JURNAL VARIDIKA
Vol. 34, No. 1, 2022, pp. 42-52
p-ISSN 0852-0976 | e-ISSN 2460-3953
Website: http://journals.ums.ac.id/index.php/varidika

Misconceptions and Difficult Concepts as Determinant of Students' Academic Engagement and Retention in Physics

Emmanuel Edoja Achor[1], Barnabas Obiaje Ellah[2]*, Joy Okache Omaga[1]
[1]Department of Science and Mathematics Education, Benue State University, Nigeria
[2]Department of Educational Foundations and General Studies, Joseph Sarwuan Tarka University, Nigeria
*Corresponding author's email: ellizee_2010@yahoo.com

DOI: 10.23917/varidika.v1i1.17660

Submission Track:
Received:
March 1st, 2022
Final Revision:
July 11th, 2022
Available online:
July 11th, 2022

ABSTRACT

The study determined the predictive power of students' misconceptions and difficult concepts in physics on academic engagement and retention. The study adopted a correlational survey research design with a population comprising 3148 science students in Benue State. The sample was 650 science students. Six research questions were answered and six null hypotheses were tested. The instruments for data collection were Physics Difficult Concepts Retention Test (PDCRT), Physics Academic Engagement Scale (PAES) and Physics Students' Misconceptions Identification (PSMI). The PDCRT, PAES and PSMI were face validated and PDCRT was also content validated. Estimate of internal consistency was obtained through Cronbach's Alpha for PAES and Kuder-Richardson (K-R_{21}) for PDCRT. The coefficient of internal consistency was 0.73 for PAES and 0.88 for PDCRT. Regression analysis was used for data analysis. It was spotlighted that students' misconceptions and difficulty levels in Physics significantly predicted academic engagement. However, students' misconceptions and difficulty levels do not significantly predict retention in Physics. It was also found that students' misconceptions and difficulty levels jointly significantly predicted students' academic engagement in Physics. Similarly, the combination of students' misconceptions and difficulty levels significantly predicted retention in physics. It was recommended among others that Physics teachers use instructional strategies that allow self-directed learning that could give emotional safety, reduce misconceptions and enhance academic engagement. Physics teachers should guide students using the systematic procedure to acquire relevant skills essential for successful learning interplay to reduce difficulty in understanding Physics concepts and enhance retention.

Keywords: *academic engagement; difficult concepts in physics; predictive weight; retention; students' misconceptions*

INTRODUCTION

Physics is essential in helping students to possess the depth of knowledge and skills to ensure scientific and technological advancements. The application of Physics in industry and many other fields makes it crucial for practical living in the modern age of science and technology (Pember, 2014). Furthermore, the knowledge and application of Physics is required in computer and system designs, robotics, metallurgy, radio and television transmission, electronics, medicine, satellites, engineering, energy generation, fibers optics, environmental protection, and mining and prospecting. Keith (2011) stressed that careers in Physics are embedded in its application in several fields and related sciences. These careers included fence, health service, aerospace, agriculture, metallurgy, alternative energy (geothermal, solar, wave and wind), food preservation/processing, education, instrumentation, weather forecast, etc. Despite the crucial role Physics plays in the technological advancement of a nation, students developed misconceptions after formal teaching and learning of Physics in senior secondary schools. According to Oni (2014), the misconceptions have led to students' achievement in Physics not being encouraging, as Nigeria has witnessed persistent poor students' performance in Physics at the School Certificate level. The West African Examination Council (WAEC) Chief Examiner's Reports from 2009 to 2018 show students' deteriorating performances in Physics at the School Certificate Examination level. The Chief Examiners' reports indicated that a lack of understanding of fundamental physics concepts contributed to students' poor performance in physics examinations.

Misconceptions are students' wrong ideas about some content in Physics. Students' misconceptions in Physics originate from sources like interaction with the socio-physical world prior to formal instruction, textbooks, reference books, teaching, language, cultural beliefs, and practices (Ivowi, 2017). The alternative conception with which the learner comes into the classroom is a misconception that needs to be removed or repaired to enhance academic achievement (Lopresto & Mureu, 2011).

