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Metacognitive Learning Cycle Model and Secondary School Students' Achievement in Physics in Ebonyi State

***[1]Elom, I.J., & [2]Aja, L.**
[1]Department of Science Education, Ebonyi State University, Abakaliki, Nigeria
[2]Department of Science Education, Kampala International University, Western Campus, Uganda.

***Corresponding author email:** irukajohn@gmail.com

Abstract
This study examined the extent to which the metacognitive learning cycle model influenced the physics achievement of students in secondary schools. The study's compass consisted of two null hypotheses and two research questions. The study design was quasi-experimental. 924 senior secondary two students from the Izzi Local Government Area in Ebonyi State made up the study population. Using purposive sampling and straightforward random sample procedures, a total of 65 students were selected for the research. The Physics Achievement Test (PAT) was the instrument used to collect the data, and it has been validated by measurement and assessment specialists as well as physics experts. Applying Kuder Richardson Formula 20 to determine the instrument's reliability, the reliability coefficient was determined to be 0.82. The Control group and the Treatment group are the two groups for the study. To respond to the research questions, the mean was employed and the analysis of covariance was used to evaluate the hypotheses. The study's conclusions show that students' academic success in physics is significantly impacted by the metacognitive learning cycle model. The study suggests that rather than depending solely on traditional techniques, educators should redesign their lesson plans to accommodate different metacognitive learning models.

Keywords: Learning Cycle Model, Student's achievement, Gender, Metacognitive, Physics.

Introduction

In senior secondary schools, physics is taught as a science subject. Like other science courses, physics is vital to the development of the nation. The fundamental knowledge of the universe's laws is the focus of physics. Physics is the study of the laws that establish the composition of matter and energy in the cosmos according to Ugwu (2004). Physics is not concerned with only the force that exists between energy and matter but it also takes the holistic study of matter and energy. Okeke (2012) also defined physics as the physical science which studies natural forces, substances, and other physical objects. The basic science field of physics addresses those fundamental concerns about the composition of matter and the interactions between the most basic elements of existence that may be studied theoretically and experimentally. As per the Federal Republic of Nigeria (FRN, 2014), secondary school physics goals are to: impart fundamental physics literacy for society's functional needs; develop students' scientific aptitude and attitudes to prepare them for physics' technological applications; produce scientists for the country's development; introduce students to the fundamental ideas, laws, and principles of physics; encourage and enhance creativity; and get them ready for higher education (Akanbi, 2019).

The demand for technological development in Nigeria obliges her to encourage students to choose careers in science especially engineering and medicine which a student cannot offer without the knowledge of physics. Physics can be seen as a subject that provides room for all technological development in the world. Its application to real-life situations transcends the above profession to everyday life. Daniton (2012) said that Physics lies at the heart of science. The invention of spaceships, video machines, satellites, war missiles, and x-ray machines are all based on one or more of the fundamental laws of physics. Hence, Marrison (2008) saw Physics as a great triumph of the human mind and essential to developing civilization. Despite all these roles played by physicists in the field of civilization, students' performance in physics is still low at all levels (Wenno, 2015). One of the science courses, physics, has continued to rank among the hardest for secondary school pupils to master. According to research, Nigerian students have historically performed poorly in ordinary-level physics, and this has been linked to a variety of issues, comprising physics teachers' utilization of inadequate instruction strategies (Owolabi, 2014). Parents, the government, and the general public have been paying more attention to secondary school students' physics academic performance as reported by WAEC officials for some time now (Eze et al., 2023a; Ogenyi et al., 2023; Eze & Eze, 2023; Eze et al., 2023b). Students' general science performance has not been encouraging, particularly in physics (Lacambra, 2016, Awodun et al., 2014). The metacognitive learning cycle model is among the instructional methods that have been recommended for use in science classrooms to address this issue.

