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Adaptation of Meta-Cognitive Awareness Inventory in Physics (MAIP) for Public and Private Senior Secondary School Nigerian Students

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Abstract

Purpose: The study focused on the adaptation of the Meta-Cognitive Awareness Inventory in Physics (MAIP) for senior secondary school students in Nigeria, both in public and private schools. **Methodology:** The study employed an adaptation research design. The sample included 1,382 SSII students who had taken Physics as a subject. To ensure its validity, the MAIP underwent face validation by five experts. Construct validation of the MAIP was conducted using factor analysis. This involved applying the principal component analysis extraction method and the Varimax rotation method with Kaiser Normalization. Items with a factor loading of 0.40 or higher on any of the factors were selected to be included in the instrument. The coefficient of internal consistency was calculated using Cronbach's Alpha and was found to be 0.78. Research question 1 was addressed through factor analysis, while research question 2 was answered by calculating the coefficient of internal consistency using Cronbach's Alpha. Research question 3 was answered by calculating means and standard deviations. The null hypothesis was tested using an independent t-test at a significance level of 0.05. **Findings:** The findings of the study revealed that the MAIP consisted of 52 factorially simple or pure items and 23 factorially complex items based on their factor loadings. **Significance:** The coefficient of internal consistency for the MAIP was found to be 0.98. Furthermore, a statistically significant difference in the mean meta-cognitive awareness ratings was observed between students in private and public schools, favoring students in private senior secondary schools when using the MAIP.

Keywords: adaptation, construct validity, meta-cognition, meta-cognitive awareness, reliability, school type, usability of instrument.

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Introduction

Meta-cognition plays an important role in the learning of Physics because it may help students become capable of planning, monitoring, and evaluating the effectiveness of their learning. It can answer questions related to development in cognitive and affective areas. Meta-cognition has also been described as one's ability to know and regulate cognitive processes, calibrate or monitor one's performance, and chart learning plans based on learning and performance estimates and our understanding of cognitive processes and how we use them to learn and remember (Salari et al., 2013). Additionally, meta-cognition enables students to solve new problems by retrieving and deploying strategies they have learned in similar contexts (Ozturk, 2017). Therefore, to help students learn Physics effectively, teachers need to enhance their students' use of meta-cognition so that they gain control and awareness of themselves as learners.

Meta-cognitive awareness is a crucial factor in attaining reasonable academic excellence. It refers to an individual's personal understanding of their cognitive and affective state, as well as their ability to consciously regulate their own learning. The impact of meta-cognitive awareness on students' academic achievement has been found to be statistically significant (Mohammed, 2015; Dogra, 2016; Aurah, 2018). Additionally, Sawhney & Bansal (2015) identified significant differences between undergraduate students categorized into high and low meta-cognitive awareness groups, in terms of their academic achievement. However, Yilmaz & Yalcin (2012) discovered that students' levels of success did not necessarily reflect their levels of knowledge. These students experienced difficulties when attempting to convert procedural knowledge into declarative knowledge, which in turn hindered their understanding of Newton's laws of motion. Consequently, students with low meta-cognitive awareness often struggle to solve non-routine physics problems.

To measure meta-cognition, the Meta-cognitive Awareness Inventory (MAI) developed by Schraw & Dennison (1994) and the Junior Meta-cognitive Awareness Inventory (Jr.MAI) developed by Sperling, Howard, Miller, & Murphy (2002) are widely used. These inventories are considered domain-general meta-cognitive instruments rather than domain-specific instruments for Physics. However, the question of whether meta-cognitive awareness should be domain-general or domain-specific remains unresolved. Considering the domain-specific nature of meta-cognitive awareness, it becomes imperative to develop a Physics-specific Meta-cognitive Awareness Inventory.

