International Journal of Innovative Research in Arts, Education and Technology | IJIRAET
p-ISSN: 2682-6216 | e-ISSN: 2682-5880
Volume 3, Number 1 February, 2025

Utilisation of Produced Engine Mock-Ups for Students' Excellent Performance

[1]Isiaka A. Raheem, [2]Michael A. Fakomogbon, [3]Oyeronke O. Ogunlade, [4]Mudasiru O. Yusuf, [5]Abd-el-latif A. Abd-Elaziz, [6]Jelili A. Jimoh, [7]Ahmed I. Issa, & [8]Ganiyat P. Raheem-Folayinka

[1]Department of Physics, University of Lagos, Lagos
[2,3,4,5&7]Department of Educational Technology, University of Ilorin, Ilorin,
[6]Department of Technology and Vocational Education, University of Lagos, Lagos.
[8]Department of Science Education, University of Lagos, Lagos, Nigeria

Article DOI: 10.48028/iiprds/ijiraet.v3.i1.06

Abstract

This study determined the effects of the treatment instrument on students' performance in Auto Mechanical Work (AMW); and the effect of gender on students' achievement in AMW. The quasi-experimental research design with a pretest-post-test non-equivalent control study was adopted for this study. Two Teachers and thirty-five students at two schools in Lagos State participated in this study. The treatment instrument and students' achievement test were used as research instruments for this study. The instruments were validated and pilot-tested with reliability coefficient of 0.84. The data collected were analysed quantitatively. Findings revealed that the experimental group students outperformed the control group students, and the experimental female group students outperformed the experimental male group students in the test. The study concluded that locally produced instructional materials facilitate students' academic excellence and eradicate learning difficulties. The study recommended that students' academic performance should be sustained through regular availability of instructional materials.

Keywords: *Auto Mechanical Work, Internal Combustion Engine, STEM Education, Students' Performance*

Corresponding Author: **Isiaka A. Raheem** - https://orcid.org/0000-0002-0092-2596
Michael A. Fakomogbon - https://orcid.org/0000-0002-5182-3037
Oyeronke O. Ogunlade - https://orcid.org/0000-0002-5231-9676
Mudasiru O. Yusuf - https://orcid.org/0000-0003-0936-5949
Abd-el-latif A. Abd-Elaziz - https://orcid.org/0009-0004-0334-2994
Jelili A. Jimoh - https://orcid.org/0000-0002-4066-8932
Ahmed I. Issa - https://orcid.org/0009-0009-4322-1093
Ganiyat P. Raheem-Folayinka - https://orcid.org/0009-0002-1757-2016)

Background to the Study

An effective instructional delivery by teacher can be enhanced through proficient practical demonstration of curriculum contents which can be facilitated with the availability of functional school facilities and instructional resources. The Organisation for Economic Co-operation and Development (OECD) (2023), Holmlund et al. (2018) opined that there is a need for dynamic curriculum implementation based on innovations in science and technology mainly to meet students' instructional needs at all times irrespective of their location, gender, and age. Darling-Hammond et al. (2019) and Verma (2014) stated that up-to-date teaching resources are meant for functional educational outcomes that can boost instructional activities and sustain worthwhile instructional activities.

Resources for instructional deliveries could be obtained either through the selection of existing ones, improvisation, or the creation of new ones. National Science Foundation (2004) and Tahir (2002) opined that production methods of instructional materials involve imitative, adaptive, and creative methods which depend on the instructional objectives, and availability of production materials, experts, and processing. The U.S. Department of Education (2020) and Fakomogbon (2012) stated that the development of new instructional materials involved design, production and the small group try-out stages which could be easily achieved by production experts, well-trained and qualified teachers, and students who are end beneficiaries of instructional resources. Setyowati and Sukmawan (2019), Ogbondah (2008), Ndirangu (2010), and Chingos and Whitehurst (2012) also stated that the authenticity and usefulness of instructional materials were discovered through teachers' utilization and learners' performance during and after teaching/practical activities in the academic environments or training centers.

The availability of instructional materials for teaching can encourage students to acquire all necessary STEM-related subject knowledge and skills that will make them to be creative, productive and self-reliant at all times. Also, the performance of female students can be exceptionally improved in STEM practical-based subjects without gender discrimination whenever appropriate instructional resources are available and utilized.