To make sure that every student is making sufficient progress, the model of the metacognitive learning cycle is a modified instructional model that incorporates a deliberate pause known as check status into each of the models of the learning cycle's early phases. The Metacognitive Learning Cycle Model was developed by Blank (2000) as an organized learning cycle model that incorporates metacognitive components and develops a broad variety of students' scientific concepts, experiences, and understanding. The author maintained that the model is made up of four different phases: Concept exploration, Assessment, Introduction, and Application. Figure 1 presents the MLCM adopted from Blank (2000)

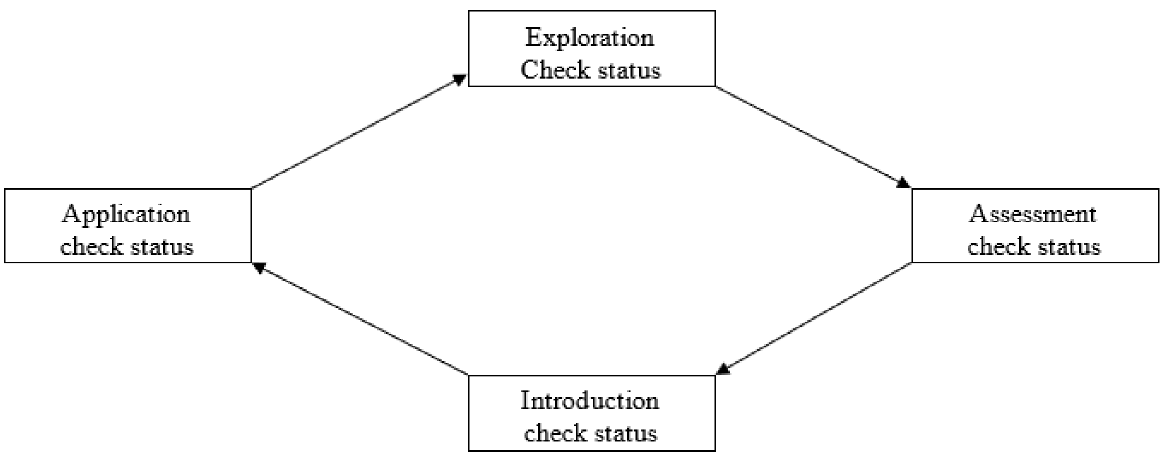

Figure 1: Metacognitive Learning Cycle Model (Blank (2000)

During the concept exploration stage, the teacher assigns a task to the class that is both enough precise to give guidance to the students and sufficiently open-ended to allow for a variety of approaches. The phase allows students to employ their knowledge about natural phenomena. At the concept assessment, the students are asked to reflect on their science ideas of the task before the instruction begins. Students keep a concept journal in which they record their ideas and the condition of those ideas. At the concept introduction level, the teacher gathers information from the students' discrepancies at the exploration level and introduces the main concept of the lesson. Materials like as textbooks, audiovisual assistance, and other teaching resources may be used to facilitate the concept introduction. During the application phase, students are challenged with additional examples of new tasks that can be solved based on previous exploration activities. Students' thinking is supposed to advance via this sequence from thinking in concrete terms about science subjects to being able to handle abstract concepts. All things considered, the consensus is that physics achievement is statistically connected with students' cognitive capacities and general intelligence is thought to be the most potent predictor of academic success (Roth et al., 2015). Intelligent tests are frequently utilized by psychologists in education to evaluate and analyze students' cognitive capacities and challenges as well as to give them self-information that influences their career and professional choices.

According to the Oxford English Dictionary 6th edition, achievement is seen as something that has been accomplished through superior effort or ability. Any accomplishment that requires exceptional work, bravery, or a valiant act is referred to as an achievement. Achievement is the ultimate accomplishment of something significant, usually after a substantial amount of work and frequently in the face of setbacks and discouragement According to these definitions, physics achievement may be seen from two angles. The first is based on the discoveries made thus far in the field; for example, the world's best astronomy and physics research has had a significant influence on the discipline. The discovery of the Higgs boson occurred at CERN, the European Organization for Nuclear Research has profound implications for the fundamentals of physics and has inspired a new generation of physicists (Higgs, 2013). Concurrently, the University of Southampton strengthened its prominent position in radio astronomy by acquiring a new LOFAR telescope, expanding our understanding of the beginnings of the universe's biggest scale of magnetic fields as well as our leadership in transient effects. Also, tremendous achievements have been recorded in the areas of electronics, computer science, and photoelectric research. The second component of achievement is determined by how well students perform in physics after all internal or external exams. This is known as academic achievement, and it may be determined by looking at students' grades after each term's exams. As stated by Roth et al. (2015), academic grades are a reliable indicator of students' academic success given that they take into account details from students' performance on written exams or in class over an extended period. Gender is the most reliable predictor of academic success. For a long time, there has been debate concerning the relationship between gender and how one responds to physical science, particularly physics. Numerous researchers have become interested in the debate around gender and performance in science. Igwe (2006) opined that the general performance of boys and girls in physical sciences was in favour of boys except in chemistry and geological studies. Hazari et al. (2010) also revealed that gender was strongly associated with physics achievement as boys significantly demonstrated better than girls did. This is in line with Anderson (2012) asserted that there were very few American women working in science and engineering. According to a study by Onyedike (2011), male students demonstrated higher academic accomplishment, suggesting that gender has a major influence on students' academic achievement when taught in a metacognitive classroom setting.