The development of an instrument is the most important part of conducting a quality instrumentation or developmental research study. A developmental study takes cognizance of several salient steps, including the content outline, objectives of the instrument, construction of items, face validation, item selection, trial testing, item analysis, reliability of the instrument, norming, inventory manual, final production, and marketing of the inventory and its manual, among others (Emaikwu, 2011; Nworgu, 2015). Therefore, the development and factorial validation of the Meta-cognitive Awareness Inventory in Physics (MAIP) for Senior Secondary School Nigerian students involved a number of steps, beginning with the content outline.

The content outline of the Meta-cognitive Awareness Inventory in Physics (MAIP) was prepared based on the components of meta-cognitive awareness, which include declarative, procedural, and conditional knowledge, as well as planning, monitoring, evaluation, debugging, and information management. After the content outline, the objective of the instrument was specified in order to develop a valid and reliable Meta-cognitive Awareness Inventory in Physics (MAIP) and utilize the instrument based on school location, students' gender, and school type. The items on the Meta-cognitive Awareness Inventory in Physics (MAIP) were constructed to reflect the components of meta-cognitive awareness. The instrument was then submitted to experts for critiquing and weighting to ensure face validity. The criticisms, suggestions, and inputs of the experts were considered to produce a working instrument, which was used for trial testing to generate data for item analysis and assess the internal consistency of the Meta-cognitive Awareness Inventory in Physics (MAIP) for Senior Secondary school students (Emaikwu, 2011).

Item analysis was carried out to establish the construct validity of Meta-cognitive Awareness Inventory in Physics (MAIP). Construct validation was done using factor analysis. Having executed the item analysis, the items that have satisfactory statistical qualities are selected for inclusion on the final form of the instrument. Then the instrument is assembled in the form that it should be. The assembly is based on the ease with which students can understand what to do, when and where to respond as well as the ease with which the researcher can locate and rate students' responses. The responses are used for the establishment of reliability index of the instrument. Having selected and assembled the inventory items, the next thing is to go for final testing by administering the inventory on a fairly large sample of students similar to those whom the inventory is intended (Nworgu, 2015). However, the present study would be limited to establishing the construct validity of Meta-cognitive Awareness Inventory in Physics (MAIP).

The validity of an instrument refers to the extent an instrument measures what it is designed to measure (Nworgu, 2015). Validity of an instrument is purpose dependent; this implies that, an instrument which is valid for one purpose may not be valid for another. For instance, construct validity is the extent to which a particular test can be shown to measure a hypothetical construct or trait (Nworgu, 2015; Emaikwu, 2019). It is also the purity with which an instrument measures any construct it is designed to measure. Establishing construct validity involves a statistical procedure called factor analysis.

Factor analysis is a mathematical procedure which can be used in describing certain areas of nature. According to Emaikwu (2011) factor analysis refers to a variety of statistical techniques whose common objective is to present a set of variable in terms of smaller number of hypothetical variables. The rationales for factor analysis are to investigate pattern of relationship

to identify whether the correlation between a set of observed variables stem from their relationship to one or more variables in the data, analyze the structure of a phenomena and development of measurement scale which is Meta-cognitive Awareness Inventory in Physics (MAIP) (Geisinger, 2016). This is because, meta-cognitive awareness is a construct that does not lend itself to experimental manipulations.

The initial consideration involves sample size. The initial considerations according to Andy (2006) involves Kaiser-Meyer-Olkin Measure of sampling adequacy (KMO) and Bartlett's Test of Sphericity to check for sampling adequacy, assumption of sphericity respectively and communality which is the proportion of common variance present in a variable. The factor extraction is either based on Kaiser recommendation of retaining all factors with eigenvalues greater than 1 or Jollife suggestion of retaining all factors with eigenvalues more than 0.7 (Andy, 2006). The use of Scree plots is important because factor rotation should not be based on these criterions alone. It is pertinent to note that, the minimum number of factors that will best explain the data set or structure of the instrument as well as the factor loading of each item on each of the factors will emerge after rotation.

Factor loading are the relative contributions that a variable makes to a factor. Based on a predetermined minimum loading, the researcher selects only those items that are highly loaded on any factor. An item that loads highly on one factor is said to be pure or factorially simple. On the other hand, if an item loads highly on two or more factors, it is said to be factorially complex. The quality of the items of Meta-cognitive Awareness Inventory in Physics (MAIP) is also ascertained in terms of its internal consistency which is the reliability index.