Misconceptions hindered the learning progress in Physics class and students' academic performance. The misconception is a learner's incorrect opinion based on faulty thinking or fraud. It is, however, expected that formal instructions in Physics should lead to the modification, reduction, or even adjustment of students' misconceptions. Effective teaching should not only make students knowledgeable about what is correct it also ensures that they do not believe what is incorrect. The issue of students' misconceptions about Physics in secondary schools is a significant problem that befalls the educational sector. This is because the teaching and learning of Physics in senior secondary schools are facing many challenges that make students find it difficult to understand the contents of the curriculum in use mainly due to its difficulty level (Obafemi & Onwoiduakit, 2013).

The physics curriculum has many concepts that students find challenging to learn. Obafemi and Onwoiduakit (2013) opined that the difficulty in understanding of Physics concepts by students centers on teaching and textbooks. Also observed was that the difficulties stem from the way Physics concepts are taught; hence, there is a noticeable drastic and constant reduction in level of Physics at all levels of education in Nigeria (Paden, & Moyer, 1969; Emaikwu, 2012). According to Okeke (2015), the physics concepts that pose challenges to students at the secondary school level in terms of conceptual understanding include waves, light waves, sound waves, electricity, magnetism, nuclear physics, pressure, and simple harmonic motion. Similarly, Fisher (2009); Samela (2010); Erinosho (2013); Omek, Robinson, and Haugan (2013); Oon and Subramaniam (2013) identified the following concepts as an area that students have challenges in their conceptual understanding: energy quantization, AC circuit, projectile motion, electric field, and simple harmonic motion. Previous research on the branches of Physics did not address the issue of students' misconception in area of thermal Physics concept. The difficulty students experience in understanding Physics concepts appears to be at the global level, as can be seen from previous studies (Obafemi & Onwioduokit, 2013; Ogunleye, 2013; Bao & Koeing, 2019). Students can benefit from a teacher who motivates and possesses theoretical and pedagogical content knowledge from how he/she delivers instruction, which could boost their academic engagement in physics.

Academic engagement is seen as the learner's time on academic tasks, completing homework, participating in school and class activities, and developing a sense of belonging to school or activity groups. It is a multidimensional construct depicted by observable and internal activities, and it is not only what the students do in class that constitutes academic engagement. Academic achievement is different from academic engagement in that achievement is the measure of students' ability to carry out activity and provide correct responses on activities carried out in learning complex concepts. Therefore, it is necessary to improve students' academic achievement through practical and behavioral aspects. This is because the psychological feature of engagement tends to promote students' more significant effort and participation in learning complex concepts, which could enhance retention.

Retention could be defined as the capacity to remember content materials. According to Musa, Achor, and Ellah (2021), retention is one's ability to preserve or keep knowledge of learned materials and to be able to call to remembrance and reproduce it when required. Individuals can also retain and play back their experiences and what has been learned after a particular learning approach or period. Critical factors in this information retrieval include what has been stored, how it has been stored, and the patterns present in the problem that help the individual perceive what information to access from memory. In order to retrieve information, knowledge from a content domain must be present in memory, to begin with; it should also be organized in a way that facilitates its retrieval in an appropriate context (Ellah, Achor, & Enemarie, 2019). The human mind acquires the materials of knowledge through sensation and perception. The acquired materials need to be preserved or retained in the human mind in the form of images for knowledge to develop. Retaining images are revived or reproduced whenever a stimulating situation occurs to make memory possible (Ellah & Achor, 2018; Majiwa, Njoroge, & Cheseto, 2020).

Eysenck (2012) asserted that man is endowed with limited capacity for memorization, and to correctly and effectively use or apply whatever one has learned, retention must come to play an important role. Low retention in Physics may not be unconnected with students' misconceptions and level of difficulty of the concepts in the subject. As long as this persists, the hope of raising physics graduates to ensure continuity in the relevant medical, science, and technological applications would remain a mirage. Quite unlike the previous studies (Achor, 2003; Achor, Aligba & Omananyi, 2010; Achor & Bileya, 2022) that examined cognitive correlates of Physics achievement, the predictive power of selection examinations, and effectiveness of teaching strategies respectively, a strength of the current study lies with the inclusion of the measure of students' misconceptions and difficulty levels of concepts alongside academic engagement and retention. Therefore, the objectives of the study are to:

- Determine the predictive power of students' misconceptions on their academic engagement and retention in Physics.
- Determine the predictive power of difficulty levels on students' academic engagement and retention in Physics.
- Determine the joint predictive power of students' misconceptions and difficult concepts on students' academic engagement as well as retention in Physics.

