate and fast way of assessing the main drivers of someone's personality.

2.5 Learning Styles and Learning Style Models

Learning Styles

Many definitions have been given to learning styles by different scholars. However, the following examples as given by some researchers provide a useful overview of a range of definitions of individual learning style. They are as follows:

- * the composite of characteristic cognitive, affective, and psychological traits that serve as relatively stable indicators of how an individual perceives, interacts with, and responds to the learning environment, Kieve (1979);
- * the generalised difference in learning orientations based on the degree to which people emphasise four stages of the learning process: concrete experience, reflective observation, abstract conceptualisation, and active experimentation, as measured by a self-report test called Learning Style Inventory, Kolb (1985);
- * a typical mode or manner of an individual of acquiring, retaining and applying knowledge, skills, the way of perceiving, organising and retaining experiences, responding to particular methods of instructions, Kolesnik, (1996);
- * general cognitive and learning characteristics of self-consistent mode of functioning which an individual shows in his perception and intellectual activities, Stern (1996);
- * the way that an individual use to focus his knowledge and skills on problem situations that have not been encountered, Gagne (1997);
- * the predisposition of an individual to learn in a particular way, Parrot (1998);
- * a student's individual reaction to 23 elements of instructional environment as the following:
 - i. immediate environment (noise, temperature, light, design);
 - ii. emotionality (general motivation, being motivated by a teacher, parents, a peer, persistence, responsibility, the attitude to the structure of a learning task);
 - iii. social preferences (learning alone, with peers in a group, learning in combined ways);
 - iv. physical characteristics (auditory, visual, tactile/kinesthetic preferences, time of day, intake, mobility);
 - v. psychological inclinations (global/analytic, hemispheric preferences, impulsive/reflective), Dunn and Price, (1998);
- * a characteristics manner in which an individual chooses an approach to a learning task, Skehan (1998);
- * the unique complex of conditions under which an individual concentrates on, obtains, processes, retains and applies new and difficult information, Milgram, (2000);
- * the whole unique, genetically predetermined complex of characteristics conditions under which an individual concentrates, perceives, processes,

retains, and applies new and difficult information, in the unity of progress in learning and acquisition of learning objectives of curriculum with the help of successful interaction with the learning environment and creative use of one's own potential-capacities, Tatarinceva (2005).

Examining the various definitions of learning style as given by different scholars, one may say that learning style is the unique complex of conditions, a preferred way, an identifiable individual approach, and the genetically predetermined conditions under which a learner learns best.

Learning Style Models

Learning style models explain different styles of learning. It is interesting to say that individuals perceive and process information in very different ways. This view is supported by Sihunk (2000) who states that people have preferred ways of absorbing, processing, and retaining information. Several models of learning styles have been developed by different scholars. Some of these learning style models are: David Kolb's Learning Style Model, Grasha-Richmann Learning Style Model, Honey and Mumford's Learning Style Model, Anthony Gregorc's Learning Style Model, and VAK Learning Style Model.

VAK Learning Style Model

VAK learning style is the focus of this work because the learning styles typology developed by Dunn and Dunn is distinct from the other models reviewed so far. It is distinct in the sense that it is based on students' responses to actual classroom activities rather than on a more general assessment of cognitive traits, Susan and Linda, (1998). Also, VAK is derived from the accelerated learning world seems to be about the most popular model nowadays due to its simplicity, University of Pennsylvania, (2009).

According to Dunn and Griggs (2003), VAK learning styles was developed by Dunn and Dunn. However, Jackson, Hobman, Jummieson, and Martin (2008), reported that the original VAK concepts were first developed by psychologist and teaching (of children) specialists, like Fernald, Keller, Orton, Gillingham, Stillman, and Montessori. The VAK learning style uses the three main sensory receivers: Visual, Auditory, and Kinesthetic. It is based on modalities-channels by which human expression can take place and is composed of a combination of perception and memory: (University of Pennsylvania, 2009). According to the VAK theorists, we need to present information using all three styles. This allows all

learners the opportunity to become involved, no matter what their preferred style may be, Rounke, et.al, (2002).

Apart from the detailed explanation of VAK given at the background of this study, University of Pennsylvania brought up some hints for recognising and implementing the three VAK styles.

Visual Learners: They have two sub-channels, linguistic and spatial. Learners who are visual-linguistic like to learn through written language, such as reading and writing tasks. They remember what has been written down, even if they do not read it more than once. They like to write down directions and pay better attention to lectures if they watch them. Learners who are visual-spatial have difficulty with the written language and do better with charts, demonstrations, videos, and other visual materials. They easily visualise faces and places by using their imagination and seldom get lost in new surroundings. To integrate this style into the learning environment, University of Pennsylvania suggests the following activities:

- * Use graphs, charts, illustrations, or other visual aids.
- * Include outlines, concept maps, handouts, etc. for reading and taking notes.
- * Include plenty of content in handouts to read after the learning session.
- * Invite questions to help learners stay alert in auditory environments.
- * Post flip charts to show what will come and what has been presented.
- * Eliminate potential distractions.
- * Supplement textual information with illustrations whenever possible.
- * Have them draw pictures in the margins.
- * Have the learners envision the topic or have them act out the subject matter.

Auditory Learners: Auditory learners often talk to themselves. They also may move their lips and read out loud. They may have difficulty with reading and writing tasks. They often do better talking to a colleague or a tape recorded and hearing what was said. To integrate this style into the learning environment:

- * Begin new material with a brief explanation of what is coming.
- * Conclude with a summary of what has been covered. This is the old adage of “tell them what they are going to learn, teach them, and tell them what they have learnt”.

- * Use the Socratic Method of lecturing by questioning learners to draw as much information from them as possible and then fill in the gaps with your own expertise.
- * Include auditory activities, such as brainstorming, buzz groups.
- * Leave plenty of time to debrief activities. This allows them to make connections of what they learnt and how it applies to their situation.
- * Have the learners verbalise the questions.
- * Develop an internal dialogue between yourself and the learners.

Kinesthetic Learners: They learn best while touching and moving. It also has two sub-channel; kinesthetic (movement) and tactile (touch). They tend to lose concentration if there is little or no external stimulations or movement. When listening to lectures, they may want to take notes for the sake of moving their hands. When reading, they like to scan the material first, and then focus in on the details (get the big picture first). They typically take notes by drawing pictures, diagram, or doodling. To integrate this style into the learning environment:

- * Use activities that get the learners up and moving.
- * Play music, when appropriate, during activities
- * Use coloured markers to emphasise key points on flip charts or white boards.
- * Give frequent stretch breaks (brain breaks)
- * Guide learners through a visualisation of complex tasks.
- * Have them transfer information from the text to another medium such as a keyboard.

Other learning style models are:

David Kolb Learning Style Model

The David A. Kolb styles model is based on the scientific method theory, as explained in his book *Experiential Learning: Experience as the source of learning and development*, Rita and Adrian, (2008). David A. Kolb outlines two related approaches toward grasping experience: **Concrete Experience** and **Abstract Conceptualisation**, as well as two related approaches toward transforming experience: **Reflective Observation** and **Active Experimentation**. According to Kolb's model, the ideal learning process engages all four of these modes in response to situational demands.

In order for learning to be effective, all four of these approaches must be incorporated. As individuals attempt to use all four approaches, however, they tend to develop strengths in

one experience-grasping approach and one experience-transforming approach. The resulting learning styles are combinations of the individuals preferred approaches. These learning styles are as follows:

Converger;

Diverger;

Assimilator;

Accommodator;

Convergers are characterised by abstract conceptualisation and active experimentation. They are good at making practical applications of ideas and using deductive reasoning to solve problems. Divergers tend toward concrete experience and reflective observation. They are imaginative and are good at coming up with ideas and seeing things from different perspectives. Assimilators are characterised by abstract conceptualisation and reflective observation. They are capable of creating theoretical models by means of inductive reasoning. Accommodators use concrete experience and active experimentation. They are good at actively engaging with the world and actually doing things instead of merely reading about and studying them. Kolb's model gave rise to the Learning Style Inventory, an assessment method used to determine an individual's learning style. An individual may exhibit a preference for one of the four styles-Accommodating, Converging, Diverging and Assimilatory-depending on their approach to learning via the experiential learning theory model, Rita and Adrian , (2008).

Grasha and Reichmann Learning Style Model

Anthony Grasha is a professor of psychology at the University of Cincinnati. His areas of specialisation are in cognitive and social processes in human error, learning and teaching styles, cognitive processes in stress and coping, and in conflict resolution. According to Muhammed (2008), Grasha and Sheryl Reichmann developed the Grasha-Reichmann Learning Style Scales (GRLSS) in 1974 to determine college students' styles of classroom participation. The Grasha-Reichmann model focuses on student attitudes toward learning, classroom activities, teachers, and peers rather than studying the relationships among methods, student style, and achievement.

Grasha became interested in learning styles while he was a psychology teaching assistant at the University of Cincinnati. His earliest interests were in styles he thought to be negative (Avoidant, Competitive, Dependent). He interviewed 50-75 students in their reactions traditional classroom procedures and found the negative reactions he later labeled as

styles. To test his ideas, he compared student attitudes in his classes and those of a traditionally oriented colleague. He found his students to be by their analysis, more Participative, Collaborative, and Independent than those of his colleague. Grasha original idea was that Avoidant, Dependent, and Competitive styles were always dysfunction Grasha described students with each of his learning styles as:

Avoidant: Avoidant students tend to be at the lower end of the grade distribution. They tend to have high absenteeism; they organise their work poorly, and take little responsibility for their learning.

Participative: They are characterised as willing to accept responsibility for self-learning and create well to their peers.

Competitive: Competitive students are described as suspicious of their peers leading to competition for rewards and recognition.

Dependent: They are students that typically become frustrated when facing new challenges not directly addressed in the class room.

Independent: Independent students prefer to work and require little direction from the teacher.

Honey and Mumford Learning Style Model

In the mid 1970's Peter Honey and Alan Mumford adapted David Kolb's model for use with a population of middle/senior managers in business. According to Roberts (2007), they published their version of the model in *The Manual of Learning Styles* (1982) and *Your Learning Styles* (1983). Two adaptations were made to Kolb's experiential model.

Firstly, the stages in the cycle were renamed to accord with managerial experiences of decision making/problem solving. The Honey and Mumford stages are:

- Having an experience
- Reviewing the experience
- Concluding from the experience
- Planning the next steps.

Secondly, the styles were directly aligned to the stages in the cycle and named **Activist, Reflector, Theorist and Pragmatist**. These are assumed to be acquired preferences that are adaptable, either at will or through changed circumstances, rather than being fixed personality characteristics. The Honey and Mumford Learning Styles Questionnaire (LSQ) is self-development tool and differs from Kolb's Learning Style Inventory by inviting managers to complete a checklist of work-related behaviours without directly asking

managers how they learn. Having completed the self-assessment, managers are encouraged to focus on strengthening under utilised styles in order to become better equipped to learn from a wide range of every day experiences. Robert (2007) confirmed that A MORI survey commissioned by (The Campaign for Learning) in 1999 found the Honey and Mumford LSQ to be the most widely used system for assessing preferred learning styles in the local government sector in the UK.

Anthony Gregorc Learning Style Model

According to Rita and Adrian (2008), Dennis W. Mills discusses the work of Anthony F. Gregorc and Krathleen A. Butter in his article entitled “Applying What We Know: Student Learning Styles”, Gregorc and Butter worked to organised a model describing how the mind works. This model is based on the existence of perceptions-our evaluation of the world by means of an approach that makes sense to us. These perceptions in turn are the foundation of our specific learning strengths, or learning styles.

In this model, there are two perceptual qualities- 1) concrete and 2) abstract; and two ordering abilities- 1) random and 2) sequential. Concrete perceptions involve registering information through the five senses, while abstract perceptions involve the understanding of ideas, qualities, and concepts which cannot be seen. In regard to the two ordering abilities, sequential involves the organisation of information in a linear, logical way and random involves the organisation of information in chunks and in no specific order. Both of the perceptual qualities and both of the ordering abilities are present in each individual, but some qualities and abilities are more dominant within a certain individuals. There are four combinations of perceptual qualities and ordering abilities based on dominance: 1) Concrete Sequential; 2) Abstract Random; 3) Abstract Sequential; 4) Concrete Random. Individuals with different combinations learn in different ways. They have different strengths, different things make sense to them, different things are difficult for them, and they ask different questions throughout the learning experience.

2.6 Personality Type Preferences and Learning Style Preferences

Several studies had been carried out to describe the personality type and learning style preferences of individuals, and to explain the relationships that might exist between the two. The conclusion drawn from these studies is that not all students exhibit the same personality type and learning style preferences in a classroom situation. For instance, Gregory (2005) in his study: Learning Style and Personality Type Preferences of Community Development

Extension Educators, used 67 subjects which comprised of 37 (55.2%) males and 30 (44.8%) females. He found that, of the 16 possible personality type preference combinations, the most common personality (23.9%) among the subjects was the-ISTJ type combination. In addition, Gregory observed that more subjects preferred the field dependent learning style (56.7%) than the field independent learning style (43.3%). He also found that nearly 60% of community development extension educators who preferred a field dependent learning style favored extroversion personality preference. Thus, he concluded that there was a negligible association between the personality type and learning style sub scales of community development extension educators.

In another related study, Tracy and Ronna (2004) examined the personality and learning style differences in graduate science programmes incorporating business skills training. They compared multidisciplinary graduate student with traditional engineering students to investigate personality and learning style differences. Tracy and Ronna found that in each of the four learning style categories, a larger proportion of the student in the multidisciplinary programme were classified as active learners (60%) than the traditional programme (43%). The percentage of students preferring the sensing and sequential styles of learning were approximately equal for both engineering programmes. However, student in both engineering programmes typically considered themselves visual rather than verbal learners (88% and 86%, respectively for the multidisciplinary and traditional programmes).

For the personality types, Tracy and Ronna claimed that, a larger percent of the students in traditional programmes showed a preference toward introversion personality type (67%) as compared to the multidisciplinary group (46%). Both groups were more often classified as intuitive rather than sensing (67% of the disciplinary students and 87% of the traditional students). The multidisciplinary group classified themselves as thinkers (77%), whereas the traditional group tended towards the feeling personality type (53%). Both groups had slightly larger proportions of judges than perceivers (69% and 60% in the multidisciplinary and traditional groups, respectively). Summarily, according to them, the students in the multidisciplinary group were slightly more extraverted, had a slightly greater preference toward active learning, and had a greater preference toward thinking personality type than students in traditional programmes.

Jamie, Bryan, and Matt (1992) investigated the learning styles, teaching styles and personality styles of preservice teachers of agricultural education at The Ohio State University. The result indicated that 11 (44%) of the subjects were field dependent learners but 14 (56%) were independent learners. This implied that preservice teachers do differ in

their preferred learning styles. They further revealed that the majority of the subjects were either ESFJ, ESTJ, or ISTJ. They maintained that, in analysing the Extroversion-Introversion (EI) dimension, 15 (60%) were E and 10 (40%) were I. on the Sensing-Intuition (SN) dimension, 19 (36%) were S and 6 (24%) were I. analysing the Thinking-Feeling (TF) dimension, 14 (56%) were T and 11 (44%) were F. On the final dimension, Judgment-Perception (JP), 15 (60%) were J and 10 (40%) were P. they concluded that, just as there were learning style differences found within the sample, many personality types were also identified. This implies that learners differ in their personality type and Learning style characteristics.

2.7 Personality Type Preferences and Achievement

A learner who is aware of his or her personality type preferences may be able to understand his or her nature. This may enable him or her to acknowledge and embrace the characteristic way by which he or she could learn best. This may go a long way in determining his or her achievement. For example, a learner who is usually energised by being with people and interacting with them, and can often think best if he can talk over his ideas with other people is considered an extrovert. This implies that such a learner will learn effectively in dependent situations but not in independent ones. The above assertion concurs with the research findings of Felder and Brent (2000); Provost, (1992) which revealed that, being sensible to the role that personality type plays in learning and teaching cannot only make a student's first encounter with the different subjects less dismay, it may also help making learning interesting.

Several researchers have worked on effects of personality type preferences on student's achievement in combination with different learning style preferences. For instance, Rosalti (1999) reported that in 1980, a consortium consisting of eight universities and The Center for Applications of Psychology Type was formed to study the role of personality type preferences in engineering education. Introverts, intuitors, and judgers generally out performed their extroverted, sensing, and perceiving counter parts in the population studied. In a work done as part of this study, Rosalti obtained similar results for some engineering courses. He affirmed that the average grade for the intuitors in most of the engineering courses was indeed higher than that for the sensors but in the few "solid sensing" courses in the curriculum (such as engineering economics) the sensors scored higher. It follows that the demand placed upon the student by different courses may determine the personality type preference a student is expected to exhibit. However, Rosati declared that, students who came

into engineering with strong predictors of success were equally likely to succeed, regardless of their type.

In a similar study, R.M. Felder of Department of Chemical Engineering, North Carolina State University; G.N. Felder of Department of Physics, Stanford University and E.J. Dietz of Department of Statistics North Carolina State University used The Myers-Briggs Type Indicator (MBTI) on a group of 116 students taking the introductory chemical engineering course at North Carolina State University. They observed that, when chemical engineering courses were taught in a manner that emphasised active and cooperative learning and inductive presentation of course material, (extroverts, sensors, and feelers) were found to have improved performance. The reason for this was that the experimental instructional approach appeared to have improved the performance of MBTI types (extroverts, sensors, and feelers) found in previous studies to be disadvantaged in the engineering curriculum. They therefore, concluded that the MBTI is a useful tool for helping science engineering instructors to understand their students and to design instruction that can benefit students of all types

Felder, (1995) supported the above findings by saying that students with different type preferences tend to respond differently to different modes of instruction. He observed that extroverts like working in settings that provide for activity and group work; introverts prefer settings that provide opportunities for internal processing. Sensors like concrete learning experiences and clearly defined expectations and dislike instruction heavy in abstractions like theories and mathematical models; intuitors like instruction that emphasises conceptual understanding and deemphasises memorisation of facts, rote substitution in formulas, and repetitive calculations. Thinkers like logically organised presentations of course material and feedback related to their work; feelers like instructors who establish a personal rapport with them and feedback that shows appreciation of their efforts. Judgers like well-structured instruction with clearly defined assignments, and goals; perceivers like to have choice and flexibility in their assignments and dislike having to observe rigid timelessness. Therefore, one may say that biology teachers should pain to understand their students and employ suitable teaching methods that can benefit students of varying personality type preferences. This may help improve student's performance in the subject (Biology).

However, Felder (1995) suggested that professionals in every field must function in all type modalities to be fully effective, and the goal of education should therefore be to provide balanced instruction. Students should be taught sometimes in the style they prefer. This will keep them from being too uncomfortable for learning to occur. On the other hand,

they should sometimes be taught in their less preferred mode. This will help them develop the diverse strengths they will need to function effectively in their careers. Unfortunately, many of our secondary school teachers in Nigeria do not provide this balance. More often than not severe mismatches commonly occur between the teaching styles of teachers and the learning styles of their students. This seems to bring detrimental effects on the academic performance of the students and on their attitudes toward their education.

The major aim of secondary school education is to provide a stepping stone that would serve as basis for preparing a learner to be an achiever or a performer in whichever field he or she may find himself or herself after schooling. This might be the reason why Stevens and Burley (2003) went a step forward by investigating the effects of personality characteristics on job performance. They conducted 10-year study to investigate the relationship between personality characteristics and job performance in a Fortune 500 Chemical Company. They utilised the MBTI personality scales and the MBTI creating index to investigate the relationship between personality, creativity and profitability. They found that extroversion, intuition, thinking, and perceiving are positively related to creativity. Also, the results from the MBTI were significantly related to performance and profitability.

Further, Stevens and Burley used MBTI-CI to classify 69 new business development (NBD) analysts into two groups and followed the success rate of their 267 NBD projects over 10 years. They established that creativity and profitability was high for the group with the higher MBTI-CI scores as compared with low creativity and profitability for the group with the lower MBTI-CI scores. The total profit of the NBD group with the higher MBTI-CI scores was \$197.5 million as compared to \$15.2 million for the low creativity group. They identified that the two most important subscales of the MBTI appeared to be the Sensing-Intuitive scale and the Thinking-Feeling scales. Thus, Stevens and Burley concluded that certain personality characteristic in combination with training, maybe an important consideration in the hiring and training process for certain industry job position. This means that personality type characteristic may have a negligible relationship with job performance.

2.8 Learning Style Preference and Achievement

Learning style describes the process that learners use to sort and process information. Learning style is an important factor in several areas, including students' academic achievement, how students learn and teachers teach, and student-teacher interaction, Gregory (2005). Several studies have measured and explained learning style preferences, Gregory, Jacobs, (2005); Roberts and Dyer, (2005). The conclusion drawn from the previous research

is that not all students learn the same. Because not all students learn the same it therefore becomes imperative that teachers recognise students' learning styles differences and teach in a manner in which all learning style preferences are incorporated.

Arif, Hale, Ataturk, and Istanbul (2000) conducted a study on "The Effect of Learning Styles on Academic Achievement and Attitude through Internet Assisted Chemistry Education". In their study, they investigated the effect of web-based homework on academic achievement and science teaching attitude for students with different learning style preferences and made a comparison to the use of traditional homework. Their findings showed that academic achievement of the students differed significantly with respect to their learning style preferences. They went further to say that, academic achievement of the students who had independent learning style preference was significantly higher than collaborative, dependent and avoidant learners. Academic achievement scores of cooperative learners were significantly higher than avoidant ones. However, there was no significant difference in terms of attitudes towards science teaching for learners with different learning styles preferences.

In another study (The Influence of Learning Styles on Student Attitude and Achievement When an Illustrated Web Lecture is Used in an Online Learning Environment), Roberts and Dyer (2005) used Gregorc Learning Style Delineator (Concrete Sequential (CS), Concrete Random (CR), Abstract Sequential (AS), and Abstract Random (AR) on their subjects). They found that participants expressed different learning style preferences. The majority of participants were concrete in their learning style preference while few of them were Abstract Sequential learners. However, there was no difference in achievement and attitudes, for students of different learning style preferences. Therefore, they concluded that when an illustrated web lecture is used to deliver content, students of varying learning styles achieve at similar levels and have similar attitudes toward the learning activity.

Also, Ali, (2008) worked on the "Effect of Learning Styles on Students' Performance". He investigated the relationships among Technology-Enhanced Blended Instruction, Traditional Pedagogical Approach, and Felder-Silverman Learning Styles (active-reflective, sensing-intuitive, visual-verbal, and sequential-global). He reported that the students' learning style preferences can play important roles in their quantitative performance. Despite that, they argued that they would not blindly recommend that instructors employ technology-enhanced approaches to improve learning outcomes solely based on students' learning style preferences. He said, there are advantages to broad spectrum training outside the domain of the students' preferred learning approach. For example, in multidisciplinary studies, active,

visual or global learners may significantly benefit from exposure to reflective, verbal and/or sequential pedagogical styles.

Therefore, one may conclude that researchers have reported mixed findings on the influence of learning style preferences on student achievement. Apart from the above researchers, several scholars reported a relationship (Daniel, 1999; Oxford, Park-oh, Ito and Sumrall, 1993); while others reported that learning style preferences had no influence on achievement or attitudes (Day, Raven, and Newman, 1998; Freeman, 1995). Therefore, the arguments on influence of learning style preferences on achievement are inconclusive.

2.9 Gender and Personality Type Preferences

Teachers are faced with the daunting task of preparing both male and female students for the rapidly changing demands of the century ahead. Personality type preferences may help explain some of the variability among secondary school biology students. Learning differs from most other activities in that male and female students need to transform their classroom experience into learning outcome. This requires ability to retain, recall, and apply new information to solve immediate and future problem.

The distinction between the term sex and gender is a frequent topic for debates within research and epistemology, Tatarinceva (2005). In view of this, it is necessary to make a clear cut distinction between the two terms. According to Deaux, 2005; Oakley, 1992; a common use of the term sex is to restrict to referring to biological distinctions between males and females, while reserving the term gender to refer to the psychological features or attributes associated with such categories as feminine or masculine.

Many researchers have uncovered relationship between gender and personality type preferences. For instance, Archana (2007) made a comparative study of personality profiles between male and female students and also in full time and part time students. He administered MBTI test questionnaire on 229 students chosen from a management institute. He found that full time male students were having a significantly higher preference of N (iNtuition) and P (Perception) than part time male students who were having preference for S (Sensing) and J (Judging). Additionally, it was found that the female students were having a significantly higher attributes of F (Feeling), than their male counterparts of full stream of management students in whom T (Thinking) attribute was high. He maintained that only 32.4 percent of females were S (Sensing) as compared to 47.8 percent males.

Also, females are generally more Extrovert, though marginally, than their Male counter parts. He added that in the population only 56.5 percent males were judging as

compared to 70.6 percent of females. In a similar study, Kroeger and Thuesen, (1988) established that about two-thirds of women have profiles in which feeling predominates, while two-thirds of men have profiles in which thinking predominates.