Literature Review

Effective teaching and learning towards the actualization of students' excellent performance could be enhanced by the provision and utilization of instructional materials, teachers' competency, appropriate teaching methodologies, and students' interest in learning. New instructional materials could be obtained through Research and Development. (U.S. Department of Education, 2020 & Nwafor & Eze, 2014). Teaching and learning of Auto Mechanical Curriculum (AMW) curriculum at all technology education institutions can be fully achieved with adequate provision and proper utilization of these instructional materials. Tripura University (2015), Iwu et al. (2011); and Chingos and Whitehurst (2012)explained that instructional materials are broadly classified into visual, audio, audio-visual, electronics, web-based, non-projected, projected, phenomenal and manipulative materials (models & mock-ups).

Curriculum implementation depends on the continuous availability of qualified teachers; teaching materials and equipment; and excursion opportunities. In a situation where there is a shortage or non-availability of such teaching materials and equipment in the immediate environment; design, development, or improvisation of 3-dimensional models and specimens of real objects proffer solutions (Nigerian Educational Research and Development Council (NERDC), 2009 & Olumorin, 2014). Harvard Library (2024) and Teplá et al. (2022) noted that 3-dimensional models reflect the original shape of any objects and are more appreciative of the instructional activities than conventional academic materials.

Successful design and production of instructional materials with locally sourced materials by the teachers, educational technologists and engineers have worthwhile advantages to the nation, citadels of learning, learners, and end-users. Onasanya (2014) stated that the production of low-cost teaching materials with locally sourced materials possesses great educational value towards instructional delivery and acquisition activities in the school system. Locally produced teaching materials as discovered by Fakomogbon (2012) and Ogunleye and Raheem (2013) save the cost of procurement and importation from foreign countries; students learn better with instructional materials produced with available materials in their immediate environment; and add value to Nigerian economic development.

The subjects' selection at Senior Secondary Education as stated by the Federal Republic of Nigeria (FRN) (2013) and Nigerian Educational Research and Development Council (NERDC) (2017) are classified into compulsory cross-cutting and fields of studies subjects. Compulsory Cross-Cutting Subjects comprised the English language, general mathematics, trade and entrepreneur subjects and civic education. Trade and Entrepreneur subjects are sub-set of STEM education subjects that students were encouraged to offer at the secondary school level in Nigeria's educational system mainly for their skill development and self-reliance. (United Nations, 2022). The subjects according to NERDC (2017) consist of auto body repair and spray painting; auto electrical work; auto mechanical work; auto parts merchandising; air conditioning and refrigeration; and welding and fabrication engineering craft practice among others. As the best way of exposing students.

STEM education in Nigeria's Educational System, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) (2015) mandated that Trade and Entrepreneur education should commence from Post-Basic Education and Career Development level to tertiary education with distinct qualifications at each different level**.** Okon and Uke (2015) confirmed that the Nigerian Trade and entrepreneur education curriculum emphasized on acquisition of theory and practical skills that prepare Nigerian youths for self-reliance towards national industrialization and economic development. Nikolov, Shoikova and Kovatcheva (2014) described the Trade education curriculum as an integration of a Broad-Field Curriculum and a Competency-Based Curriculum type.

The transportation of human beings, animals, goods, and services globally as noted by Alanazi (2023) is successfully achieved with automobiles and other movable engines. Based on the relevance of the automobile as an essential daily need throughout the world, the National

Board for Technical Education (NBTE) (2016) and NERDC (2017) requested that the Automobile Systems skills and knowledge toward youth independence should be inculcated in the younger generations. Students' trade knowledge and skills literacy at all levels of education according to Wicklein et al. (2009) is immensely developed by Trade and Entrepreneur education. The wide-reaching Trade and Entrepreneur curriculum implementation can be successfully achieved through the availability and utilization of appropriate resources at the right time of need. Arop, Umanah and Effiong (2015), Maxwell et al. (2014) and the School Improvement Network (SIN) (2012) postulated that the best way to reinforce students' interest in learning is by teaching them with appropriate instructional materials in a conducive learning environment. World Skills International (2018) maintained that all categories of instructional materials are needed for excellent delivery and learning of the Trade and Entrepreneur education curriculum at all levels of academic institutions worldwide.

