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Students' Critical Thinking, Process Skills in Science and Controlled attention in Mixed Ability Physics Classrooms

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ABSTRACT
The study determined the predictive power of thinking critically, process skills in science and controlled attention on cognitive ability levels of students in Physics in Benue State, Nigeria. This study was anchored on Gardner (1983) theory of multiple intelligences. Correlationnal research design was utilized for the study. The study population was 5138 public senior secondary science students. A sample of 550 SSII students who offered Physics in 20 secondary schools was used. Science Students Process Skills (CTSAS), Critical Thinking Self-assessment Scale (CTSAS), Attention Lapses Clicker (ALC) and Ability Group Test (AGT) were used for data collection. Validation of the instruments was done by three experts and the reliability index of SSPS, CTSAS, ALC and AGT was established using Cronbach Alpha and found to be 0.87, 0.85, 0.79 and 0.77 respectively. Linear normalization and transformation to standard scores of raw data collected for all variables was done. Administration of the instruments was done by the researchers with the help of teachers teaching Physics. Regression analysis was used for data analysis. Findings revealed that, the foretelling power of process skills in science on students' cognitive ability level in physics is significant. Similarly, the predictive weight of critical thinking on students' ability level in physics is significant. Likewise, the foretelling power of controlled attention on students' cognitive ability level in physics is significant. Finding further revealed that the joint predictive power of process skills in science, critical thinking and controlled attention on students' ability levels in Physics is significant. The study therefore recommend in the midst of others that Physics teachers should monitor students in Physics class to ensure that they possess appropriate insight knowledge to develop their intellectual, social and physical skills which are fundamental basis of student's identity. These are necessary ingredients for proper acquisition of high scientific process skills.

KEY WORDS: Critical thinking, Controlled Attention, Mixed Ability, Process skills in science, Physics

INTRODUCTION

Physics could be defined as a subject that studied matter's properties and its energy interaction. Natural phenomena are interpreted using principles and concepts generated from Physics. The instructional delivery of Physics is concerned with guiding learners to be appreciative of Physics concepts and gain capability to relate knowledge acquire to everyday life. Physics as a subject has two aims. The aims are to produce scientifically literate society and to develop potential scientific and technological manpower (Aderonmu & Obafemi, 2015). These aims involve indispensible and laudable terminology that could bring about fundamental technological growth for national progress if all collaborating variables are put in place. This is because economic and social development could be brought about by technological augmentation of a country.

There was public outcry for effective instructional delivery of Physics in secondary education in Nigeria for technological growth, social and economic development. The students' accomplishment in internal and external assessments pinpoints a fact that there was unproductive instructional delivery. There are challenges to effective learning of Physics which include high difficulty nature of subject perception, qualified teachers' shortage, pitiable reading practice, futile instructional strategies, depressing interest/mind-set of students towards Physics, location of schools, discriminations in gender, insufficient facilities in laboratory, derisory motivation of staff and leaning aid as well as insufficient teaching and learning aid and inappropriateness of contents to the daily experiences of students (Aina, 2012; Akingbede & Omotade, 2013; Adolphus, 2018). A fundamental goal of teaching of Physics is to stimulate and enhance creativity which could help students to become independent, autonomous, efficient and life-long learners (Aurah, 2018). For instance, one of the major areas which most Physics teachers tend to overlook and yet very important for effective teaching of Physics in schools is process skills of students in Physics classrooms.

Process skills in science could be described as defining a dilemma and variables, making hypotheses and predictions, assumptions testing by carrying out experiments, data collection, analysis and presentation of findings (Yalçınkaya-Onder, Zorluoglu, Timur, Timur, Guvenç, Ozergun & Ozdemir, 2022). Process skills in science could be insights to development of physical skills as well as social and intellectual which are person's personality sources (Atmojo, 2012). Process skills in science is a significant skill that every student must possess because it globally affect social, personal and individual lives when employed in everyday life (Siregar, Rajagukguk & Sinulingga, 2020). The process skills are indivisible from the conceptual understanding of Physics. Students could sculpted, scrutinized, research or experiment due to the scenery of the topic and difficulty (Choirunnisa, Prabowo & Suryanti, 2018). Students are expected to acquire science process skill competency for content/concept knowledge as well as inquiry and research. The learning of science subjects Physics in particular by understanding requires using process skills in science. The task of Physics teachers therefore is to enable learners gain critical thinking cleverness of scientists.