This study examined whether the presumption that boys perform better than girls in the physical sciences, particularly physics, is typically true or whether there are other factors, such as learning styles, that may account for their discrepancies. The increasing level of poor academic achievement of students in physics calls for further investigation. It is perceived that some factors could be responsible for this seemingly poor achievement. For instance, WAEC (2014), (2015), and (2016) consecutively reported the declining performance of students in ordinary-level physics. Physics being an essential branch of science that has many applications in real-life situations regrettably turns out to be an area where students exhibit poor performance over the years. Several academics propose that pupils' poor academic performance in physics may be due to the instructional strategies or approaches used by physics teachers. If the low physics academic achievement of students is not addressed, it may hurt the intended objective of physics education in Nigeria. In light of this, the study confirms whether students who taught in a metacognitive learning cycle model classroom and those who received instruction in traditional classrooms will differ in their academic accomplishment.

Aim and Objectives of the Study

Finding out how the metacognitive learning cycle model affected students' academic achievement in physics was the primary goal of the research. The investigation precisely ascertained the:

i. The effects of the metacognitive learning cycle model (MLCM) on physics achievement in secondary school pupils.
ii. The effects of the metacognitive learning cycle model (MLCM) on male and female students' performance in physics at secondary schools.

Research Questions

The investigation was guided by the following research questions:

i. How do the mean scores of students who were taught physics using the metacognitive learning cycle model compare to those of students who were taught using conventional teaching methods?
ii.
iii. What are the average achievement levels of students, both male and female, who were taught physics using the metacognitive learning cycle model?

Hypotheses
The following null hypotheses were examined with significance set at 5% alpha.
$H0_1$: The mean achievement scores of students taught physics using the conventional teaching technique (CTM) and those taught using the metacognitive learning cycle model (MLCM) do not differ significantly.
$H0_2$: The mean achievement scores of male and female students taught physics using the metacognitive learning cycle model (MLCM) do not differ significantly.

Methodology
To carry out the study, a quasi-experimental design was adopted. A quasi-experimental design was used in the creation of the study. This is because there was no subject randomization. After all, intact classes were used (Nworgu, 2015). The study employed two groups: the experimental group and the control group. The experimental group, also known as the treatment group, got physics instruction utilizing the metacognitive learning cycle model (MLCM) approach, while the control group was instructed in physics using the conventional teaching method (CTM). All of the coeducational secondary government-owned schools in Ebonyi State's Izzi Local Government Area were the sites of the research. Izzi L.G.A. is situated in Ebonyi State's northern region. The region borders Cross River State and Benue State. The study population is comprised of all the SSII physics students in Izzi Local Government Area of Ebonyi State. There are nine hundred and twenty-four (924) students offering physics in Izzi LGA as recorded by the Statistics Unit of Abakaliki Educational Zone, Ugwu- Achara in 2021.

The sample consisted of sixty-five (65) senior secondary two (SS2) students from two secondary schools. A multi-stage sampling strategy was used in the study to choose participants. Using a purposive sample technique, 13 coeducational secondary schools were chosen to start the investigation. The researcher used purposeful sampling because mixed gender is a particularly fascinating issue. Secondly, two schools were selected for the study using simple random selection, which involves balloting without replacement, because entire classes were saved for this experiment. After that, a coin flip was used to randomly allocate the schools to either the experimental or control groups. The Physics Achievement Test (PAT) was administered as a pre-test at the beginning to both the treatment group and the control group. After four weeks of instruction, the same test, rearranged, was administered as a posttest to both the treatment and control groups. The pre-and post-test outcomes of the students in the treatment and control groups were analyzed using descriptive and inferential statistics. The statistical mean was utilized to solve the research concerns, and the significance level of the study hypotheses was set at 0.05.