In terms of students' performance in Trade and Entrepreneur subjects concerning gender, Maxwell et al. (2014)stated that the subjects empower youth to contribute positively toward the nation technologically and economically irrespective of their gender. Wrigley-Asante et al. (2023), Wangu (2014), Awolaju (2016), and Omiko and Oketa (2017) discovered that male students outperformed their female counterparts whenever both genders are exposed to either locally produced or imported instructional materials. Regarding students' gender performance based on different institution's grade levels, Wrigley-Asante et al. (2023) discovered that male students perform better in STEM-related subjects than female students at the senior high school level, whilst female students perform better in STEM-related subjects than female students at the tertiary level.

Mbah and Azubuike (2015), Ogbu (2015), and Kehinde and Adewuyi (2015) noted that more than a decade ago, the implementation of the Trade and Entrepreneur education curriculum as an integral part of STEM education at Nigerian Government and Private Senior Secondary Schools had experienced setbacks due to insufficient instructional materials and facilities; dilapidated structures; shortage of well-trained and qualified teachers; and negative perception of Trade and Entrepreneur education relevancies.

Statement of the Problem

In the absence or shortage of factory-made instructional materials for teaching and learning activities in school environments, the need for utilization of locally produced instructional materials for the support of teaching and learning activities may become mandatory for most Nigerian secondary schools. There is a shortage of instructional materials to impact STEM education knowledge and skills to students which may likely arise due to the high cost of importation rate; lack of well-equipped school service workshops; and lack of instructional production technical staff. In this kind of situation, teachers are teaching STEM education subjects only in theory without demonstration of practical activities with relevant instructional materials. Because of the problems identified, therefore the present study utilized the Produced Two-stroke and Four-stroke Engine Mock-ups (PTFEM) for teaching Auto Mechanical Work in Senior Secondary Schools, in South-West, Nigeria.

Purpose of the Study

The main purpose of this study was to utilize the Produced Two-stroke and Four-stroke Engine Mock-ups (PTFEM) for teaching some selected topics in Auto Mechanical Work in Senior Secondary Schools, in South-West, Nigeria. Specifically, this study:

1. Determined the effect of the Produced Two-stroke and Four-stroke Engine Mock-ups on students' performance in Auto Mechanical Work; and
2. Determined the effect of gender on students' achievement in Auto Mechanical Work.

Research Questions

In this study, answers were sought for the following research questions:

1. What is the effect of the Produced Two-stroke and Four-stroke Engine Mock-ups on students' performance in Auto Mechanical Work?
2. What is the effect of gender on students' achievement in Auto Mechanical Work?

Research Hypotheses

The following null hypotheses were tested at a significant level of 0.05:

H_{O1}: There is no significant mean difference in the performances of students taught Auto Mechanical Work with the Produced Two-stroke and Four-stroke Engine Mock- ups and those taught with the Traditional Method.

H_{O2}: There is no significant effect of gender on students' achievement in Auto Mechanical Work.

H_{O3}: There is no significant interaction effect of treatment and gender on students' performance in Auto Mechanical Work.

Scope of the Study

The study was carried out at the Senior Secondary Schools (S.S.S.) offering Auto Mechanical Work as a Trade and Entrepreneur subject in Lagos state. The Engine System theme aspect of the S.S.S. 2 AMW curriculum scheme of work was treated for this study. The theme consists of (i) engine types, (ii) engine components, (iii) principles of a four-stroke cycle (spark ignition engine), (iv) principles of a two-stroke cycle (spark ignition engine), and (v) advantages of a four-stroke cycle over the two-stroke cycle topics.

Methodology

Research Design

The quasi-experimental design was adopted for this study. The design was a Pretest-posttest non-equivalent control type that involved intact classes of experimental and control groups. The experimental group was subjected to treatment using PTFEM, while the Control Group was not subjected to treatment. The design involved the use of two research instruments for the delivery of instruction and collection of data for this study.