METHOD

A correlational survey research design was adopted for the study. This study was conducted in Otukpo, Apa, and Ohimini Local Government Areas of Benue State. The population for the study comprised 3148 science students in public senior secondary schools in the study area. Six hundred fifty science students studied Physics as a school subject in Term II for the 2019/2020 session from 38 public senior secondary schools in the study area. The sampled schools were drawn from the Local Government Areas used for the study using a simple random sampling technique through a lucky dip with replacement.

The instruments for data collection were Physics Difficult Concepts Retention Test (PDCRT), Physics Academic Engagement Scale (PAES), and Physics Students' Misconceptions Identification (PSMI). PDCRT was adapted by the researchers using some of the items from WASSCE that were relevant to the study. The PDCRT comprises two sections: A and B. Section A consists of respondents' biodata. Section B consists of 40 multiple choice questions on energy quantization, AC circuit, projectile motion, electric field, and simple harmonic motion as difficult concepts in Physics identified by Ford (1989) and Erinosho (2013). The number of questions on each concept depended on the volume of the content in WASSCE syllabus and as guided by the test Blue Print.

The researchers adapted the PAES from the college student report of National Survey of Student Engagement (Krause & Coates, 2008; NSSE, 2015). The student college report was modified to suit the purpose of this study and then renamed Physics Academic Engagement Scale (PAES). It consists of two sections, A and B. Section A requires the demographic information of respondents, while section B consists of 40 statements on students academic, cognitive, and behavioral activities in Physics learning. The respondents were requested to express the extent of their agreement or disagreement with them in order of Strongly Agree (SA), Agree (A) Undecided (U), Disagree (D) and Strongly Disagree (SD). The researchers developed the PSMI. It consists of three sections, A, B and C. Section A requires the respondents' demographic information while section B consists of 5 columns on the students' misconceptions in Physics learning. Column A- serial number, Column B –Concepts/Contents, Column C –origin/sources of misconceptions, Column D - nature of misconceptions, Column E – alternate conceptions. Section C requested students to give any other comment that have not been expressed.

The Physics Difficult Concepts Retention Test (PDCRT), Physics Academic Engagement Scale (PAES) and Physics Students' Misconceptions Identification (PSMI) were face validated by an expert in Measurement and Evaluation from Department of Educational Foundations and General Studies, University of Agriculture, Makurdi and two experts in Physics Education from Science and Mathematics Education Department, Benue State University Makurdi as well as an experienced Physics teacher at the secondary school level. Estimate of internal consistency was obtained through Cronbach's alpha for PAES and Kuder-Richardson ($K\text{-}R_{21}$) for PDCRT. The internal consistency estimate was found to be 0.73 for PAES and 0.88 for PDCRT. The instruments were administered by the researchers with the assistance of the regular Physics teacher in each of the sampled senior secondary schools. Five days were used for data collection. Permission was sought from the school management to administer the instruments.

The continuous data collected were measured to interval level and analyzed using regression analysis to answer the research questions and test the null hypotheses at a 0.05 level of significance. Regression analysis is applied in the present study since it can predict outcomes. The reason is that if a regression model can be generalized, it must be capable of accurately predicting the same outcome variable from the same set of predictors with different groups of people. If the regression model is applied to a different sample and there is a severe drop in its predictive power, then the regression model does not generalize. Regression analysis also shows how strong the relationship is measured and how much predictive power has been detected. To draw conclusion about a population based on a regression analysis done on the sample of the present study, the following assumptions are found to be true: variable types, non-zero variance, no perfect multicollinearity, predictors are uncorrelated with external variance, homoscedesticity, independence error, normality of distributed error, independence, linearity. The decision rule was that null hypotheses were rejected if the P-value was less than or equal to 0.05 and not rejected if otherwise.

