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AMALGAMATING WESTERN SCIENCE AND AFRICAN INDIGENOUS KNOWLEDGE SYSTEMS IN THE MEASUREMENT OF GRAVITATIONAL ACCELERATION

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Abstract. *There is the need to liberate the school science teaching process to suit the culturally bound day-to-day experiences of learners. The clarion call becomes expedient in the light of pedagogical failure in science education, which precipitates poor science achievement, especially in non-Western cultures. Non-Western knowledge systems, specifically African indigenous knowledge systems (AIKs), have been excluded from science teaching, which accounts for the poor achievement of learners. This research therefore measured the effect of the type of teaching materials, gender and the interaction between gender and type of teaching materials on the measurement of gravitational acceleration. The analysis of covariance (p≤ .05) was used to analyse data which were collected from 264 sampled learners. The results from the research indicated that amalgamating Western science and culturally bound AIKs teaching materials in a non-Western culture enhanced the determination of gravitational acceleration and bridged the gender divide in Physics achievement. The amalgam of Western science and non-Western culturally bound science can transform science teaching, make science more relevant to everyday experiences of learners and enhance their understanding of science and ultimately their achievement.*

Keywords: *African Indigenous Knowledge Systems, amalgamating, gravitational acceleration and experimental*

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Introduction

Ethnophysics is one of the branches of Ethnoscience teaching strategies. The centre-point of Ethnophysics teaching strategy is the utilization of locally-sourced materials to teach Physics content. The locally sourced materials are nested within the learners' socio-cultural environment. Thus, they constitute what the learners see or play with in their day-to-day life experiences. Teaching Physics with locally sourced materials has the propensity to remove the perceived abstractness in the subject. However, some Physics concepts including but not limited to time may not be effectively measured within the AIKs, thus creating a need to amalgamate AIKs and the Western tradition in an African Physics classroom. Mansour (2009) used the concept Ethnophysics which encapsulates the learners' cultural practices to promote the teaching and learning of the Physics content. Ethnophysics is rooted in the belief system of the Science, Technology and Society (STS) movement as an international research field. Ethnophysics is aimed at exploring the multiple ways through which science and technology transform modern culture, values as well as institutions or vice versa (Mansour, 2009). In line with the above assertion about Ethnophysics, STS is a curriculum approach that strives to inculcate relevance of what is taught to the lives of learners through the indigenous concepts and processes available in "typical science and social studies programs" (Mansour, 2009, p. 287). It should be noted that teaching science and technology from the learners' cultural perspective means more than merely relating traditional concepts and processes to the learners' lives. Rather, how these concepts and processes are treated in society should be determined so that they guide teaching and learning of the subject (Mansour, 2009). There is therefore a need to start from the real-world problems in learners' environments and their own frames of reference.

In the light of the title of this paper, it should be noted that the approach in question is an amalgam approach to teach and learn science that is informed by cultures, values and institutions (Mansour, 2009). According

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to Fourez (1995), the STS movement opposes science teaching that is too theoretical and irrelevant to the learners' daily lives. This implies that the teaching of meaningful science education should reflect the day-to-day activities of the learners which are part and parcel of their cultural worldviews. The learners' background knowledge is basically shaped by their experiences within a culture. Cultural practices can be material or immaterial (Ogunbure, 2011). The material practices are physical objects that exist within the learners' physical or social environment (e.g., dress codes, dance steps, objects of play), whereas immaterial practices are abstract entities (e.g., dialect or language). Often, the materials and language of teaching used in Physics classrooms are not appropriate to the learners' cosmological orientations. Learners come from specific cultures; they have acquired knowledge that is deeply rooted in their cultural practices at different stages of mental and social developments.