Study Area

This study was carried out in six S.S.S. offering Auto Mechanical Work as a Trade and Entrepreneur subject in Lagos state. The S.S.S. offering Auto Mechanical Work as a Trade and Entrepreneur subject in Lagos state involved Command Secondary School, Command Road,

Ipaja; Adeniran Ogunsanya College of Education (AOCOED) International School, Ijanikin; Well Spring College, Ikeja; Apostolic Faith Secondary School, Anthony Village; King's College, Lagos Island; and Command Day Secondary School, Ojoo.

Population, Sample and Sampling Technique

The population for this study consists of all Auto Mechanical Work teachers and students offering Auto Mechanical Work as a Trade and Entrepreneur subject at the Command Secondary School, Command Road, Ipaja; Adeniran Ogunsanya College of Education (AOCOED) International School, Ijanikin; Well Spring College, Ikeja; Apostolic Faith Secondary School, Anthony Village; King's College, Lagos Island; and Command Day Secondary School, Ojoo. The sample for this study consisted of two Auto Mechanical Work teachers and intact classes of 35 Senior Secondary 2 (S.S.2) students. Only eight S.S.2 students offering Auto Mechanical Work at the Apostolic Faith Secondary School, Anthony Village were classified as the experimental group, while twenty-seven S.S.2 students offering Auto Mechanical Work at the Adeniran Ogunsanya College of Education (AOCOED) International School, Ijanikin were classified as the control group.

The sample for this study was purposefully selected from Adeniran Ogunsanya College of Education (AOCOED) International School, Ijanikin and Apostolic Faith Secondary School, Anthony Village because at the schools, students consistently enrolled for the subject from S.S.1 to S.S.3 since the inception of the subject and their students have been registered for West African Examination Council (WAEC) School Certificate for more than four years among others schools offering the subject as a Trade and Entrepreneur subject in Lagos state. The teaching activities in both sampled schools were normally conducted based on their academic calendar approved by the Lagos State Ministry of Education. Each school's teacher carried out instructional activities on the same topics in both experimental and control groups. The topics taught at both schools involved engine types; engine components; principles of a four-stroke cycle (spark ignition engine); principles of a two-stroke cycle (spark ignition engine); and advantages of a four-stroke cycle over the two-stroke cycle.

Research Instruments

The research instruments used for this study consist of Treatment instruments and Students' Achievement Tests. The treatment instruments titled "Produced Two-stroke and Four-stroke Engine Mock-ups, (PTFEM)" projections were drafted with Autodesk Inventor Professional Software and produced at the Department of Physics Workshop, University of Lagos for this study. The PTFEM was built from locally sourced materials and used to teach and demonstrate practical activities to students on the Engine System theme aspect of the S.S.S. 2 AMW curriculum. The PTFEM were probably produced; parts were easy to assemble and disassemble for easy maintenance; could be powered manually and electrically; and parts were painted with distinguishing SAE recommended colours. Also, the PTFEM fitted with LED bulbs that displayed intake air-fuel mixture, exhaust of burnt gas, transfer of air-fuel from crankcase to cylinder and ignition of air-fuel mixture actions during PTFEM operations pictures were available in figures 1 and 2.

The achievement test titled "Auto Mechanical Work Students' Written Achievement Test (AMWSWAT)" was made up of twenty-four multiple-choice objective questions and six theory questions allotted for the students to answer within only forty-five minutes. The achievement test was strictly structured based on the Automobile Engine System theme for the S.S.S. 2 curriculum.

Figure 1

Figure 2

Data Collection and Analysis

The fieldwork exercises at the experimental group and control group schools lasted for six weeks. The instructional deliveries of the Engine System theme at both schools lasted for the duration of six periods (80 minutes per week). The instructional deliveries were simultaneously carried out by the Auto Mechanical Work teachers at the sample schools based on the approved Lagos State Ministry of Education Scheme of Work for Auto Mechanical Work. Two weeks before the instructional deliveries at the experimental group school, the Auto Mechanical Work teacher was intensively trained on the utilization and maintenance of the PTFEM by the researchers. During instructional deliveries, the PTFEM was utilized at the experimental group school, while cardboard with pictorial elevations of the Induction Engines was utilized at the control group school. The pre-test and post-test assessments were conducted in both schools accordingly. The Auto Mechanical Work Students' Written Achievement Test (AMWSWAT) results were analyzed quantitatively with Statistical Package for the Social Science (SPSS) software to calculate mean, standard deviation, ANCOVA and independent t-test were appropriate.