RESULTS &DISCUSSION

Result

Predictive power of students' misconceptions on their academic engagement and retention in Physics

Table 1 shows the summary of stepwise regression analysis of students' misconceptions and difficulty level of concepts on academic engagement in Physics. The analysis reveals that the correlation between students' misconceptions and academic engagement in Physics is 0.453 with a coefficient of determination as 0.240. This implies that 24.0% of the variation in students' academic engagement in Physics can be attributed to misconceptions. The analysis implies that the predictive power of students' misconceptions is 0.086. The table further revealed that the probability associated with the calculated value of t(0.031) is 0.05. Since the probability value of 0.000 is less than the 0.05 level of significance, students' misconceptions significantly predicted academic engagement in Physics. Table 1 further reveals that the correlation between difficulty levels of concepts and academic engagement in Physics is 0.337, with a coefficient of determination is 0.014. This implies that only 1.4% of the variation in students' academic engagement in Physics can be attributed to difficulty level of concepts. The analysis implies that the predictive power of difficulty levels of concepts is 0.048. The table shows that the probability associated with the calculated value of t(0.067) is 0.05. Since the probability value of 0.000 is less than the 0.05 level of significance, difficulty levels of concepts significantly predicted academic engagement in Physics.

Table 1. Summary of Stepwise Regression Analysis of Students' Misconceptions and Difficult Concepts on Academic Engagement in Physics

Variables	R	Regression Square (R^2)	*B*	B (Reg. Weight)	*t*	Sig.
Students' Misconceptions	0.453	0.240	3.663	0.086	0.031	0.000
Difficulty Level of Concepts	0.337	0.014	0.669	0.048	0.067	0.000

Table 2 summarizes the stepwise regression analysis of students' misconceptions and difficulty levels of concepts on retention in Physics. The analysis reveals that the correlation between students' misconceptions and retention in Physics is 0.531 with a coefficient of determination of 0.282. This implies that 28.2% of the variation in retention in Physics can be attributed to students' misconceptions. The analysis implies that the predictive power of students' misconceptions is 0.086. The table shows that the probability associated with the calculated value of t(0.075) is 0.05. Since the probability value of 0.720 is greater than the 0.05 level of significance, students' misconceptions do not significantly predict retention in Physics.

The analysis further reveals that the correlation between difficulty levels of concepts and retention in Physics is 0.137, with a coefficient of determination is 0.019. This implies that only 1.9% of the variation in students' retention in Physics can be attributed to difficulty levels of concepts. The analysis implies that the predictive power of difficulty levels of concepts is 0.117. The table shows that the probability associated with the calculated value of t(0.442) is 0.05. Since the probability value of 0.103 is greater than 0.05 level of significance, the problematic concepts do not significantly predict students' retention in Physics.

Table 2. Summary of Stepwise Regression Analysis of Students' Misconceptions and Difficulty Levels of Concepts on Retention in Physics

Variables	R	Regression Square (R^2)	*B*	β (Reg. Weight)	t	Sig.
Students' Misconceptions	0.531	0.282	29.596	0.460	0.075	0.720
Difficulty Levels of Concepts	0.137	0.019	28.878	0.117	0.442	0.103

The predictive power of difficulty levels on students' academic engagement and retention in Physics

Table 3. Regression Analysis of Academic Engagement and Combination of Students' Misconceptions and Difficulty Levels of Concepts in Physics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	$.603^{b}$	.364	.600	.39427

Table 3 shows the regression analysis of academic engagement and the combination of students' misconceptions and difficulty levels of concepts. The analysis implies that the correlation between academic engagement and the combination of students' misconceptions and difficulty levels of concepts is 0.603 with a coefficient of determination of 0.364. This implies that 36.4% variation in academic engagement can be explained by the combination of students' misconceptions and difficulty levels of concepts.

Table 4: Analysis of Variance of Academic Engagement and the Combination of Students' Misconceptions and Difficulty Levels of Concepts in Physics

	Model	Sum of Squares	df	Mean Square	F	Sig.
2	Regression	.001	2	.000	.003	$.007^{c}$
	Residual	100.573	647	.155		
	Total	100.574	649			

Table 4 shows that the probability associated with the calculated value of F (=.003) is 0.05. Since the probability value of 0.007 is less than the 0.05 level of significance, the null hypothesis is rejected. This implies that Students' misconceptions and difficulty levels of concepts jointly significantly predicted students' academic engagement in Physics.

The joint predictive power of students' misconceptions and difficulty level of concepts on students' academic engagement and retention in Physics

Table 5 shows the regression analysis of retention and the combination of students' misconceptions and difficulty levels of concepts. The analysis implies that the correlation between retention and the combination of students' misconceptions and difficulty levels of concepts is 0.417 with a coefficient of determination of 0.174. This implies that a 17.4%

variation in retention in Physics can be accounted for by the combination of students' misconceptions and difficulty levels of concepts.