However, one of the findings of Archana contrary to figures suggested by US National average and available data on similar attributes of different tests that females have, a slightly higher percentage of S (Sensing), than in males, Archana (2008). Therefore, it becomes evidence that the influence of gender on personality type preferences still deserves the attention of researchers.

2.10 Gender and Learning Style Preferences

One way to improve performance is to adapt teaching approaches to meet the different learning style preferences of both male and female students. It is known that students have a variety of learning style preferences but it is unknown if gender differences in learning style preferences exists among secondary school biology students.

However, according to Tatarinceva (2005), the influence of gender is always considered important in the process of learning. Wehrwein, Lujan and Dicarolo (2009) investigated the influence of gender differences in learning style preferences among undergraduate physiology students. They administered VARK questionnaire on 86 students who enrolled in a capstone physiology course at Michigan State University. They found that females preferred unimodal learning, whereas, males preferred multimodal learning. They went further to say that 87.5% of males but only 45% of females preferred multiple modes of presentation. In contrast, the majority of female (54.2%) preferred a single mode of information presentation, either V, A, R, or K. this means that, unlike male students, females preferred information to be presented in a single mode. Although female learners can use all the sensory modes in learning, one is dominant and preferred. But male students may adjust to the different teaching styles faced in a day or they may opt in and out of a alternative strategies, such as being visual in cardiovascular physiology and reading/writing in respiratory physiology, for example (Fleming,1995).

Other researchers, (such as Grebb, 1999; Ebel, 1999; Cavanaugh, 2002) established that males and females learn differently from each other. Males tend to be more kinesthetic, tactual, and visual. According to Marcus, 1999; Pizzo, 2000, females, more than males tend to be auditory. Studies conducted by Aries (1996), Leet-Pellegrini (2000) and Fox (1999) suggest that males feel more comfortable in a lecturing role, which is a demonstration of

expertise and status, but females feel more a desire to collaborate, bond and to be liked by products of world of connection, not status.

In the context of the available literature so far reviewed, one may suggest that male and female students should be prepared to expand their learning style repertoire so that, they may be more empowered to learn in a variety of learning situations. They should bear in mind that an individual may not totally have preferences for certain learning styles but somewhere along the continuum. What an individual may aim is to strengthen those areas where he believes he is weak.

2.11 Gender and Achievement

A gender aspect of behaviour and performance is one important part of this study. There is always a need for investigations regarding reasons why differences emerge and are developed; what the consequences may be in the process of learning. The research on human cognitive abilities or intelligence many years ago showed the assumption of female intellectual inferiority (Shields, 1995; Dijkstra, 2006). But some investigations produced scientific evidence which considered females and males to be equally intellectually capable (Elliot, 1991; Gadira and Griggs, 1995).

We have to be aware that if gender is a social phenomenon, one should be able to find learning evidence of it, since learning is the primary means by which children acquire knowledge, skills, values, and world views. According to Hauberg (1992), such evidence is indeed to be found: From the different treatment by parents of children in terms of educational opportunity depending on sex. Also, through the social approval of associating little girls with domestic responsibility, while their male counterparts get on with the business of finding out how the world outside school is, how people in family work, what the power of the world is. The maintenance of female subordination may be understood by the principle of *hegemonic masculinity*, Connel (1997), which states that a higher value is automatically assigned to things masculine, Hirdman (1998). All these views which center round female subordination have made the under-valuing of female education to be a world wide phenomenon, expressed both in and out of school. This may in turn have some relationships with the girls' attainment in education.

For instance, Jegede and Inyang (1990) investigated gender difference and achievement in Integrated Science among Nigeria Junior Secondary School Students. They used JSS2 and 3 students in 22 randomly selected schools of Akwa-ibom state. They found that differences in achievement existed between males and females in integrated science.

However, on specific effects of gender, Alebiosu (1998) found no significant main effect on learning outcomes in chemistry. In addition, there was no significant interaction effect of treatment and gender on students' learning outcome. Thus, it is evidence that, researchers have continuously reported mixed findings about the effects of gender on students' achievement

2.12 Age, Personality Type Preference, Learning Style preference, and Achievement.

Students not only differ in gender, personality type preferences, and learning style preferences, they also differ in age. This diversity can affect classroom settings in many ways. For example, Gregory (2005) reported that levels of association between age and personality type preferences were negligible. He said that there was a general preference across age group toward introversion, sensing, thinking, and judging.

Also, findings associated with the influence of age on learning styles have been reported by many researchers. For instance, older students who can draw from their life experience are more likely to be independent, "self-directed" learners (Tatarinceva, 2007). This is in line with the Grasha's findings which state that older engineering students scored substantially higher on the independent scale, Grasha (1996). However, Grasha did not find any consistent relationship between academic major and his learning style typology (avoidant, participative, competitive, collaborative, dependent, and independent).

Concerning age and achievement, Grasha further revealed that students over 25 years tend to employ more independent and participatory styles; and students with a participatory style get higher grades than those with avoidant styles. This implies that age has an indirect effect on achievement.

2.13 Research Gap

Despite the amount of related research regarding personality types and learning styles preferences, secondary school Biology students may be unable to fully utilise the results. This is because secondary school Biology students were not included in the sample of most of the previous research. Thus, within the secondary school education, a problem exists in that there is a lack of data which identifies the personality types and learning style preferences that students possess.

Apart from this, most of the research work pertaining to personality type and learning style preferences were carried out by researchers from the developed countries. But very

insignificant similar studies have been carried out within the borders of research domain in Nigeria.

Also, in most of the available research work on personality type and learning style preferences, various learning style models were investigated along Myers-Briggs personality models. However, few of the researchers have combined VAK learning style model in their investigation. Similarly, none of the researchers used path analysis and multiple regression to analysis their data.

It was on the premise of the research gap identified above that this present study was carried out.

2.14 Appraisal Literature Reviewed.

Theories of personality include – Behavioural theory, Psychodynamic theory and Humanist theory. According to Carver and Scheier (2000), Behavioural theory suggests that personality is a result of interaction between the individual and the environment. Behavioural theorists include B.F. Skinner and Albert Bandura. Psychodynamic theory of personality emphasises the influence of the unconscious mind and childhood experiences on personality, Carver and Scheier, (2000). Humanist theory emphasises the importance of free will and individual experience in the development of personality, Rogers (1987). There are many theories of how people learn. Some of these learning theories include Behaviourism, Cognitivism, Constructivism, Transformative, and Neuroeducation learning theories.

Different definitions of personality have been given by different researchers. For instance, Jung (1934) refers to personality as the supreme realisation of the innate idiosyncrasy of a living being. Similarly, Carver & Scheier (2000) define personality as a dynamic organisation, inside the person, of psychophysical systems that create a person's characteristic patterns of behaviours, thoughts, and feelings. Personality type theory aims to classify people into distinct and discontinuous personality categories. It helps to distinguish a personality type approach from a personality trait approach, which takes a continuous approach. According to Archana (2007) Myers-Briggs Type Indicator (MBTI) categorises people into 16 basic personality types. They are: ESTJ, ESTP, ESFP, ESFJ, ENTJ, ENTP, ENFP, ENFJ, INFP, INTP, INFJ, INTJ, ISTJ, ISTP, ISFP, ISFJ. Personality models explain personality types and traits. These personality models include: Myers-Briggs Personality model, the Big Five Factor personality model, Cattell's 16PF model, Saville & Holdsworth's OPQ model, and Belbin 'team role' personality model.

Learning style models explain different styles of learning. It is interesting to say that individuals perceive and process information in very different ways. This view is supported by Schunk (2000) who states that people have preferred ways of absorbing, processing, and retaining information. Several models of learning style have been developed by different researchers. Some of these learning style models are: David Kolb's learning Style Model, Grasha-Richmann Learning Style Model, Anthony Gregorc's Learning Style Model, and VAK Learning Style Model.

In a related study Williams and Turner (2004) investigated the personality and learning style differences of multidisciplinary graduate students and traditional engineering students. They found that students in the multidisciplinary group are slightly more extroverted and have a slightly greater preference toward active learning. Also, they have a greater preference toward thinking personality type than students in traditional programs. Similarly, Davis (2005) measures the learning styles and personality type preferences of community development extension educators. He found that females are more field dependent than males. Males are more than three times more likely to prefer gathering information using their senses (sensing) than females. He concluded that there is a negligible level of association between learning style and personality type subscales.

Felder, Felder and Dietz (2002) worked on the effects of personality type on chemical engineering students. They find that extroverts significantly outperformed introverts in chemical engineering classes using active and cooperative learning methods. Stevens and Burley (2003) conducted a 10-year study to investigate the relationship between personality characteristics and job performance in a 500 chemical company. They utilize the MBTI personality scales on the subjects. They found that personality classifications of extroversion, intuition, thinking, and perception are positively related to creativity.

Males and females learn differently from each other (Cavanaugh, 2002; Ebel, 1999; Grebb, 1999). They go further to say that males tend to be more kinesthetic, tactile, and visual, and they need more mobility in a more informal environment than females. Studies conducted by Aries (1996) and Leet-Pellegrim (2006) suggested that males feel more comfortable in a lecturing role which is a demonstration of expertise and status, but females feel more comfortable in a listening role. The influence of gender is always considered important in the process of learning, Tatarinceva (2007). According to Dijkstra (2006), the research on human cognitive abilities or intelligence many years ago showed the assumption of female intellectual inferiority. However, some investigations produced scientific evidence which showed females and males to be equally intellectually capable, Elliot (1991; Godwa

and Griggs, 1995). Thus, the issue of gender differences in achievement still needs the attention of researchers.

Students not only differ in gender, cultural background, socio-economic status and learning styles but they also differ in age. This diversity can affect classroom settings in many ways. For example, older student who can draw from their life experience are more likely to be independent, “self-directed” learners, Tatarinceva (2007). This is in line with the Grasha’s findings which state that older engineering students scored substantially higher on the independent scale, Grasha (1996). However, Grashas has not found any consistent relationship between academic major and his learning style typology. On the hand, his research has demonstrated some consistent variations due to student age. More specifically, students over 25 years tend to employ more participating style; and students with a participatory style get higher grades than those with avoidant styles.

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CHAPTER THREE

METHODOLOGY

3.1 Research Design.

The study was a survey research that used causal-comparative design. In this study, the independent variables had occurred much earlier in the population. Therefore, random assignment and manipulation of variables were not carried out by the researcher.

3.2 Target Population.

The target population comprised all the SSS 2 Biology students in the thirty one local government areas of Osun State. The choice of SSS 2 was based on the fact that the class was free from the pressure of external examinations usually noticed with SSS 3 students. Also the group had been exposed to the teaching and learning of Biology for almost two years unlike SSS 1 students who have only been exposed to one year of learning Biology.

3.3 Sampling Procedure and Sample:

Multistage sampling technique was used to select the sample. Fifteen local government areas were randomly selected from the thirty one local government areas in Osun State, Nigeria. Seventy four (74) senior secondary schools were selected randomly from the one hundred and eighty-six (186) senior secondary schools in the fifteen selected local governments areas across the 6 educational zones (see Appendix I). For students' sample, twenty (20) students were selected randomly from each participating school. Thus, total of one thousand, four hundred and eighty (1,480) students were selected using purposeful sampling technique.

The sampling distribution is presented in Table 3.1.

Table 3.1**Sampling Distribution of a Multistage-Sampling Technique**

Zone	No. of LGAs in the Zone	No. of Snr. Sec. in the LGAs	No. of Selected LGAs (50%)	No. of Snr. Sec. Sch. in the Selected LGAs	No. of Selected Snr. Sec. Schs. (40%)	Total No. of Students Used
Ede	Ede North	5	Ede South	7	3	60
	Ede South	7	Egbedore	7	3	60
	Egbedore	7				
	Ejigbo	17				
Ife	Ife south	22	Ife South	22	9	180
	Ife East	16	Ife North	14	5	100
	Ife East Area Office	6				
	Ife Central	8				
	Ife North	14				
Ifelodun	Boluwaduro	9	Boripe	9	4	80
	Boripe	9				
	Ifedayo	4				
	Ifelodun	10				
	Ila	7				
	Odo-Otin	19				
Ijesa	Atakumasa West	14	Atakumosa W.	14	5	100
	Atakumasa East	13	Ilesa East	12	5	100
	Ilesa East	12				
	Ilesa West	9				
	Obokun	16	Oriade	20	8	160
	Oriade	20				
Iwo	Irewole	14	Irewole	14	5	100
	Isokan	8	Iwo	12	5	100
	Iwo	12				
	Ola Oluwa	10				
	Ayedaade	17	Ayedaade	17	7	140
	Ayedire	6				
Osogbo	Irepodun	8	Irepodun	8	3	60
	Orolu	7	Osogbo	13	5	100
	Olounda	13				
	Osogbo	13				
Total	31	352	15	186	74	1,480

LGAs:- Local Government Areas

Source:- Ministry of Education, Science and Technology, Planning, Research and Statistics, Osogbo (2010/2011 Academic Year)

3.4 Variables in the study.

3.4.1 Predictor Variables:

Z_1 = Gender

Z_2 = Age

Z_3 = Extroversion

Z_4 = Sensing

Z_5 = Thinking

Z_6 = Judging

Z_7 = Visual

Z_8 = Auditory

Z_9 = Kinesthetic

3.4.2 Criterion Variable

Z_t = Biology Achievement

3.5. Instrumentation:

Three instruments were used to collect data.

- i. Cognitive Type Inventory (CTI)- see Appendix II
- ii. VAK learning Style Indicators (VLSI)- see Appendix III
- iii. Biology Achievement Test (BAT)- see Appendix IV

3.5.1. Cognitive Type Inventory (CTI)

CTI was an adapted instrument from Reinhold (2006). The instrument contained twenty four (24) items. The instrument measured the respondents' personality type-preferences (extroversion, sensing, thinking and judging). A three point scale of **Very True of Me (VTOM), True of Me (TOM), Not True of Me (NTOM)** was used for the respondents to select which statement best fits their personality type preference. Section A contained four items on bio-data and school background information of the student.

Validity of CTI:

The instrument was carefully examined by seven fellows of the International Centre for Educational Evaluation (ICEE), University of Ibadan, Ibadan. This is to ensure the face, and the content validity of the instrument. Six of the experts considered the instrument relevant while one of the experts did not. The content validity index was established as follows:

$$CVI = \frac{N_e - N/2}{N/2}$$

Where CVI = content validity index, N_e = number of judges that consider the instrument relevant, N = total number of judges.

$$\begin{aligned} \text{Therefore, } CVI &= \frac{6 - 7/2}{7/2} \\ &= \frac{6 - 3.5}{3.5} \\ &= 2.5/3.5 \\ &= \mathbf{0.71} \end{aligned}$$

This shows that the instrument is valid.

Reliability of CTI:

Cronbach Alpha was used to establish the reliability coefficient of the instrument. The reliability of the whole scale was established on a sample of 50 SS II students from two schools that are not among the randomly selected ones. The estimated reliability of CTI was 0.52. Cronbach coefficient alpha value (See Appendix II for CTI).

3.5.2. VAK Learning Style Indicators (VLSI)

VLSI was adapted from Chislett and Chapman (2005). It was a 22-item instrument. Each of these items is followed with three statements that represent the learning style preferences of the respondents in terms of visual, auditory and kinesthetic. Each of these items is followed with three statements that represent the learning style preferences of the respondents in terms of visual, auditory and kinesthetic respectively. A three point scale of **To a large extent (3), To a moderate extent (2), To a low extent (1)** was used for the respondents to rate the extent to which they prefer the three learning styles. Section A of the instrument contained four items on bio-data and school background information of the student.

Validity of VLSI:

The instrument was carefully examined by eight fellows of the International Centre For Educational Evaluation (ICEE), University of Ibadan, Ibadan. This is to in ensure the face and content validity. Seven of the experts considered the instrument relevant while one of the experts did not. The content validity index was established as follows:

$$CVI = \frac{N_e - N/2}{N/2}$$

Where CVI = content validity index, N_e = number of judges that consider the instrument relevant, N = total number of judges.

$$\begin{aligned}
 \text{Therefore, } CVI &= \frac{7 - 8/2}{8/2} \\
 &= \frac{7 - 4}{4} \\
 &= 3/4 \\
 &= \mathbf{0.75}
 \end{aligned}$$

This shows that the instrument is valid.

Reliability of VLSI:

Cronbach Alpha was used to establish the reliability coefficient of the instrument. The reliability of the whole scale was established on a sample of 50 SSS 2 students from two schools that were not among the randomly selected ones. The established reliability of VLSI was 0.65 Cronbach Coefficient alpha values. (See Appendix III for VLSI)

3.5.3. Biology Achievement Test (BAT)

BAT is a 60-item multiple choice objective test carefully developed by the researcher to test the knowledge of SSS 2 students in Biology. The test blue print for the items is shown in Table 3.2

The Table of specification showing the distribution of the 60 selected items is shown below:

Table 3.2: Test Blue Print for a 60 Multiple Choice Test in Biology

S/N	Topics	Knowledge	Comprehension	Application	Total %
1.	Biology and Living Things	3, 4, 5, 6, 7, 8, 10, (07) 11.7%	2, (1) 1.7%	1, 9, (2) 3.3%	(10) 16.6%
2.	Plant and Animal Nutritions	12, 14, 15, 18, 19, (5) 8.3%	11, 16, 17, (3) 5%	13, 20, (2) 3.3%	(10) 16.6%
3.	Ecological Concepts and Functioning Ecosystem	22, 28, (2) 3.3%	26, 27, (2) 3.3%	2, 23, 24, 25 (4) 6.7%	(08) 13.3%
4.	Ecological Management and Conservation	29, (1) 1.7%	30, 31, 32, 34, 35, 36, (6) 10%	33, (1) 1.7%	(08) 13.3%
5.	Micro-Organisms and Better Health	37, (1) 1.7%	39, 40, 43, (3) 5%	38, 41, 42, (3) 5%	(07) 11.7%
6.	The Cell and It's Environment	44, (1) 1.7%	45, 47, 48, 49, 50, (5) 8.3%	46, 51, (2) 3.3%	(08) 13.3%
7.	Tissue and Supporting System	55, 56, 57, 60, (4)	52, 53, 59, (3) 5%	54, 58, (2) 3.3%	(09) 15%

		6.7%			
Total	(21) 35%	(23) 38.3 %	(16) 26.6%	(60) 100%	

Table 3.2 indicated that blue print is a two-way grid consisting of contents in rows and process objectives in columns. The researcher started with a pool of 180 items initially developed following the principle of test construction. The draft copy of the pool of items was revised by three Biology teachers in senior secondary school, each of whom was given a copy of the draft and a Report Form. The form requested for the comments of the teachers on the adequacy of the items in terms of content, clarity of instruction, adequacy of time allowed; appropriateness of language for each item, non-ambiguity of the stem and correctness of the key for each item (See Appendix IV for BAT). Based on their comments and suggestions, nine of the items were substituted with new ones, while fifteen others had either their stem or options modified. The modified instrument was given back to these Biology teachers for confirmation.

Thereafter, the pool of items was administered to four hundred and twenty six (426) S.S.2 students who were not part of the sample of study. Their responses to the items were scored, followed by item analysis using discriminating power and difficulty index to select the best 60 items that constitute the final BAT (See Appendix IV). The distribution of the 60 selected items was as indicated in Table 3.2. The 60 selected items were those with positive discriminating power between 0.32 and 0.45, and difficulty index range of 0.40 to 0.75.

Validity of BAT:

The instrument was later examined by two fellows of the International Centre For Educational Evaluation (ICEE), University of Ibadan, Ibadan. It was also given to four experienced WASSCE examiners, making a total of six experts, in order to ensure the face and content validity. The content validity index was established as follows:

$$CVI = \frac{N_e - N/2}{N/2}$$

Where CVI = content validity index, N_e = number of judges that consider the instrument relevant, N = total number of judges.

$$\begin{aligned} \text{Therefore, } CVI &= \frac{5 - 6/2}{6/2} \\ &= \underline{5 - 3} \end{aligned}$$

$$\begin{aligned} & 3 \\ & = 2/3 \\ & = \mathbf{0.67} \end{aligned}$$

Reliability of BAT:

Cronbach Alpha was used to establish the reliability coefficient of BAT. The reliability of the whole scale was established on a sample of 50 SS II students from two schools that were not among the randomly selected ones. The established reliability of BAT was 0.75 Cronbach Coefficient alpha values (see Appendix IV for BAT).

3.6 Data Collection

The researcher engaged four research assistants who were trained for two days on how to handle the administration of the research instruments effectively. The researcher himself monitored the data collection exercise. A letter of introduction from the Institute of Education was collected for all the selected schools in order to enlist their consent and maximum cooperation. The administration of the instruments in each school was in a sequence of CTI and VLSI coming up the first day, and BATS the second day. Data collection exercise lasted for seven weeks.

3.7 Scoring of the instruments

3.7.1 CTI:

Gender of student in section A was coded 1 and 2 for 'male' and 'female' respectively. The coding for age of student was 1 and 2 for 'Between 15 years and 16 years' and 'Between 17 years and 18 years' respectively. Items 1 to 24 in section B were coded using 3 for 'VTOM', 2 for 'TOM', and 1 for 'NTOM'.

3.7.2 VLSI:

The coding for 'gender of student' and 'age of student' remained same as in CTI. All the items in section B were coded as follows: 3 for 'To a large extent', 2 for 'To a moderate extent', and 1 for 'To a low extent'.

3.7.3 BAT:

Dichotomous scoring pattern of 1 and 0 for correct and incorrect responses was adopted respectively.

3.8 Data Analysis Procedure

The data collected were analysed using descriptive statistics and Structural Equation Modeling (SEM) involving a multivariate analytical technique known as path analysis. The choice of multivariate approach was made because of the fact that it enables the researcher to establish the combined effect of the predictor variables as well as isolate their separate contributions to the criterion variable (Kerlinger & Lee, 2000). The breakdown of the statistical analysis is as follows:

Research Question 1 (RQ₁): Mean and Standard Deviation

Research Question 2 (RQ₂): Correlation Matrix

Research Question 3 (RQ₃): Path Analysis and Multiple Regressions

Research Question 4 (RQ₅): Path Analysis and Multiple Regressions

The details of the procedure for causal modeling required the researcher to:

- (i) build an hypothesised causal model involving gender, age, extroversion, sensing, thinking, judging visual, auditory, kinesthetic, and Biology achievement on the basis of research findings, logic, expert opinions, personal observation and experiences, and theoretical grounds as suggested by Kerlinger and Pedhazur (1973); Bryant and Doran, (1977); Mertler & Vannatta, (2005). In doing this, caution was taken to bring in the third kind of variable 'e' which stands for all unexplained variables since no survey research can explain one hundred percent variable Agomoh (2006);
- (ii) identify the paths in the model through structural equations;
- (iii) trim the paths in the model based on statistical significance; and meaningfulness of the values of the path coefficients.
- (iv) validate the new model by reproducing the zero order correlation matrix of the variables from a set of normal equations using the path coefficient in the new model.

3.8.1 Building the Hypothesised Recursive Path Model

The building of hypothesised recursive path model stands upon a number of assumptions that must be met as stated below, Kerlinger and Pedhazur (1973), Mertler and Vannatta (2005):

- (i) there is a one way causal flow in the system. That is, reciprocal causation between variables is ruled out

- (ii) the residuals are neither correlated among themselves nor with the variables preceding them in the model;
- (iii). each of the endogenous or dependent variables is directly related to all the variables preceding it in the hypothesised causal sequences;
- (v) the relations among the variables in the model are linear, additive and causal. Consequently, curvilinear, multiplication or interaction relations are excluded. However, it is important to note that the hypothesised recursive model being presented in this study is not the only possible version. Considering the submission of Turner and Stevens (1979) that for a five-variable study, several thousand-path diagrams are possible. Thus, the decision as to most meaningful diagram was made in consideration of temporal order; research findings, theory, logic, expert opinions, personal observations and experiences (Tate, 1992).

Variables Z_i ($i=1,2$):

Consider the variables: Z_i ($i=1,2$). Theoretically, the linkage between Gender (Z_1) and Age of student (Z_2) indicates that the two variables are correlated. This is because the two variables are exogenous. Their variability is assumed to be explained by other variables outside the causal model under consideration. No attempt is made to explain the variability of the exogenous variables or its relation with one another.