Reliability of an instrument is the degree of consistency with which a measuring instrument measured what it is supposed to measure (Nworgu, 2015). For an instrument to be reliable, it has to show consistency between independent measurements of the same phenomena over times. Thus, it is the stability, dependability and predictability of a measuring instrument in producing consistent set of results in subsequent measures (Emaikwu, 2011; Nworgu, 2015). In this study, the reliability index of Meta-cognitive Awareness Inventory in Physics (MAIP) for students is established using Cronbach's Alpha. The estimate of internal consistency provides a measure of how homogenous or otherwise the items are. As a result, the present study took the position that, research instrument is best served by improvement in its reliability and usability.

The usability of an instrument refers to the extent to which the majority of the people meant to use the instrument can easily use it given the realities and practical conditions around (Emaikwu, 2011). In other words, usability of a test refers to the degree to which a test can be successfully used by the classroom teachers and administrators without undue expenditure of time, money and energy and the extent to which the examinees can understand the items and finish the test without experiencing fatigue, stress or boredom. Therefore, this study found the extent to which the secondary students can easily use Meta-cognitive Awareness Inventory in Physics (MAIP) to determine their level of meta-cognitive awareness in both public and private secondary schools may also need investigation.

The influence of school type on students' meta-cognitive awareness and academic performance in Physics has been a concern for all Physics education researchers and other researchers. Yet no consistent conclusion has emerged. For instance, Pillas & Manjobi (2011) found that, the type of school has strong relationship with academic performance in favour of private schools since their teachers are more likely to use innovative teaching methods. However, Sabitu, Babatunde & Oluwole (2012); Jaleel & Premachandran (2016) found no significant difference in the meta-cognitive awareness of Senior Secondary students based on type of management of the school and that students are identically distributed. The inconsistency in research reports could be attributed to the fact that, the teachers were unable to take into cognizance the level of their students' meta-cognitive awareness in Physics.

One of the basic problems of the study in the field of meta-cognition is the development and use of valid and reliable instrument for determining the level of students' meta-cognitive awareness. Literature is replete with evidence which suggests that, students irrespective of their location are unable to solve non-routine Physics problems due to low meta-cognitive awareness. Students that are aware of their thinking may be more strategic to perform better than those who are unaware. But how can students use meta-cognitive strategies in Physics while learning if they are not aware of their meta-cognition? Therefore, the determination of learners' meta-cognitive awareness level, would put the Physics teacher and student in a better position to decide what can be done and how, what will not work and why.

Research Questions

The following research questions were raised to guide the study:

1. What is the construct validity of the items of the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary schools in terms of their factor loadings?
2. What is the internal consistency reliability index of the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary schools in Nigeria?
3. What is the mean meta-cognitive awareness rating of students in public and private schools using the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary schools in Nigeria?

Hypothesis

Is there a significant difference in the mean meta-cognitive awareness rating of students in public and private schools using Meta-Cognitive Awareness Inventory in Physics (MAIP) for secondary schools in Nigeria?

Materials and methods

The study adopted an adaptation research design. The population for the study comprised all 15,030 SSII science students in public and private secondary schools. The sample comprised 1,382 SSII students who offered Physics as a school subject for the 2020/2021 Academic Session. The instrument for data collection was the Meta-cognitive Awareness Inventory in Physics (MAIP). The Meta-cognitive Awareness Inventory in Physics (MAIP) was face-validated by five experts, and their observations were used for the review of the instrument's items. Construct validation was carried out on the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary schools to establish its construct validity using factor analysis. This was based on the extraction method of principal component analysis and the rotation method of Varimax with Kaiser Normalization.