Results

Research question 1: How do the mean scores of students who were taught physics using the metacognitive learning cycle model compare to those of students who were taught using conventional teaching methods?

Table 1: Pretest and posttest achievement scores of students taught physics in both the experiment and control group.

Groups		Pre-test		Post-test		Mean gain	Mean gain
	N	$\bar{x}$	SD	$\bar{x}$	SD		difference
Experimental	28	30.43	8.32	40.64	10.41	10.21	9.67
Control	37	31.78	8.04	32.32	9.31	0.54	

The aforementioned table displays the treatment and control groups' respective mean accomplishment scores during the pretest and posttest, which were 30.43 and 31.78 40.64 and 32.32, respectively. The experimental group's mean gain score was 10.21, whereas the control group's was 0.54, as seen in the table. The mean gain score was greater in the experimental group.

Research question 2: What are the average achievement scores of students, both male and female, who were taught physics using the metacognitive learning cycle model?

Table 2: Pretest and posttest achievement scores of male and female students taught physics using MLCM

Gender		Pre-test		Post-test		Mean gain	Mean gain
	N	$\bar{x}$	SD	$\bar{x}$	SD		difference
Male	17	33.41	9.44	43.29	12.02	9.88	0.85
Female	11	25.82	9.01	36.55	11.82	10.73	

Table 2 displays the results of the experimental group's male and female students on the pretest and posttest. The pretest and posttest mean scores for male students were 33.41 and 43.29, respectively, whereas the mean scores for female students were 25.82 and 36.55. With a mean gain score of 10.73, female students outscored male students, who had a mean gain score of 9.88.

Hypothesis 1: The mean achievement scores of students taught physics using the conventional teaching technique (CTM) and those taught using the metacognitive learning cycle model (MLCM) do not differ significantly.

Table 3: Summary of ANCOVA on the students' pretest and posttest achievement scores in physics for the experimental and control group at p= 0.05.

Source	SS	DF	MS	F	p
Corrected model	1666.290ª	2	833.145	14.812	.000
Intercept	2422.283	1	2422.283	43.065	.000
Pretest	415.389	1	415.839	7.385	.009
Method	1413.041	1	1413.041	25.122	.000
Error	3487.310	62	56.247		
Total	87532.000	65			
Corrected total	5153.600	64			

Table 3, shows that at a 0.05 percent significant level, 1 degree of freedom of the numerators and 62 of the denominators yielded the calculated F of 25.12 is much higher than the 4.00 essential F. That is, $P = 0.00 < 0.05$, $F(1,62) = 25.12$. This demonstrates that the mean accomplishment scores of students who were taught physics using the metacognitive learning cycle model and those who were taught physics using the lecture technique differ significantly. The study concludes that there is a significant difference between MLCM and CTM, favoring MLCM, and rejects the null hypothesis as a result.

Hypothesis 2: There is no significant difference in the effectiveness of MLCM on the physics achievement scores of male and female secondary school students.

Table 4: Summary of ANCOVA on the pretest and posttest of male and female students' achievement scores in physics for the treatment group.

Source	SS	Df	MS	F	p
Corrected model	373. 052ª	2	186.526	3.611	.042
Intercept	2725. 968	1	2725. 968	52.773	.000
Pretest	68.880	1	68. 880	1.333	.259
Gender	370.309	1	370. 309	7.169	.013
Error	1291.377	25	51. 655		
Total	47916. 000	28			
Corrected total	1664. 429	27			

Table shows a statistically significant variation in physics achievement scores by gender. $F(1, 25) = 7.169$, $p < 0.05$ for each. This indicates that the metacognitive learning cycle model which was used to teach physics to both male and female pupils differs significantly from one another. Consequently, the null hypothesis is disproved.