Ethnoscience represents the native's thinking about the classification of natural world (Abonyi et al., 2014). Provided Ethnoscience solves part of the problems of a culture, it should be treated with respect and honour. This is because Western science cannot solve all the problems of a given culture. Thus, Ethnoscience provides a basis for the alternative conceptualization of nature. In their empirical investigation, Coll et al (2014) reported that scientists were more open to alternative thinking than could be expected. Open-mindedness is a concept that is emphasized in science education. This suggests that science teachers should create an environment in which different worldviews can be accommodated about addressing the problems and challenges of nature. The cultural experiences which learners encounter during their developmental stages are not easily forgotten as they continue to impact on learning positively or negatively. Therefore, they should not be ignored. Jegede and Okebukola (1991) note the underrepresentation of indigenous people after they have graduated from secondary science education or who are in the science professions – apparently due to the conflict that exists between indigenous knowledge and the Western science knowledge. Gekwerere (2016) blames it on the gap between the science which is taught in schools and the scientific knowledge which is taught in other indigenous contexts. Therefore, meaningful teaching and learning of school Physics in non-Western civilizations can be achieved by properly linking the learners' cultural experiences with the Western Physics content.

The amalgam of Western science and AIKs on African soil is being hypothesized as a way to enhance the meaning of science teaching and learning. The reason for this is the potency of non-Western science to de-emphasize rote learning and mere regurgitation of the science content, including Physics, which hitherto have been the bane of science understanding. Obviously, some of the learners' worldviews cannot be accurately measured. For instance, in terms of the concept of time, morning, afternoon and night are not specific moments in time. These time phases suggest that duration and cannot be measured precisely with a device. Although the concept of time uses the periodical motion that can be measured, some other periodical motions, such as heartbeat, vary in people and therefore cannot be used to measure time accurately. This is confirmed by Mpofu (2016, p. 65), who asserted that in traditional worldviews, time is framed cyclically in relation to space size, progression and continuity. Thus, in indigenous perspectives, time exists in real life happenings as a lived experience such as it pertains to a woman's menstrual cycle (Mpofu, 2016). This, according to Mpofu (2016), differs from the Western tendency to view time quantitatively, numerically, physically and as a measured space. Thus, there is a need to amalgamate various worldviews in as far as teaching and learning school science is concerned in order to overcome any deficiency, including time measurement arising from a particular culture. The amalgam of science teaching strategies informed by various cultures can also make science teaching and learning more functional and interesting to learners.

Through the years, the prevailing teaching approach avoided the use of local materials within the limits of experimental errors in science teaching and learning or treating them as inferior. The consequence of seeing locally sourced teaching materials in non-Western classrooms as inferior has resulted in poor learners' concept formation and achievement in school subjects including Physics. One of the authors of this article has a personal experience with the accreditation team from the West African Examinations Council (WAEC) and its university counterpart, the National Universities Commission (NUC) which is responsible for ensuring high standards of education in the Nigerian universities' departments. Both the accreditation teams seem to support the use of Western materials in teaching much to the disadvantage of indigenous materials. For instance, there was a time when the WAEC accreditation team demanded ray boxes, threads and pendulum bobs as prerequisites for accreditation of a school Physics laboratory, but the team was given paper cartons with crosswires, banana rids and palm nuts as substitutes. The team rejected the materials without knowing that they were close substitutes and could perform similar functions. Such belief that whatever comes from the West is superior to AIKs ignores the open-mindedness that is emphasized in science education. That is an aspect of neo-colonialism and should be condemned.

In response to the belief system that whatever comes from the West is better than AIKs, Emeagwali and Shizha

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(2016) indicate that AIKs followed the trial-and-error method of problem-solving in the discoveries of ancient fire and paint making. Another assertion is that by Gumbo and Mapotse (2020), that paints were used for ornamentation and beauty. AIKs are personally constructed based on the prior cultural experiences of the learners. As with constructivism, Tobin and Tippins (1993) state that scientific knowledge was constructed from personal experiences and was influenced by the social context in which knowledge was constructed. The social context of knowledge construction represents children's environments, which are influenced by their cultural worldviews. Scott and Palincsar (2013, p. 1) cite Vygotsky, who claims that the educational processes that individuals and society go through are interdependent in terms of how they learn and develop. The authors of the current paper identify three themes related to the learners' socio-cultural and mental developments, which include:

- *Intermental and intramental categories*: An individual child's development originates in social sources with his/her cultural development appearing first in the social space between people and within him-/herself. A learner acquires the new strategies and knowledge as he/she participates in learning activities and internalizes the effects of co-construction of knowledge.
- *Human action*: Learners' learning is mediated on the social and individual planes by semiotics such as language, ways of counting, association techniques, mathematic symbol systems. These semiotic means facilitate knowledge co-construction.
- *Examination of the themes above through genetic or developmental analysis*: This relates to observing a child in his or her process of change – his or her nature and essence.