The item selection was done using the rotated component matrix. The items with a factor loading of 0.40 and above on any of the factors were identified and selected to form part of the instrument. The coefficient of internal consistency was obtained through Cronbach's Alpha and was found to be 0.78. Research question 1 was answered using factor analysis. Research question 2 was answered using the coefficient of internal consistency obtained through Cronbach's Alpha. Research question 3 was answered using the mean and standard deviations. The null hypothesis was tested using an independent t-test at a 0.05 level of significance. The choice of the independent t-test as a statistical technique was based on the fact that each of the null hypotheses dealt with two self-determining groups.

Results and Discussions

Table 1

Construct Validity of the Items of Meta-cognitive Awareness Inventory in Physics (MAIP) in Terms of their Factor Loadings

Factor 1				Factor 2		Factor 3		Factor 4		Factor 5	
Item	Loading	Item	Loading	Item	Loading	Item	Loading	Item	Loading	Item	Loading
9	0.56	33	0.62	1	0.62	2	0.60	3	0.56	8	0.43
10	0.65	34	0.64	4	0.50	6	0.48	7	0.47	9	0.41
11	0.63	35	0.65	5	0.62	44	0.47	31	0.49	16	0.49
12	0.55	36	0.57	6	0.42	51	0.65	38	0.50	49	0.41
13	0.64	37	0.56	8	0.62	54	0.44	52	0.53	56	0.49
14	0.64	38	0.43	11	0.42	55	0.49	59	0.46	65	0.42
15	0.68	39	0.64	29	0.43	58	0.58	63	0.47	70	0.50
16	0.56	40	0.59	32	0.58	61	0.45	66	0.69		
17	0.58	41	0.61	33	0.45	62	0.46	73	0.67		
18	0.63	42	0.70	39	0.41	63	0.44	74	0.43		
19	0.66	43	0.67	40	0.42	65	0.52				
20	0.67	44	0.67	46	0.49	68	0.45				
21	0.70	45	0.65	47	0.41	71	0.50				
22	0.66	46	0.57	53	0.73	72	0.48				
23	0.57	47	0.50	54	0.44	75	0.54				
24	0.71	48	0.55	57	0.64						
25	0.72	49	0.67	60	0.68						
26	0.69	50	0.65	61	0.45						
27	0.45	55	0.41	62	0.42						
28	0.69			64	0.65						
29	0.60			67	0.69						
30	0.50			68	0.47						
31	0.64			75	0.45						
32	0.46			76	0.40						

Table 1 reveals the construct validity of the items of Meta-cognitive Awareness Inventory in Physics (MAIP) for senior secondary students in terms of their factor loadings. The table shows that 43 items loaded above 0.40 on factor 1, 24 items loaded above 0.40 on factor 2, 15 items loaded above 0.40 on factor 3, 10 items loaded above 0.40 on factor 4, and seven items loaded above 0.40 on factor 5.

The table indicates that items 1, 2, 3, 4, 5, 7, 10, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 34, 35, 36, 37, 41, 42, 43, 45, 48, 50, 51, 52, 53, 55, 56, 57, 58, 59, 60, 64, 66, 67, 70, 71, 72, 73, 74 and 76 loaded more than 0.4 on only a factor. The loading of the items on only one factor shows that the items are factorially simple or pure items. The table further reveals that items 6, 8, 9, 11, 16, 29, 31, 32, 33, 38, 39, 40, 44, 46, 47, 49, 54, 61, 62, 63, 65, 68, and 75 loaded more than 0.4 on two factors. The loading of these items on more than one factor shows that these items are factorially complex. Therefore, the construct validity of the items of the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary school students in terms of their factor loadings is that, the MAIP has 52 factorially simple or pure items and 23 factorially complex items in terms of their factor loadings.