The development of students' critical thinking is a goal of Physics instruction. Varieties of disciplines and pursuance of profession in prospect require critical thinking (Santos, 2017). The 21st-century education recognized it as important success capital in the place of work (Saavedra & Opfer, 2012). The intellectual process that is active and

skillful in the formulation of concepts as well as application, analysis, synthesis and evaluation data. Observation, familiarity, reflection, reckoning and communication could be used to achieve the complete development (Ennis, 2016). It is a thinking procedure that is associated with our capability to reflect realistically. This implies the use of knowledge of facts and information in the thought domain to solve problems as a result of motive. It could be referred to as a cognitive action linked with the exploit of the psyche. Mental practice like attention, classification, assortment and conclusion require individuals to thinking critically, analytically and evaluatively (Cottrell, 2017). The important of critical thinking is the role it plays in the development of assorted potential response needed in the place of work to resolve progressively more multifaceted tribulations (Duran & Sendag, 2012; Stephenson & McKningt, 2015; Quattrucci, 2017). Making a right decision footed on facts and sturdy reasons needed in daily existence is a typical task of critical think (Bassham, Irwin, Nardone & Wallace, 2011; Vong & Kaewurai, 2017).

The benefit of thinking critically: 1) advance the aptitude to scrutinize; 2) spotlight more when reading; 3) develop the facility to recognize vital points in the manuscript; 4) proficiency to gain comprehension; 5) diagnostic talent can be related to diverse circumstances (Cottrell, 2017). Conversely, these skills are not unavoidably obsessed by the learners as Nuryanti, Zubaidah & Diantoro (2018) found that the percentage of students answering questions in the acceptable category is only 40.46% which is poor critical thinking skills. Excellent critical thinking skills in a knowledge upbringing have connotation for learners in terms of nurturing control of attention in Physics classroom.

The term attention has assumed a plethora of meanings from different scholars based on different reference frames as it is not a unitary concept (Ellah & Achor, 2023). The word attention can be conceptualized from numerous dimensions. The characteristic of attention is related to some degree of resource and the process or mechanism for selection available information for processing with priority (Ellah & Achor, 2023). Attention to our currently perceived background is different from attention to information not presently apparent. This implies that attention to image or acoustic streams is not same as attention to keep in mind idea that we learn in Physics. Similarly, attention to stuff and proceedings in the world around us is different from attention to our own objective and rational or explicit events. The second type of attention consist of choice of our contemporary objective or duty set and protecting it from interruption, assortment of numerous probable dealings as well as checking of proceedings and its result in Physics class. Equally, the distinction between controlled and automatic deployment of attention is apparent. Attention is said to controlled when it is aimed at present objective (Awh, Belopolsky & Theeuwes, 2012).

The supposed attention-demanding course of action is usually carried out using limited resources in the cognitive system. The task demands split the resource which is in continuous quantity arbitrarily. Split-half attention effect occurs when two or more sources of information cannot be understood in seclusion. Split-half attention effect was studied in instructional circumstances (Mayer, Heiser, Lonn, 2001; Moreno & Mayer, 2002). The studies established that knowledge and transfer are supported by approaches that eradicate split attention in methodological areas and provisional features like students' understanding accounted for within a given awareness domain. This is because processing efficiency, that is speed and precision is an affirmative monotonic utility of ability level and sum of resource allocate to a course when attention is controlled (Ellah & Achor, 2023).

The feature that establishes the ability of a learner to be engaged in educational assignment which entails higher cognitive performance significantly is called academic potentiality. This is called academic attainment or ability level. Students' ability level is

an important parameter in measuring students' accomplishment in Physics at secondary schools. It is commonly measured by assigning scores to all formative and summative assessments used by teacher in Physics class. Observation revealed clearly that no two students in Physics class are precisely the same in general individuality. That means no two students have equal potentials as far as knowledge is concerned since students may not have equivalent echelon of process skill, critical thinking and control of attention. The overriding issue of worth in an educational system, according to Ricarda (2017) was students' ability level. To this end teachers use dissimilar techniques of assessment to obtain academic accomplishment of student and used it for ability level classification. The ability level of students is improved by their own objective, psychological or unconcealed measures, which involve rejoinder selection, action scheduling, defending the quest of existing objective from interruptions and enticements, while changing from solitary duty to another which is attention. The vigor of the present research is the addition of determination of the predictive weight of students' process skills in science, critical thinking skills and controlled attention alongside ability levels in Physics. The objectives of this study are to:

- Establish the predictive influence of process skills in science on students' ability levels in Physics.
- Find out the predictive weight of critical thinking on students' ability levels in Physics.
- Ascertain the predictive power of controlled attention on students' ability levels in Physics.
- Determine the joint predictive weight of process skills in science, critical thinking and controlled attention on students' ability levels in Physics.

THEORETICAL FRAMEWORK

Gardner (1983) Theory of Multiple Intelligences

Gardner (1983) theory of multiple intelligences states that individuals used diverse intelligences in their daily lives base on different ways of learning. The theory holds that people have different kinds of intelligences. The human intelligence is differentiates into specific modalities rather than a single general ability by theory of multiple intelligences. Gardner projected eight facility areas. These are musical-rhythmic, visual-spatial, verbal-linguistic, logical-mathematical, bodily-kinesthetic, interpersonal, intrapersonal and naturalistic. This theory has implication for the Physics teacher because each student have different intelligence. Students are inbuilt with diverse intelligence which may be controlled by occurrence and background. The Physics teacher should provide the legroom for enhanced process skills in science, high critical thinking and effective control of attention so that students are not deprived and can learn better according to their ability levels.

METHODS

The blueprint of the study was correlational survey research design. Benue State was the area of the study. The study population was 5138 secondary students. The sample for the study comprised 550 SSII students in Physics class of 20 public secondary schools in Apa, Otukpo and Ohimini local government areas of Benue State. Purposive sampling technique was used for sample selection. The use of purposive sampling was based on the fact that only schools that suit certain necessities and measures vital to the study objectives can be selected.

Four research instruments Science Students Process Skills, Critical Thinking Self-assessment Scale, Attention Lapses Clicker and Ability Group Test were used in this study. The Science Students Process Skills (SSPS) solicit information from the respondents on the demographic variable and measures the extent of the things students' do when they study and investigate in Physics class. The items were rated thus: Very Low Extent, Low Extent, High Extent and Very High Extent. The study

adapted Critical Thinking Self-assessment Scale (CTSAS) developed by Payan-Carreira, Sacau-Fontenla, Rebelo, Sebastião, Pnevmatikos (2022**)**. The students are to report attention lapses by poignant a button on the clickers of Attention Lapses Clicker whenever they experienced a phase of inattention. The learners clacked a knob to specify an attention slip lasting a minute or less, another switch to show a fall of 2 to 3 minutes, and a third switch to signify a lapse of 5 minutes or more. A computer is used to map this clicker-responses information into a timeline to determine an average length attention lapse of the students. An Ability Group Test (AGT) was used to determine the cognitive ability levels of the students. The AGT is a 20-item multiple choice tests adapted from Test Booklet General Ability Test (TBGAT, 2003). The test questions were read to the students by the researcher and they were allowed one minute to provide answers to each question.

The Validation of the instruments was done by three experts in Science and Mathematics Education Department, Benue State University, Makurdi. The reliability index of SSPS, CTSAS, ALC and AGT was established using Cronbach Alpha and found to be 0.87, 0.85, 0.79 and 0.77 respectively. Linear normalization and transformation to standard scores of raw data collected for all variables was done to permit easier judgment and reduce any vagueness coming from individual differences. Administration of the instruments was done by the researchers with the help of teachers teaching Physics. One week was used for data collected works. Consent of the principal was required for the smooth admin of instruments. Regression analysis was employed for data analysis.