Results

The results obtained from the analysis of data collected in this study were presented according to research questions as follows:

Research Question 1: What is the effect of the Produced Two-stroke and Four-stroke Engine Mock-ups on students' performance in Auto Mechanical Work?

Table 1: Analysis of Mean Differences and Standard Deviation of Students' Pretest and Posttest Scores in Test for Experimental and Control Groups

Groups	N	Pretest Scores		Posttest Scores		Mean Gain
		Mean	SD	Mean	SD	
Experimental	8	13.44	1.29	21.00	2.61	7.56
Control	27	10.17	2.90	15.41	2.60	5.24

The result presented in Table 1 revealed that the pretest means achievement score ($\bar{X}$=13.44; SD = 1.29) of experimental group was higher than the pretest means achievement score ($\bar{X}$=10.17; SD = 2.90) of the control group before treatment. After the treatment, the posttest means achievement score ($\bar{X}$=21.00; SD = 2.61) of experimental group taught Auto Mechanical Work with Produced Two-stroke and Four-stroke Engine Mock-ups was higher when compared with posttest mean achievement score ($\bar{X}$=15.41; SD = 2.60) of the control group taught Auto Mechanical Work using Traditional Method. The mean gain (7.56) of the experimental group was higher than the mean gain (5.24) of the control group. This result shows that the Produced Two-stroke and Four-stroke Engine Mock-ups was more effective in improving students' performance in Auto Mechanical work than the Traditional Teaching Method.

Research Question 2: What is the effect of gender on students' achievement in Auto Mechanical Work?

Table 2: Mean Achievement Scores of Male and Female Students

Gender	n	Pretest	SD	Posttest	SD	Mean Gain
Male	21	18.52	1.11	22.07	1.36	3.55
Female	14	16.63	2.35	24.40	1.45	7.77

Table 2 revealed that male students had a pre-test mean achievement score of 18.52 and a post-test mean achievement score of 22.07 with a pre-test post-test mean gain of 3.55. The female students had a pre-test mean achievement score of 16.63 and a post-test mean achievement score of 24.40 with a mean gain of 7.77. The result shows that the mean gain (7.77) of female students was higher than the mean gain (3.55) of male students. Hence, there was an effect of gender on the achievement of students in Auto Mechanical work.

H_{O1}: There is no significant mean difference in the performances of students taught with the Produced Two-Stroke and Four-stroke Engine Mock-ups and those taught with Traditional Method.

Analysis of Covariance was used to test hypothesis One (H_{O1}) in order to find out whether the difference in the groups' means after the treatment was statistically significant. The results of ANCOVA are presented in Table 3.

Table 3: ANCOVA analysis showing the difference in the performance of Students in the Experimental Group and Control Group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	333.170[a]	4	83.292	29.971	.000
Intercept	181.073	1	181.073	65.155	.000
Pre-Test	85.089	1	85.089	30.618	.000
Treatment	77.964	1	77.964	28.054	.000
Gender	7.040	1	7.040	2.533	.122
Treatment * Gender	28.755	1	28.755	10.347	.003
Groups	52.925	1	52.925	15.002	.000
Error	83.373	30	2.779		
Total	10161.000	35			
Corrected Total	416.543	34			

a. R Squared = .800 (Adjusted R Squared = .773)

The result in Table 3 revealed that the difference between the mean achievement scores of the experimental and control groups was statistically significant ($F_{1, 30} = 28.054$, $P < .05$) in favour of the experimental group. Hence, H_{O1} was rejected. This revealed that, there was a significant mean difference in the achievement of students taught Auto Mechanical work using the Produced Two-stroke and Four-stroke Engine Mock-ups and those taught using the traditional teaching method after treatment in favour of the experimental group.

H_{O2}: There is no significant effect of gender on students' achievement in Auto Mechanical Work.

Results of ANCOVA in Table 3 revealed that there was no significant main effect of gender on students' achievement in Auto Mechanical work ($F_{1, 30} = 2.533$, $P>.05$). Thus, the null hypothesis of no significant effect of gender on students' achievement in Auto Mechanical work was upheld at .05 level of significance. Result shows that the difference in Auto Mechanical work performance between the male and female students presented in Table 2 was not statistically significant. Therefore, gender has no significant effect on students' achievement in Auto Mechanical work.