Table 2

Estimates of coefficient of Internal Consistency of Components of Meta-cognitive Awareness Inventory in Physics (MAIP)

Cluster	Components of Meta-cognition	No of Items	Reliability Index
1	Declarative	15	0.92
2	Procedural	8	0.89
3	Conditional	6	0.87
4	Monitoring	8	0.91
5	Evaluation	11	0.93
6	Debugging	8	0.87
7	Planning	6	0.82
8	Information Management	13	0.91
Full Length Reliability		75	0.98

Table 2 shows the coefficient of internal consistency of the clusters of Meta-cognitive Awareness Inventory in Physics (MAIP) and the overall coefficient of internal consistency of the Meta-cognitive Awareness Inventory in Physics (MAIP). The table reveals that declarative knowledge with 15 items has coefficient of internal consistency of 0.92 while procedural knowledge with eight items has coefficient of internal consistency of 0.89, and conditional knowledge with six items has coefficient of internal consistency of 0.87. The table further reveals that, monitoring with eight items has coefficient of internal consistency of 0.91 while evaluation with 11 items has coefficient of internal consistency of 0.93 but debugging with eight items has coefficient of internal consistency of 0.87 and planning with six items has coefficient of internal consistency of 0.82, then information management with 13 items has coefficient of internal consistency of 0.91. Based on excellent reliability (0.90 and above), high reliability (0.70-0.90), moderate reliability (0.50-0.70) and low reliability (0.50 and below). The coefficients of internal consistency of the sub-scales show that, declarative knowledge, monitoring, evaluation and information management have excellent internal consistency while procedural knowledge, conditional knowledge, debugging and planning have high internal consistency. The coefficient of internal consistency of Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary school Nigerian students is 0.98. This coefficient shows that the Meta-cognitive Awareness Inventory in Physics (MAIP) has excellent internal consistency hence reliable.

Table 3

Mean and Standard Deviation of Meta-cognitive Awareness Ratings of Students in Public and Private Secondary Schools using Meta-cognitive Awareness Inventory in Physics (MAIP)

School Type	N	Mean	Standard Deviation	Standard Error
Public	635	1.98	0.47	0.01
Private	747	2.71	0.62	0.02
Mean difference		0.73	0.15	

Table 3 shows the mean and standard deviation of meta-cognitive awareness of 635 students in public senior secondary schools and 747 students in private senior secondary schools. The table reveals that, the mean meta-cognitive awareness rating of students in public senior secondary schools is 1.98 with a standard deviation of 0.47. The table further indicates that, the mean meta-cognitive awareness rating of students in private senior secondary schools is 2.71 with a standard deviation of 0.62. These obtained mean and standard deviations shows that students in public senior secondary schools are more homogenous in their meta-cognitive awareness rating than their counterparts in private senior secondary schools. The difference in the mean meta-cognitive awareness rating of students in public and private schools using Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary schools in Nigeria is 0.73 in favor of students in private schools. To ascertain if the difference in the mean meta-cognitive awareness of students in public and private senior secondary schools was statistically significant, the corresponding hypothesis was tested.

Table 4

t-test for Mean Meta-cognitive Awareness ratings of Students in Public and Private Secondary Schools using Meta-cognitive Awareness Inventory in Physics (MAIP)

School Type	N	Mean	Standard Deviation	t	df	Sig	Remark
Public	635	1.98	0.47	-24.487	1380	0.000	Sig
Private	747	2.71	0.62				

N = Number of respondents, t = Critical value of t-test, df = Degree of freedom

Table 4 shows that, the probability associated with the critical value of t (-24.487) at df = 1380 is 0.05. Since the probability value of 0.000 is less than the 0.05 level of significance, the test statistic is significant, and as such, the null hypothesis is rejected. Thus, there is a significant difference in the mean meta-cognitive awareness ratings of students in public and private schools in favor of private schools using the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary schools in Nigeria. This implies that students in private schools have a higher meta-cognitive awareness rating than public secondary school students. Hence, school type is a factor in the meta-cognitive awareness rating of students using the Meta-cognitive Awareness Inventory in Physics (MAIP).