The hypothesised linkage with a two way directional arrow heads is illustrated in figure 3.1

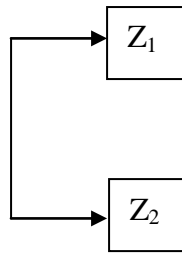


Figure: 3.1: Correlation between Z_i ($i = 1.2$)

Z_1 = Gender of student

Z_2 = Age of student

Variables Z_i ($i = 1.3.9$):

Consider the variables Z_i ($i = 1.3.9$) Research finding indicates that gender (Z_1) has influence on extroversion (Z_3) Archana (2007) who established that females were generally more extrovert than their male counter parts. Also, logic and research reports show that gender (Z_1) is a predator variable to kinesthetic (Z_9) (Grebb, 1999; Ebel, 1999; Cavanaugh, 2002) who revealed that males tend to be more kinesthetic than females. Similarly, logic and findings from research reveal that extroversion (Z_3) has significant association with kinesthetic (Z_9) (Felder & Brent 2000). It is logical to say that extroversion personality type preference can have a significant relationship with kinesthetic learning style. This is because extrovert naturally likes to demonstrate what they know to people, and kinesthetic learning style has to do with practical information. This implies that extroverts are likely going to prefer practical information. The causal linkages are indicated by single arrow head meaning that all linkages are recursive. The relationship is illustrated in figure 3.2 below:

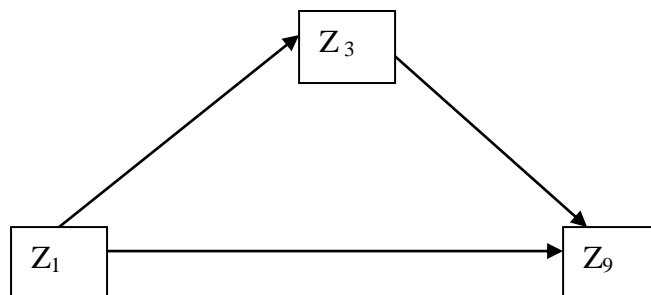


Figure 3.2.: Hypothesised Causal paths among X_i ($i = 1.3.9$)

Z_1 = Gender

Z_3 = Extroversion

Z_9 = Kinesthetic

Variables Zi (i=2.4.7.8):

Consider the variables Zi (i = 2.4.7.8). The prediction of sensing (Z₄) by age (Z₂) is supported by logic. This is because older people can sense well and better than younger ones. Also, research reports indicate that age (Z₂) is a predictor variable to Visual (Z₇) and Auditory (Z₈), (Confied, Moseley, and Ecclestone (2004) who claimed that the learning style of students, that is, visual, auditory, kinesthetic, and tactile changed substantially as they matured from adolescence to adulthood. One directional arrow heads are used to indicate the causal relationship among the variables meaning that they are recursive.

The relationship is illustrated in figure 3.3 below

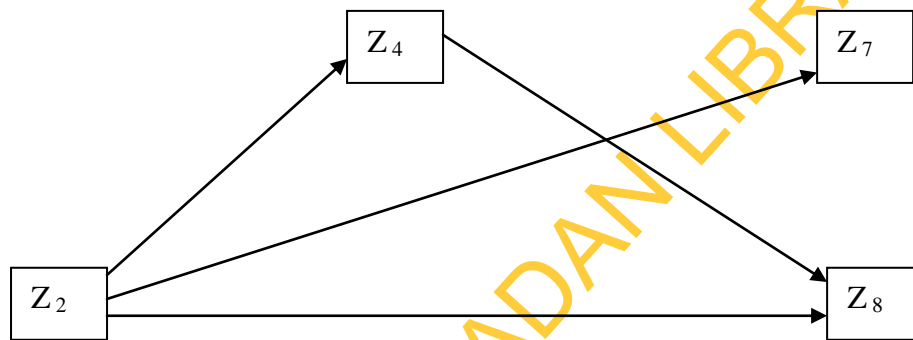


Figure 3.3: Hypothesised Causal paths among Xi (i = 2.4.7.8)

Z₂ = Age
Z₄ = Sensing
Z₇ = Visual
Z₈ = Auditory

Variables Zi (i = 1.3.4.5.6.7.8.9.t):

Consider the variables Zi (i = 1.3.4.5.6.7.8.9,t). Research reports indicate that gender (Z₁) is a predictor variable to Extroversion (Z₃), (Dorval, 2000; Tannen, 1992). Also, Gregory (2005) shows that Gender (Z₁) has significant association with Sensing (Z₄) and Thinking (X₆). He found that males were more than three times likely to prefer gathering information using their senses (sensing). Also, males preferred reacting to information with logic (thinking). Similarly, Pizzo (2000), reported that Gender (Z₁) is a predictor to Auditory (Z₈). He established that females more than males tend to be auditory. Also, the predictions of Visual (Z₇) and Kinesthetic (Z₉) by Gender (Z₁) are supported by research findings (Ebel, 1999; Cavanaugh, 2002) who established that males were more kinesthetic and visual than their females counter parts. Similarly, logic and research reports indicate that Gender (Z₁) has significant influence on Achievement (Z_t) (Tatarinceva, 2005). One directional arrow heads are used to indicate the causal relationship among the variables meaning that they are recursive. The relationship is illustrated in fig. 3.4 below:

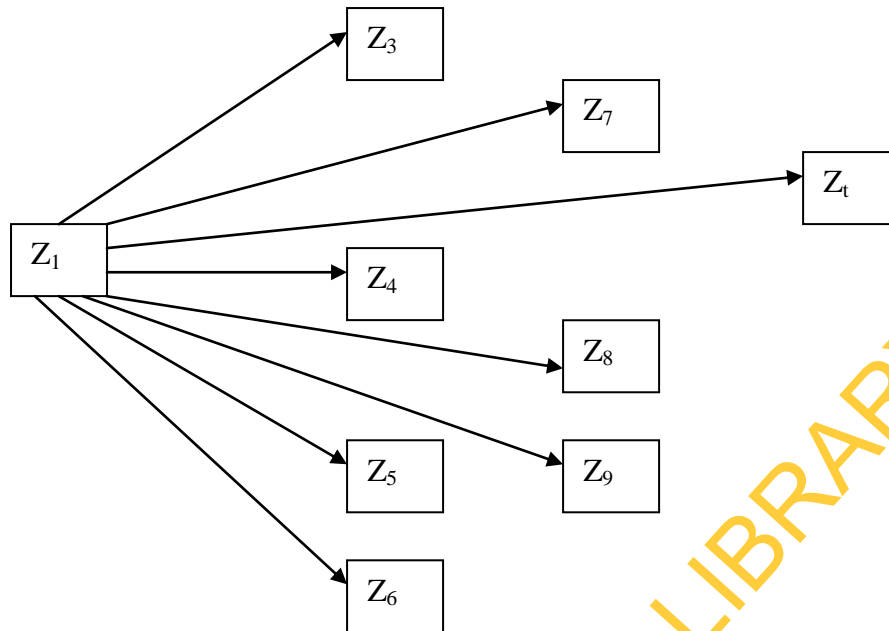


Fig.3.4: Hypothesized Causal paths among Z_i ($i = 1.3.4.5.6.7.8.9.t$)

$Z_1 =$ Gender

$Z_3 =$ Extroversion

$Z_4 =$ Sensing

$Z_5 =$ Thinking

$Z_6 =$ Judging

$Z_7 =$ Visual

$Z_8 =$ Auditory

$Z_9 =$ Kinesthetic

$Z_t =$ Achievement

Variables Z_i ($i=1.2.3.4.5.6.7.8.9.t$):

Consider the variables Z_i ($i = 1.2.3.4.5.6.7.8.9.t$). Available research information indicates that Achievement (Z_t) is causally influenced by Extroversion (Z_3), Sensing (Z_4), Thinking (Z_5), and Judgment (Z_6) (Adele et al., 2007; Terrance et al., 1998) who established that extroversion, sensing, thinking and judging were predictor variables to achievement.

Further, research reports indicate that Achievement (Z_t) is predicted by Visual (Z_7) and Kinesthetic (Z_9), (Ebel, 1999; Cavanaugh 2002) who found that students learn best through different learning styles. They maintained that many students learn best through kinesthetic learning style. Also, research information reveals that Auditory (Z_8) has influence on Achievement (Z_t) (Marcus, 1999; Pizzo, 2000) who established that some students learn best through auditory learning style. Similarly, research finding indicates that gender (Z_1) is a predictor of achievement (Z_t) (Jegede & Inyang, 1990) who found that differences in achievement existed between males and females in integrated science. The causal linkages among the variables are shown by one directional arrow heads meaning that they are recursive (see figure 3.5 below)

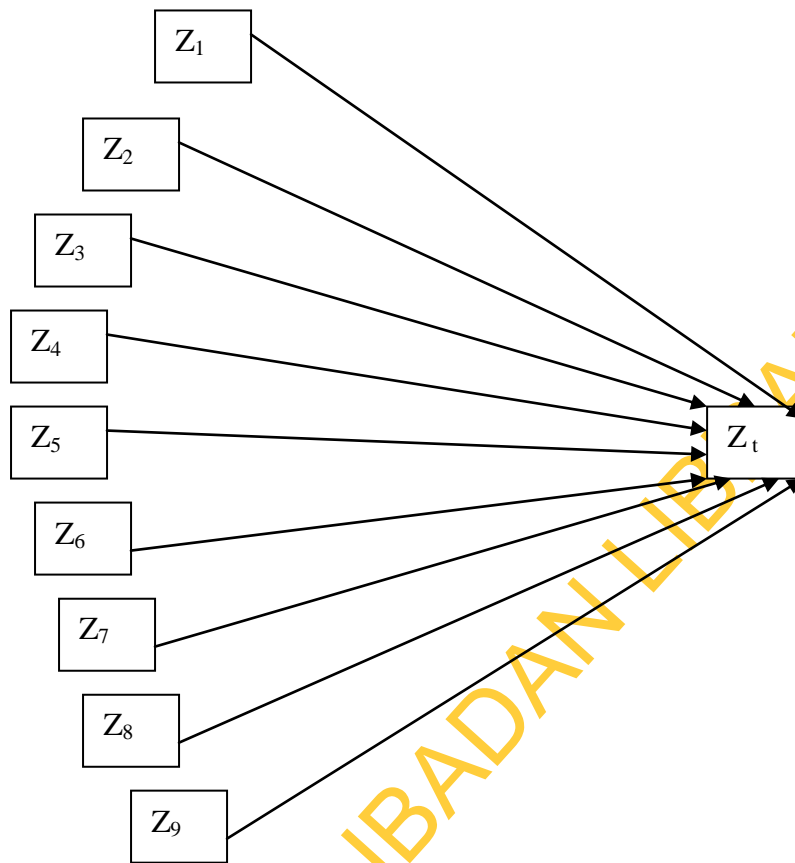


Figure. 3.5: Hypothesised Causal paths among Zi (I = 1.2.3.4.5.6.7.8.9.t)

Z₁ = Gender

Z₂ = Age

Z₃ = Extroversion

Z₄ = Sensing

Z₅ = Thinking

Z₆ = Judging

Z₇ = Visual

Z₈ = Auditory

Z₉ = Kinesthetic

Z_t = Achievement

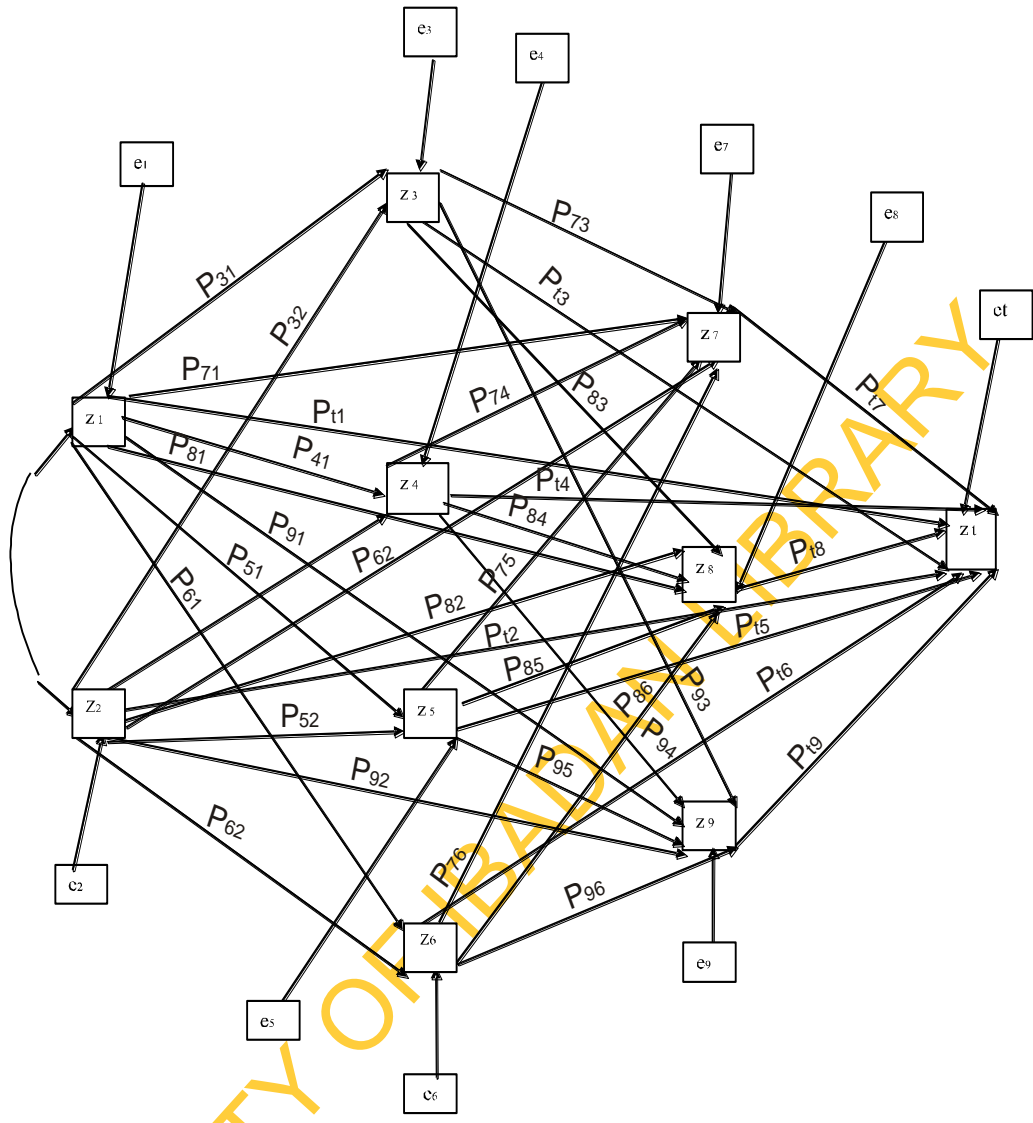


Figure 3.2: Hypothesised Recursive Path Model of a Ten Variable System.

Key:

Z₁ = Gender of student

Z₂ = Age of student

Z₃ = Extroversion

Z₄ = Sensing

Z₅ = Thinking

Z₆ = Judging

Z₇ = Visual

Z₈ = Auditory

Z₉ = Kinesthetic

Z_t = Achievement

3.8.2: Identifying the paths in the model.

The researcher identified the significant paths in the model following a careful examination of the hypothesised linkages from a set of equations labeled 3.1 to 3.8 employing the technique of path analysis theorem, Wolfe (1977).

Structural equations of the hypothesised model.

$Z_1 = e_1$	3.1
$Z_2 = e_2$	3.2
$Z_3 = P_{31} Z_1 + P_{32} Z_2 + e_3$	3.3
$Z_4 = P_{41} Z_1 + P_{42} Z_2 + e_4$	3.4
$Z_5 = P_{51} Z_1 + P_{52} Z_2 + e_5$	3.5
$Z_6 = P_{61} Z_1 + P_{62} Z_2 + e_6$	3.6
$Z_7 = P_{71} Z_1 + P_{72} Z_2 + P_{73} Z_3 + P_{74} Z_4 + P_{75} Z_5 + P_{76} Z_6 + e_7$	3.7
$Z_8 = P_{81} Z_1 + P_{82} Z_2 + P_{83} Z_3 + P_{84} Z_4 + P_{85} Z_5 + P_{86} Z_6 + e_8$	3.8
$Z_9 = P_{91} Z_1 + P_{92} Z_2 + P_{93} Z_3 + P_{94} Z_4 + P_{95} Z_5 + P_{96} Z_6 + e_9$	3.9
$Z_t = P_{t1} Z_1 + P_{t2} Z_2 + P_{t3} Z_3 + P_{t4} Z_4 + P_{t5} Z_5 + P_{t6} Z_6 + P_{t7} Z_7 + P_{t8} Z_8 + P_{t9} Z_9 + e_t$	3.10

3.8.3: Trimming the paths in the model

To trim the model, the researcher employed the criterion: significance (at the pre-specified level of 0.05).

The application of the criterion helped the researcher to:

- (i). avoid any uncomfortable situations where some minute path coefficients may be found significant due to large sample size as in this study (Pedhazor, 1982) and;
- (ii). provide a more adequate testing of the hypothesised model under consideration.

In all, the trimming helped the researcher to ascertain whether a more parsimonious model would be produced without much loss of information.

3.9 Methodological Challenges

The challenges the methodological approach adopted in this study contend with are as follows:

3.9.1 Design Challenges

Since this study is a non-experimental survey, the cause-effect relationship between the variables is not easy to establish. This is so because of the fact that the

variables considered have naturally occurred in the population, and so, they are beyond the control of the researcher. It follows that one independent variable is not in any way sufficient to explain a dependent variable. This is because, for every criterion variable, there are several other inherent predictor variables in the respondents. It was for this reason the researcher decided to include more independent variables in the study to develop a causal model.

3.9.2 Challenges from Sampling Techniques

Private secondary schools are found not to be so widely distributed across local government areas of study, and so, the researcher deliberately excluded them from the study. It was also observed that in most of the randomly selected senior secondary school, the population of female students is more than that of the male. To assuage this problem of gender imbalance, the research used 1:1 male to female ratio. This implies that ten boys and ten girls were selected from each of the schools.

3.9.3 Instrumentation Challenges

It was envisaged that the respondents may not understand the items in the questionnaire the way intended or indeed not ready to respond with high integrity. In view of this, the instrument was trial tested in addition to being earlier given to experts for review, before it was finally taken to the field.

Apart from this, the use of “undecided”, the middle (neutral) category was deliberately excluded from the response format in CTI as a measure to plug the escape route to respondents with apathy. But then, this is not without its own limitation. It may disallow respondents with genuine reluctance, those who are undecided, unclear or just neutral to responses of either true of me or not true of me might be forced to do otherwise.

Faking and pretence from respondents are other challenges from the use of questionnaire. However, the researcher minimised this, if not completely ruled out by holding a brief address with the respondents with a view to reassuring them of the confidentiality of their responses.

Another challenge that cannot be completely avoided is that the use of achievement test gives room for guessing. The researcher went around this challenge by ensuring near uniform conditions for all the testee-respondents.

Also, the 60 items in BAT was inadequate to test every detail of the content in the Biology curriculum for SSS 2. However, the use of test blueprint for the construction of test items was anticipated to enhance the representativeness of all the units of the contents.

3.9.4 Challenges Relating to Data Collection Procedure

Attrition problem with the selected sample was anticipated due to the time lapse between the first and second administration of the instrument for data collection. Meanwhile, the researcher was convinced that the robustness of the statistical analysis employed had put the effect of the problem under control.

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CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The results of the statistical analysis of data obtained from the administration of research instruments are presented and discussed in this chapter. The presentation follows the orders in which the research questions were listed in chapter one.

4.1 Answer to Research Question one (RQ1)

What is the pattern of student's responses to measurement items on extroversion, sensing, thinking, judging, visual, auditory, kinesthetic and Biology achievement?

Table 4.1 Mean and Standard Deviation of Students' Responses (N = 1,480)

Variables	Means	Minimum Obtainable	Maximum Obtainable	Standard Deviation
Extroversion	11.21	7.00	18	2.07
Sensing	11.93	6.00	18	2.74
Thinking	11.39	7.00	18	2.42
Judging	11.35	6.00	18	2.75
Visual	41.58	31.00	66	3.91
Auditory	51.52	32.00	66	4.03
Kinesthetic	23.60	13.00	66	3.89
Biology Achievement	40.01	10.00	100	13.98

Table 4.1 shows the mean and standard deviation of students' responses to measurement items on extroversion (M= 11.21, SD=2.07), sensing (M= 11.93, SD= 2.74), thinking (M= 11.40, SD = 2.42), judging (M=11.35, SD = 2.75), visual (M= 41.58, SD= 3.91), auditory (M= 51.51, SD = 4.03), kinesthetic (M= 23.60, SD = 3.89), Biology achievement (M= 40.01, SD= 13.98).

The mean score of 11.21 or 62.3% in extroversion indicated that a large number of students exhibited extroversion personality preference in the learning of Biology. For sensing, a mean score of 11.93 or 66.3% showed that the students' response to sensing was high. The student's response to thinking was above average with a mean score of 11.39 or 63.3%. The implication is that they would exhibit thinking personality preference when

learning Biology. The mean score of 11.35 or 63.1% in judging implies that a large number of students exhibited judging personality preference. Considering the mean score of extroversion, sensing, thinking and judging, it is evident that more than half of the students exhibited personality type – ESTJ in the learning of Biology.

The mean score of 41.58 or 63.0% in visual suggested that a large number of students preferred visual learning style in the learning of Biology. For auditory, a mean score of 51.51 or 78.1% showed that a very large number of students preferred auditory learning style. The mean score of 23.60 or 35.8% in kinesthetic showed that a small number of students preferred kinesthetic learning style in the learning of Biology. The mean score of 40.01 or 40.0% in Biology achievement revealed that the students performed poorly. This is consistent with WAEC (2011) SSCE results.

4.2 Answer to Research Question Two (RQ2)

What is the pattern of relationships (correlations) in the model consisting of gender, age, extroversion, sensing, thinking, judging, visual, auditory, kinesthetic and Biology achievement?

To obtain the pattern of relationships (correlations), there is need to determine the zero-order correlations among the ten variables. Table 4.2 presents the correlation matrix of the bivariate relationships (Pearson's correlation coefficient) among the variables.

Table 4.2: Obtained Correlation Coefficients

Variables	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z _t
Z ₁	1.000									
Z ₂	.014	1.000								
Z ₃	-.154	-.012	1.000							
Z ₄	-.119	.060	.637	1.000						
Z ₅	.029	.094	.542	.755	1.000					
Z ₆	-.124	.063	.692	.803	.671	1.000				
Z ₇	.148	-.055	-.405	-.356	-.339	-.325	1.000			
Z ₈	.129	-.068	-.490	-.347	-.342	-.323	.946	1.000		
Z ₉	.146	-.061	-.407	-.362	-.343	-.330	.993	.994	1.000	
Z _t	-.074	-.008	.269	.417	.376	.327	-.430	-.408	-.438	1.000

Key:Z₁ = GenderZ₆ = JudgingZ₂ = AgeZ₇ = VisualZ₃ = ExtroversionZ₈ = AuditoryZ₄ = SensingZ₉ = KinestheticZ₅ = ThinkingZ_t = Biology Achievement

The table showed high significant relationships among the variables ($p < 0.05$). However, there is low relationship between Age and Extroversion.(-0.012). Also, there is low relationship between Gender and Thinking. It is quite interesting to note that the highest correlation (0.994) is between Auditory and Kinesthetic.

The table revealed positive and statistically significant relationship ($p < 0.05$) between Biology achievement and Sensing (0.417); Thinking (0.376); Judging (0.327); Extroversion (0.269). This shows the importance of these factors in predicting students' achievement in Biology at the secondary school level. Furthermore, the table revealed negative and statistically significant relationship between biology achievement and kinesthetic (-0.438): visual (-0.408) and auditory (-0.430). This equally shows that these factors are important factors that predict students' achievement in biology.

4.3 Answer to Research Question Three (RQ3)

Is the model which describes the causal effect among the variables (gender, age, extroversion, sensing, thinking, visual, auditory, kinesthetic, and biology achievement) consistent with the observed correlation among these variables?

To determine this, two sets of eight multiple regressions (SPSS Version 17.0) were conducted. The first set of eight multiple regression for the hypothesised model were conducted. These are:

One: Z_3 was regressed on Z_1 and Z_2

Two: Z_4 was regressed on Z_1 and Z_2

Three: Z_5 was regressed on Z_1 and Z_2

Four: Z_6 was regressed on Z_1 and Z_2

Five: Z_7 was regressed on $Z_1, Z_2, Z_3, Z_4, Z_5,$ and Z_6

Six: Z_8 was regressed on $Z_1, Z_2, Z_3, Z_4, Z_5,$ and Z_6

Seven: Z_9 was regressed on $Z_1, Z_2, Z_3, Z_4, Z_5,$ and Z_6

Eight: Z_t was regressed on $Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7, Z_8,$ and Z_9

The values on the path coefficient i.e., beta coefficients β of the independent variables obtained from each of the eight-regression analysis was shown in table 4.3, and on the hypothesised model (see figure 4.1).

Table 4.3 Path Coefficients of the Obtained Hypothesised Model.