In the light of this discussion, socio-cultural theory (including constructivism) suited the research because of its emphasis on the cultural perspective of science and the social approach to learning. The theory embraces a transmission model in which the cultural meanings from prior generations can be inculcated in children. Deliberations on the socio-cultural theory and its relevance to this research are anchored on the work of Scott and Palincsar. Scott and Palincsar (2013) distinguished between constructivism and socio-cultural theories. Constructivism focuses on the learning and representations which are formed in the mind of the learner, while the socio-cultural theory is about learning through enculturation (Scott & Palincsar, 2013). Scott and Palincsar (2013) claim that these theories may be applied simultaneously in the teaching of science by attending to the learner's knowledge in which science is an active construction, and traditions developed from science over the centuries (science learning as enculturation). Enculturation should not ignore the science that the learner has learnt from home. Hence, the traditions on which the school subject teaching and learning are based must show the amalgam of the in-school and out-of-school conceptualizations, meanings and applications.

Scott and Palincsar (2013) shared the educational implications of socio-cultural theory. According to them, learning should happen through the tenets of cooperative learning, i.e., interaction, negotiation, and collaboration. Attention should be given to discussions, norms and practices which are related to certain communities, including indigenous communities. It is in this light that Scott and Palincsar claim that teaching aims to support learners as they do learning activities, discuss and use tools which are consistent with the community practices they are introduced to, i.e., scientists, mathematicians or historians. The scientific communities should include those from indigenous communities instead of Western communities only. Representations in themselves carry fundamental tones which have a significant psychological effect on learners. By implication, if learners who come from the marginalized communities cannot read the science related work by authors that they know in those communities, they will struggle to make sense of what they learn, as they may not easily identify with the non-indigenous scientists. Indigenous people are underrepresented in science fields (Gekwerere, 2016). As stated above, the socio-cultural theory promotes the co-inquiry strategy in which teachers mediate learners' personal meanings as they emerge from collaborative thinking and talk, as well as the cultural meanings of the wider society. According to the authors, the socio-cultural theory promotes the kind of teaching that can resolve inequalities in the present system of education. Given the impetus of socio-cultural theory, teachers should approach their teaching in such a way that learners' discussions from their homes or societies (first space) and the school-based discussion (second space) combine to form the third space (Scott & Palincsar, 2013, p. 6). Scott and Palincsar (2013) cite Varellas' and Pappas' (2006) research to illustrate fruitful use of discussions in the third space-based teaching which can promote the learning of science. Their research revealed that urban primary school teachers encouraged their learners to explore the phenomena of science (e.g., water cycle) during their class, at their homes and community contexts, to have the first discussions, then consult other textbooks in addition to the prescribed ones (Scott & Palincsar, 2013, p. 6). Hence, the knowledge of science that learners learnt in their indigenous contexts can be used to make

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their learning experiences at school understandable. In addition, since teaching is currently dominated by digital technologies, socio-cultural theory can ensure the multimodal strategies to make the teaching of science relevant to learners. For example, video games, word processors and analytical tools can inculcate added skills and shift the focus from just reading and writing to these multiple strategies.

Cultural forces are exogenous to the prior knowledge systems of learners on which knowledge systems are anchored. However, the socio-cultural theory emphasizes a conceptual change. In AIKs, conceptual change is achieved through trial and error, which is especially possible through collaboration and negotiation of meaning. Moreover, the bottom line of both AIKs and Western knowledge systems is problem-solving, and both systems are dynamic. What may be conceptualized as science today may not necessarily become science tomorrow. This is attributed to the uncontrolled biases in science measurement. In this sense, scientific knowledge is a complex enterprise. Thus, science conceptualization, with its explanations from a particular culture, is not anchored in fairness and truth. Consequently, science and technology evolve from peoples' cultures (Godin & Gingras, 2000; Niculescu, 2016).