H_{O3}: There is no significant interaction effect of treatment and gender on students' performance in Auto Mechanical Work.

Table 3 revealed that there was a significant interaction effect of treatment and gender on students' performance in Auto Mechanical work ($F_{1,30} = 10.347$, $P<.05$). The null-hypothesis of no significant interaction effect of treatment and gender on students' achievement was rejected.

Discussion of Findings

Based on the results shown in Tables 1 and 3 on the effect of the Produced Two-stroke and Four-stroke Engine Mock-ups on students' performance in Auto Mechanical Work, the means

scores indicated that the experimental group (group taught with PTFEM) outperformed the control group (group taught with conventional method). There was a significant difference between the performance of students in the experimental group and the control group. This finding is the same as the finding of Siyanbola *et al.* (2009) who discovered that students performed excellently in Trade and Entrepreneur subjects whenever they were taught with the right and up-to-date instructional materials by qualified teachers. Similarly, Harvard Library (2024) and Maxwell *et al.* (2014)ascertained that students were eager to know and explore more whenever they were exposed to 2 or 3-dimensional instructional materials that were perfectly related to the Engine System theme and other areas of their interests. Likewise, Fakomogbon (2012); Ogunleye and Raheem (2013); and Omiko and Oketa (2017) discovered in their studies that students performed exceptionally whenever they are taught with locally produced instructional materials.

On the effect of gender on students' performance in Auto mechanical work, this study found no significant effect of gender on students' performance in Auto Mechanical work. These findings contradicted Wangu's (2014), Awolaju's (2016) and Omiko and Oketa's (2017) findings of who found out that male students outperformed female counterparts whenever both genders were exposed to either locally produced or imported instructional materials. Also, the findings in this study contradict Wrigley-Asante et al (2023) findings on students' gender performance in any practical-based subjects where male students academically performed better than female students at secondary/high schools.

On the interaction effect of treatment and gender on students' performance in Auto Mechanical Work, the F-calculated and p-values indicated that there was a significant interaction effect of treatment and gender on students' performance in Auto Mechanical Work. This result means that treatment and gender combined to produce desired change in students' performance in Auto Mechanical work. In other words, there was a differential effect of treatment over levels of gender on students' performance in Auto Mechanical work. Although, this result could be attributed to the relatively small number of female students that participated in the study. These findings agreed with Wangu (2014), Awolaju (2016) and Omiko and Oketa (2017) findings of who also discovered that there were interaction effects of treatment and gender on students' performance in Auto Mechanical Work and other related subjects in Nigerian schools.

Conclusions and Recommendations

The study investigated the effects of locally produced Internal combustion engine Mock-ups on Senior Secondary School students' performance in Auto-Mechanical Work. Therefore, this study concluded that locally produced instructional materials enriched with all necessary functional and usability values do facilitate the rate of students' understanding and solve immediate instructional problems.

Based on the findings and conclusion of this study, the following recommendations are hereby made:

1. The Government should collaborate with Automobile industries in Nigeria on regular provision of STEM education teaching models for Secondary schools and others.
2. Local Educational District in all Nigerian Local Government Areas should construct at least an instructional material production center and organise periodic training for teachers on the production, improvisation, and maintenance of instructional materials.
3. STEM, Trade and Entrepreneur teachers should liaise with community resources for subjects-related practical activities in situations where there is a shortage of instructional materials to teach students necessary knowledge and skills.
4. STEM, Trade and Entrepreneur teachers should be encouraged towards the effective use of instructional materials in all their instructional delivery.
5. Teachers should be self-motivated to improvise the engine system model for teaching students to facilitate teaching activities and rate students' understanding of the Engine System theme.
6. Students should be encouraged to enroll for STEM, Trade and Entrepreneur subjects without gender discrimination at all Nigerian schools through regular provision of subjects-related instructional resources.

Acknowledgement

Authors appreciate the efforts of Messrs. A. M. Owoseni and O.O. Atanda of the Department of Physics, University of Lagos; and Messrs. Ikwuonwu J. U. and Aderonmu I. O. of Department of Mechanical Engineering, University of Lagos for their unrelenting support both during design and production exercises. This study was produced from a part of the first author's doctoral thesis.