Path	Path Coefficient	Significance	Decision
P ₃₁	-.154***	Significant	Retain
P ₄₁	-.120***	Significant	Retain
P ₅₁	.028	Not Significant	Delete
P ₆₁	-.125***	Significant	Retain
P ₇₁	.105***	Significant	Retain
P ₈₁	.091**	Significant	Retain
P ₉₁	.103***	Significant	Retain
P _{t1}	-.011	Not Significant	Delete
P ₃₂	-.010	Not Significant	Delete
P ₄₂	.062**	Significant	Retain
P ₅₂	.094**	Significant	Retain
P ₆₂	.064**	Significant	Retain

P ₇₂	-.045	Not Significant	Delete
P ₈₂	-.055*	Significant	Retain
P ₉₂	-.050*	Significant	Retain
P _{t2}	-.058*	Significant	Retain
P ₇₃	-.298***	Significant	Retain
P ₈₃	-.276***	Significant	Retain
P ₉₃	-.296***	Significant	Retain
P _{t3}	-.106***	Significant	Retain
P ₇₄	-.097**	Significant	Retain
P ₈₄	-.073**	Significant	Retain
P ₉₄	-.104***	Significant	Retain
P _{t4}	.293***	Significant	Retain
P ₇₅	-.157***	Significant	Retain
P ₈₅	-.173***	Significant	Retain
P ₉₅	-.155***	Significant	Retain
P _{t5}	.117***	Significant	Retain
P ₇₆	.081**	Significant	Retain
P ₈₆	.058*	Significant	Retain
P ₉₆	-.078**	Significant	Retain
P _{t6}	-.026	Not Significant	Delete
P _{t7}	.219***	Significant	Retain
P _{t8}	.052*	Significant	Retain
P _{t9}	-.612***	Significant	Retain

Note: * P < .05; ** P < .01; *** P < .001

The path coefficients were written on each pathway of the model. (See Figure 4.1).

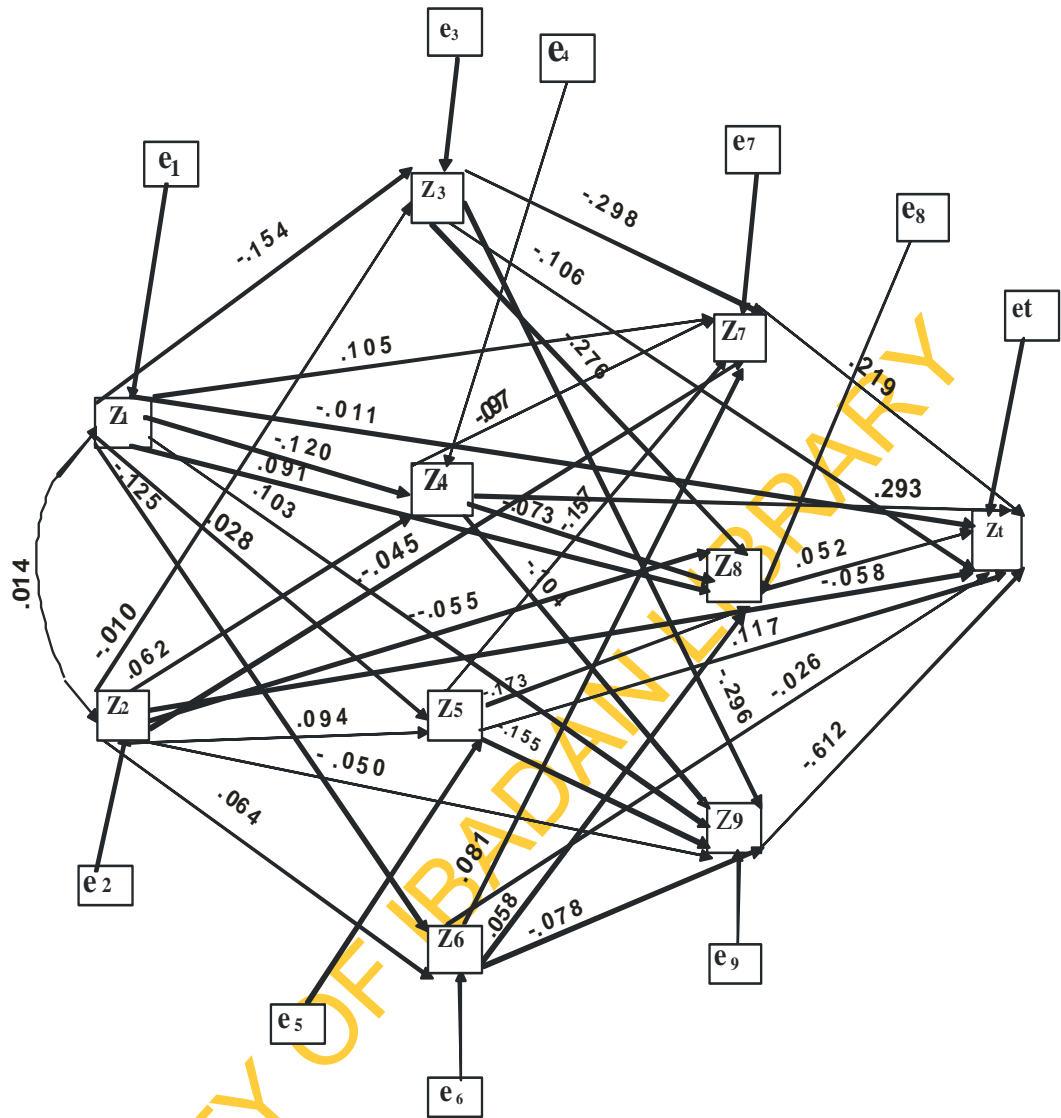


Fig. 4.1. Hypothesised recursive path model of a ten variable system showing path coefficients.

Key:

- Z_1 = Gender
- Z_2 = Age
- Z_3 = Extroversion
- Z_4 = Sensing
- Z_5 = Thinking

- Z_6 = Judging
- Z_7 = Visual
- Z_8 = Auditory
- Z_9 = Kinesthetic
- Z_t = Biology Achievement

From table 4.3, paths which are not statistically significant were deleted. This is in line with Adegoke (2012), Kerlinger and Pedhazur (1981), and Kline (2005) recommendations that paths whose coefficients (beta weight) are lower than 0.05 should be deleted. Therefore, paths P_{32} , P_{51} , P_{72} , P_{11} and P_{16} were deleted.

Having deleted these paths, the second set of eight multiple regression were conducted without the deleted paths as thus:

One: Z_3 was regressed on Z_1

Two: Z_4 was regressed on Z_1 and Z_2

Three: Z_5 was regressed on Z_2

Four: Z_6 was regressed on Z_1 and Z_2

Five: Z_7 was regressed on Z_1 , Z_3 , Z_4 , Z_5 and Z_6 .

Six: Z_8 was regressed on Z_1 , Z_2 , Z_3 , Z_4 , Z_5 and Z_6 .

Seven: Z_9 was regressed on Z_1 , Z_2 , Z_3 , Z_4 , Z_5 and Z_6 .

Eight: Z_t was regressed on Z_2 , Z_3 , Z_4 , Z_5 , Z_7 , Z_8 and Z_9 .

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The re-specified model is shown in figure 4.2

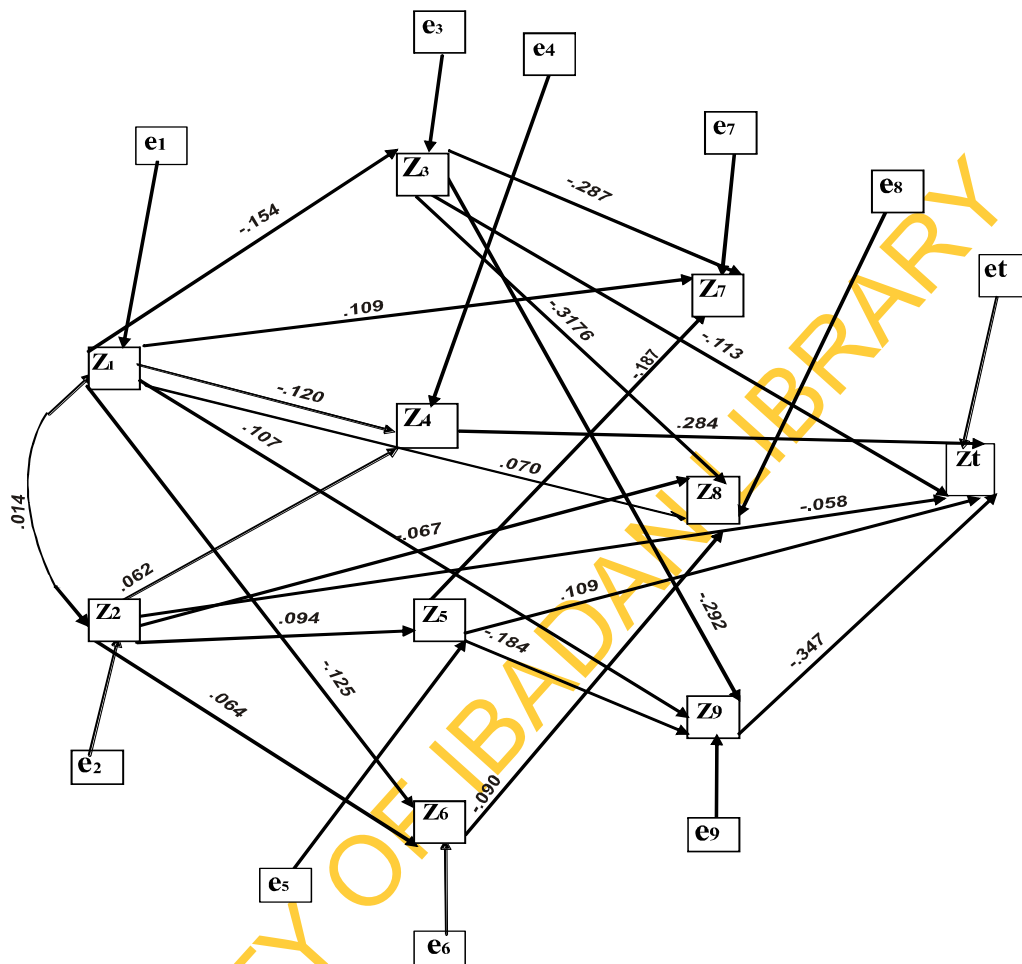


Fig. 4.2: Re-specified {parsimonious} model with path coefficients

Key:

- | | |
|----------------------|-----------------------------|
| Z_1 = Gender | Z_6 = Judging |
| Z_2 = Age | Z_7 = Visual |
| Z_3 = Extroversion | Z_8 = Auditory |
| Z_4 = Sensing | Z_9 = Kinesthetic |
| Z_5 = Thinking | Z_t = Biology Achievement |

Figure 4.2 revealed that only five of the predictor variables directly contributed to variance in biology achievement. The directions of the casual paths of the variables on the other hand are shown in the pathways with one direction arrow heads indicating that they are recursive.

The second set of the eight multiple regressions were conducted with $Z_3, Z_4, Z_5, Z_6, Z_7, Z_8, Z_9,$ and Z_t , as dependent variable. The new structural equations for this second set of the eight multiple regressions are thus provided.

Structural Equations of the Re-specified Model

$Z_1 = e_1$	4.1
$Z_2 = e_2$	4.2
$Z_3 = P_{31}Z_1 + e_3$	4.3
$Z_4 = P_{41}Z_1 + P_{42}Z_2 + e_4$	4.4
$Z_5 = P_{52}Z_2 + e_5$	4.5
$Z_6 = P_{61}Z_1 + P_{62}Z_2 + P_{63}Z_3 + e_6$	4.6
$Z_7 = P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7$	4.7
$Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$	4.8
$Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$	4.9
$Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t$	4.10

Table 4.4 showed the path coefficients of the multiple regressions involving the ten variables.

Table 4.4: Path coefficients of the re-Specified model.

Path	Path coefficient	Decision
P_{31}	-.154***	Retained path
P_{41}	-.120***	Retained path
P_{61}	-.125***	Retained path
P_{71}	.109***	Retained path
P_{81}	.070**	Retained path
P_{91}	.107***	Retained path
P_{42}	.062**	Retained path
P_{52}	.094**	Retained path
P_{62}	.064**	Retained path
P_{82}	.067**	Retained path
P_{t2}	-.058*	Retained path
P_{73}	-.287***	Retained path

P ₈₃	-.317***	Retained path
P ₉₃	-.292***	Retained path
P _{t3}	-.113***	Retained path
P _{t4}	.284***	Retained path
P ₇₅	-.187***	Retained path
P ₉₅	-.184***	Retained path
P _{t5}	.109***	Retained path
P ₈₆	-.090**	Retained path
P _{t9}	-.347***	Retained path

Note: * P < .05; ** P < .01; *** P < .001

The path coefficients of the re-specified model were thereafter used to calculate the reproduced correlation coefficients. The process of calculating the reproduced correlation coefficient indicating the effect of variable x on y is given by:-

$$r_{xy} = \frac{1}{N} \sum Z_x Z_y \quad \dots \text{Eqn.4.11}$$

For example, r_{12} is the reproduced correlation. It was obtained using the new structural equation.

From Eqn.4.11 we have

$$r_{12} = \frac{1}{N} \sum Z_1 Z_2 \quad \dots \text{Eqn.4.12}$$

Recall that $Z_2 = P_{21}Z_1 + e_2$ (See Eqn.4.2)

By substituting, Eqn.4.12 becomes

$$r_{12} = \frac{1}{N} \sum Z_1 (P_{21}Z_1 + e_2) \quad \dots \text{Eqn.4.13}$$

By opening the bracket, we have

$$r_{12} = P_{21}Z_1^2 + e_2 \quad \dots \text{Eqn.4.14}$$

Note that $Z_1^2 = 1$; $Z_1 e_1$ gives zero.

By substituting, Eqn.4.14 becomes

$$r_{12} = P_{21}$$

By using the value of path coefficient, we have

$$r_{12} = .014$$

Another example is:

$$r_{13} = \frac{1}{N} \sum Z_1 Z_3 \quad \dots \text{Eqn.4.15}$$

Recall that $Z_3 = P_{31}Z_1 + e_3$ (See Eqn.4.3)

By substituting, Eqn.4.15 becomes

$$r_{13} = \frac{1}{N} \sum Z_1 (P_{31}Z_1 + e_3) \quad \dots \text{Eqn.4.16}$$

By opening the bracket, we have

$$r_{13} = P_{31}Z_1^2 + e_3 \quad \dots \text{Eqn.4.17}$$

Note that $Z_1^2 = 1$

By substituting, Eqn.4.17 becomes

$$r_{13} = P_{31}$$

By using the value of path coefficient, we have

$$r_{13} = \mathbf{-.154}$$

Always remember that path coefficient is equal to a zero order correlation whenever a variable is conceived to be dependent on a single cause and a residual. The above method was applied to obtain other correlation (see appendix IV)

For a more detailed discussion of procedure to calculate reproduce correlation, see Adegoke (2009); Mertler and Vannata(2005); Tabachnick and Fidel (2001); Kerlinger and Pedharzur (1973).

The values of the reproduced correlation coefficients are as shown in table 4.5.

Table 4.5: Reproduced Correlation Coefficients

Variables	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z _t
Z ₁	1.000									
Z ₂	.014	1.000								
Z ₃	-.154	-.002	1.000							
Z ₄	-.119	.060	.017	1.000						
Z ₅	.001	.094	-.001	.006	1.000					
Z ₆	-.124	.062	.018	.019	.002	1.000				
Z ₇	.146	-.004	-.405	-.341	-.341	.337	1.000			
Z ₈	.129	-.068	-.390	-.284	-.236	-.332	.171	1.000		
Z ₉	.147	-.012	-.408	-.342	-.339	-.338	-.196	.191	1.000	
Z _t	-.066	-.011	.269	.418	.376	.334	-.434	-.433	-.437	1.000

Key:

Z₁ = Gender

Z₂ = Age

Z₃ = Extroversion

Z₄ = Sensing

Z₅ = Thinking

Z₆ = Judging

Z₇ = Visual

Z₈ = Auditory

Z₉ = Kinesthetic

Z_t = Biology Achievement

If we combine Table 4.2 and 4.5 we have Table 4.6 which showed the reproduced correlation at the top of the diagonal and obtained correlation at the bottom of the diagonal formed by 1.000. Thereafter, the differences between the obtained correlation coefficients and the reproduced correlation coefficients were determined.

Table 4.6 Obtained and Reproduced Coefficients

Variables	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z _t
Z ₁	1.000	.014	-.154	-.119	.001	-.124	.146	.129	.147	-.066
Z ₂	.014	1.000	-.002	.060	.094	.062	-.004	-.068	-.012	-.011
Z ₃	-.154	-.012	1.000	.017	-.001	.018	-.405	-.390	-.408	.269
Z ₄	-.119	.060	.637	1.000	.006	.019	-.341	-.284	-.342	.418
Z ₅	.029	.094	.542	.755	1.000	.002	-.341	-.236	-.339	.376
Z ₆	-.124	.063	.692	.803	.671	1.000	.337	-.332	-.338	.334
Z ₇	.148	-.055	-.405	-.356	-.339	-.325	1.000	.171	.196	-.434
Z ₈	.129	-.068	-.490	-.347	-.342	-.323	.946	1.000	.191	-.433
Z ₉	.146	-.061	-.407	-.362	-.343	-.330	.993	.994	1.000	-.437
Z _t	-.074	-.008	.269	.417	.376	.327	-.430	-.408	-.438	1.000

Key:

Z₁ = Gender

Z₆ = Judging

Z₂ = Age

Z₇ = Visual

Z₃ = Extroversion

Z₈ = Auditory

Z₄ = Sensing

Z₉ = Kinesthetic

Z₅ = Thinking

Z_t = Biology Achievement

Note: Entries above the diagonal are the reproduced correlation coefficients.

Entries below the diagonal are the obtained correlation coefficients.

Table 4.7 showed the differences between the obtained correlation coefficients and the reproduced correlation coefficients.

Table 4.7: Differences between Obtained and Reproduced Correlation Coefficients

Correlation	Obtained	Reproduced	Difference
r ₁₂	.014	.014	.000
r ₁₃	-.154	-.154	.000
r ₁₄	-.119	-.119	.000
r ₁₅	.029	.001	.028
r ₁₆	-.124	-.124	.000

r ₁₇	.148	.146	.002
r ₁₈	.129	.129	.000
r ₁₉	.146	.147	-.001
r _{1t}	-.074	-.066	-.008
r ₂₃	-.012	-.002	-.010
r ₂₄	.060	.060	.000
r ₂₅	.094	.094	.000
r ₂₆	.063	.062	.001
R ₂₇	-.055	.004	-.059 *
r ₂₈	-.068	-.068	.000
r ₂₉	-.061	-.012	-.049
r _{2t}	-.008	-.011	.003
r ₃₄	.637	.017	.620 *
r ₃₅	.542	-.001	.543 *
r ₃₆	.692	.018	.674 *
r ₃₇	-.405	-.405	.000
r ₃₈	-.390	-.390	.000
r ₃₉	-.407	-.408	.001
r _{3t}	.269	.269	.000
r ₄₅	.755	.006	.749 *
r ₄₆	.803	.019	.784 *
r ₄₇	-.356	-.341	-.015
r ₄₈	-.347	-.286	-.061 *
r ₄₉	-.362	-.342	-.020
r _{4t}	.417	.418	-.001
r ₅₆	.671	.002	.669 *
r ₅₇	-.339	-.341	-.002
r ₅₈	-.342	-.236	-.106 *
r ₅₉	-.343	-.339	-.004
r _{5t}	.376	.376	.000
r ₆₇	-.325	-.337	-.012
r ₆₈	-.323	-.322	-.001

r_{69}	-.330	-.338	.008
r_{6t}	.320	.334	-.007
r_{78}	.946	.171	.775 *
r_{79}	.993	.196	.797 *
r_{7t}	-.430	-.434	-.026
r_{89}	.944	.191	.753 *
r_{8t}	-.408	-.433	.025
r_{9t}	-.488	-.437	-.001

Note: Difference between reproduced and obtained correlation is greater than .05.

To verify the efficacy of the re-specified model (fig. 4.2), the obtained and reproduced correlations were compared. It was established that, twelve of the forty five reproduced correlations have differences greater than 0.05. This difference accounted for 26.7%. This shows that the criterion level is under 40% (Kerlinger & Lee, 2000). This implies that the hypothesised model fits the empirical data. Therefore, the model describes the causal effects of the variables and their correlations.

4.4: Answer to research question four. (RQ4)

If the model is consistent, what are the estimates of direct, indirect and total causal effects among the variable?

Table 4.9 showed the decomposition of the reproduced correlation into direct as well as indirect paths. The spurious and undetermined effects are not reflected in the table. It is the decomposition or tracing of paths that resulted in a correlation coefficient for each path in the re-specified model.

Table 4.9 Decomposition of Re-specified Hypothesised Model

Correlation	Direct	Indirect
r_{13}	P_{31}	-
r_{14}	P_{41}	$P_{42}P_{21}$
r_{15}	-	$P_{52}P_{21}$
r_{16}	P_{61}	$P_{62}P_{21}$
r_{17}	P_{71}	$P_{73}P_{31} + P_{75}P_{51}$
r_{18}	P_{81}	$P_{82}P_{21} + P_{83}P_{31} + P_{86}P_{61}$
r_{19}	P_{91}	$P_{93}P_{31} + P_{95}P_{51}$
r_{1t}	-	$P_{12}P_{21} + P_{t3}P_{31} + P_{t4}P_{41} + P_{t5}P_{51} + P_{t9}P_{91}$

r ₂₃	-	P ₃₁ P ₂₁
r ₂₄	P ₄₂	P ₄₁ P ₂₁
r ₂₅	P ₅₂	-
r ₂₆	P ₆₂	P ₆₁ P ₂₁
r ₂₇	-	P ₇₁ P ₂₁ + P ₇₃ P ₃₂ + P ₇₅ P ₅₂
r ₂₈	P ₈₂	P ₈₁ P ₂₁ + P ₈₃ P ₃₂ + P ₈₆ P ₆₂
r ₂₉	-	P ₉₁ P ₂₁ + P ₉₃ P ₃₂ + P ₉₅ P ₅₂
r _{2t}	P _{t2}	P _{t3} P ₃₂ + P _{t4} P ₄₂ + P _{t5} P ₅₂ + P _{t9} P ₉₂
r ₃₄	-	P ₄₁ P ₃₁ + P ₄₂ P ₃₂
r ₃₅	-	P ₅₂ P ₃₂
r ₃₆	-	P ₆₁ P ₃₁ + P ₆₂ P ₃₂
r ₃₇	P ₇₃	P ₇₃ P ₃₁ + P ₇₅ P ₅₃
r ₃₈	P ₈₃	P ₈₁ P ₃₁ + P ₈₂ P ₃₂ + P ₈₆ P ₆₂
r ₃₉	P ₉₃	P ₉₁ P ₃₂ + P ₉₅ P ₅₃
r _{3t}	P _{t3}	P _{t2} P ₃₂ + P _{t4} P ₄₂ + P _{t5} P ₅₃ + P _{t9} P ₉₃
r ₄₅	-	P ₅₂ P ₂₄
r ₄₆	-	P ₆₁ P ₁₄ + P ₆₂ P ₂₄
r ₄₇	-	P ₇₁ P ₄₁ + P ₇₃ P ₄₃ + P ₇₅ P ₄₅
r ₄₈	-	P ₈₁ P ₄₁ + P ₈₂ P ₄₂ + P ₈₃ P ₄₃ + P ₈₆ P ₄₆
r ₄₉	-	P ₉₁ P ₄₁ + P ₉₃ P ₄₃ + P ₉₅ P ₄₅
r _{4t}	P _{t4}	P _{t2} P ₄₂ + P _{t3} P ₃₅ + P _{t5} P ₅₄ + P _{t9} P ₉₄
r ₅₆	-	P ₆₁ P ₅₁ + P ₆₂ P ₅₂
r ₅₇	P ₇₅	P ₇₁ P ₅₁ + P ₇₃ P ₅₃
r ₅₈	-	P ₈₁ P ₅₁ + P ₈₂ P ₅₂ + P ₈₃ P ₅₃ + P ₈₆ P ₅₆
r ₅₉	P ₉₅	P ₉₁ P ₅₁ + P ₉₃ P ₅₃
r _{5t}	P _{t5}	P _{t2} P ₅₂ + P _{t3} P ₅₃ + P _{t4} P ₃₄ + P _{t9} P ₉₅
r ₆₇	-	P ₇₁ P ₆₁ + P ₇₃ P ₆₃ + P ₇₅ P ₆₅
r ₆₈	P ₈₆	P ₈₁ P ₆₁ + P ₈₂ P ₆₂ + P ₈₃ P ₆₃
r ₆₉	-	P ₉₁ P ₆₁ + P ₉₃ P ₆₃ + P ₉₅ P ₆₅
r _{6t}	-	P _{t2} P ₆₂ + P _{t3} P ₆₃ + P _{t4} P ₆₄ + P _{t5} P ₆₅ + P _{t9} P ₉₆
r ₇₈	-	P ₈₁ P ₇₁ + P ₈₂ P ₇₂ + P ₈₃ P ₇₃ + P ₈₆ P ₇₆
r ₇₉	-	P ₉₁ P ₇₁ + P ₇₃ P ₇₃ + P ₇₅ P ₇₅

r_{7t}	-	$Pt_2P_{72} + Pt_3P_{73} + Pt_4P_{74} + Pt_5P_{75} + Pt_9P_{79}$
r_{89}	-	$P_{91}P_{81} + P_{95}P_{85}$
r_{8t}	-	$Pt_2P_{82} + Pt_3P_{83} + Pt_4P_{84} + Pt_5P_{85} + Pt_9P_{85}$
r_{9t}	Pt_9	$Pt_2P_{92} + Pt_3P_{93} + Pt_4P_{94} + Pt_5P_{95}$

Table 4.10 showed the summary of causal effects for re-specified model (Biology Achievement)

Table 4.10: Summary of Causal Effect for Re – specified Model (Biology Achievement)

Outcome	Determinants	Causal effect		
		Direct	Indirect	Total
Extroversion (Z_3) Adj: $R^2 = .023$	Gender (Z_1)	-.154	—	-.154
	Age (Z_2)	—	—	—
Sensing (Z_4) Adj: $R^2 = .017$	Gender (Z_1)	-.120	—	-.120
	Age (Z_2)	.062	—	.062
Thinking (Z_5) Adj: $R^2 = .008$	Gender (Z_1)	—	—	—
	Age (Z_2)	.094	—	.094
Judging (Z_6) Adj: $R^2 = .018$	Gender (Z_1)	-.125	—	-.125
	Age (Z_2)	.064	—	.064
Visual (Z_7) Adj: $R^2 = .194$	Gender (Z_1)	.109	.044	.153
	Age (Z_2)	—	-.018	-.018
	Extroversion (Z_3)	-.287	—	-.287
	Sensing (Z_4)	—	—	—
	Thinking (Z_5)	-.187	—	-.187
	Judging (Z_6)	—	—	—

Auditory (Z ₈) Adj: R ² = .164	Gender (Z ₁)	.070	.049	.119
	Age (Z ₂)	-.067	—	-.067
	Extroversion (Z ₃)	-.317	—	—
	Sensing (Z ₄)	—	—	—
	Thinking (Z ₅)	—	—	—
	Judging (Z ₆)	-.090	—	-.090
Kinesthetic (Z ₉) Adj: R ² = .198	Gender (Z ₁)	.107	.045	.152
	Age (Z ₂)	—	-.017	-.017
	Extroversion (Z ₃)	-.292	—	-.292
	Sensing (Z ₄)	—	—	—
	Thinking (Z ₅)	-.184	—	-.184
	Judging (Z ₆)	—	—	—
Biology Achievement (Z _t) Adj: R ² = .279	Gender (Z ₁)	—	-.017	-.017
	Age (Z ₂)	-.058	.011	-.067
	Extroversion (Z ₃)	-.113	—	—
	Sensing (Z ₄)	-.284	—	.284
	Thinking (Z ₅)	.109	.064	.173
	Judging (Z ₆)	—	—	—
	Visual (Z ₇)	—	—	—
	Auditory (Z ₈)	—	—	—
	Kinesthetic (Z ₉)	-.347	—	-.347

Note: Direct effects are significant at .05 levels

Table 4.10 showed the direct, indirect, and total effects of the eight endogenous variables.