Discussion

The result as contained in Table 1 clearly shows that students who received instruction under the metacognitive learning cycle model MCLM performed better academically than those who received instruction in a conventional classroom. The ANCOVA of Table 2 also shows that the experimental group's mean difference from that of the control group's students is statistically significant. On the other hand, it is noted that after instruction, the experimental group's post-test mean score was greater than the control group, but had higher mean scores on the pre-test than the treatment group. The results corroborate the research of Avargil et al. (2018), Nwosu (2015), and Achufusi (2011), who suggested that students' academic progress is greatly positively and significantly impacted by metacognitive learning in the classroom. The results, however, are at odds with those of Blank (2000) and Offiah & Akusoba (2009), who argued that there is no discernible advantage to the metacognitive learning cycle model in terms of raising students' topic knowledge. Given that female students had a larger academic mean gain than their male counterparts, Table 2's results demonstrate the academic strength of both male and female students who received instruction within the metacognitive learning cycle model. The academic achievement of male and female students differs significantly at a 5% level, with a preference for female students, as indicated by ANCOVA Table 4. The study contradicts Bianchi (2007) who investigated the effect of efficient evaluation using contextualized metacognitive cues on students' achievement and the finding shows no significant interaction effect for gender. The study also conflicts with Onyedike (2011) who maintained that gender difference exists but in favour of males. The study equally contradicts Glory and Ihenko (2017) whose findings showed that gender has no significant influence on students' achievement.

Conclusion

According to the metacognitive learning cycle model, which incorporates the exploration learning model, children who received physics education under the MLC paradigm outperformed their peers academically. This suggests that the experimental group, which received training using the MLC model, significantly outperformed the other groups in terms of mean physics scores. Additionally, there were significant academic differences between male and female students who received physics education under the MLC approach. Because female students had better academic records than male students who got an education under the MLC model, the investigation suggests the fact that there is a substantial disparity between the two student groups.

Recommendations

The study's conclusions led to the following recommendations being made:

1. Physics teachers ought to re-examine additionally redesign their teaching trends
   to allow for various metacognitive learning cycle l models instead of relying on conventional methods.
1. Educators of physics should plan a curriculum that can allow students' active participation in physics tasks to foster gender friendliness rather than making them passive learners.
2. The government on their part should constantly organize workshops and seminars for physics teachers who are already in the field with emphasis on adopting a metacognitive model for teaching physics and sciences in general.
3. To spark students' interest in physics while they are teaching, the Ministry of Education and other educational authorities should make sure that physics teachers adopt the proper metacognitive learning cycle models. This could be accomplished by routinely monitoring and inspecting various schools.

References

Achufusi, N.N. (2011), Effect of metacognitive learning cycle on academic achievement of Secondary School Physics Students. Nnamdi Azikiwe University, *UNIZIK Journals of STM of Education*, 2(1), 34-38.

Akanbi, G. O., &Jekayinfa, A. A. (2019). Education and emancipation, educational policies and «de-emancipation»: A history of the Nigerian education system from 1914 to 2014. *Espacio, Tiempo y Educación*, *6*(2), 177-196.

Anderson, C.W. (2012). Teaching Science in Y- Richard –Kochler.The educator handbook. A research perspective New York. *Longman* 84-111

Avargil, S., Lavi, R., & Dori, Y. J. (2018). Students' metacognition and metacognitive strategies in science education. *Cognition, metacognition, and culture in STEM education: Learning, teaching and assessment*, 24, 33-64.

Awodun, A. O., Oni, S. A., &Aladejana, A. L. (2014). Students' variables as predictor of secondary school students' performance in physics. *International Journal of Scientific and Research Publications*, *4*(8), 1-5.

Bianchi, G. A. (2007). Effects of metacognitive instruction on the academic achievement of students in the secondary sciences. Seattle Pacific University ProQuest Dissertations, 3272507, 1-24

Blank, L. M. (2000). A metacognitive learning cycle: A better warranty for student understanding. *Science*