References

Alanazi, F. (2023). Electric vehicles: Benefits, challenges, and potential solutions for widespread adaptation, *Appl. Sci.*, *13*, 6016. https://doi.org/10.3390/app13106016

Arop, B. A., Umanah, F. I., & Effiong, O. E. (2015). Effect of instructional materials on the teaching and learning of basic science in junior secondary schools in Cross River State, Nigeria. *Global Journal of Educational Research, 14*(1), 67-73. https://doi.org/10.4314/gjedr.v14i1.9

Awolaju, B. A. (2016). Instructional materials as correlates of students' academic performance in biology in senior secondary schools in Osun State. *International Journal of Information and Educational Technology, 6*(9), 705-708. http://www.ijiet.org/vol6/778-PS043.pdf

Chingos, M. W., & Whitehurst, G. J. (2012). *Choosing blindly: Instructional materials, teacher effectiveness, and the common core*. Brown Center on Educational Policy at Brookings. http://www.brookings.edu

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2019). Implications for educational practice of the science of learning and development, *Applied Developmental Science, 24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Fakomogbon, M. A. (2012). Problems of using foreign instructional media in the Nigerian environment, *African Journal of Information Technology, 1*(5), 62-71.

Federal Republic of Nigeria. (2013). *National policy on education*, Lagos: Nigeria Educational Research and Development Council (NERDC).

Harvard Library. (2024). *Teach with 3D content*, https://library.harvard.edu/services-tools/teaching-and-learning-3d-content

Iwu, R. U., Ijioma, B. C., Onoja, A. I., & Nzewuihe, G. U. (2011). Teaching aids: A panacea for effective instructional delivery in biology, *Researcher, 3*(2), 62-65. http://www.sciencepub.net/researcher

Japan Automobile Manufacturers Association Inc. (2015, November). *The motor industry of Japan*, Tokyo: Japan Automobile Manufacturers Association Inc. http://www.jama-english.jp/publications/MIJ2015.pdf

Kehinde, T. M., & Adewuyi, L. A. (2015). Vocational and technical education: A viable tool for transformation of the Nigerian economy, *International Journal of Vocational and Technical Education Research, 1*(2), 22-31. www.eajournals.org

Maxwell, O., Falola, H., Ibidunni, S., & Inelo, F. (2014). An assessment of the taught entrepreneurship program in Nigerian secondary schools. *Merit Research Journal of Education and Review, 2*(11), 257-275. http://www.meritresearchjournals.org/er/index.htm

Mbah, P. E., & Azubuike, O. C. (2015). Towards qualitative teaching of vocational subjects in secondary schools in Nigeria, *American Based Research Journal, 4*(4), 9-15. http://www.abrj.org

National Board for Technical Education. (2016). *NBTE and skilling of young people in Nigeria: Advances and challenges*. Retrieved August 9, 2016, from http://www.nbte.gov.ng/Ileoluji.html

National Science Foundation. (2004). *NSF 04-562: Instructional materials development (IMD)*. https://new.nsf.gov/funding/opportunities/instructional-materials-development-imd/5468/nsf04-562/solicitation

Ndirangu, C. W. (2010). *Teaching methodology*, African Virtual University, http://creativecommons.org/licenses/by/2.5/

Nigerian Educational Research and Development Council. (2017). *Auto mechanical works e-curriculum*. http://www.nerdc.org.ng/eCurriculum

Nikolov, R., Shoikova, E., & Kovatcheva, E. (2014). *Competence based framework for curriculum development*. PICTET: EQF-based professional ICT training for Russia and Kazakhstan, State University of Library Studies and Information Technologies, Russia. https://unesco.unibit.bg

Nwafor, C. E., & Eze, S. O. (2014). Availability and utilization of instructional materials in teaching basic science in selected secondary schools in Abakaliki Education Zone of Ebonyi State, Nigeria, *Global Journal of Bio-Science and Biotechnology (GJBB), 3*(3), 292-295. www.scienceandnature.org

Ogbondah, L. (2008). An appraisal of instructional materials used to educate migrant fishermen's children in Rivers State, Nigeria. *International Journal of Scientific Research in Education (IJSRE), 1*(1), 13-25. http://www.ijsre.com

Ogbu, J. E. (2015). Influences of inadequate instructional materials and facilities in teaching and learning of electrical/electronic technology education courses. *International Journal of Vocational and Technical Education, 7*(3), 20-27. https://doi.org/10.5897/IJVTE2014.0164

Ogunleye, A., & Raheem, I. A. (2013). The development and production of low-cost improvised mobile-micro science apparatus and kits. *UNILAG Journal of Humanities (UJH), 1*(14), 97-108.