Direct Effect

Biology Achievement

From the study, a criterion variable is Biology achievement. Out of the nine hypothesised direct predictors of Biology achievement, only five had statistically significant direct effect on it. These are age, extroversion, sensing, thinking, and kinesthetic.

Kinesthetic

Out of the six hypothesised direct predictors of kinesthetic, only three had statistically significantly direct effect on it. These are gender, extroversion, and thinking.

Auditory

Out of the six hypothesised direct predictors of auditory, only four had statistically direct effect on it. These are gender, age, extroversion, and judging.

Visual

Out of the six hypothesised direct predictors of visual, only three had statistically direct effect on it. These are gender, extroversion, and thinking.

Judging

The two hypothesised direct predictors of judging had statistically significant direct effect on it. These are gender and age.

Thinking

Out of the two hypothesised direct predictors of thinking, only one had statistically significant direct effect on it. This predictor variable is age.

Sensing

The two hypothesised direct predictors of sensing had statistically significant direct effect on it. These are gender and age.

Extroversion

Out of the two hypothesised direct predictors of extroversion, only one had statistically significant direct effect on it. This is gender.

Indirect Effect

Table 4.10 equally revealed that some of the predictor variables exert statistically significant indirect effect on the other, and on the criterion variable.

Achievement in Biology

Out of the nine hypothesised predictors of Biology achievement, only three had statistically significant indirect effect on it. These are gender, age, and thinking.

Kinesthetic

Out of the six hypothesised predictors of kinesthetic, only two had statistically significant indirect effect on it. These are gender, and age.

Auditory

Out of the six hypothesised predictors of auditory, only one had statistically significant indirect effect on it. This is gender.

Visual

Out of the six hypothesised predictors of visual, only two had statistically significant indirect effect on it. These are gender, and age.

Interpretation of Direct, Indirect and Total Effects

Direct Effect

The direct effects as given in table 4.10 are the path coefficients or the beta weights in the multiple regression analysis for the re-specified data (see figure 4.2). As usual, they give the estimated change (increase or decrease) in the criterion variable in standard deviation units where there is one full standard deviation (above the mean) change in each of the predictor variable holding the other predictor variables constant. For example, the direct effect of gender on extroversion was $-.154$. This implies that extroversion decreased by $.154$ for every one standard deviation increase in gender, controlling for other predictors.

Also, the direct effect of gender on sensing was $-.120$. This means that sensing decreased by $.120$ for every one standard deviation increase in gender, controlling for other predictors. The direct effect of age on sensing was $.062$. This shows that sensing increased by $.062$ for every one standard deviation increase in age, controlling for other predictor variables. Similarly, the direct effect of age on thinking was $.094$. This implies that thinking increased by $.094$ for every one standard deviation increase in age, controlling for other predictors. Also, the direct effect of gender on judging was $-.125$. This shows that judging decreased by $.125$ for every one standard deviation increase in gender, controlling for other predictors. The direct effect of age on judging was $.064$. It means that judging decreased by $.064$ for every one standard deviation increase in age, controlling for other predictor variables.

The direct effect of gender on visual was $.109$. This shows that visual increased by $.109$ for every one standard deviation increase in gender, controlling for other predictors. The direct effect of extroversion on visual was $-.287$. This implies that visual decreased by $.287$ for every one standard deviation increase in extroversion, controlling for other predictor variables. Also, the direct effect of gender on auditory was $.070$. This means that auditory increased by $.070$ for every one standard deviation increase in gender, controlling for other predictors. Similarly, the direct effect of age on auditory was $-.067$. This shows that auditory decreased by $.067$ for every one standard deviation increase in age, controlling for other predictors. The direct effect of

extroversion on auditory was $-.317$. This means that auditory decreased by $.317$ for every one standard deviation increase in extroversion, controlling for other predictors. The direct effect of judging on auditory was $-.090$. This means that auditory decreased by $.090$ for every one standard deviation increase in judging, controlling for other predictors. Also, the direct effect of gender on kinesthetic was $.107$ for every one standard deviation increase in gender, controlling for predictors. The direct effect of thinking in kinesthetic was $-.184$, this implies that kinesthetic decreased by $.184$ for every one standard deviation increase in thinking controlling for other predictor variables.

Similarly, the direct effect of age on biology achievement was $-.058$. This means that Biology achievement decreased by $.058$ for every one standard deviation increase in age, controlling for other predictors. The direct effect of extroversion on biology achievement was $-.113$. This shows that biology achievement decreased by $.113$ for every one standard deviation increase in extroversion, controlling for other predictors. Also, the direct effect of sensing on biology achievement was $.284$. This means that Biology achievement increased by $.284$ for every one standard deviation increase in sensing, controlling for other predictors. The direct effect of thinking on biology achievement was $.109$. This means that biology achievement increased by $.109$ for every one standard deviation increase in thinking, controlling for other predictors. Lastly, the direct effect of kinesthetic on biology achievement was $-.347$. This implies that biology achievement decreased by $.347$ for every one standard deviation increase kinesthetic, controlling for other predictor variables.

Indirect Effect

The indirect effect was estimated statistically as the products of direct effects i.e. the standardised path coefficients of the paths that comprise them. For example, the standardised indirect effect of gender on visual was estimated as the product of standardised coefficient for the paths: from Gender to Extroversion X from Extroversion to Visual or $(-.154) (-.287)$. This gives $.044$. For the interpretation, the indirect effect of gender on visual was $.044$. This means that visual increased by $.044$ standard deviation for every increase in the gender effect of one full standard deviation via its' prior effect on extroversion. Similarly, the indirect effect of age on visual was estimated as the product of standardised coefficients for the paths: from Age to Thinking X from Thinking to Visual or $(.094) (-.187) = -.081$. To interpret this, it means that visual decreased by $.018$ standard deviation for every increase in age effect of one full standard deviation via its' prior effect on thinking.

Also, the indirect effect of gender on auditory was estimated as the product of the standardized coefficient for the paths: from Gender to Extroversion X from Extroversion to Auditory or $(-.154) (-.317) = .049$. For the interpretation, it implies that auditory increased by .049 standard deviation for every increase in gender effect of one full standard deviation via its' prior effect on extroversion. The indirect effect of gender on kinesthetic was estimated as the product of the standardized coefficients for the paths: from Gender to Extroversion X from Extroversion to Kinesthetic or $(-.154) (-.290) = .045$. To interpret this, it means that kinesthetic increased by .045 standard deviations for every increase in gender effect of one full standard deviation via its' prior effect on extroversion.

The indirect effect of gender on kinesthetic was estimated as the product of the standardised coefficients for the paths: from Gender to Extroversion X from Extroversion to Kinesthetic or $(-.154) (-.290) = .045$. To interpret this, it means that kinesthetic increased by .045 standard deviations for every increase in gender effect of one full standard deviation via its' prior effect on extroversion.

The indirect effect of age on kinesthetic was estimated as the product of the coefficients for the paths: from Age to Thinking X from Thinking to Kinesthetic or $(.094) (-18.4) = -.017$. For the interpretation, it implies that kinesthetic decreased by .017 standard deviations for every increase in age effect of one full standard deviation via its' prior effect on thinking.

Also, the indirect effect of gender on Biology achievement was estimated as the product of the standardised coefficients for the paths: from Gender to Extroversion X from Extroversion to Biology Achievement or $(-.154) (-.113)$ + from Gender to Sensing X from Sensing to Biology Achievement or $(-.120) (.284)$ + From Gender to Kinesthetic X from Kinesthetic to Biology Achievement or $(.107) (-.347)$. This gives $.017 + (-.034) + (-.037)$. This equals .054. For the interpretation, it means that Biology achievement increased by .054 standard deviations for every increase in gender effect of one full standard deviation via its' prior effect on extroversion, sensing and kinesthetic.

Similarly, the indirect effect of Age on Biology achievement was estimated as the product of the standardized coefficients for the paths; from Age to Sensing X from Sensing to Biology Achievement or $(.062) (.284)$ + from Age to Thinking X from Thinking to Biology Achievement or $(.094) (.109)$ + from Age to Thinking X from Thinking to Kinesthetic X from Kinesthetic to Biology Achievement or $(.094) (-.184) (-.347)$. This gives: $.018 + .010 + (-.017) (-.347) = .018 + .010 + .005 = .033$. For the interpretation, It implies that biology achievement increased by .033. Standard deviations for every increase in age effect of one full standard deviation via its prior effects on sensing, thinking, and kinesthetic.

Finally, the indirect effect of thinking on Biology achievement is given by the paths: from Thinking to Kinesthetic X from Kinesthetic to Biology Achievement or $(-.184) (-.347) = .064$. For the interpretation, it implies that Biology achievement increased by .064 standard deviations for every increase in thinking effect of one full standard deviation via its' prior effect on kinesthetic. Note that when the path coefficients are negative, the term decrease is used. But, when the path coefficients are positive, the term increase is used.

Total Effects

Total effects are the sum of all direct and indirect effects of one variable on the other. For instance, the standardised total effects of age on Biology achievement were $-.067$. For the interpretation it means that increasing age by one standard deviation reduces Biology achievement by .067 standard deviations via all presumed direct and indirect causal links between them. Also, the standardised total effects of thinking on Biology achievement were $.173$. To interpret this, it implies that increasing thinking by one standard deviation increases biology achievement by .173 standard deviations via all presumed direct and indirect causal links between them.

Similarly, the standardised total effects of gender on visual were $.153$. For the interpretation, it means that increasing gender by one standard deviation increases visual by .153 standard deviation via all presumed direct and indirect causal links between them. Also, the standardised effect of gender on auditory were $.119$. To interpret this, it means that increasing gender by one standard deviation increases auditory by .119 standard deviation via all presumed direct and indirect causal links between them.

From table 4.10, the outcome of primary interest was Biology achievement of which its major determinants were age, extroversion, sensing, thinking and kinesthetic. It was established that this model explained approximately 27.9% of the variances in Biology achievement. For extroversion, the primary determinants was gender, this model explained approximately 2.3% of the variance in extroversion. The primary determinants of sensing were gender, and age, this model explained approximately 1.7% of the variance in sensing. Also, for thinking, the primary determinant was age. This model explained approximately 0.8% of the variance in thinking. The primary determinants of judging were gender, and age, this model explained approximately 1.8% of the variance in judging.

Similarly, the primary determinants of visual were gender, extroversion and thinking. This model explained approximately 19.4% of the variance in visual. The primary determinants of auditory were gender, age, extroversion and judging. The model explained

approximately 16.4% of the variance in auditory. For kinesthetic, its primary determinants were gender and thinking. This model explained approximately 19.8% of the variance in kinesthetic.

4.5 Discussion of Findings

The result in table 4.1 (in relation to research question one) revealed that the students performed above average on measurement scales involving extroversion (62.3%), sensing (66.3%), thinking (63.3%) and judging (63.1%). What this suggests is that, the students preferred personality type-ESTJ in the learning of Biology. Arguably, they demonstrated that they like to learn biology best through these personality type preferences (extroversion, sensing, thinking, and judging). This is consistent with the study of Archana (2007) who said that ESTJ type was found to be the dominant one in the population of management students.

Also, the students' performances in terms of visual (63.0%) and auditory (78.1%) were above average. This is in line with the findings of Sandra and Metka, (2009) who found that students who had preferences for visual, auditory and kinesthetic had high academic achievement and good attitudes toward learning. This implies that, the learning styles the students preferred to learn Biology effectively were visual and auditory. The students had highest preference for auditory. The reason for this might be connected with the fact that more often than not, Biology Teachers engage the use of lecture method to pass instructions to students. This might have helped the students develop and improve their sense of listening (auditory) over the visual and kinesthetic learning styles.

However, their performances in terms of kinesthetic (35.0%) and achievement (40.0%) in Biology were low. This observation provided evidence that the students were not having interest in the practical aspect of Biology. The effect of this perhaps accounted for their poor performance in the Biology achievement test.

Findings from the re-specified parsimonious model (in relation to research question two) showed that there were moderately positive significant relationships between Biology achievement and extroversion (0.269); Biology achievement and sensing (0.417); Biology achievement and thinking (0.376); Biology achievement and judging (0.327). These results are consistent with the findings of Adele et al., (2007); Terrance et al., (1998) who established that extroversion, sensing, thinking and judging are predictor variables to achievement. However, these findings were of variance with Gregory (2006) who reported low positive relationship between academic achievement and judging. The positive relationships among the variables are not unexpected, since the types of attributes which

extroverts, sensors, thinkers and judgers naturally possess are those that can make them learn Biology effectively. For instance, extroverts thrive in an environment that allows for group or team work, and demonstrating what they know to people; sensors learn best through perceiving information directly by their senses; while, thinkers trust information that are logical and objective; judgers learn best by planning many of the details in advance before moving into action. Thus, students can significantly improve their achievement in Biology learning if they can develop and exhibit these personality type preferences (extroversion, sensing, thinking, and judging)

Also, the findings showed that negative statistically significant correlations existed between Biology achievement and visual (-0.430); Biology achievement and auditory (-0.408); Biology achievement and kinesthetic (-0.438). These results were consistent with the findings of Ebel (1999); Cavanagh (2002) who reported that visual, auditory and kinesthetic were predictors of students' achievement.

However, statistically insignificant correlation existed between age (-0.008) and Biology achievement. This disagrees with the finding of Grasha (1996) who established a significant relationship between age and students' achievement. The reason for the present finding could be associated with the fact that more often than not learners consider themselves equal as far as they are classmates not minding the age difference.

The findings of the study (in relation to research question three) established that out of the thirty five (35) causal path in the hypothesised recursive model (Fig. 4.1) only twenty one (21) were significant for producing the re-specified causal model. The twenty one causal path were derived from the eight (8) new structural equations. It is not that the path deleted were non-existent in terms of variable linkage but rather were not strong enough for consideration in the hypothesised model. The efficacy of the re-specified model was verified comparing the obtained and reproduced correlation coefficients. In the comparison, it was established that the differences were noticed in twelve instances of relationship which accounted for 27%. Thus, the re-specified model is retained and sustained for providing explanations about variance in Biology achievement. This corroborate the study of Kerlinger and Lee, (2000) who reported that hypothesised model fits the empirical data when the differences between hypothesised and reproduced correlation coefficients fall under 40%.

Findings from the study (in relation to research question four) indicated that kinesthetic (-0.347) had the highest direct effect on Biology achievement. The reason behind this could be attributed to poor instructional techniques often associated with classroom teaching in our schools. Practical classes and field trips are often neglected by many Biology

teachers in senior secondary schools. This can hinder the zeal students may have for practical work which may in turn affect their achievement in Biology. It follows that kinesthetic as a learning style is a strong factor that needs to be given due attention in order to bring about desirable improvement on Biology achievement. The adequate exposure of students to practical Biology both in the laboratory and on the field will go a long way to influence their performance in the subject. The challenge therefore, is for both the government and the teachers to find an effective way of teaching practical Biology with a view to bringing about meaningful understanding of the subject. This is also necessary because the practical aspect of Biology, unlike the theoretical aspect cannot be easily carried out privately by students.

The findings also revealed that gender had no direct effect on Biology achievement. What this suggests is that there was no remarkable relationship between gender and achievement in Biology. This finding disagrees with the findings of Shields (1995); Rossiter (1992); Dijkstra (2006), who reported that males performed better than females in sciences. The reason for this disagreement could be associated with the provision of equal educational opportunity for all children by Nigerian government. Similarly, it could be linked with the welcome development among many parents to give equal attention to the education of their male and female children.

It was established in this study that thinking had both statistically significant direct (0.109) and indirect (0.064) effects on Biology achievement. This agrees with the findings of Adele et al., (2007) who reported that thinking had a high significant relationship with academic performance. This could be so because the way and individual thinks may affect the way he/she processes new and difficult information which in turn may affect his/her level of achievement. This implies that thinking is a strong factor that determines students' achievement in Biology. So, students should develop and exhibit thinking preference in order to learn Biology effectively.

Also, the findings from the parsimonious model revealed that gender of student had significant influence on extroversion (-0.154), sensing (-0.120) and judging (-0.125). This corroborate the findings of Cano, Garton, and Raven, (1992); Gregory, (2006). They reported that males preferred gathering information through extroversion, sensing and thinking more than their female counter parts. This could be attributed to the fact that two individuals are not exactly the same in terms of personality type preferences. This suggests that male and female are likely to exhibit different personality types even, when they are under the same learning conditions.

The relative contributions of the nine predictor variables to variance in students' achievement in Biology were indicated by path coefficients (See table 4.3). Apart from the five predictor variables [age (-0.058), extroversion (-0.113), sensing (-0.284), thinking (0.109) and kinesthetic (-0.347)] having direct relationships with the criterion variable, there were sixteen other direct relationships (see table 4.9) involving the four other endogenous variable. In addition, one hundred and fifteen (115) indirect relationships involving the variables of study were established in the parsimonious model for Biology achievement. All the pathways involving both the exogenous and endogenous variables in the parsimonious model are recursive, meaning that, there were no reciprocal causations among them.

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CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Introduction

This chapter presents the summary of findings as well as their educational implication and recommendations. Also, the limitations of the study and suggestions for further research were given attention.

5.1 Summary of Findings

The findings of this study are summarized below:

1. A large number of students exhibited extroversion, sensing, thinking, and judging personality type preferences in learning Biology.
2. A large number of students preferred visual and auditory learning styles in learning Biology.
3. The number of students who showed preference for kinesthetic learning style in learning Biology was very low.
4. There was significant correlation between gender and students' achievement in Biology.
5. There was no significant correlation between age and students' achievement in Biology.
6. There were significant correlations between extroversion, sensing, thinking, judging, and students' achievement in Biology.
7. There were significant correlation between visual, auditory, kinesthetic, and student' achievement in Biology.
8. The empirical data was consistent with the hypothesised model.
9. Gender had no significant direct effect on students' achievement in Biology.
10. Age had significant direct effect on students' achievement in Biology.
11. The indirect effects of gender and age on students' achievement in Biology were insignificant.
12. There were significant direct effects of extroversion and sensing on students' achievement in Biology.
13. Thinking had both significant direct and indirect effects on students' achievement in Biology.
14. Kinesthetic had significant direct effect on students' achievement in Biology.

5.2 Implications of the study

The findings of the study have many implications for Biology education. The new model produced by the study showed that personality type preferences (extroversion, sensing, thinking) and learning style preference (kinesthetic) had significant direct effects on students' achievement in Biology. This is a pointer to the fact that there is need to pay more attention to the personality and learning characteristic of students in order to improve their achievement. Students should therefore try to develop and exhibit extroversion, sensing, thinking, and kinesthetic preferences so as to improve their performance in Biology at senior secondary school level. It is envisaged that the exhibition of extroversion, sensing, thinking, and kinesthetic by students during teaching-learning situation could further enhance the achievement of students not only in Biology, but also in other science subjects

The study has also exposed the teachers to the role personality type and learning type preference can play in the achievement of students in Biology. Therefore, Biology teacher should not consider their students as a homogeneous group without due cognizance to individual inherent innate personality type and learning style preferences which students tend to exhibit in the classroom situation. In other words, Biology teachers should put into consideration these individual differences among students. If this is done, Biology teachers will be able to use instructional strategies that will accommodate the personality type and learning style preferences which students tend to exhibit in learning situation, especially those ones (extroversion, sensing, thinking, and kinesthetic) which this study has identified to have significant effects on students' achievement in Biology.

A large number of studies discussed in this study stressed the desirable effects which personality type-ESTJ (Extroversion, Sensing, Thinking, Judging) and learning style- VAK (Visual, Auditory, Kinesthetic) have on students' achievement. Therefore, it is very necessary for parents to be aware of this so as not to discourage their children each time they exhibit any of these personality type and learning style preferences at home. The findings of this study have educational implications for Biology classroom teacher, Biology students, human psychologists, curriculum planners and parents.

5.3 Conclusion

Conclusively, the findings of study revealed that personality type – ESTJ (Extroversion, Sensing, Thinking, Judging) were predictor variables to learning style – VAK (Visual, Auditory, Kinesthetic), and both in turn were predictor variables to students' achievement in Biology. However, the study showed that only personality type preferences

(extroversion, sensing and thinking), learning style preference (kinesthetic), and age had statistically significant effects on the achievement of SSS 2 Biology students in the sampled Senior Secondary Schools in Osun State.

5.4 Recommendations

- a. Students should develop and exhibit extroversion, sensing, thinking, and kinesthetic preferences to learn Biology effectively.
- b. It is advocated that teachers should adopt and combine right approaches that could encourage and allow students exhibit these learner personal variables (extroversion, sensing, thinking, and kinesthetic) when teaching Biology.
- c. Since students spend most of their time at home with their parents, thus, parent should not discourage their children each time they exhibit any of these personality type and learning style preferences..
- d. Government should endeavour to provide enabling school environment that could allow for group work and interactive activities, exposure to modern audio, and practical materials. This will in no small measure encourage senior secondary school students to exhibit those personal variables (extroversion, sensing, thinking, auditory, and kinesthetic) that were found to have significant influence on their achievement in Biology.

5.5 Limitations of the Study

The research is subject to a few limitations.

- i. It is based on one school subject (Biology) at some selected public senior secondary schools. It should be generalised by having data from several senior secondary schools in order to ensure a larger sample size.
- ii. In addition, the sample is based on only SSS 2 Biology students, and it should cover SSS 1 and SSS 3 Biology students in order to have a general view of education.
- iii. The most prominent deficiency of the research is that it does not recognise the dimension of time. For instance, the concept of this research is inherently static. Therefore, further analysis should focus on determining this development –styles are not necessarily fixed, but can change over time.