The consistent poor state of learner achievement in sciences, including Physics in Nigeria is attributed to pedagogical failure (Nworgu, 2016). Nworgu's observation corroborates Tindimubona (1993), who earlier reported that the method of science teaching in Africa is biased and fails to recognize indigenous knowledge fields and cognition protocols. In a research study conducted by Oladejo et al (2011), learners who were taught Physics with teaching materials which were improvised achieved better results than learners who were taken through the same concept with Western teaching materials. The aforementioned authors further reported that gender and its interaction with method were not significant in the Physics achievement. Therefore, there is a need to recognize AIKs and cognition protocols and their amalgamation with Western science to produce teaching that can address the shortcomings of using only Western teaching materials in non-Western classrooms. The teaching amalgam can improve the understanding of science and solve the problem of consistent poor achievement in external Physics examinations.

The external Physics examination is usually made up of three parts, namely theory, objective and practical. The WAEC Resume of Chief Examiners' Report for the Science Papers (n.d.) indicate that Physics learners' weaknesses in the practical Physics examination included the wrong determination of physical laws and the candidates' inability to plot graphs to the accuracy of the chosen scales. Also, the National Business and Technical Examinations Board (NABTEB) Chief Examiners' Report (2017) in Nigeria attested to learners' poor achievement in Physics. In addition to other factors, NABTEB attributes poor achievement in Physics to poor graphing skills among learners.

Accurate readings and good graphing skills are necessary for the determination of physical laws in Physics, one of which is gravitational acceleration (*g*). Simply put, *g* is the object receiving an acceleration due to the force of gravity acting on it. It has a value of about $9.8\frac{m}{s^2}$. Physics learners are normally tested by external examination bodies in West Africa on the measurement of the value of g using a variety of techniques that are rooted in simple harmonic motion, including the simple or compound pendulum. From a Western point of view, the simple pendulum equipment includes a stop clock, calibrated metric ruler, pendulum bob, inextensible string, boss, clamp, and retort stand. From the AIKS' perspective, banana rids processed from the banana trunk and normally used as one of the masquerade costumes in Igbo culture were used as inextensible strings, palm nuts were used as pendulum bobs and a retort stand was replaced with a bamboo stand. The amalgam of the teaching materials therefore became a stop clock, a calibrated metric ruler, banana rids, palm nuts and a bamboo stand.

Another source of concern to science teachers is gender disparity in achievement. Gender disparity in science achievement basically reflects the differential ability levels of male and female science learners in science examinations. The differentials in Physics achievement by gender is a cog in the wheel of progress towards realizing the science-for-all policy objectives of the United Nations. In support of gender disparity in Physics achievement, Eryilmaz (2004) indicated that gender is one of the variables that contribute towards poor achievement in Physics. Therefore, there is a need in Physics for the type of teaching materials that are capable of forestalling achievement differentials among learners on the basis of gender. Besides, the hallmark of the research was to compare the scores of Physics learners in the determination of gravitational acceleration, based on the teaching materials-type and gender.

Research Purpose

This research measured the (i) effect of teaching materials-type on the measurement of gravitational acceleration, (ii) influence of gender on the measurement of gravitational acceleration, and (iii) the interaction effect of teaching materials-type with gender on the measurement of gravitational acceleration.

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Hypotheses

The following null hypotheses which were tested at .05 level of significance, guided the research:

$H0_1$: There is no significant difference of mean between teaching materials-type in the measurement of gravitational acceleration.
$H0_2$: There is no significant difference of mean between male and female Physics learners in the measurement of gravitational acceleration.
$H0_3$: Interaction of teaching materials-type with gender is not a meaningful variable in determinant of the measurement of gravitational acceleration.