Okon, F. I., & Uke, A. F. (2015). Entrepreneur education: A panacea for youth unemployment in Nigeria. *International Journal of Small Business and Entrepreneurship Research, 3*(5), 11-22. http://www.eajournals.org

Olumorin, C. O. (2014). Design and production of 3-dimensional instructional models and specimens. In M. O. Yusuf & S. A. Onasanya (Eds.), *Critical issues in educational technology* (62-68). Ilorin: Department of Educational Technology, University of Ilorin.

Omiko, A., & Oketa, I. O. (2017). Effect of improvised and standard instructional materials on students' achievement in chemistry in secondary schools, *International Research Journal of Natural and Applied Sciences, 4*(6), 58-72. www.aarf.asia

Onasanya, S. A. (2014). Design and production of instructional materials. In M. O. Yusuf & S. A. Onasanya (Eds.), *Critical issues in educational technology* (43-53). Ilorin: Department of Educational Technology, University of Ilorin.

Organisation for Economic Co-operation and Development. (2023). *Review education policies –OECD: Curriculum & instruction time*, https://gpseducation.oecd.org/revieweducationpolicies/#!node=41715&filter=all

School Improvement Network. (2012). *Teaching: Positive vs negative reinforcement*, http://schoolimprovementnetwork.blogspot.nl

Setyowati, L., & Sukmawan, S. (2019). Authentic materials for teaching writing: A critical look. *International Journal of Language Education, 3*(2), 68-77. https://files.eric.ed.gov/fulltext/EJ1244358.pdf

Tahir, E. (2002). Creativity: A new era in educational technology, *The Turkish Online Journal of Educational Technology, 1*(1), 8-20. www.tojet.net

Teplá, M., Teplý, P., & Šmejkal, P. (2022). Influence of 3D models and animations on students in natural subjects, *International Journal of STEM Education, 9*(1), 65. https://doi.org/10.1186/s40594-022-00382-8

Tripura University. (2015). *Educational technology, MA (Education)*. Directorate of Distance Education. https://tripurauniv.ac.in

United Nations. (2022). *Science, technology, engineering and mathematics (STEM) as an enabler for development and peace*, https://www.un.org/osaa/sites/www.un.org.osaa/files/docs/2116613_stem_policy_paper_web_rev.pdf

United Nations Educational, Scientific and Cultural Organization. (2015). *World TVET database Nigeria*. Germany: UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training. www.unevoc.unesco.org

U.S. Department of Education. (2020). *Continuous improvement in education: A toolkit for schools and districts*. Institute of Education Sciences. https://ies.ed.gov/ncee/edlabs/regions/northeast/pdf/REL_2021014.pdf

Verma, D. (2014). *Strategies and theories of vocational education*, New Delhi: Random Publications.

Wangu, M. J. (2014). *The impact of gender differences on students' academic performance in secondary schools in Ndumberi Division, Kiambu County, Kenya in science subjects and languages* (Postgraduate diploma). University of Nairobi. erepository.uonbi.ac.ke

Wicklein, R., Smith, C. P., & Kim, S. J. (2009). Essential concepts of engineering design curriculum in secondary technology education. *Journal of Technology Education, 20*(2), 65-80.

Wrigley-Asante, C., Ackah, C. G., & Frimpong, L. K. (2023). Gender differences in academic performance of students studying science technology engineering and mathematics (STEM) subjects at the University of Ghana, *SN Social Sciences, 3*(1), 12. https://doi.org/10.1007/s43545-023-00608-8

WorldSkills International. (2018). *Automobile technology technical description*, https://www.worldskills.org