5.6 Suggestions for Further Research

- i. The study could be replicated with focus on senior secondary school 3, and in addition on a wider geographical area, for instance south-west Nigeria could be considered.
- ii. School location is one other variable envisaged to mediate between students' personality type and learning style preferences, and achievement in biology and so, it is being suggested for inclusion while modeling the said criterion variable.
- iii. Apart from the nine predictors variables considered in this research work, there still remain some other learner personal variables which interested researcher could explore to further shed light on the explanation of students' achievement in Biology.
- iv. It is also the view of the researcher that an experimental design could be carried out using a small sample to explain variation in students' achievement in Biology. This could be done using any of the strong predictor variables identified in the study.

5.7 Contribution to knowledge

The study has produced a parsimonious model that is able to explain students' personality type and learning style preferences in relation to their achievement in Biology at senior secondary school level.

The findings of the study have shown that extroversion, sensing, thinking, and kinesthetic had significant effects on the achievement of Biology students.

The study revealed that the explanation of factors associated with students achievement in Biology should not be restricted to parent, teacher, and government factors.

In sum, the results of the study will provide the policy makers, curriculum developers, human psychologist, parents, classroom teachers, and students the empirical information needed in relation to the contributions of the nine predictor variables of this study to the achievement of students in Biology at senior secondary school level.

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Appendix I

ZONES AND THE RANDOMLY SELECTED LOCAL GOVERNMENT AREAS AND THE SCHOOL, IN OSUN STATE.

* EDE ZONE

Ede South Local Government:

1. Seventh Day Adventist Grammar School, Ede.
2. Baptist High School, Ede.
3. Obalaoye Grammar School, Ede.

Egbedore Local Government:

4. Okinni Community Grammar School, Okinni.
5. Ido-osun High School, Ido-osun.
6. Alawo High School, Awo.

* IFE ZONE

Ife North Local Government:

7. Origbo Community High School, Ipetumodu.
8. L.A Secondary Grammar School, Ipetumodu.
9. Origbo Anglican Grammar School, Origbo.
10. C & S Grammar School, Ipetumodu.
11. Asipa Community High School, Asipa.

Ife South Local Government:

12. Ifetedo High School, Ifetedo.
13. Community Grammar School, Oniperegun.
14. Ayanbeku memorial Grammar School, Ifetedo.
15. Ifetedo Grammar School, Ifetedo.
16. L.A Grammar School, Ifetedo.
17. Olode Grammar School, Olode.
18. Ifesowapo Community Grammar School, Egbejoda.
19. St. Peter Grammar School, Olode.
20. Aderemi Memorial Grammar School, Aye-Oba.

*** IFELODUN ZONE:**

Boripe Local Government:

21. Baptist Secondary Grammar School, Iragbiji.
22. Okeragbiji Grammar School, Iragbiji.
23. African Church Grammar School, Ire
24. Ado Commercial Secondary School, Ado.

Ifelodun Local Government:

25. Holy Michael High School, Ikirun.
26. Orimolade Community Grammar School, Ikirun.
27. Akinorun Grammar School, Ikirun.
28. African Church Grammar School, Ikirun.

Ila local Government:

29. Igbonnibi High School, Ila.
30. Ila Grammar School, Ila.
31. Ajagunnla Grammar School, Ila.

*** IJESA ZONE**

Atakumosa West Local Government:

32. Akinyemi Memorial Grammar School, Ifewara.
33. Ibodi Grammar School, Ibodi.
34. Osu community Grammar School, Osu.
35. Ifewaara high School, ifewara.
36. Atakumosa High School, Osu.

Ilesa East Local Government:

37. St. Lawrence's Senior Grammar School, Ilesa.
38. Obokun High School, Ilesa.
39. Ilesa Grammar School, Ilesa.
40. The Apostolic College, Oke-Oye, Ilesa.
41. Muslim Grammar school, Irojo, Ilesa.

Oriade Local Government:

42. Oso-Wusi Muslim Community High School, Iloko.
43. Ijebu-jesa Grammar School, Ijebu-jesa.
44. Urban Day Grammar School, Ijebu-jesa.
45. Iwoye Grammar School, Iwoye.
46. Ebenezer Grammar School, Ijeda.
47. C.A.C Community Grammar School, Iwaraja.
48. Erinmo Community High School, Erinmo.
49. Community High School, Ere-jesa.

*** IWO ZONE**

Irewole local government:

50. St. Augustine Commercial Grammar School, Ikire.
51. Community High School, oke-Ada, Ikire.
52. Anwarul Islam Grammar School, Ikire.
53. Baptist Grammar School, Ikire.
54. Akinrere School of Science, Ikire.

Iwo local Government:

55. United Methodist High School, Iwo.
56. Iwo Grammar School, Iwo.
57. Ansarul Islam Grammar School, Iwo.
58. L.A Senior Grammar School, Iwo.
59. Baptist Grammar School, Iwo.

Ayedaade Local Government:

60. Odeomu High School, odeomu.
61. St. Patric's Grammar School, Gbongan.
62. Olufi High School, Gbongan.
63. Community High School, Owoope, Gbongan.
64. St. Michael's Grammar School, Odeomu.
65. The Apostolic Grammar School, Orile-Owu.
66. Orile-Owu Grammar School, Orile-owu.

*** OSOGBO ZONE**

Irepodun Local Government:

67. Ilobu Secodary Commercial Grammar School, Ilobu.
68. A.D.S Grammar School, Ilobu.
69. Anzaruldeen grammar School, Ilobu.

Osogbo Local Government:

70. Fakunle Comprehensive High School, Osogbo.
71. Ataoja School, of Science, Osogbo.
72. Osogbo grammar School, Osogbo.
73. Laro Grammar School, Osogbo.
74. Christ African Church grammar School, Osogbo.

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Appendix II
INTERNATIONAL CENTRE FOR EDUCATIONAL EVALUATION (ICEE)
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COGNITIVE TYPE INVENTORY (CTI)

Dear Respondent,

This questionnaire is intended to collect information from students on their personality types in the learning of Biology in secondary school. The questionnaire is purely for research purpose and your responses will be treated with utmost confidentiality

SECTION A

Instruction: Please respond to the items either by a tick (v) in the relevant box most applicable to you filling in your response.

- 1 *Name of school* _____
- 2 *Class* _____
- 3 *Gender of student:* Male () Female ()
- 4 *Age of student:* Between 15 yrs and 16 yrs () Between 17 yrs and 18 yrs ()

SECTION B

Each of the statement below represents the personality type characteristics you exhibit learning Biology. Choose the one that describes the way you really are by marking (v) in any of the boxes to each statement on a three point scale **Very True of Me (VTOM)**, **True of me (TOM)**. **Not True Of Me (NTOM)**.

S/N	ITEMS	VTOM	TOM	NTOM
	EXTROVERSION			
1	I feel disturbed when cutoff from group interaction.			
2	I like to demonstrate what I know to people.			
3	I feel motivated by outside world of people.			
4	I enjoy relating with many people.			
5	I need frequent breaks when I engage in activity.			
6	Interruptions don't bother me when I engage in activity.			
	SENSING			

7	I like factual information.			
8	Using common sense in solving problem is automatic.			
9	Creating practical solution to problem is instinctual.			
10	I dislike guessing when facts are not clear.			
11	I emphasize observation on imagination.			
12	I like practical information.			
	THINKING			
13	I instinctively search for facts in a decision situation.			
14	I like to ponder over issues critically before taking decision.			
15.	I like to be objective in decision making.			
16.	I accept conflict as a natural part of relationship with people.			
17.	I like to use my initiative in decision situation			
18.	I am able to notice work to be accomplished.			
	JUDGING			
19.	I plan many of the details in advance before moving into action			
20.	When I engage in activity, I complete meaningful segments before moving on.			
21.	I like to take the control of situations.			
22.	I use targets to manage life.			
23.	I work best when I am able to keep ahead of deadlines			
24.	I use dates to manage life.			

Thanks for your cooperation

Appendix III
INTERNATIONAL CENTRE FOR EDUCATIONAL EVALUATION (ICEE)
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VAK LEARNING STYLES INDICATORS [VLSI]

Dear Respondent,

This questionnaire is intended to collect information from students on their preferred learning styles in the learning of Biology in secondary school. The questionnaire is purely for research purpose and your responses will be treated with utmost confidentiality.

SECTION A

Instruction: Please respond to the items either by a tick (v) in the relevant box most applicable to you filling in your response.

- 1 *Name of school* _____
- 2 *Class* _____
- 3 *Gender of student:* Male () Female ()
- 4 *Age of student:* Between 15yrs and 16yrs () Between 17yrs and 18yrs ()

SECTION B

Each of the statements below represents the preferred learning style you exhibit when learning biology. Rate each to show the extent to which you prefer it. Use the scale: **To a large extent (3) To a moderate extent (2) To a low extent (1).**

Example 1:

S/N		Visual	Auditory	Kinesthetic / physical
A	When I revise for tests, I ...	write lots of revision notes. 3	talk over my notes to myself. 2	Imagine creating the formula. 1

Considering the 1st example given, it means, when I revise for tests, to a large extent, I prefer visual learning style; to a moderate extent, I prefer auditory learning style; whereas, to a low extent, I prefer kinesthetic learning style.

Example 2:

S/N		Visual	Auditory	Kinesthetic / physical
A	When I revise for tests, I ...	write lots of revision notes. 2	talk over my notes to myself. 1	Imagine creating the formula. 3

In the 2nd example, it means, when I revise for tests to a moderate extent, I prefer visual learning style; to a low extent, I prefer auditory learning style; whereas, to a large extent, I prefer kinesthetic learning style.

Example 3:

S/N		Visual	Auditory	Kinesthetic / physical
A	When I revise for tests, I ...	write lots of revision notes. 1	talk over my notes to myself. 3	Imagine creating the formula. 2

In the 3rd example, it means, when I revise for tests, to a low extent, I prefer visual learning style; to a large extent, I prefer auditory learning style; whereas, to a moderate extent, I prefer kinesthetic learning style.

Now, kindly respond to the following items

S/N		Visual	Auditory	Kinesthetic/ Physical
1.	I remember things best by ...	writing notes or Keeping printed details. <input type="checkbox"/>	saying them Aloud or repeating words and key points in my head. <input type="checkbox"/>	Doing and practicing the activity, or imagining it being done. <input type="checkbox"/>
2.	My first memory is of	looking at something. <input type="checkbox"/>	Being spoken to. <input type="checkbox"/>	Doing something. <input type="checkbox"/>
3.	When learning a new skill	I watch what the teacher is doing. <input type="checkbox"/>	I talk through with the teacher exactly what I am supposed to do. <input type="checkbox"/>	I like to give it a trial and work it out as I go along by doing it. <input type="checkbox"/>
4.	When I revise for an exam, I ..	write lots of revision notes (using lots of colours). <input type="checkbox"/>	talk over my notes, to myself or to other people. <input type="checkbox"/>	imagine making the movement or creating the formula. <input type="checkbox"/>
5.	Most of my free time is spent..	watching television. <input type="checkbox"/>	talking to friends. <input type="checkbox"/>	doing physical activity or making things. <input type="checkbox"/>
6.	I first notice how people ..	look and dress. <input type="checkbox"/>	sound and speak. <input type="checkbox"/>	stand and move. <input type="checkbox"/>
7.	I find it easiest to remember	faces. <input type="checkbox"/>	names. <input type="checkbox"/>	things I have done. <input type="checkbox"/>
8.	I feel especially connected to others because of	how they look. <input type="checkbox"/>	what they say to me <input type="checkbox"/>	how they make me feel. <input type="checkbox"/>

9.	When operating new equipment for the first time I prefer to	read the instructions. <input type="checkbox"/>	listen to or ask for an explanation. <input type="checkbox"/>	have a go and learn by 'trial and error' <input type="checkbox"/>
10.	I tend to say..	"show me" <input type="checkbox"/>	"tell me" <input type="checkbox"/>	"let me try" <input type="checkbox"/>
11.	I tend to say..	"I see what you mean." <input type="checkbox"/>	"I hear what you are saying." <input type="checkbox"/>	"I know how you feel" <input type="checkbox"/>
12.	I tend to say..	"watch how I do it" <input type="checkbox"/>	"listen to me explain" <input type="checkbox"/>	"you have a go" <input type="checkbox"/>
13.	I prefer these leisure activities.	Museums or galleries. <input type="checkbox"/>	music or conversation. <input type="checkbox"/>	physical activities or making thing. <input type="checkbox"/>
14.	When listening to a band	I sing along to the lyrics (in my head or out loud!) <input type="checkbox"/>	I listen to the lyrics and the beats. <input type="checkbox"/>	I move in time with the music. <input type="checkbox"/>
15.	When concentrating I ...	focus on the words or pictures in front of me. <input type="checkbox"/>	discuss the problem and possible solutions on my head. <input type="checkbox"/>	move around a lot, fiddle with pens and pencils and touch unrelated things. <input type="checkbox"/>
16.	My main interests are	photography or watching films or people <input type="checkbox"/>	listening to music, or listening to the radio or talking to friends. <input type="checkbox"/>	physical / sports activities or dancing. <input type="checkbox"/>
17.	When I first contact a new person	I arrange a face to face meeting. <input type="checkbox"/>	I talk to him/her on the telephone <input type="checkbox"/>	I try to get together to share an activity. <input type="checkbox"/>
18.	When explaining something to someone, I tend to..	show them what I mean. <input type="checkbox"/>	explain to them in different ways until they understand. <input type="checkbox"/>	encourage them to try and talk them through the idea as they try. <input type="checkbox"/>

19.	When I'm meeting with an old friend..	I say "it's great to see you!". <input type="checkbox"/>	I say "its great to hear your voice". <input type="checkbox"/>	I give him/her a hug or a handshake. <input type="checkbox"/>
20.	When anxious, I...	visualize the worst-case scenarios. <input type="checkbox"/>	talk over in my head what worries me most. <input type="checkbox"/>	can't sit still, fiddle and move around constantly. <input type="checkbox"/>
21.	If I am very angry..	I keep replaying in my mind what it is that has upset me. <input type="checkbox"/>	I shout lots and tell people how I feel. <input type="checkbox"/>	I stomp about, slam doors and throw things. <input type="checkbox"/>
22.	To teach someone something, I ..	write instructions. <input type="checkbox"/>	explain verbally. <input type="checkbox"/>	demonstrate and let them have a go. <input type="checkbox"/>

Thanks for your cooperation.

Appendix IV

**INTERNATIONAL CENTRE FOR EDUCATIONAL EVALUATION (ICEE)
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BIOLOGY ACHIEVEMENT TEST (BAT)

CLASS: SSS 2

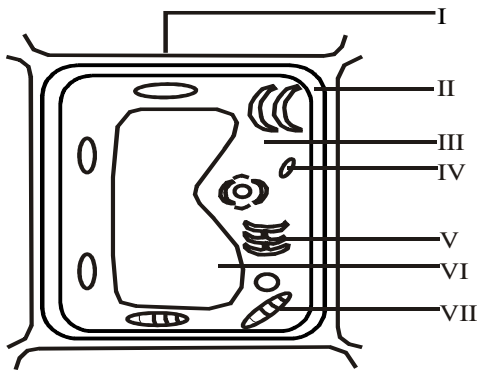
TIME: 60 MINS

INSTRUCTIONS: Read and comply with the following instructions carefully:

1. Write your gender, age, school and date the test is being taken on your answer sheet.
 2. Ensure the answer to the question indicated on your answer sheet corresponds to the number of the questions you have answered.
 3. Ask for any clarification from the examiner.
 4. Answer all questions.
 5. Do not write or make any marks on this question paper.
-
1. Which of the following is **not** classified as an animal?
(A) Amoeba (B) Paramecium (C) Euglena *(D) Obelia
 2. A typical plant cell is **mainly** distinguished from an animal cell by the possession of
(A) Chloroplast and nucleus
(B) Cell wall and cytoplasm
*(C) Chloroplast and cell wall
(D) Cell wall and mitochondrion
 3. A group of closely related organisms capable of interbreeding to produce fertile offspring are known as members of a
(A) kingdom (B) class (C) family *(D) species
 4. The living material of the cell consists of
*(A) nucleus and cytoplasm

- (B) cytoplasm and vacuole
 - (C) cytoplasm and cell membrane
 - (D) nucleus and cell membrane
5. The group mollusca is characterised by the presence of
- (A) jointed appendages
 - (B) star-shaped bodies
 - (C) backbones
 - * (D) soft, non-segmented bodies

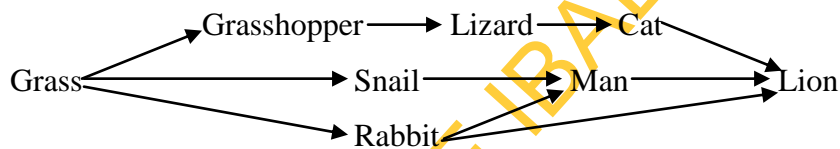
Use the diagram below to answer Question 6 and 7



6. The structure that produces ATP is labeled
- * (A) VII
 - (B) V
 - (C) VI
 - (D) I
7. The structure labeled V is the
- (A) cell wall
 - (B) nucleus
 - * (C) endoplasmic reticulum
 - (D) mitochondrion
8. Carbohydrates are stored in the animal cell in form of
- (A) starch
 - * (B) glycogen
 - (C) plastid
 - (D) maltose
9. Which of the following organisms does not exist as a single cell?
- (A) Amoeba
 - (B) Euglena
 - * (C) Volvox
 - (D) Chlamydomonas
10. Euglena can be classified as animal because of the possession of
- (A) nucleus
 - (B) cytoplasm
 - (C) cell wall
 - * (D) pellicle
11. In testing for starch in a leaf, the leaf is first boiled in water for about a minute so that the
- (A) cell wall are hardened
 - * (B) cells are killed
 - (B) chlorophyll is dissolved out

- (D) iodine will penetrate
12. Carbon dioxide enters the stomata during photosynthesis through the process known as (A) osmosis (B) active transport *(C) diffusion (D) ventilation
13. Which of the following process removes carbon from the atmospheric?
(A) Putrefaction *(B) Photosynthesis (C) Volcanic eruption (D) Burning of fuels
14. Raw materials required by green plants to manufacture their food are
(A) mainly fluids
*(B) inorganic substances
(C) living materials
(D) mainly gases
15. A solution which contains all the required elements in their correct proportion is known as a
*(A) culture nutrient
(B) growth medium
(C) complete culture solution
(D) nutrient solution
16. An organism is considered an heterotroph when it
(A) feeds on inorganic food
*(B) feeds on already manufactured food
(C) feeds on atmospheric nitrogen
(D) respire anaerobically
17. The oxygen that is given off during photosynthesis is a product of
(A) dark reaction only
*(B) light reaction only
(C) light and dark reaction
(D) enzymes reaction
18. The break-down of food into simple, soluble and absorbable end-product is termed
(A) absorption (B) ingestion (C) nutrition *(D) digestion
19. The deficiency of vitamin D and calcium ions in the diet of human causes
(A) anaemia (B) night blindness (C) kwashiorkor *(D) rickets
20. Which of the following food substances turns bright red when warmed with Sudan III solution?
(A) Starch (B) Reducing sugar (C) protein *(D) Fat

21. Which of the following instruments is used to measure wind speed?
 (A) Thermometer (B) Barometer (C) Hygrometer *(D) Anemometer
22. A community is best defined as
 (A) living things in an habitat interacting with the non-living part of the environment.
 (B) the total number of individuals of one species of organisms living in a particular habitat
 *(C) populations of different species living together and interacting with each other in one habitat
 (D) the individuals of a particular group living together in an area and sharing the same resources
23. Which of the following instruments is used to measure the speed of a stream?
 *(A) Simple float (B) Secchi disc (C) Quadrat frame (D) Rain gauge
- Study the food web below carefully and use it to answer questions 24 and 25**



24. Tertiary consumers within the web are
 *(A) cat and lion only
 (B) man and lion only
 (C) man and cat only
 (D) man, cat and lion
25. What would be the effect of taking the lion out of the web?
 (A) The number of organisms of each trophic level would increase
 *(B) Man would occupy the apex of the web
 (C) There would be more rabbits in the web
 (D) The energy reaching the remaining trophic levels would increase
26. In an ecosystem, the organisms which changes light energy into stored chemical energy is the
 (A) consumer (B) decomposer *(C) producer (D) carnivore
27. All the following can illustrate the dynamic nature of the ecosystem EXCEPT
 (A) nitrogen cycle

- (B) carbon cycle
(C) water cycle
*(D) locomotion in organism
28. The gas produced during decomposition of water is
*(A) hydrogen sulphide (B) carbon monoxide (C) chlorine (D) oxygen
29. A biological association between two organisms in which both of them benefit from each other is referred to as
(A) commensalism (B) predation *(C) symbiosis (D) parasitism
30. An effective management of natural resources to ensure their continuous use from generation to generation may involve all the following except.
(A) protection of wild life
(B) prevention of habitat destruction
(C) biological control of pests
*(D) disposal of raw sewage into the sea
31. An example of a saprophytic relationship is/an
(A) vulture feeding on decaying meat
*(B) mushroom growing on decaying vegetation
(C) boy eating stale bread
(D) earthworm feeding on decaying vegetation
32. Carbon is added to the atmosphere by the following processes except
(A) respiration (B) burning *(C) photosynthesis (D) volcanic eruption
33. Which of the following is not a renewable natural resource?
*(A) Air (B) Timber (C) Soil (D) Mineral
34. The following structures are adaptation for water conservation except
(A) sunken stomata
(B) scales in animals
*(C) pines in plants
(D) thick leaves
35. The following practices are aimed at soil conservation except
(A) contour ridging
(B) application of manures
(C) strip cropping
*(D) bush clearing

36. The main reason for the conservation of wildlife is to
- (A) create national parks for recreation
 - (B) maintain ecological balance in communities
 - (C) prevent hunters from being cruel to animals
 - * (D) save some species from extinction
37. Micro-organisms which break down dead organisms and absorb their contents are called
- * (A) decomposers
 - (B) consumers
 - (C) parasites
 - (D) commensals
38. Which of these is a vector of malaria fever?
- * (A) Female anopheles mosquito
 - (B) Male anopheles mosquito
 - (C) Female culex mosquito
 - (D) Male culex mosquito
39. In medicine, bacteria have proved very useful due to the production of
- (A) nitrate
 - * (B) antibiotics
 - (C) cured tobacco
 - (D) tanned leather
40. The substances recycled in the soil by the activities of micro-organisms during the decay of dead organisms are first utilised by the
- (A) carnivores
 - (B) herbivorous
 - (C) scavengers
 - * (D) autotrophs
41. Which of these diseases cannot be spread by an insect?
- (A) Cholera
 - (B) Malaria
 - (C) Trypanosomiasis
 - * (D) Measles
42. Which of these is not correct about the tsetse fly and mosquito? They
- (A) harbour protozoa as disease agents
 - (B) possess piercing and sucking mouth parts
 - * (C) have intermediate host
 - (D) inject disease-causing organisms into the blood stream
43. The following are useful effect of micro-organisms except
- (A) production of vaccines
 - (B) curing of tobacco
 - * (C) tanning of leather
 - (D) decay of meat
44. The physical process which occurs when a red blood cell is placed in distilled water

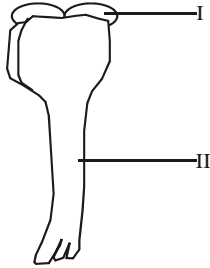
causing it to burst and break down is known as

(A) crenation (B) plasmolysis (C) turgidity *(D) haemolysis

45. During the process of osmosis, a selectively permeable membrane allows
- (A) only solute molecules to pass through it
(B) both solute and solvent molecules to pass through it
*(C) only solvent molecules to pass through it
(D) only gaseous molecules to pass through it
46. Which of the following processes does not contribute towards growth?
- (A) Cell division
(B) Cell enlargement
(D) Cell differentiation
*(D) Cell plamolysis
47. The mechanism of opening and closing of stomata in plants is based on
- (A) turgidity and diffusion
(B) turgidity and flaccidity
*(C) osmosis and diffusion
(D) diffusion of digested food into the villi
48. The cytoplasm of the cell is considered a very important component because it
- (A) regulates the amount of energy in the cell
*(B) suspends all cell organelles
(C) is the outermost part of the cell
(D) is solely responsible for cell division
49. Diffusion is most effective in living organisms, when the surface area is
- (A) large and the thickness is also large
(B) small while the thickness is large
*(C) large while the thickness is small
(D) the same as its thickness
50. A red blood cell haemolyses when placed in a hypotonic solution because
- (a) it contains hemoglobin
*(b) the cytoplasm is less dense
(c) the cell lacks a wall
(d) its pigment has affinity for water

51. Which of the following phenomena affects plant growth in an alkaline soil?
*(A) Excessive plasmolysis
(B) Excessive transpiration
(C) Excessive sunlight
(D) poor drainage
52. The following are functions of the skeleton except
(A) providing support for the body
(B) protection of delicate internal organs
(C) maintenance of the shape of the Body
*(D) controlling growth rate in animals
53. Muscles are attached to bones by means of
(a) ligament (b) cartilage (c) synovial membrane *(d) tendons
54. Which of the following is found immediately next to the skull?
*(A) Cervical vertebrae
(B) Sacral vertebrae
(C) Lumbar vertebrae
(D) Thoracic vertebrae
55. The inorganic components of bone consists of
(A) magnesium sodium and calcium
*(B) magnesium, phosphorous and calcium
(C) sodium, phosphorous and calcium
(D) potassium, magnesium and calcium
56. The axial skeleton is composed of the
*(A) skull and vertebral column
(B) limbs and girdles
(C) atlas and axis
(D) radius and ulna
57. The longest bone in the body is the
(A) humerus *(B) femur (C) scapula (D) tibia
58. Which of the following structures is not a skeletal material?
(A) Chitin (B) Cartilage (C) Bone *(D) Muscle

Study the diagram below and use it to answer questions 59 and 60



59. To form a ball and socket joint, the structure labeled I fits into another structure in the scapula called the
(A) blade *(B) glenoid cavity (C) olecranon fossa (D) patella
60. The structure labeled II is called
(A) deltoid ridge (B) trochanter *(C) shaft (D) torch lea

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Appendix V
INTERNATIONAL CENTRE FOR EDUCATION EVALUATION (ICEE)
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REPORT FORM ON BAT

Herewith attached is a pool of items on biology for SSS 2 class. Kindly review the test item by item and write your report using the outline hereunder.