Table 5. Regression Analysis of Retention in Physics and the Combination of Students' Misconceptions and Difficult Concepts

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.417[b]	.174	.410	.54668

Table 6. Analysis of Variance of Retention in Physics and the Combination of Students' Misconceptions and Difficulty Levels of Concepts in Physics

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	82.610	2	41.305	.098	.017[c]
	Residual	273141.544	647	422.166		
	Total	273224.154	649			

Table 6 shows that the probability associated with the calculated value of F (=.098) is 0.05. Since the probability value of 0.017 is less than 0.05 level of significance, the null hypothesis is rejected. This implies that the combination of students' misconceptions and difficulty level of concepts significantly predicted retention in Physics.

Discussion

The focus of the current study is the inclusion of the measure of students' misconceptions and difficulty levels of concepts alongside academic engagement and retention in Physics. This allows for a more in-depth investigation of the contribution of different facets of students' misconceptions and an understanding of Physics due to difficulty of concepts in relation to academic engagement and retention in Physics.

The predictive power of students' misconceptions on their academic engagement and retention in Physics

The study's finding revealed that students' misconceptions significantly predicted academic engagement in Physics. This implies that students' misconceptions are determinants of their academic engagement in Physics. This might result from instances where the ideas in the mind of students in Physics class are different from what is scientifically correct. What is of great concern about misconceptions is that individuals continue to build knowledge on their current understanding, which may negatively impact future learning. The finding is also in conformity with the earlier findings of Ugwuanyi (2011) that most students responded to force and motion concepts using the impetus model, which is not exactly the correct model. The finding agrees with the earlier findings of Howard, Brown, Chung (2013), and Bello (2015) that students held different misconceptions about cultural beliefs and values which they take into the classroom. The finding is also in conformity with the earlier findings of Efe (2015) that students have misconceptions about Physics.

The study's finding further revealed that students' misconceptions do not significantly predict retention in Physics. This implies that students' misconceptions are not determinants of retention in Physics. This may be due to the learners' willingness and ability to accept other more scientifically grounded explanations of how the world works. The finding is in conformity with earlier findings of Shipstone (2018) that students in five European countries have similar misconceptions about simple electric circuits. As such, the students held erroneous beliefs or alternative views of scientific principles or wrong notions about certain scientific concepts.

Retention is maintaining the availability of a replica of an acquired concept or part of the concept (Nneji, 2013). This implies that the amount of the original concept retained at any time is the variable of the quantity at hand. However, some stipulated factors influence retention. They include time interval between learning and retrieval, intervening experience, learners' cognitive level, instructional strategy/materials, the specified subject involved, and environmental situation. Nneji opined that retention could also be improved through the organization of material in some meaningful fashion; self-retention is the recitation of material to oneself rather than reading and re-reading and learning, which means learning a concept well beyond the point of bare recall.

The predictive power of difficulty levels on students' academic engagement and retention in Physics

The study's findings further showed that difficulty levels of concepts in Physics significantly predicted academic engagement. This means that difficulty of concepts is a determinant of students' academic engagement in Physics. This might be because the Physics curriculum has many concepts students find difficult to learn. Paden and Moyer (1969) found that the difficulties stem from how physics concepts are taught. Hence, there is a noticeable drastic and constant reduction in level of achievement in Physics. Academic engagement is an indicator of combined academic identification of students as getting along with Physics teachers, their interest in subject matter, behaviors, attitudes, academic participation as well as students study effort both inside and outside the school. The concept of student engagement is predicated on the belief that learning improves when students are inquisitive, curious, interested, inspired and that learning tends to suffer when students are bored and disengaged due to the difficulty of concepts.

The study's finding also revealed that difficulty levels of concepts do not significantly predict students' retention in Physics. This implies that the difficulty level of concepts in Physics lessons is not a determinant of students' retention. This is because the contents of the curriculum seem to matter to the learners, especially its difficulty level.

Joint predictive power of students' misconceptions and difficulty level of concepts on students' academic engagement and retention in Physics

It is found that students' misconceptions and difficulty level of concepts jointly significantly predicted students' academic engagement in Physics. This means that the combination of students' misconceptions and difficulty levels of concepts determines academic engagement in Physics.