Results

Table 1: Stepwise Regression of Predictive Power of Process Skills, Critical Thinking and Controlled Attention on Students' Ability Level

Variables	**R**	**Reg. Square (R^2)**	***B***	**Std. Error**	**β(Reg. Weight)**	***t***	**Sig.**
Process skills in science	0.473	0.239	0.346	0.038	0.444	9.013	0.000
Critical Thinking	0.547	0.220	0.272	0.038	0.369	7.230	0.000
Controlled Attention	0.441	0.216	0.092	0.037	0.591	2.510	0.012

Table 1 explains the précis of stepwise regression investigation of predictive power of process skills in science, critical thinking and controlled attention on Students' Ability Level in Physics. The investigation reveals that the power of prediction of process skills in science is 0.444 with an R^2 of 0.239. This entails that 23.9 percent of discrepancy in ability level is accounted for by process skills in science in Physics. From the table the likelihood linked with the calculated worth of t(9.013) is 0.000. Because the likelihood value of 0.000 is less than 0.05 level of significance, the predictive power of science students' process skills on their cognitive ability level in physics is significant.

The table further reveals that the predictive power of thinking critically is 0.369 with an R^2 of 0.220. This entails that 22.0 percent of disparity in ability level is ascribed to critical thinking skills in physics. From the table the likelihood connected with the calculated worth of t(7.230) is 0.000. Since the likelihood value of 0.000 is less than 0.05 level of significance, the predictive power of students' critical thinking on their ability level in physics is significant.

Similarly, the table reveals that the predictive power of controlled attention is 0.591 with R^2 of 0.216. This entails that 21.6 percent of variation in ability level is

credited to controlled attention in physics. From the table the likelihood connected with the calculated value of t(2.510) is 0.012. Since the chance value of 0.012 is less than 0.05 level of significance, the predictive power of students' controlled attention on their cognitive ability level in physics is significant.

Table 2: Regression Analysis of Joint Predictive Power of Process skills in science, Critical Thinking and Controlled Attention on Students' Ability Level

Model	R	R^2	Adjusted R^2	Estimated Std. Error
2	.803	.645	.601	.394

The regression analysis of the joint predictive power of process skills in science, critical thinking and controlled attention on students' ability level is as shown on Table 2. This table reveals the relationship connecting ability level and the combination of process skills, critical thinking and controlled attention of 0.803 with an R^2 of 0.645. The meaning is 64.5 percent of discrepancy in ability level is explained by joint power of process skills in science, thinking critically and controlled attention.

Table 3: ANOVA of Regression of Joint Predictive Power of Process skills in science, Critical Thinking and Controlled Attention on Students' Ability Level

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.942	2	15.942	1.071	.005
	Residual	6670.789	449	14.890		
	Total	6686.731	550			

Table 3 reveals the likelihood connected with the calculated worth of F (2,550) = 1.071 is 0.005. Since the chance value of 0.005 is less than 0.05 level of significance, the null hypothesis is discarded. Thus, the joint predictive power of process skills in science, critical thinking and controlled attention on students' ability levels is significant.

Discussion of Findings

A. Predictive Power of Process Skills in Science on Students' Cognitive Ability Levels

The findings revealed a moderate predictive power of process skills in science on students' cognitive facility levels. Accordingly, the measure of students' process skills in physics had 0.444 regression weight which means 44.4 percent predictive power. The predictive power of science students' process skills on their cognitive ability level in physics was significant. This implies that measure of students' process skills in science is prognostic of their cognitive ability level in physics. The finding agrees with Aydogdu (2017) who found assessment of crucial process skill achievement to be higher among the upper status unlike the lower class in primary school. The finding is also consistent with Duruk, Akgun, Dogan, and Gulsuyu (2017) who found status altitude increment brings a normal augment in knowledge result with the quotient of process skills in science differentiated.

The finding is in consonance with Halim, Ngadimin, Soewarno, Sabaruddin and Susanna (2018) that process skills in science are also part of higher order thinking skills. The finding also agrees with Saban, Aydogdu, and Elmas (2019) that the attainment of process skills in science via observing, measuring, comparing, predicting and classifying was at average or above average with 5th-grade students. The finding is in accord with Ozkan and Umdu Topsakal (2021) that the slightest universal process skills in science were hypothesizing and measuring of proportions, whereas the most frequent are data taking to mean and inferring magnitudes. The finding also agrees with Dogan (2021) who found among classes 9-12 Biology students that watching and inferring are habitually used skills for textbooks.

B. Predictive Power of Critical Thinking on Students' Cognitive Ability Levels

A predictive power of critical thinking on students' cognitive ability level was found to be moderate. Thus, the measure of students' critical thinking in physics has

0.369 regression weight which means 36.9 percent predictive power. The predictive power of students' critical thinking on their ability level in physics was significant. This implies that measure of students' critical thinking ability is extrapolative of their cognitive ability level in physics. The finding agree with Ariyanti and Maulina1 (2020) who found scientific strategies developed based on instructional materials advance students' critical thinking skills, harmonized the feasibility in content, language and appearance with a score of 4.28 in the very good group.