The study found that the Meta-cognitive Awareness Inventory in Physics (MAIP) has excellent psychometric properties of construct validity. Findings from a principal components analysis with varimax rotation conducted on the Meta-cognitive Awareness Inventory in Physics (MAIP) for senior secondary school students revealed equivalence in the pattern of factor loadings of the ratings of the Meta-cognitive Awareness Inventory in Physics (MAIP). A higher percentage of the items in the Meta-cognitive Awareness Inventory in Physics (MAIP) are factorially simple or pure. Few items were cross-loaded on more than one interpretable factor and were considered factorially complex.

Explicitly, the high number of factorially simple or pure items found in this study may be due to the high mean meta-cognitive awareness ratings found for students in urban areas and private senior secondary schools across the area of study. Furthermore, the complex items of the Meta-cognitive Awareness Inventory in Physics (MAIP) in terms of their factor loadings may be the result of the interaction between the shifting conception of meta-cognition and external effects such as the students' culture, background, and learning styles. The difference in conception could be a measurement artifact arising from biases that are typically found in self-reported inventories, such as the Meta-cognitive Awareness Inventory in Physics (MAIP).

The finding agrees with that of Fung & Leung (2017) that factor analysis with Oblimin rotation yielded four factors classified as prediction, planning, monitoring, and evaluation according to the content of the items. The finding also agrees with that of Harrison & Vallin (2017) that the 52 items function better as two theoretical dimensions, knowledge and regulation, than as a single dimension. Even though the two dimensions correlated strongly, the factor structure better explained the empirical data than the unidimensional model. It was also found that this theoretical structure fit better than the one based on Schraw and Dennison's exploratory factor analysis, which questions scoring procedures based on that structure. The finding concurs with that of Sirajuddin et al. (2018) that the empirical validation resulted in 45 valid items in topics such as Newton's law, gravitational force, work and energy, momentum and impulse, and harmonic motion, and I-KPS is a valid instrument both theoretically and empirically. The finding also agrees with that of Arum et al. (2019) that the assessment instrument is valid in content validation and empirical validation and is able to measure Physics problem-solving skills. The finding agrees with that of Panaoura & Philippou (2019) that the first-order factor contained items for the knowledge of cognition, and a different first-order factor contained items for the regulation of cognition. The finding is consistent with that of Haeruddin et al. (2020) that the Physics Meta-cognition Inventory (PMI) has good valid psychometric properties. Therefore, the PMI can be used to measure the level of meta-cognition of students when solving physics problems. However, the finding disagrees with that of Teo & Lee (2012) that the eight-factor hypothesized model underlying the responses to the 52 items in the MAI did not fit adequately.

The findings regarding the coefficient of internal consistency of the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary school Nigerian students reveal that each cluster of the MAIP has a high and excellent coefficient of internal consistency. The coefficient of internal consistency of the Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary school students was 0.98. This coefficient shows that the Meta-cognitive Awareness Inventory in Physics (MAIP) has excellent internal consistency, which is considered reliable.

The high coefficient of internal consistency found for the Meta-cognitive Awareness Inventory in Physics (MAIP) among secondary school students may be attributed to the fact that the instrument measures the acquisition of domain-specific awareness within the specific subject matter of instruction. The high coefficient of internal consistency found for the clusters of the Meta-cognitive Awareness Inventory in Physics (MAIP), along with the coefficient of internal consistency of the instrument, demonstrates the consistency of the ratings for different items within the same construct being measured. The reliability results determine the extent to which individual differences in the ratings on the inventory are attributed to true differences in the constructs or to the characteristics of students offering Physics as a school subject in the study area. It helps determine whether the observed individual differences are simply a result of chance or biased errors. The findings reveal that the Meta-cognitive Awareness Inventory in Physics (MAIP) has displayed high and excellent reliability, indicating minimal error or variance.