Education, *84*(4), 486-506.
Daniton M. (2012) Role of science and technology in educational development. *Nigeria Journal of Educational Research* 5(3) 30-34
Eze, C. E., & Eze, V. H. U. (2023). Employer's administrative strategies as correlates to workers ' job performance. *Journal of Humanities and Social Sciences*, *5*(2), 65–74. https://doi.org/10.36079/lamintang.jhass-0502.547
Eze, C. E., Eze, V. H. U., Ezenwaji, O. I., & Nwabueze, A. I. (2023a). Principals' Administrative Strategies as Correlates of Teachers' Job Performance in Public Secondary Schools in Obollo-Afor Education Zone of Enugu State, Nigeria. *IDOSR Journal of Humanities and Social Sciences*, *8*(1), 76–87.
Eze, C. E., Eze, V. H. U., & Ugwu, N. J. (2023b). Educational Administrative Strategies and Its Effect on Employers Job Performance : A Review. *INOSR Journal of Experimental Sciences*, *11*(1), 67–76.
Eze, V. H. U., Eze, C. E., Mbabazi, A., & Ugwu, J. N. (2023c). Administrative Leaders' Strategies as Correlates of Workers' Job Performance. *Journal of Humanities and Social Sciences*, *5*(2), 101–113. https://doi.org/10.36079/lamintang.jhass-0502.562
Federal Republic of Nigeria, (FRN, 2014). *National Policy on Education*. Yaba: Revised Edition NERDC Press.
Glory, G. E., & Ihenko, S. (2017). Influence of gender on interest and academic achievement of students in integrated science in ObioAkpor Local Government Area of Rivers State. *European Scientific Journal*, *13*(10), 211-219.
Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of research in science teaching*, *47*(8), 978-1003.
Higgs, P. W. (2013). The Nobel prize, https://www.nobelprize.org/prizes/physics/2013/higgs/ facts/.
Igwe, I . O (2006) Gender imbalance in students achievement in chemistry. The Team assisted instruction strategy to rescue. *Ebonyi State Journal of Education,* Timex publishers, 29, Ogui Road Enugu.
Lacambra, W. T. (2016). Students' academic performance in physics 1: Basis for teaching and learning enhancement. *Research on Humanities and Social Sciences*, *6*(4), 78-84.
Marrison C.O (2008) The Purpose of Teacher Education in Developing Africa. *WAJE*. 15(3) Hopkins Press Lagos.
Nworgu, B.G. (2015). Educational research, basic issues and methodology(third edition) Nsukka-Nigeria: *university trust publishers*.
Nwosu, B. I (2004) Effects of metacognitive training in strategic questioning on students' achievement, interest and retention of biology concepts. *Unpublished Ph.D Thesis, Nnamdi Azikiwe University Awka, Anambra.*
Offiah, F. C., &Akusoba, E. U. (2009). Effectiveness of Metacognitive learning cycle to science instruction for secondary school chemistry Students. *Journal of Science Technology and Mathematics*, *1*(1), 23-30.
Ogenyi, F. C., Eze, V. H. U., & Ugwu, C. N. (2023). Navigating Challenges and Maximizing Benefits in the Integration of Information and Communication Technology in African Primary Schools. *International Journal of Humanities, Management and Social Science*, *6*(2), 101–108. https://doi.org/10.36079/lamintang.ij-humass-0602.599
Okeke P.N. (2012) Electromagnetism and Modern Physics Nigeria University Physics Series 2nd Edition. *Nazareth Press Ltd, Ibadan*.
Onyedike, C. C . (2011). Effects of metacognitive classroom environment on students' academic achievement and self-regulation learning skills of senior secondary school students. *Unpublished Thesis Unizik*
Owolabi, T. (2004). A diagnosis of students' difficulties in physics. *Educational perspectives*, *7*(2), 15-20.
Roth, B., Becker, N., Romeyke, S., Schäfer, S., Domnick, F., &Spinath, F. M. (2015). Intelligence and school grades: A meta-analysis. *Intelligence*, *53*, 118-137.
Statistics Unit: Abakaliki Educational Zone, Ugwu- Achara (2021). Senior Secondary Student Records
Ugwu G.Z (2004) Modern Physics Revised Edition. *John baz Publisher, Ibadan*.
Wenno, I. H. (2015). The correlation study of interest in physics and knowledge of mathematics basic concepts towards the ability to solve physics problems of 7th grade students at junior high school in Ambon Maluku Province, Indonesia. *Education Research International*, *2015*, 1-7, https://doi.org/10.1155/2015/396750
West African Examinations Council. (2014). Chief Examiner's Report. Yaba: Lagos, Nigeria..
West African Examination Council. (2015). Chief Examiner's Report. Yaba: Lagos, Nigeria.
West African Examinations Council. (2016). Chief Examiner's Report. Yaba: Lagos, Nigeria.