Research Methodology

Research Design

This research was conducted during March 2021. It adopted a pre-test-post-test non-equivalent control-group research design. The design was deemed appropriate for the research because of the non-randomization of the senior secondary 2 Physics learners in their respective classes. Intact classes were used which were assumed to have varying abilities in achievement.

Sample

The sample size comprised of 264 (143 males and 121 females) senior secondary two (SS2) Physics learners. This sample consisted of 214 (119 females and 95 males) for the two experimental groups and 50 learners (31 female and 19 male) for the control group. The sample is assumed to be representative of the SS2 Physics learners' population of 5343 (PPSMB Nsukka Zone, 2021) in Nsukka Education Zone of Enugu State in Nigeria by virtue of the design of this research. Taro Yarmane's method for measuring sample size at .05 tolerance error was used (Yamane, 2016). Initially, only the intact classes were used. Nsukka Education Zone consists of three local Government areas, which are Uzo-uwani, Nsukka and Igbo Etiti Local Government Areas (LGAs). Enugu State has 17 LGAs. One intact class each was sampled from Community Secondary School Nkpologu and Community Secondary School Adaba all in Uzo-uwani. One intact class each was also sampled from Community High School Ekwegbe and Community Secondary School Aku, all of which are in Igbo-Etiti Local Government Area. The schools in Uzo-Uwani and Igbo-Etiti are mixed schools. Three intact classes from three schools nested within Nsukka Local Government Area were sampled. The schools included Queen of the Rosary secondary school Nsukka (QRSSN) and St Teresa's College (STC). QRSSN and STC are single-sex schools. Specifically, balloting with replacement was used in sampling the schools from the list of schools nested within each LGA and the SS2 science class in schools with multiple streams of SS2 science classes. Two out of the six schools were randomly assigned to the control group while the remaining four became the experimental groups. Two schools were sampled for the first and second experimental groups using simple random sampling.

Instrument and Validation

The instruments used for data collection included a stop clock, calibrated meter rule, banana rids and palm nuts. Other instruments were a bamboo stand, a science notebook and a practical guide for g measurement. The practical guide, which was developed by the researchers initially contained 50 skills. Twenty (20) copies of the practical guide scored polytomously were administered on the parallel sample. The preliminary data collected were validated using a polytomous-only item response theory (IRT) model, and a specifically generalized partial credit model (GPCM). GPCM is the most appropriate model for validating achievement-type questions, specifically essay questions where marks are awarded in parts (Guyer & Thompson, 2014). Forty-three (43) of the 50 practical skills for g measurement emerged as valid skills.

The first five measurement skills included the correct measurements of 0.10m, 0.20m, 0.30m, 0.40m and 0.50m lengths, L of banana rids. The second set of five measurements included a measurement of the first time (*t1*) for each of the lengths. The third set included the measurement of the second time (*t2*) for each of the lengths. The fourth, fifth, sixth and seventh sets of the five measurements included the measurement of mean time ($\dot{t}$) of *t1* and

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t2 in seconds, period T= ($\dot{t}$/10) for ten oscillations, $\log_{10}$ L and $\log_{10}$ T in each of the five lengths. Graphing skills included the correct scale on vertical and horizontal axes, presence of zero-zero origin, correct units on vertical and horizontal axes and correct plotting of each of the five points on a graph of $\log_{10}$ L against $\log_{10}$ T. Other graphing skills included drawing the best line of fit, correct slope determination, correct determination of vertical intercept and correct evaluation of $g = 10^{(vertical\ intercept + 2log\pi + 2log2)}$. $\log_{10}\pi = 0.4971$. $\log_{10} 2$=0.3010.

Experimental Procedure

The first experimental group was taught measurement of gravitational acceleration using the Western-type teaching materials. The second experimental group was taught same concept using the amalgam of Western-type teaching materials and AIKs. The control group was taught the same content through the lecture method. However, both groups were given the pre-test and post-test. The experiment lasted for four weeks during the second term of 2019/2020 session which was conducted in the first quarter of year 2021 due to Covid-19 pandemic.