The findings also agree with those of Heli et al. (2017) that the internal consistency of all the factors was found to be good. Moreover, the Alpha of the entire questionnaire was 0.90. The finding is consistent with that of Rahmawati et al. (2018), indicating that the value of the reliability coefficient (α) of 0.87 indicated that the instrument of the Conception Test on Electrical and Magnetism topics was valid and sufficient to measure students' conception of the electrical and magnetism topic. The finding is consistent with that of Sirajuddin et al. (2018), stating that the reliability coefficient of the Science Process Skills Instrument (I-KPS) is 0.935, demonstrating that the I-KPS is a reliable instrument both theoretically and empirically. The finding agrees with that of Unlu & Dokme (2019), indicating that the measurement reliability of the sub-scale ranges from 0.87 to 0.72, and the Cronbach's Alpha reliability coefficient for the whole scale was calculated as 0.92. The finding agrees with that of Panaoura & Philippou (2019), showing that the inventory demonstrated an overall high reliability of Cronbach's Alpha 0.83. The finding is consistent with that of Azza & Mundilarto (2020), stating that the reliability of the items of Physics Cognitive Learning Achievement was 0.89 for the ability ranging from -2 to 2, with a standard error of measurement of 0.23, which means it was in a very high category. The finding is consistent with that of Ike, Harry, & Agus (2020), stating that the result of this research obtained a reliable Concept Mastery Test that is enriched with all four types of representations.

Findings regarding the mean meta-cognitive awareness ratings of students in public and private secondary schools using the Meta-cognitive Awareness Inventory in Physics (MAIP) revealed that school type influenced the mean meta-cognitive awareness of students in Physics. It was found that there was a significant difference in the mean meta-cognitive awareness ratings of students in private and public senior secondary schools, favoring students in private senior secondary schools who used the Meta-cognitive Awareness Inventory in Physics (MAIP). This implies that students in public and private senior secondary schools demonstrate a discrepancy in their mean meta-cognitive awareness in physics, as indicated by the ratings on the Meta-cognitive Awareness Inventory in Physics (MAIP). The finding contradicts that of Jaleel & Premachandran (2016), who found no significant difference in the meta-cognitive awareness of secondary school students based on the type of school management, and that students are identically distributed among each group in terms of meta-cognitive awareness.

The significant difference found in the mean meta-cognitive awareness of students in public and private senior secondary schools, favoring students in private schools based on Meta-cognitive Awareness Inventory in Physics (MAIP) ratings, may be attributed to the fact that students in private secondary schools exhibit a higher level of meta-cognitive thinking about their learning activities compared to their counterparts in public secondary schools. Students in private schools may be encouraged to explore alternative approaches to learning, monitor their learning progress, evaluate the effectiveness of their strategies, and use feedback from their teachers to prepare for future physics lessons. These factors enable them to develop greater awareness and control over their learning process, thereby enhancing their meta-cognitive awareness in Physics. Additionally, the significant difference found in terms of lower mean meta-cognitive awareness among students in public senior secondary schools based on Meta-cognitive Awareness Inventory in Physics (MAIP) ratings could also be attributed to the fact that teachers in public secondary schools may not adequately consider the level of their students' meta-cognitive awareness during physics classes.

Conclusions

The Meta-cognitive Awareness Inventory in Physics (MAIP) for secondary school Nigerian students had excellent psychometric properties of construct validity, reliability and usability. The Meta-cognitive Awareness Inventory in Physics (MAIP) is effective in determining the level of meta-cognitive awareness in Physics of students in private and public senior secondary schools in Nigeria.

Recommendations

The following recommendations were made in the light of the findings of this study:

1. Educational administrator like State Ministry of Education should organize seminars, workshops or symposia for Physics teachers on the relative effectiveness of Meta-cognitive Awareness Inventory in Physics (MAIP) in the teaching and learning process in both private and public senior secondary schools, in order to improve their students' level of meta-cognitive awareness irrespective of their school location.
2. Researchers should adapt/adopt Meta-cognitive Awareness Inventory in Physics (MAIP) in other studies that involve meta-cognitive awareness. This is because the MAIP has excellent psychometric properties of construct validity, reliability and usability.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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APPENDIX

META-COGNITIVE AWARENESS INVENTORY (MAI)

PART A: Demographic Information of the Students

INSTRUCTION: Please tick (√) as appropriate

School Location Urban ☐ Rural ☐

PART B

This instrument contains a number of statements. It is simply a matter of what is true for you. There are no 'right' or 'wrong' answers but your opinion is what is needed. For each statement, tick (√) A if you ALWAYS do it; U if you USUALLY do it; S if you SOMETIMES do it; NA if you NOT AT ALL do it. Suppose you AGREE with a statement then tick A, if you change your mind about the option, cross it out and tick another one. Although some statements are fairly similar to others, you are required to indicate your opinion about all statements.