Students' engagement as a concept is fairly complex in practice but it is utilized in the present study to help out students' misconceptions and difficulty levels of the concepts in Physics. Students engagement arises when teachers in Physics class prioritize educational strategies and teaching techniques to address the intellectual, emotional, behavioral, physical and social factors that either enhance or undermine learning by students. Students engagement in schools may be primarily understood in terms of internal states such as enthusiasm, curiosity, motivation, interest, and optimism. Engagement involves the active participation of students in academic, co-curricular, school-related activities and the commitment of Physics students to educational goals. Thus, student engagement is a key driver to learning; it requires energy and effort and is affected by several contextual influences such as students' misconceptions and difficulty level of concepts. One more finding revealed that the combination of students' misconceptions and difficulty levels of concepts significantly predict retention in Physics. This means that the combination of students' misconceptions and difficult concepts determines retention in Physics.

CONCLUSION

Based on the findings of this study, it was concluded that students' misconceptions and difficulty levels of concepts are determinants of their academic engagement in Physics. However, students' misconceptions and difficulty levels of concepts are not determinants of retention in Physics. The study further concludes that students' misconceptions and difficulty levels of concepts are the specific determinants of academic engagement in Physics. Similarly, the combination of students' misconceptions and difficulty levels of concepts are determinants of retention in Physics.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

1. Physics teachers should use instructional strategies that allow self-directed learning or learning by choice that may give emotional safety, reduce misconceptions and enhance academic engagement.
2. Physics teachers should guide students using the systematic procedure to acquire relevant computational skills essential for successful teaching and learning interplay that could reduce the difficulty in understanding Physics concepts and enhance retention.
3. Physics teachers should focus on identifying and correcting preconceived notions, nonscientific beliefs, conceptual misunderstandings, and vernacular and factual misconceptions in students to enhance retention in Physics class.
4. School administrators should design interventions and accommodations to help Physics teachers differentiate instruction with explanations on how a strategy can address students' misconceptions and the level of difficulty of concepts in Physics in and outside the classroom.

REFERENCES

Achor, E.E. (2003). Cognitive correlates of physics achievement of some Nigeria senior secondary students. *Journal of Science Teachers Association of Nigeria,* 38 (1&2), 10-15.

Achor, E. E., Aligba, S. O. &Omananyi, E. O. (2010). Predictive power of two selection examination scores on senior school certificate examination result of pre-degree science students of Benue State University, Makurdi, Nigeria. *Journal of Science and Technology Education Research*, 1(2), 37-43.

Achor, E. E. &Bileya, S. G. (2022). Towards enhancement of students' achievement in Physics using concept mapping and guided discovery strategies. *Innovare Journal of Education*, 10(3), 18-23. DOI: https://dx.doi.org/10.22159/ijoe.2022v10i3.44573

Bao, L. & Koeing, K. (2019). Physics education research for 21st century learning. *Disciplinary and Interdisciplinary Science Education Research,* 1(2), 1-12. https://doi.org/10.1186/s43031-019-0007-8

Bello, T. O. (2015). Influence of cultural belief and values on secondary school students' understanding of atmospheric related physics concepts. *Journal of Education and Practice* 6(.36), 122-127

Efe, M. O. (2015). Enhancing academic achievement and retention in senior secondary school chemistry through discussion and lecture methods: A case study of some selected secondary schools in Gboko, Benue State, Nigeria. *Journal of Education and Practice*. 6(21), 155-161

Ellah, B. O. & Achor, E. E. (2018). Effect of 5E constructivist instructional approach on students' achievement and attitude to physics in senior secondary schools. *Journal of Research in Curriculum and Teaching*. 10(3), 120-132.

Ellah, B. O; Achor, E. E. & Enemarie, V. (2019). Problem-solving skills as correlates of attention span and working memory of low ability level students in senior secondary schools. *Journal of Education and e-Learning Research*. 6(3), 135-141. https://doi.org/10.20448/journal.509.2019.63.135.141

Emaikwu, S. O. (2012). Assessing the relative effectiveness of three methods in the measurement of students' achievement in Mathematics. *Journal of Emerging Trends in Educational Research and Policy Studies*. 3, 22-31.