Data Analysis

The collected data were calculated through the arithmetic mean and standard deviations because the data were continuous in nature. The mean and standard deviations provided descriptive measures to be used for significance testing. The analysis of covariance (ANCOVA) was engaged to test the hypotheses at .05 level of significance because it equalised any variation (at statistical level) in the initial ability of the learners occasioned by their non-randomization into approximately equal ability groups prior to the present research. Under the SPSS version 20 environment, the data were loaded. The independent variables, i.e., methods and gender, were loaded on the independent variable field while data on post-test were loaded as the dependent variable. The pre-test was loaded under the covariate field. The model was full factorial with type 111 error rate. Scheffe test was used for post hoc analysis.

Research Results

Table 1 shows the descriptive statistics of Physics learners' scores in gravitational acceleration measurement by method and gender. From Table 1, the female learners who were exposed to lecture (EXPG0) seemed to perform better than their male counterparts. The female learners had a group mean score of 21.20 while the male learners had a group mean of 18.45. The standard deviation of the group means of female and male learners were 1.42 and 1.23 respectively. The group mean of male learners in the control group appeared more stable than the mean of their female counterparts. The female learners who were exposed to the Western science-type teaching materials (EXPG1) seemed to perform better than their male counterparts, achieving a mean score of 35.23. Their male counterparts had a mean score of 34.29. However, the mean score of the female learners relative to their male counterparts in EXPG1 appeared to be more stable, with a lower standard deviation score of 0.67.

Table 1
Descriptive Statistics of Physics Learners' Scores in Gravitational Acceleration Measurement by Method and Gender

	Teaching materials-type		Male	Female	Total
Teaching Materials-type	Lecture (EXPG0)	*M*	18.45	21.20	19.65
		SD	1.23	1.42	1.35
		N	39	19	50
	Western science-type teaching materials (EXPG1)	*M*	30.29	35.23	33.53
		SD	0.95	0.67	0.78
		N	36	48	84
	Amalgamated Western science and AIKs type teaching materials (EXPG2)	*M*	38.87	39.32	39.07
		SD	0.71	0.84	0.76
		N	59	63	130
	Total	*N*	134	130	264

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The female learners who were exposed to the amalgam of Western science and AIKS-type of teaching materials (EXPG2) seemed to perform better than their male counterparts in the measurement of gravitational acceleration. The female learners in the Western-type teaching materials (EXPG1) had a mean score of 35.23, while their male counterparts had a lower mean score of 30.29. Although the male learners appeared to have a lower mean score relative to their female counterparts, the mean score for the male learners appeared to be less stable and had a higher standard deviation score of .95 while that of the female learners was .67. A closer look at Table 1 reveals that the group mean of 39.07 for EXPG2 was the highest of the three followed by the group mean of 33.53 for EXPG1. The least group mean of 19.65 was for EXPG0. The standard deviation of 0.76 for EXPG2 indicated that the mean was the most stable, followed by EXPG1 with standard deviation of 0.78. The least standard deviation was 1.35 for EXPG0.

The results in Table 2 show the analysis of ANCOVA for the Physics learners' scores on gravitational acceleration measurement.

Table 2
ANCOVA for Physics Learners' Scores on Gravitational Acceleration (g) Measurement

Source	Dependent variable	Type III sum of squares	*df*	Mean square	*F*	*p*
Corrected model	*g* measurement	617.530[a]	3	205.843	1.825	.161
Intercept	*g* measurement	25644.217	1	25644.217	227.346	.002
Teaching_materials type	*g* measurement	347.095	2	447.230	2.431	.002
Gender	*g* measurement	224.392	1	304.377	1.430	.017
Teaching_materials_ type x gender	*g* measurement	332.022	1	238.351	3.327	.031
Error	*g* measurement	3835.130	262	112.798		
Total	*g* measurement	249711.399	264			
Corrected total	*g* measurement	4452.661	263			

a. *R* squared = .116 (Adjusted *R* squared = .109)