C. Predictive Power of Controlled Attention on Students' Cognitive Ability Levels

Finding revealed a moderate predictive power of controlled attention on students' cognitive ability levels. Accordingly, the measure of controlled attention in physics class has 0.591 regression weight which means 59.1 percent predictive power. The predictive power of students' controlled attention on their cognitive ability level in physics was significant. This implies that measure of students' controlled attention could project their cognitive ability level in physics. This might result from students' careful chase of present objective using activities plans that shield it from interruptions and temptation while changing from a undertaking to another. A necessary ingredient of controlled attention is the deliberate assortment of the contents in functioning memory which is controlled by mechanisms sorting out extraneous stimuli and eliminating no longer germane representations from working memory. This is because a single item is often chosen into the center of attention for processing within working memory contents. What is of great concern about controlled attention upshot is that cognitive power of perceptual attention is contributed by working memory. This is achieved while maintaining template of targets of insightful selection and controlling students' approaches to problem-solving in Physics class by holding task sets to achieve stated behavioural objectives.

The finding agrees with Luria, Balaban, Awh and Vogel (2016) that the contralateral impediment doings amplitude improved with set dimension up to about 3 substances and then levelled off. Students' performance associated with contralateral impediment doings amplitudes on a examination of a arbitrarily chosen item in spite of the item been in view awaiting the period of examination or be held in memory for a second. The finding is also consistent with Souza and Oberauer (2017) who found retention period of a visual working memory task observed only slight dual-task costs when introducing a visual attention task such as examining a stimulus for a understated brightness alteration. The finding agrees with Ellah and Achor (2023) that split-half attention had significant predictive power on students' learning outcome in Physics. However, the finding disagrees with that of Ellah, Achor and Enemarie (2019) that there was no significant association linking problem-solving skills of low cognitive ability level in science and students' appraise of attention span.

D. Joint Predictive Power of Process Skills in Science, Critical Thinking and Controlled Attention on Students' Ability Levels

Finding revealed that the joint predictive power of process skills in science, critical thinking and controlled attention on students' ability levels in Physics was significant. This implies that measure of mutual predictive power of process skills in science, critical thinking and controlled attention are major factors of students' ability levels in Physics. The finding agrees with Ellah and Achor (2023) that the combination of split-half attention and dual-processing in working memory had significant predictive power on students' learning outcome in Physics.

The important upshot of the research is the constancy of the outcome right through the independent variables as it strengthened assurance in the model obtained as presupposed originally. The scrutiny of our domino effect indicates that both affective and cognitive factors are important predictors of student's cognitive ability level in Physics as a school subject. In fact, the occurrence of emotional and cognitive

factors as predictors in the model for the variables authenticate the initial affirmation that students' cognitive ability level is preeminently foretell when using a multivariate procedure. The findings were statistically significant for all independent variables and the dependent variable.

CONCLUSION

This study conclude that all the variables focused viz: process skills in science, critical thinking and controlled attention are student related factors that contribute to students' cognitive ability level in physics and are significant predictor of students' cognitive ability level in physics. The combination of process skills in science, thinking critically and controlled attention are also significant determinant of students' cognitive ability level in physics. As such, these important student variables should be focused when trying to look for solution to related persistent low ability level students in physics.

RECOMMENDATIONS

The study recommended that:

a. Persons teaching Physics ought to monitor learners in Physics class toward ensuring that they possess appropriate insight knowledge for cerebral, collective and bodily proficiency which is fundamental basis of learner's identity. These are necessary ingredients for proper acquisition of high scientific process skills.
b. The state government in conjunction with other stakeholders ought to arrange periodic seminars, workshops and conferences for persons teaching Physics to improve their ability in managing the skills required in monitoring the complex variable like critical thinking for effective teaching of concepts in physics.
c. Persons teaching Physics ought to guide the learners via orderly modus operandi so that their attention could be directed to their current goals during problem-solving and appropriate explanation of all physics parameters during content delivery for effective learning of physics.

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