1. Clarity of instruction.....
.....
.....
2. Adequacy of time limit.....
.....
.....
3. Adequacy of content.....
.....
.....
4. Appropriateness of language (where in appropriate, please specify items and offer suggestion).....
.....
.....
.....
5. Clarity of the stem (where ambiguous, state the item(s) and offer suggestion).....
.....
.....
.....
6. Correctness of the key (where a key is wrong, make your suggestion).....
.....
.....
.....

Thank you very much

Appendix VI

CALCULATION OF THE REPRODUCED CORRELATION CO-EFFICIENTS

Appendix VI presents the process of calculating the reproduced correlation coefficients. A common approach for determining the reproduced correlations between two variables (and therefore among all variables in the set) involves the identification of all legitimate paths between the variables in the model in a process known as *path tracing or path decomposition*. Path tracing is the processes that result in a correlation coefficient for each path, which is equal to the product of all coefficients in the path. The process of calculating the reproduced correlation coefficient indicating the effect of variable x on y is given by

$$r_{xy} = \frac{1}{N} \sum Z_x Z_y \text{ (see Eqn.4.11).}$$

$$r_{14} = \frac{1}{N} \sum Z_1 Z_4 \quad \dots \text{Eqn.4.18}$$

Recall that $Z_4 = P_{41}Z_1 + P_{42}Z_2 + e_4$ (See Eqn.4.4)

Therefore, by substituting, Eqn.4.8 becomes

$$r_{14} = \frac{1}{N} \sum Z_1 (P_{41}Z_1 + P_{42}Z_2 + e_4) \quad \dots \text{Eqn.4.19}$$

By opening the bracket, we have

$$r_{14} = P_{41}Z_1^2 + P_{42}Z_2Z_1 + e_4 \quad \dots \text{Eqn.4.20}$$

Note that $Z_2Z_1 = r_{12}$; $Z_1^2 = 1$

By substituting, Eqn.4.20 becomes

$$r_{14} = P_{41} + P_{42}r_{12}$$

By using the value of path coefficient and obtained correlations, we have

$$r_{14} = (-.120) + (.062)(.014)$$

$$r_{14} = -.120 + .001$$

$$r_{14} = \mathbf{-.119}$$

$$r_{15} = \frac{1}{N} \sum Z_1 Z_5 \quad \dots \text{Eqn.4.21}$$

Recall that $Z_5 = P_{52}Z_2 + e_5$ (See Eqn.4.5)

By substituting, Eqn.4.21 becomes

$$r_{15} = \frac{1}{N} \sum Z_1 (P_{52}Z_2 + e_5) \quad \dots \text{Eqn.4.22}$$

By opening the bracket, we have

$$r_{15} = P_{52}Z_2Z_1 + e_5 \quad \dots \text{Eqn.4.23}$$

Recall that $Z_2Z_1 = r_{12}$

By substituting, Eqn.4.23 becomes

$$r_{15} = P_{52}r_{12}$$

Using the values of path coefficient and obtained correlation, we have

$$r_{15} = (0.94) (.014)$$

$$r_{15} = \mathbf{.001}$$

$$r_{16} = \frac{1}{N} \sum Z_1 Z_6 \quad \dots \text{Eqn.4.24}$$

Recall that $Z_6 = P_{61}Z_1 + P_{62}Z_2 + e_6$ (See Eqn.4.6)

By substituting, Eqn.4.24 becomes

$$r_{16} = \frac{1}{N} \sum Z_1 (P_{61}Z_1 + P_{62}Z_2 + e_6) \quad \dots \text{Eqn.4.25}$$

By opening the bracket, we have

$$r_{16} = P_{61}Z_1^2 + P_{62}Z_2Z_1 \quad \dots \text{Eqn.4.26}$$

Note that $Z_1^2 = 1$; $Z_2Z_1 = r_{12}$

By substituting, Eqn.4.26 becomes

$$r_{16} = P_{61} + P_{62}r_{12}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{16} = -.125 + (.064) (.014)$$

$$r_{16} = -.125 + .001$$

$$r_{16} = \mathbf{-.124}$$

$$r_{17} = \frac{1}{N} \sum Z_1 Z_7 \quad \dots \text{Eqn.4.27}$$

Recall that $Z_7 = P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7$ (See Eqn.4.7)

By substituting, Eqn.4.27 becomes

$$r_{17} = \frac{1}{N} \sum Z_1 (P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7) \quad \dots \text{Eqn.4.28}$$

By opening the bracket, we have

$$r_{17} = P_{71}Z_1^2 + P_{73}Z_3Z_1 + P_{75}Z_5Z_1 + e_7 \quad \dots \text{Eqn.4.29}$$

Note that, $Z_1^2 = 1$; $Z_3Z_1 = r_{13}$; $Z_5Z_1 = r_{15}$

By substituting, Eqn.4.29 becomes

$$r_{17} = P_{71} + P_{73}r_{13} + P_{75}r_{15}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{17} = .109 + (-.270) (-.154) + (-.187) (.029)$$

$$r_{17} = .109 + .042 + -.005$$

$$r_{17} = \mathbf{.146}$$

$$r_{18} = \frac{1}{N} \sum Z_1 Z_8 \quad \dots \text{Eqn.4.30}$$

Recall that $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.30 becomes

$$r_{18} = \frac{1}{N} \sum Z_1 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8) \quad \dots \text{Eqn.4.31}$$

By opening the bracket, we have

$$r_{18} = P_{81}Z_1^2 + P_{82}Z_2Z_1 + P_{83}Z_3Z_1 + P_{86}Z_6Z_1 + e_8 \quad \dots \text{Eqn.4.32}$$

Note that $Z_1^2 = 1$, $Z_2Z_1 = r_{12}$; $Z_3Z_1 = r_{13}$; $Z_6Z_1 = r_{16}$

By substituting Eqn.4.31 becomes

$$r_{18} = P_{81} + P_{82}r_{12} + P_{83}r_{13} + P_{86}r_{16}$$

By using the values of path coefficient and obtained correlations, we have

$$r_{18} = .070 + (-.067) (.014) + (-.317) (-.154) + (-.090) (-.125)$$

$$r_{18} = .070 + (-.001) + (.049) + (.011)$$

$$r_{18} = \mathbf{.129}$$

$$r_{19} = \frac{1}{N} \sum Z_1 Z_9 \quad \dots \text{Eqn.4.33}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.33 becomes

$$r_{19} = \frac{1}{N} \sum (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.34}$$

By opening the bracket, we have

$$r_{19} = P_{91}Z_1^2 + P_{93}Z_3Z_1 + P_{95}Z_5Z_1 + e_9 \quad \dots \text{Eqn.4.35}$$

Note that $Z_1^2 = 1$; $Z_3Z_1 = r_{13}$; $Z_5Z_1 = r_{15}$

By substituting Eqn.4.35 becomes

$$r_{19} = P_{91} + P_{93}r_{13} + P_{95}r_{15}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{19} = .107 + (-.292) (-.154) + (-.184) (.029)$$

$$r_{19} = .107 + .045 + (-.005)$$

$$r_{19} = \mathbf{.147}$$

$$r_{1t} = \frac{1}{N} \sum Z_1 Z_t \quad \dots \text{Eqn.4.36}$$

Recall that $Z_t = P_2Z_2 + P_3Z_3 + P_4Z_4 + P_5Z_5 + P_9Z_9 + e_t$ (See Eqn.4.10)

By substituting, Eqn.4.35 becomes

$$r_{1t} = \frac{1}{N} \sum Z_1 (Pt_2Z_2 + Pt_3Z_3 + Pt_4Z_4 + Pt_5Z_5 + Pt_9Z_9 + et) \quad \dots \text{Eqn.4.37}$$

By opening the bracket, we have

$$r_{1t} = Pt_2Z_2Z_1 + Pt_3Z_3Z_1 + Pt_4Z_4Z_1 + Pt_5Z_5Z_1 + Pt_9Z_9Z_1 + et \quad \dots \text{Eqn.4.38}$$

Note that, $Z_2Z_1 = r_{12}$; $Z_3Z_1 = r_{13}$; $Z_4Z_1 = r_{14}$; $Z_5Z_1 = r_{15}$; $Z_9Z_1 = r_{19}$

By substituting, Eqn.4.38 becomes

$$r_{1t} = pt_2r_{12} + Pt_3r_{13} + pt_4r_{14} + pt_5r_{15} + pt_9r_{19}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{1t} = (-.058) (.014) + (-.113) (-.154) + (.254) (-.119) + (.109) (.029) + (-.347) (.146)$$

$$r_{1t} = (-.001) + .017 + (-.034) + .003 + (-.051)$$

$$r_{1t} = \mathbf{-.066}$$

$$r_{23} = \frac{1}{N} \sum Z_2Z_3 \quad \dots \text{Eqn.4.39}$$

Recall that $Z_3 = P_{31}Z_1 + e_3$ (See Eqn.4.3)

By substituting, Eqn.4.39 becomes

$$r_{23} = \frac{1}{N} \sum Z_2 (P_{31}Z_1 + e_3) \quad \dots \text{Eqn.4.40}$$

By opening the bracket, we have

$$r_{23} = P_{31}Z_2Z_1 + e_3 \quad \dots \text{Eqn.4.41}$$

Note that, $Z_2Z_1 = r_{12}$

By substituting, Eqn.4.41 becomes

$$r_{23} = P_{31}r_{12}$$

By using the values of path coefficient and obtained correlation, we have

$$r_{23} = (-.154) (.014)$$

$$r_{23} = \mathbf{-.002}$$

$$r_{24} = \frac{1}{N} \sum Z_2Z_4 \quad \dots \text{Eqn.4.42}$$

Recall that $Z_4 = P_{41}Z_1 + P_{42}Z_2 + e_4$ (See Eqn.4.4)

By substituting, Eqn.4.42 becomes

$$r_{24} = \frac{1}{N} \sum Z_2 (P_{41}Z_1 + P_{42}Z_2 + e_4) \quad \dots \text{Eqn.4.43}$$

By opening the bracket, we have

$$r_{24} = P_{41}Z_1Z_2 + P_{42}Z_2^2 + e_4 \quad \dots \text{Eqn.4.44}$$

Note that $Z_1Z_2 = r_{21}$, $Z_2^2 = 1$

By substituting, Eqn.4.44 becomes

$$r_{24} = P_{41}r_{21} + P_{42}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{24} = (-.120) (.014) + .062$$

$$r_{24} = -.002 + .062$$

$$r_{24} = \mathbf{.060}$$

$$r_{25} = \frac{1}{N} \sum Z_2 Z_5 \quad \dots \text{Eqn.4.45}$$

Recall that $Z_5 = P_{52}Z_2 + e_5$ (See Eqn.4.5)

By substituting, Eqn.4.45 becomes

$$r_{25} = \frac{1}{N} \sum Z_2 (P_{52}Z_2 + e_5) \quad \dots \text{Eqn.4.46}$$

By opening the bracket, we have

$$r_{25} = P_{52}Z_2^2 + e_5 \quad \dots \text{Eqn.4.47}$$

Recall that, $Z_2^2 = 1$

By substituting, Eqn.4.47 becomes

$$r_{25} = P_{52}$$

By using the values of path coefficient and obtained correlation, we have

$$r_{25} = \mathbf{.094}$$

$$r_{26} = \frac{1}{N} \sum Z_2 Z_6 \quad \dots \text{Eqn.4.48}$$

Recall that $Z_6 = P_{61}Z_1 + P_{62}Z_2 + e_6$ (See Eqn.4.6)

By substituting, Eqn.4.48 becomes

$$r_{26} = \frac{1}{N} \sum Z_2 (P_{61}Z_1 + P_{62}Z_2 + e_6) \quad \dots \text{Eqn.4.49}$$

By opening the bracket, we have

$$r_{26} = P_{61}Z_1 Z_2 + P_{62}Z_2^2 + e_6 \quad \dots \text{Eqn.4.50}$$

Note that $Z_1 Z_2 = r_{21}$; $Z_2^2 = 1$

By substituting, Eqn.4.50 becomes

$$r_{26} = P_{61}r_{21} + P_{62}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{26} = (-.125) (.014) + .064$$

$$r_{26} = -.002 + .064$$

$$r_{26} = \mathbf{.062}$$

$$r_{27} = \frac{1}{N} \sum Z_2 Z_7 \quad \dots \text{Eqn.4.51}$$

Recall that, $Z_7 = P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7$ (See Eqn.4.7)

By substituting, Eqn.4.5 becomes

$$r_{27} = \frac{1}{N} \sum Z_2 (P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7) \quad \dots \text{Eqn.4.52}$$

By opening the bracket, we have

$$r_{27} = P_{71}Z_1 + P_{73}Z_3Z_2 + P_{75}Z_5Z_2 + e_7 \quad \dots \text{Eqn.4.53}$$

Note that $Z_1Z_2 = r_{21}$; $+ P_{73}r_{23} + P_{75}r_{25}$

By substituting Eqn. 4.53 becomes

$$r_{27} = P_{71}r_{21} + P_{73}r_{23} + P_{75}r_{25}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{27} = (.104) (.014) + (-.270) (-.012) + (-.087) (.094)$$

$$r_{27} = .001 \quad + \quad .003 \quad + \quad (-.008)$$

$$r_{27} = \mathbf{-.004}$$

$$r_{28} = \frac{1}{N} \sum Z_2 Z_8 \quad \dots \text{Eqn.4.54}$$

Recall that $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.54 becomes

$$r_{28} = \frac{1}{N} \sum Z_2 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8) \quad \dots \text{Eqn.4.55}$$

By opening the bracket, we have

$$r_{28} = P_{81}Z_1Z_2 + P_{82}Z_2^2 + P_{83}Z_3Z_2 + P_{86}Z_6Z_2 + e_8 \quad \dots \text{Eqn.4.56}$$

Note that $Z_1Z_2 = r_{21}$; $Z_2^2 = 1$; $Z_3Z_2 = r_{23}$; $Z_6Z_2 = r_{26}$

By substituting, Eqn.4.46 becomes

$$r_{28} = P_{81}r_{21} + P_{82} + P_{83}r_{23} + P_{86}r_{26}$$

By using the values of path coefficients and obtained correlation, we have

$$r_{28} = (.070) (.014) + (-.067) + (-.317) (-.012) + (-.090) (.063)$$

$$r_{28} = .001 + (-.067) + .004 + (-.006)$$

$$r_{28} = \mathbf{.068}$$

$$r_{29} = \frac{1}{N} \sum Z_2 Z_9 \quad \dots \text{Eqn.4.57}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.57 becomes

$$r_{29} = \frac{1}{N} \sum Z_2 (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.58}$$

By opening the bracket, we have

$$r_{29} = P_{91}Z_1Z_2 + P_{93}Z_3Z_2 + P_{95}Z_5Z_2 + e_9 \quad \dots \text{Eqn.4.59}$$

Note that $Z_1Z_2 = r_{21}$; $Z_3Z_2 = r_{23}$; $Z_5Z_2 = r_{25}$

By substituting, Eqn.4.59 becomes

$$r_{29} = P_{91}r_{21} + P_{93}r_{23} + P_{95}r_{25}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{29} = (.107) (.014) + (-.292) (-.012) + (-.184) (.094)$$

$$r_{29} = .001 + .004 + (-.017)$$

$$r_{29} = \mathbf{.012}$$

$$r_{2t} = \frac{1}{N} \sum Z_2 Z_t \quad \dots \text{Eqn.4.60}$$

Recall that $Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t$ (See Eqn.4.10)

By substituting, Eqn.4.60 becomes

$$r_{2t} = \frac{1}{N} \sum Z_2 (P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t) \quad \dots \text{Eqn.4.61}$$

By opening the bracket, we have

$$r_{2t} = P_{t2}Z_2^2 + P_{t3}Z_3Z_2 + P_{t4}Z_4Z_2 + P_{t5}Z_5Z_2 + P_{t9}Z_9Z_2 + e_t \quad \dots \text{Eqn.4.62}$$

Note that $Z_2^2 = 1$; $Z_3Z_2 = r_{23}$; $Z_4Z_2 = r_{24}$; $Z_5Z_2 = r_{25}$; $Z_9Z_2 = r_{29}$

By substituting, Eqn.4.62 becomes

$$r_{2t} = P_{t2} + P_{t3}r_{23} + P_{t4}r_{24} + P_{t5}r_{25} + P_{t9}r_{29}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{2t} = -.058 + (-.113) (-.012) + (.284) (.060) + (.109) (.094) + (-.347) (-.061)$$

$$r_{2t} = \mathbf{-.011}$$

$$r_{34} = \frac{1}{N} \sum Z_3 Z_4 \quad \dots \text{Eqn.4.63}$$

Recall that $Z_4 = P_{41}Z_1 + P_{42}Z_2 + e_4$ (See Eqn.4.4)

By substituting, Eqn.4.63 becomes

$$r_{34} = \frac{1}{N} \sum Z_3 (P_{41}Z_1 + P_{42}Z_2 + e_4) \quad \dots \text{Eqn.4.64}$$

By opening the bracket, we have

$$r_{34} = P_{41}Z_1Z_3 + P_{42}Z_2Z_3 + e_4 \quad \dots \text{Eqn.4.65}$$

Note that, $Z_1Z_3 = r_{31}$; $Z_2Z_3 = r_{23}$

By substituting, Eqn.4.65 becomes

$$r_{34} = p_{41}r_{31} + p_{42}r_{23}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{34} = (-.120) (-.154) + (.062) (-.012)$$

$$r_{34} = .018 + (-.001)$$

$$r_{34} = \mathbf{.017}$$

$$r_{35} = \frac{1}{N} \sum Z_3 Z_5 \quad \dots \text{Eqn.4.66}$$

Recall that $Z_5 = P_{52}Z_2 + e_5$ (See Eqn.4.5)

By substituting, Eqn.4.66 becomes

$$r_{35} = \frac{1}{N} \sum Z_3 (P_{52}Z_2 + e_5) \quad \dots \text{Eqn.4.67}$$

By opening the bracket, we have

$$r_{35} = P_{52}Z_2Z_3 \quad \dots \text{Eqn.4.68}$$

Note that, $Z_2Z_3 = r_{32}$

By substituting, Eqn.4.68 becomes

$$r_{35} = P_{52}r_{32}$$

By using the values of path coefficient and obtained correlation, we have

$$r_{35} = (.094) (-.012)$$

$$r_{35} = \mathbf{-.001}$$

$$r_{36} = \frac{1}{N} \sum Z_3 Z_6 \quad \dots \text{Eqn.4.69}$$

Recall that, $Z_6 = P_{61}Z_1 + P_{62}Z_2 + e_6$ (See Eqn.4.6)

By substituting, Eqn.4.69 becomes

$$r_{36} = \frac{1}{N} \sum Z_3 (P_{61}Z_1 + P_{62}Z_2 + e_6) \quad \dots \text{Eqn.4.70}$$

By opening the bracket, we have

$$r_{36} = P_{61}Z_1Z_3 + P_{62}Z_2Z_3 + e_6 \quad \dots \text{Eqn.4.71}$$

Note that, $Z_1Z_3 = r_{31}$; $Z_2Z_3 = r_{32}$

By substituting, Eqn.4.71 becomes

$$r_{36} = P_{61}r_{31} + P_{62}r_{32}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{36} = (-.125) (-.154) + (.064) (-.012)$$

$$r_{36} = .019 + (-.001)$$

$$r_{36} = \mathbf{.018}$$

$$r_{37} = \frac{1}{N} \sum Z_3 Z_7 \quad \dots \text{Eqn.4.72}$$

Recall that $z_7 = p_{71}z_1 + p_{73}z_3 + p_{75}z_5 + e_7$ (See Eqn.4.7)

By substituting, Eqn.4.72 becomes

$$r_{37} = \frac{1}{N} \sum Z_3 (P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7) \quad \dots \text{Eqn.47.3}$$

By opening the bracket, we have

$$r_{37} = P_{71}Z_1Z_3 + P_{73}Z_3^2 + P_{75}Z_3Z_5 + e_7 \quad \dots \text{Eqn.4.74}$$

Note that, $Z_1Z_3 = r_{31}$; $Z_3^2 = 1$; $Z_5Z_3 = r_{35}$

By substituting, Eqn.4.74 becomes

$$r_{37} = P_{71}r_{31} + P_{73} + P_{75}r_{35}$$

By using the values of the path coefficients and obtained correlations, we have

$$r_{37} = (.109)(-.154) + (-.287) + (-.187)(.542)$$

$$r_{37} = -.017 + (-.287) + (-.001)$$

$$r_{37} = \mathbf{-.405}$$

$$r_{38} = \frac{1}{N} \sum Z_3 Z_8 \quad \dots \text{Eqn.4.75}$$

Recall that $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.75 becomes

$$r_{38} = \frac{1}{N} \sum Z_3 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8) \quad \dots \text{Eqn.4.76}$$

By opening the bracket, we have

$$r_{38} = P_{81}Z_1Z_3 + P_{82}Z_2Z_3 + P_{83}Z_3Z_3^2 + P_{86}Z_6Z_3 + e_8 \quad \dots \text{Eqn.4.77}$$

Recall that, $Z_1Z_3 = r_{31}$; $Z_2Z_3 = r_{32}$; $Z_3^2 = 1$, $Z_6Z_3 = r_{36}$

By substituting, Eqn.4.77 becomes

$$r_{38} = P_{81}r_{31} + P_{82}r_{32} + P_{83} + P_{86}r_{36}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{38} = (.070)(-.154) + (-.065)(-.012) + (-.317) + (-.090)(.692)$$

$$r_{38} = -.012 + .001 + (-.317) + (-.062)$$

$$r_{38} = \mathbf{-.390}$$

$$r_{39} = \frac{1}{N} \sum Z_3 Z_9 \quad \dots \text{Eqn.4.78}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.78 becomes

$$r_{39} = \frac{1}{N} \sum Z_3 (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.79}$$

By opening the bracket, we have

$$r_{39} = P_{91}Z_1Z_3 + P_{93}Z_3^2 + P_{95}Z_5Z_3 + e_9 \quad \dots \text{Eqn.4.80}$$

Recall that $Z_1Z_3 = r_{31}$; $Z_3^2 = 1$; $Z_5Z_3 = r_{35}$

By substituting, Eqn.4.80 becomes

$$r_{39} = P_{91}r_{31} + P_{93} + P_{95}r_{35}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{39} = (.107) (-.154) + (-.292) + (-.100)$$

$$r_{39} = \mathbf{-.408}$$

$$r_{3t} = \frac{1}{N} \sum Z_3Z_t \quad \dots \text{Eqn.4.81}$$

$$\text{Recall that } Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_9 \quad \dots \text{Eqn.4.82}$$

By opening the bracket, we have

$$r_{3t} = P_{t2}Z_2Z_3 + P_{t3}Z_3^2 + P_{t4}Z_4Z_3 + P_{t5}Z_5Z_3 + P_{t9}Z_9Z_3 + e_t \quad \dots \text{Eqn.4.83}$$

Recall that $Z_2Z_3 = r_{32}$; $Z_3^2 = 1$; $Z_4Z_3 = r_{34}$; $Z_5Z_3 = r_{35}$; $Z_9Z_3 = r_{39}$