Erinosho, S. Y. (2013). How do students perceive the difficult of physics in schools: An exploratory study in Nigeria. *International Journal for Cross Disciplinary Subjects in Education.* 3(13), 512-515. https://doi.org/10.20533/ijcdse.2042.6364.2013.0212

Eysenck, M. W. (2012). Fundamentals of cognition. Psychology Press https://doi.org/10.4324/9780203720448

Fisher, N.J. (2009). Identification and examination of Physics concepts that students find most difficult. Retrieved from http://www.per-central.org/items/detaikl.cfm?ID=4387 23rd November2015. 11:52 am

Howard, Brown, Chung. (2013). College students' understanding of atmospheric ozone formation. *Chemistry Education Research Practi*ce 14, 51--61 https://doi.org/10.1039/C2RP20074K

Ivowi, U. M. O. (2017). Students' misconceptions about conservation principles and field. *Research, Science and Technology Education*, 4(2), 127-137 https://doi.org/10.1080/0263514860040203

Jeremiah, S & Bosede E. F. (2021). Effect of Constructivist instructional strategy on students' achievement in secondary school Mathematics curriculum in Rivers State. *Nigeria Journal of Education, Society and Behavioural Science*, 34(10): 47-56, DOI: https://doi.org/10.9734/jesbs/2021/v34i1030362

Keith, D. (2011). Advanced physics (2nded). India: Repro India, Ltd. NaviMumdai.

Krause, K. L., & Coates, H. (2008). Students' engagement in first year university. *Assessment & Evaluation in Higher Education*, 33 (5), 493-505. https://doi.org/10.1080/02602930701698892

Lopresto, A. & Mureu, G. (2011). Spontaneous reasoning in elementary dynamics. *European Journal of Science Education*, 1, 205-221.
https://doi.org/10.1080/0140528790010209

Majiwa, C. O., Njoroge, B., &Cheseto, N. (2020). Influence of constructivism instructional approach on students' achievement in Mathematics in secondary schools in Mandera Central Sub County, Kenya. *East African Journal of Education Studies,* 2(1), 115-128. https://doi.org/10.37284/eajes.2.1.221

Musa, J. H, Achor, E. E. & Ellah, B. O. (2021). Fostering achievement and retention in Basic Science using simulation and demonstration strategies. *Journal of Research in Instructional.* 1(2), 95 - 108. https://doi.org/10.30862/jri.v1i2.19

NSSE (2015). National survey of students' engagement. USA English version. NSSE website:nsse.iceb.edu/htmp/survey_insrument.cfm

Nneji, S. O. (2013). Effect of polyageorge's problem solving model on students' achievement and retention in algebra. *Journal of Educational and Social Research*, 3(6), 41. https://doi.org/10.5901/jesr.2013.v3n6p41

Ogunleye, A. O. (2013). Teachers and students perceptions of students' problem- solving difficulties in physics: implications for remediation. *Journal of College Teaching and Learning*.6, 785- 796. https://doi.org/10.19030/tlc.v6i7.1129

Omek, F., Robinson, W. R. & Haugan, M. P. (2013). What makes Physics difficult. *International Journal of Environmental Science Education*. 3, 30-34.

Oon, P. T. & Subramaniam, R. (2013). Factors affecting Singapore students' choice of Physics as a tertiary field of Study: A Rasch Analysis. *International Journal of Science Education*, 35(1), 86-118. https://doi.org/10.1080/09500693.2012.718098

Oni, J.O. (2014). Teacher quality and students' achievement in basic technology in junior secondary schools in South-West, Nigeria. *Journal of Educational and Social Research*, 4(3), 397- 402. https://doi:10.5901/jesr.2014.v4n3p397

Pember, S. T. (2014). *Effect of computer simulation experiments on senior secondary students' practical physics achievement and interest in Physics in education zone A, Benue State*. Unpunished PhD. Thesis, Benue State University, Makurdi, Nigeria.

Samela T. (2010). Who is joining Physics and why? Factors influencing the choice of Physics among Ethiopian university students. *International Journal of environmental and Science Education*, 5(3), 319-340

Shipstone, D. M. (2018). Pupils' understanding of simple electrical circuits. Some implication for instruction. *Physics Education*, 23, 92-96. https://doi.org/10.1088/0031-9120/23/2/004

Ugwuanyi, C. S. (2011). *Assessment of senior secondary school students' conceptual understanding of force and motion.* Retrieved from https://www.unn.edu.ng/publications/files/images/MY%20PROJECT%20WRK.2.

WAEC (2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017 & 2018). Chief examiner's report. Lagos: WAEC Press Ltd. http://waeconline.org/e-learning/physics