In Table 2, the calculated F-value of 2.431 for teaching materials-type had a probability value of .002. The .002 probability value is less than .05 set out for the research. This result reveals a significant difference between the Physics learners in the treatment group and their counterparts who were exposed to a lecture in the measurement of gravitational acceleration, in favour of the treatment groups. Furthermore, the calculated F-value of 1.430 for gender had a probability value of .017. The .017 probability value is less than .05 set out for the research. This result reveals a significant difference in the measurement of gravitational acceleration between the male and female Physics learners in the treatment groups and their counterparts who were exposed to lecture. The interaction effect of the teaching materials-type and gender had a probability value of .031 for an f value of 3.327. Since .031 is less than .05, a significant difference existed between the interaction of the teaching materials-type and gender. The result also indicated that the amount of adjusted variance in the measurement of gravitational acceleration accounted for by the main and interaction effects was .109.

Table 3 shows the Scheffe's post-hoc confirmatory test of hypotheses for the main effects of teaching materials-type and gender.

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Table3
Scheffe's Post-hoc Confirmatory Test of Alternative Hypotheses

Groups		Mean difference	*SE*	*t*	*p*Scheffe
LECTURE	EXPG1	13.88	.105	10.938	< .001
LECTURE	EXPG2	19.44	.040	19.476	< .001
EXPG1	EXPG2	5.54	.049	8.499	< .001
TEACHING MATERIALS INTERACTION	LECTURE	22.87	.208	2.876	< .001
MALE(EXPG1)	FEMALE(EXPG1)	4.49	.104	1.06	< .001
MALE(EXPG2)	FEMALE(EXPG2)	0.45	.112	2.431	.101

The value of probability due to the t-test value of 10.938 was less than .001 for the mean difference between the Physics learners who were exposed to the lecture and the Western science-type teaching materials. Since the probability value is less than .001, which is less than .05, it confirms the result of a significant difference between the two groups, in favour of EXPG1. The value of probability due to the t-test value of 19.476 was less than .001 for the mean difference between the Physics learners who were exposed to the lecture and the teaching amalgam. Since the probability value is less than .001, which is less than .05, it confirms the result of a significant difference between the two groups, in favour of EXPG2. The value of probability due to the t-test value of 8.499 was also less than .05 for the mean difference between the Physics learners who were exposed to the EXPG1 and EXPG2. Since the probability value is less than .05, it confirms the result of a significant difference between the two groups, in favour of EXPG2. The male and female learners nested within EXPG1 group had a probability value less than .001, which is less than the .05 level of significance set out for the research. This indicated that male and female learners exposed to the Western-type instructional materials vary in their measurement of gravitational acceleration. However, the male and female learners nested within EXPG2 group had a probability value of .101, which is more than the .05 level of significance set out for the research. The result indicated no significant difference between male and female learners exposed to the teaching materials amalgam in the measurement of gravitational acceleration.

Discussion

The results of this research revealed that the teaching materials-type was a meaningful determinant of measurement of gravitational acceleration. Both the Western science-type and the amalgam of Western science-type and AIKs were better than the lecture method. Most importantly, the amalgam of the Western science-type and AIKs relative to the Western science-type teaching materials in the non-Western culture is better in promoting gravitational acceleration measurement. The result partly supports Oladejo et al's (2011) finding, who reported that the non-Western learners who were exposed to the teaching materials drawn from their immediate environment achieved better results in Physics than their counterparts who were only exposed to the Western science-type teaching materials. Risdianto et al (2020) conducted a study in Bengkulu City in Sumatra Island to learn the effect of critical thinking skills after the ethnoscience-based direct instruction learning model was used in Physics learning. The authors employed the control and experimental in two Grade XI Natural Science classes of a secondary school. Using a t-test analysis technique, their research revealed similar results in the sense that the ethnoscience-based direct instruction learning model influenced the learners' critical thinking skills positively. The need for amalgamating the Western and non-Western teaching materials has been invoked to correct some deficiencies in learning science offered by the use of a particular teaching material within a culture. The result of the research showed a cultural hybridization in science learning. The interaction of teaching materials from different cultures produces the desired effect in science learning. It is in this light that Anthony (2017, p. 62) advises that linkages between schools and indigenous knowledge systems institutions be established to forge amalgamation of science