By substituting, Eqn.4.83 becomes

$$r_{3t} = P_{t2}r_{32} + P_{t3} + P_{t4}r_{34} + P_{t5}r_{35} + P_{t9}r_{39}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{3t} = (-.058) (-.012) + (-.113) + (.284) (.637) + (.109) (.542) + (-.347) (-.407)$$

$$r_{3t} = .001 + (-.113) + .181 + .059 + .141$$

$$r_{3t} = \mathbf{.269}$$

$$r_{45} = \frac{1}{N} \sum Z_3Z_5 \quad \dots \text{Eqn.4.84}$$

Recall that $Z_5 = (P_{52}Z_2 + e_5)$ (See Eqn.4.5)

By substituting, Eqn.4.84 becomes

$$r_{45} = \frac{1}{N} \sum Z_4 (P_{52}Z_2 + e_5) \quad \dots \text{Eqn.4.8}$$

By opening the bracket, we have

$$r_{45} = P_{52}Z_2Z_4 \quad \dots \text{Eqn.4.86}$$

Note that, $Z_2Z_4 = r_{42}$

By substituting, Eqn.4.86 becomes

$$r_{45} = P_{52}r_{42}$$

By using the values of path coefficient and obtained correlation, we have

$$r_{45} = \mathbf{.006}$$

$$r_{46} = \frac{1}{N} \sum Z_4 Z_6 \quad \dots \text{Eqn.4.87}$$

Recall that, $Z_6 = P_{61}Z_1 + P_{62}Z_2 + e_6$ (See Eqn.4.6)

By substituting, Eqn.4.87 becomes

$$r_{46} = \frac{1}{N} \sum Z_4 (P_{61}Z_1 + P_{62}Z_2 + e_6) \quad \dots \text{Eqn.4.88}$$

By opening the bracket, we have

$$r_{46} = P_{61}Z_1Z_4 + P_{62}Z_2Z_4 + e_6 \quad \dots \text{Eqn.4.89}$$

Note that, $Z_1Z_4 = r_{41}$; $Z_2Z_4 = r_{42}$

By substituting, Eqn.4.89 becomes

$$r_{46} = P_{61}r_{41} + P_{62}r_{42}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{46} = (-.125) (-.119) + (.064) (.060)$$

$$r_{46} = .015 + .004$$

$$r_{46} = \mathbf{.019}$$

$$r_{47} = \frac{1}{N} \sum Z_4 Z_7 \quad \dots \text{Eqn.4.90}$$

Recall that, $Z_7 = P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_9$ (See Eqn.4.7)

By substituting, Eqn.4.90 becomes

$$r_{47} = \frac{1}{N} \sum Z_4 (P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_9) \quad \dots \text{Eqn.4.91}$$

By opening the bracket, we have

$$r_{47} = P_{71}Z_1Z_4 + P_{73}Z_3Z_4 + P_{75}Z_5Z_4 + e_9 \quad \dots \text{Eqn.4.92}$$

Note that; $Z_1Z_4 = r_{41}$; $Z_3Z_4 = r_{43}$; $Z_5Z_4 = r_{45}$

By substituting, Eqn.4.92 becomes

$$r_{47} = P_{71}r_{41} + P_{73}r_{43} + P_{75}r_{45}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{47} = (.109) (-.119) + (-.287) (.637) + (-.187) (.775)$$

$$r_{47} = -.013 + (-.183) + (-.145)$$

$$r_{47} = \mathbf{-.341}$$

$$r_{48} = \frac{1}{N} \sum Z_4 Z_8 \quad \dots \text{Eqn.4.93}$$

Recall that, $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.93 becomes

$$r_{48} = \frac{1}{N} \sum Z_4 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8) \quad \dots \text{Eqn.4.94}$$

By opening the bracket, we have

$$r_{48} = P_{81}Z_1Z_4 + P_{82}Z_2Z_4 + P_{83}Z_3Z_4 + P_{86}Z_6Z_4 + e_8 \quad \dots \text{Eqn.4.95}$$

Note that: $z_1z_4 = r_{41}$; $z_2z_4 = r_{42}$; $z_3z_4 = r_{43}$; $z_6z_4 = r_{46}$

By substituting, Eqn.4.95 becomes

$$r_{48} = P_{81}r_{41} + P_{82}r_{42} + P_{83}r_{43} + P_{86}r_{46}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{48} = (.070) (-.119) + (-.067) (.060) + (-.317) (.637) + (-.090) (.803)$$

$$r_{48} = -.008 + (-.004) + (-.202) + (-.070)$$

$$r_{48} = \mathbf{-.284}$$

$$r_{49} = \frac{1}{N} \sum Z_4Z_9 \quad \dots \text{Eqn.4.96}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.96 becomes

$$r_{49} = \frac{1}{N} \sum Z_4 (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.97}$$

By opening the bracket, we have

$$r_{49} = P_{91}Z_1Z_4 + P_{93}Z_3Z_4 + P_{95}Z_5Z_4 + e_9 \quad \dots \text{Eqn.4.98}$$

Note that: $Z_1Z_4 = r_{41}$; $Z_3Z_4 = r_{43}$; $Z_5Z_4 = r_{45}$

By substituting, Eqn.4.98 becomes

$$r_{49} = P_{91}r_{41} + P_{93}r_{43} + P_{95}r_{45}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{49} = (.107) (-.119) + (-.292) (.637) + (-.184) (.775)$$

$$r_{49} = -.013 + (-.186) + (-.143)$$

$$r_{49} = \mathbf{-.342}$$

$$r_{4t} = \frac{1}{N} \sum Z_4Z_t \quad \dots \text{Eqn.4.99}$$

Recall that $Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t$ (See Eqn.4.10)

By substituting, Eqn.4.99 becomes

$$r_{4t} = \frac{1}{N} \sum Z_4 (P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t) \quad \dots \text{Eqn.4.100}$$

By opening the bracket, we have

$$r_{4t} = P_{t2}Z_2Z_4 + P_{t3}Z_3Z_4 + P_{t4}Z_4^2 + P_{t5}Z_5Z_4 + P_{t9}Z_9Z_4 + e_t \quad \dots \text{Eqn.4.101}$$

Recall that: $Z_2Z_4 = r_{42}$; $Z_3Z_4 = r_{43}$; $Z_4^2 = 1$; $Z_5Z_4 = r_{45}$; $Z_9Z_4 = r_{49}$

By substituting, Eqn.4.101 becomes

$$r_{4t} = P_{t2}r_{42} + P_{t3}r_{43} + P_{t4} + P_{t5}r_{45} + P_{t9}r_{49}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{4t} = (-.058) (.060) + (-.113) (.637) + (.284) + (.109) (.755) + (-.347) (-.362)$$

$$r_{4t} = -.074 + .366 + .126$$

$$r_{4t} = \mathbf{.418}$$

$$r_{56} = \frac{1}{N} \sum Z_5 Z_6 \quad \dots \text{Eqn.4.102}$$

Recall that: $Z_6 = P_{61}Z_1 + P_{62}Z_2 + e_6$ (See Eqn.4.6)

By substituting, Eqn.4.102 becomes

$$r_{56} = \frac{1}{N} \sum Z_5 (P_{61}Z_1 + P_{62}Z_2 + e_6) \quad \dots \text{Eqn.4.103}$$

By opening the bracket, we have

$$r_{56} = P_{61}Z_1Z_5 + P_{62}Z_2Z_5 + e_6 \quad \dots \text{Eqn.4.104}$$

Note that, $Z_1Z_5 = r_{51}$; $Z_2Z_5 = r_{52}$

By substituting, Eqn.4.104 becomes

$$r_{56} = P_{61}r_{51} + P_{62}r_{52}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{56} = (-.152) (.029) + (.064) (.094)$$

$$r_{56} = -.004 + .006$$

$$r_{56} = \mathbf{.002}$$

$$r_{57} = \frac{1}{N} \sum Z_5 Z_7 \quad \dots \text{Eqn.4.105}$$

Recall that: $Z_7 = P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7$ (See Eqn.4.7)

By substituting, Eqn.4.105 becomes

$$r_{57} = \frac{1}{N} \sum Z_5 (P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7) \quad \dots \text{Eqn.4.106}$$

By opening the bracket, we have

$$r_{57} = P_{71}Z_1Z_5 + P_{73}Z_3Z_5 + P_{75}Z_5^2 + e_7 \quad \dots \text{Eqn.4.107}$$

Note that: $Z_1Z_5 = r_{51}$; $Z_3Z_5 = r_{53}$; $Z_5^2 = 1$

By substituting, Eqn.4.107 becomes

$$r_{57} = P_{71}r_{51} + P_{73}r_{53} + P_{75}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{57} = (-.109) (.029) + (-.287) (.542) + (-.187)$$

$$r_{57} = .003 + (-.156) + (-.187)$$

$$r_{57} = \mathbf{-.341}$$

$$r_{58} = \frac{1}{N} \sum Z_5 Z_8 \quad \dots \text{Eqn.4.108}$$

Recall that $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.108 becomes

$$r_{58} = \frac{1}{N} \sum Z_5 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6) \quad \dots \text{Eqn.4.109}$$

By opening the bracket, we have

$$r_{58} = P_{81}Z_1Z_5 + P_{82}Z_2Z_5 + P_{83}Z_3Z_5 + P_{86}Z_6Z_5 + e_7 \quad \dots \text{Eqn.4.110}$$

Note that: $Z_1Z_5 = r_{51}$; $Z_2Z_5 = r_{52}$; $Z_3Z_5 = r_{53}$; $Z_6Z_5 = r_{56}$

By substituting, Eqn.4.110 becomes

$$r_{58} = P_{81}r_{51} + P_{82}r_{52} + P_{83}r_{53} + P_{86}r_{56}$$

By using the values of path coefficients and correlations, we have

$$r_{58} = (.070) (.029) + (-.067) (.094) + (-.317) (.542) + (-.090) (.671)$$

$$r_{58} = .002 + (-.006) + (-.172) + (-.090) (.67)$$

$$r_{58} = \mathbf{-.236}$$

$$r_{59} = \frac{1}{N} \sum Z_5 Z_9 \quad \dots \text{Eqn.4.111}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.111 becomes

$$r_{59} = \frac{1}{N} \sum Z_5 (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.112}$$

By opening the bracket, we have

$$r_{59} = P_{91}Z_1Z_5 + P_{93}Z_3Z_5 + P_{95}Z_5^2 + e_9 \quad \dots \text{Eqn.4.113}$$

Note that: $Z_1Z_5 = r_{51}$; $Z_3Z_5 = r_{53}$; $Z_5^2 = 1$

By substituting, Eqn.4.113 becomes

$$r_{59} = P_{91}r_{51} + P_{93}r_{53} + P_{95}$$

By using the values of path coefficients and correlations, we have

$$r_{59} = (.107) (.029) + (-.292) (.542) + (-.184)$$

$$r_{59} = .003 + (-.158) + (-.184)$$

$$r_{59} = \mathbf{-.339}$$

$$r_{5t} = \frac{1}{N} \sum Z_5 Z_t \quad \dots \text{Eqn.4.114}$$

Recall that $Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t$ (See Eqn.4.10)

By substituting, Eqn.4.114 becomes

$$r_{5t} = \frac{1}{N} \sum Z_5 (P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t) \quad \dots \text{Eqn.4.115}$$

By opening the bracket, we have

$$r_{5t} = P_{t_2}Z_2Z_5 + P_{t_3}Z_3Z_5 + P_{t_4}Z_4Z_5 + P_{t_5}Z_5^2 + P_{t_9}Z_9Z_5 + e_t \quad \dots \text{Eqn.4.116}$$

Note that $Z_2Z_5 = r_{52}$; $Z_3Z_5 = r_{53}$; $Z_4Z_5 = r_{54}$; $Z_5^2 = 1$; $Z_9Z_5 = r_{59}$

By substituting, Eqn.4.116 becomes

$$r_{5t} = P_{t_2}r_{52} + P_{t_3}r_{53} + P_{t_4}r_{54} + P_{t_5} + P_{t_9}r_{59}$$

By using the values of coefficients and obtained correlations, we have

$$r_{5t} = -.005 + (-.061) + .214 + .109 + .119$$

$$r_{5t} = \mathbf{.376}$$

$$r_{67} = \frac{1}{N} \sum Z_6 Z_7 \quad \dots \text{Eqn.4.117}$$

Recall that $Z_7 = P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7$ (See Eqn.4.7)

By substituting, Eqn.4.117 becomes

$$r_{67} = \frac{1}{N} \sum Z_6 (P_{71}Z_1 + P_{73}Z_3 + P_{75}Z_5 + e_7) \quad \dots \text{Eqn.4.118}$$

By opening the bracket, we have

$$r_{67} = P_{71}Z_1Z_6 + P_{73}Z_3Z_6 + P_{75}Z_5Z_6 + e_7 \quad \dots \text{Eqn.4.119}$$

Note that $Z_1Z_6 = r_{61}$; $Z_3Z_6 = r_{63}$; $Z_5Z_6 = r_{65}$

By substituting, Eqn.4.119 becomes

$$r_{67} = P_{71}r_{61} + P_{73}r_{63} + P_{75}r_{65}$$

By using the path coefficients and obtained correlations, we have

$$r_{67} = (.109)(-.124) + (-.287) + (.692) + (-.187)(.671)$$

$$r_{67} = -.014 + (-.119) + (-.125)$$

$$r_{67} = \mathbf{-.338}$$

$$r_{68} = \frac{1}{N} \sum Z_6 Z_8 \quad \dots \text{Eqn.4.120}$$

Recall that: $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.120 becomes

$$r_{68} = \frac{1}{N} \sum Z_6 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8) \quad \dots \text{Eqn.4.121}$$

By opening the bracket, we have

$$r_{68} = P_{81}Z_1Z_6 + P_{82}Z_2Z_6 + P_{83}Z_3Z_6 + P_{86}Z_6^2 + e_8 \quad \dots \text{Eqn.4.122}$$

Note that: $Z_1Z_6 = r_{61}$; $Z_2Z_6 = r_{62}$; $Z_3Z_6 = r_{63}$; $Z_6^2 = 1$

By substituting, Eqn.4.122 becomes

$$r_{68} = P_{81}r_{61} + P_{82}r_{62} + P_{83}r_{63} + P_{86}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{68} = (.070) (-.124) + (-.067) (.063) + (-.317) (.692) + (-.090)$$

$$r_{68} = -.090 + (-.004) + (-.219) + (-.090)$$

$$r_{68} = \mathbf{-.322}$$

$$r_{69} = \frac{1}{N} \sum Z_6 Z_9 \quad \dots \text{Eqn.4.123}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.123 becomes

$$r_{69} = \frac{1}{N} \sum Z_6 (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.124}$$

By opening the bracket, we have

$$r_{69} = P_{91}Z_1Z_6 + P_{93}Z_3Z_6 + P_{95}Z_5Z_6 + e_9 \quad \dots \text{Eqn.4.125}$$

Note that: $Z_1Z_6 = r_{61}$; $Z_3Z_6 = r_{63}$; $Z_5Z_6 = r_{65}$

By substituting, eqn.4.125 becomes

$$r_{69} = P_{91}r_{61} + P_{93}r_{63} + P_{95}r_{65}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{69} = (.107) (-.124) + (-.184) (.671) + (-.292) (.692)$$

$$r_{69} = -.013 + (-.123) + (-.202)$$

$$r_{69} = \mathbf{-.338}$$

$$r_{6t} = \frac{1}{N} \sum Z_6 Z_t \quad \dots \text{Eqn.4.126}$$

Recall that $Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t$ (See Eqn.4.10)

By substituting, Eqn.4.126 becomes

$$r_{6t} = \frac{1}{N} \sum Z_6 (P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_t) \quad \dots \text{Eqn.4.127}$$

By opening the bracket, we have

$$r_{6t} = P_{t2}Z_2Z_6 + P_{t3}Z_3Z_6 + P_{t4}Z_4Z_6 + P_{t5}Z_5Z_6 + P_{t9}Z_9Z_6 + e_t \quad \dots \text{Eqn.4.128}$$

Note that $Z_2Z_6 = r_{62}$; $Z_3Z_6 = r_{63}$; $Z_4Z_6 = r_{64}$; $Z_5Z_6 = r_{65}$; $Z_9Z_6 = r_{69}$

By substituting, Eqn.4.128 becomes

$$r_{6t} = P_{t2}r_{62} + P_{t3}r_{63} + P_{t4}r_{64} + P_{t5}r_{65} + P_{t9}r_{69}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{6t} = (-.058) (.063) + (-.113) (.692) + (.284) (.803) + (.109) (.671) + (-.347) (-.330)$$

$$r_{6t} = -.004 + (-.078) + .228 + .073 + .115$$

$$r_{6t} = \mathbf{.334}$$

$$r_{78} = \frac{1}{N} \sum Z_7 Z_8 \quad \dots \text{Eqn.4.129}$$

Recall that $Z_8 = P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8$ (See Eqn.4.8)

By substituting, Eqn.4.129 becomes

$$r_{78} = \frac{1}{N} \sum Z_7 (P_{81}Z_1 + P_{82}Z_2 + P_{83}Z_3 + P_{86}Z_6 + e_8) \quad \dots \text{Eqn.4.130}$$

By opening the bracket, we have

$$r_{78} = P_{81}Z_1Z_7 + P_{82}Z_2Z_7 + P_{86}Z_6Z_7 + e_8 \quad \dots \text{Eqn.4.131}$$

Note that: $Z_1Z_7 = r_{71}$; $Z_2Z_7 = r_{72}$; $Z_3Z_7 = r_{73}$; $Z_6Z_7 = r_{76}$

By substituting, Eqn.4.131 becomes

$$r_{78} = P_{81}r_{71} + P_{82}r_{72} + P_{83}r_{73} + P_{86}r_{76}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{78} = (.070) (.148) + (-.067) (-.055) + (-.317) (-.405) + (-.090) (-.325)$$

$$r_{78} = .010 + .004 + .128 + .029$$

$$r_{78} = \mathbf{.171}$$

$$r_{79} = \frac{1}{N} \sum Z_7 Z_9 \quad \dots \text{Eqn.4.132}$$

Recall that $Z_9 = P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.132 becomes

$$r_{79} = \frac{1}{N} \sum Z_7 (P_{91}Z_1 + P_{93}Z_3 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.133}$$

By opening the bracket, we have

$$r_{79} = P_{91}Z_1Z_7 + P_{93}Z_3Z_7 + P_{95}Z_5Z_7 + e_9 \quad \dots \text{Eqn.4.134}$$

Note that: $Z_1Z_7 = r_{71}$; $Z_3Z_7 = r_{73}$; $Z_5Z_7 = r_{75}$

By substituting, Eqn.4.134 becomes

$$r_{79} = P_{91}r_{71} + P_{93}r_{73} + P_{95}r_{75}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{79} = (.107) (.148) + (-.184) (-.339) + (-.292) (-.405)$$

$$r_{79} = .016 + .062 + .118$$

$$r_{79} = \mathbf{.196}$$

$$r_{7t} = \frac{1}{N} \sum Z_7 Z_t \quad \dots \text{Eqn.4.135}$$

Recall that $Z_t = P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_9$ (See Eqn.4.10)

By substituting, Eqn.4.135 becomes

$$r_{7t} = \frac{1}{N} \sum Z_7 (P_{t2}Z_2 + P_{t3}Z_3 + P_{t4}Z_4 + P_{t5}Z_5 + P_{t9}Z_9 + e_9) \quad \dots \text{Eqn.4.136}$$

By opening the bracket, we have

$$r_{7t} = P_{t2}Z_2Z_7 + P_{t3}Z_3Z_7 + P_{t4}Z_4Z_7 + P_{t5}Z_5Z_7 + P_{t9}Z_9Z_7 + e_9 \quad \dots \text{Eqn.4.137}$$

Note that: $Z_2Z_7 = r_{72}$; $Z_3Z_7 = r_{73}$; $Z_4Z_7 = Z_5Z_7 = r_{75}$; $Z_9Z_7 = r_9$.

By substituting, Eqn.4.137 becomes

$$r_{7t} = P_{t_2}r_{72} + P_{t_3}r_{73} + P_{t_4}r_{74} + P_{t_5}r_{75} + P_{t_9}r_{79}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{7t} = (-.058) (-.055) + (.113) (-.405) + (.284) (-.356) + (.109) (-.339) + (-.347) (.993)$$

$$r_{7t} = .003 + .046 + (-.101) + (-.037) + (-.345)$$

$$r_{7t} = \mathbf{-.434}$$

$$r_{89} = \frac{1}{N} \sum Z_8 Z_t \quad \dots \text{Eqn.4.138}$$

Recall that: $Z_9 = P_{91}Z_1 + P_{95}Z_5 + e_9$ (See Eqn.4.9)

By substituting, Eqn.4.138 becomes

$$r_{89} = \frac{1}{N} \sum Z_8 (P_{91}Z_1 + P_{95}Z_5 + e_9) \quad \dots \text{Eqn.4.139}$$

By opening the bracket, we have

$$r_{89} = P_{91}Z_1Z_8 + P_{95}Z_5Z_8 + e_9 \quad \dots \text{Eqn.4.140}$$

Note that $Z_1Z_8 = r_{81}$; $Z_5Z_8 = r_{85}$

By substituting, Eqn.4.140 becomes

$$r_{89} = P_{91}r_{81} + P_{95}r_{85}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{89} = (.107) (.129) + (-.184) (-.342)$$

$$r_{89} = .014 + .063$$

$$r_{89} = \mathbf{.191}$$

$$r_{8t} = \frac{1}{N} \sum Z_8 Z_t \quad \dots \text{Eqn.4.141}$$

Recall that, $Z_t = P_{t_2}Z_2 + P_{t_3}Z_3 + P_{t_4}Z_4 + P_{t_5}Z_5 + P_{t_9}Z_9 + e_t$ (See Eqn.4.10)

By substituting, Eqn.4.141 becomes

$$r_{8t} = \frac{1}{N} \sum Z_8 (P_{t_2}Z_2 + P_{t_3}Z_3 + P_{t_4}Z_4 + P_{t_5}Z_5 + P_{t_9}Z_9 + e_t) \quad \dots \text{Eqn.4.142}$$

By opening the bracket, we have

$$r_{8t} = P_{t_2}Z_2Z_8 + P_{t_3}Z_3Z_8 + P_{t_4}Z_4Z_8 + P_{t_5}Z_5Z_8 + P_{t_9}Z_9Z_8 + e_t \quad \dots \text{Eqn.4.143}$$

Note that, $Z_2Z_8 = r_{82}$; $Z_3Z_8 = r_{83}$; $Z_4Z_8 = r_{84}$; $Z_5Z_8 = r_{85}$; $Z_9Z_8 = r_{89}$

By substituting, Eqn.4.143 becomes

$$r_{8t} = P_{t_2}r_{82} + P_{t_3}r_{83} + P_{t_4}r_{84} + P_{t_9}r_{89}$$

By using the values of path coefficients and obtained correlations, we have

$$r_{8t} = (-.058) (-.068) + (-.113) (-.390) + (.284) (-.347) + (.109) (-.342) + (-.347) (.994)$$

$$r_{8t} = .004 + .044 + (-.099) + (-.037) + (-.345)$$

$$r_{8t} = \mathbf{-.433}$$

$$r_{9t} = \frac{1}{N} \sum Z_9 Z_t \quad \dots \text{Eqn.4.144}$$

Recall that, $Z_t = Pt_2 Z_2 + Pt_3 Z_3 + Pt_4 Z_4 + Pt_5 Z_5 + Pt_9 Z_9 + et$ (See Eqn.4.10)

By substituting, Eqn.4.144 becomes

$$r_{9t} = \frac{1}{N} \sum Z_9 (Pt_2 Z_2 + Pt_3 Z_3 + Pt_4 Z_4 + Pt_5 Z_5 + Pt_9 Z_9 + et) \quad \dots \text{Eqn.4.145}$$

By opening the bracket, we have

$$r_{9t} = Pt_2 Z_2 Z_9 + Pt_3 Z_3 Z_9 + Pt_4 Z_4 Z_9 + Pt_5 Z_5 Z_9 + Pt_9 Z_9^2 + et \quad \dots \text{Eqn.4.146}$$

Note that: $Z_2 Z_9 = r_{92}$; $Z_3 Z_9 = r_{93}$; $Z_4 Z_9 = r_{94}$; $Z_5 Z_9 = r_{95}$; $Z_9^2 = 1$

By substituting, Eqn.4.146 becomes

$$r_{9t} = Pt_2 r_{92} + Pt_3 r_{93} + Pt_4 r_{94} + Pt_5 r_{95} + Pt_9$$

By using the values of path coefficients and obtained correlations, we have

$$r_{9t} = (-.058) (-.061) + (-.113) (-.407) + (.284) (-.362) + (.109) (-.343) + (-.347)$$

$$r_{9t} = .004 + .046 + (-.103) + (-.037) + (-.347)$$

$$r_{9t} = \mathbf{-.437}$$

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