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programmes and existing indigenous systems to ensure effective hybridization, incubation, skill acquisition and sustainable development. Furthermore, the results attested to Mansour's (2009) finding that Ethnoscience emphasizes the teaching and learning of Physics content using learners' cultural practices. Anthony (2017, p. 62) adds that Ethnophysics is about the knowledge of indigenous culture which serves as "a base for the construction of reality by linking culture to advanced scientific knowledge". The need for the amalgam of teaching materials from different cultures is that some cultures may have a comparative advantage over others in the measurement of physical quantities, including time, length, and mass. The Western progressivist tradition of education which gives primacy to Western culture has been observed by Watkins and Noble (2008) specifically in the treatment of the Chinese learners. Furthermore, the result in favour of the use of the teaching materials amalgam from different cultures can be attributed to the value of the hybridization of teaching materials in the teaching and learning of science. Therefore, the integration of local and foreign teaching materials paved the way for meaningful learning.

The male and female Physics learners who were exposed to the teaching materials amalgam had no significant difference in the measurement of gravitational acceleration. This implies that the teaching materials amalgam was able to bridge the gender gap in terms of achievement in Physics. The reason for gender equality in achievement as a result of using the teaching amalgam may be that both male and female learners' attitudes towards Physics were equally boosted. Learners became enthusiastic about Physics when they discovered that their cultural activities could be used to teach and learn science. The traditional thinking that science is a male dominated subject (Miller et al., 2018) can be countered by amalgamating AIKs with the conventional content and methods of teaching to increase female learners' interest in science. The infusion of AIKs into the Physics classroom implicated high ego among the learners as the teaching and learning of Physics was domesticated. In addition, the learners now see Physics as a daily human activity rather than an abstract subject.

The interaction of the teaching materials-type with gender was a meaningful variable in the measurement of gravitational acceleration. In the context of the teaching materials amalgam, a balance was struck between the male and female Physics learners in the measurement of gravitational acceleration.

Amalgamating Western science and AIKS plays a role in boosting learner performance and plays a partial role in the competitive performance of both male and female learners. Alternative pedagogical approaches such as knowledge co-construction, collaboration, negotiation, discourse, inquiry and discovery make this amalgam possible. These approaches are related to the socio-cultural theory, as discussed according to Scott and Palincsar (2013). Since a learner's cognitive development is influenced by his or her socio-cultural context (intermental and intramental), science education should be conceptualized by relating it to the epistemologies that are informed by learners' communities and taught from a third space.

Conclusion and Implications

The result of the research showed that the amalgam of Western science and AIKS teaching materials was a meaningful factor in the measurement of gravitational acceleration. The teaching materials amalgam promoted gender equality in the measurement of gravitational acceleration. The interaction effect of the teaching materials with gender was a determinant of the measurement of gravitational acceleration. It is therefore recommended that Physics teachers in non-Western classrooms utilize the amalgam of local and foreign teaching materials in science teaching and learning. This has implications for other subjects too. The amalgam of Western science or other subjects and AIKs will help learners to learn from one another in terms of their understandings of science or other subjects from their respective cultural contexts. Moreover, this kind of dual approach to teaching, accompanied by amalgamating the teaching materials from both worlds, can boost the participation and performance of girls in science learning – a field that has traditionally been reserved for males. Hence, the main contribution of this research is in showcasing the amalgam of Western science and AIKs specifically in terms of the teaching materials-type and gender, and the resultant higher achievement and understanding of Physics. The uniqueness of the research lies in the transformation of teaching Physics by incorporating AIKs. Teachers can harness the opportunities that the local context can offer in terms of teaching resources and other aspects, which can be amalgamated with foreign ones. It would be valuable if this research could be extended to other subjects and aspects of the curriculum such as content, assessment, and language of teaching.

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Declaration of Interest

Authors declare no competing interest.

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