CLUSTER 1: Declarative

S/No	Statements	A	U	S	NA
1	I am aware of my strengths while learning in Physics				
2	I am aware of my weaknesses while learning in Physics				
3	I know what skills are most important in Physics in order to be a good student				
4	I have control over how well I learn in Physics				
5	I know what I am expected to learn in Physics				
6	I know how well I have understood the concepts I have studied in Physics				
7	I can learn more about a concept in Physics on which I have previous knowledge				
8	I am good at remembering information in Physics				
9	I learn more in Physics when I am interested in the topic				
10	I know how well I did once I finish a test in Physics				
11	I learn best in Physics when I know something about the topic				
12	I know what the teacher expects me to learn in Physics				
13	I have a specific reason for choosing each learning strategy I use in Physics				
14	I focus on the meaning of new information in Physics				
15	I focus on the significance of new information in Physics				
	CLUSTER 2: Procedural	**A**	**U**	**S**	**NA**
16	I try to use learning strategies that have worked in the past				
17	I have a specific reason for choosing each learning technique I use in Physics				
18	I find myself using helpful learning strategies automatically in Physics				
19	I change strategies when I fail to understand concepts in Physics				
20	I consider several alternatives to a problem in Physics before I answer				
21	I slow down when I encounter important information in Physics				
22	I periodically review to help me understand important relationships in Physics				
23	I try to translate new information into my words				
	CLUSTER 3: Conditional	**A**	**U**	**S**	**NA**

24	I use my strengths to compensate for my weaknesses in my learning in Physics				
25	I can motivate myself to learn Physics when I really need to learn				
26	I use different learning strategies in Physics depending on the situation				
27	I know when each learning technique I use in Physics will be most effective				
28	My performance in Physics depends on my effort				
29	I am aware of what strategies I use when I study Physics				
	CLUSTER 4: Monitoring	**A**	**U**	**S**	**NA**
30	I ask myself periodically if I meet my learning goals in Physics while I am learning				
31	I find myself assessing how useful my learning strategies in Physics are while I am learning				
32	I check regularly the extent I comprehend content in Physics while am learning				
33	I ask myself questions about how well I am doing in Physics while I am learning				
34	I examine my own performance in Physics while I am studying a new content				
35	I ask myself how well I have accomplished my learning goals in Physics once I finished				
36	I find myself pausing regularly to check my comprehension in Physics				
37	I ask myself if what I am reading is related to what I already know in Physics				
	CLUSTER 5: Evaluation	**A**	**U**	**S**	**NA**
38	I ask myself if I could have used different strategies after each learning experience in Physics				
39	After learning a point in Physics, I ask myself if I will learn it more effectively next time				
40	I ask myself if I have considered all possible options after learning a point in Physics				
41	After I finished learning Physics I know how well I performed on it				
42	After I finish leaning Physics I repeat the most important points in order to be sure that I have learnt them				
43	I re-evaluate my assumptions in Physics whenever I get confused				
44	I stop and re-read whenever I get confused while learning Physics				
45	I ask myself periodically if I am meeting my learning goals in Physics				
46	I find myself analyzing the usefulness of strategies while learning in Physics				
47	I ask myself if there was an easier way to do things in Physics after I finish a task				
48	I am a good judge of how well I understand concepts in Physics				
	CLUSTER 6: Debugging	**A**	**U**	**S**	**NA**
49	I read instructions carefully before I begin a task in Physics				
50	I think about what I really need to learn before I begin a task in Physics				
51	I usually summarize what I have learnt in Physics after I finish				

52	I consciously focus my attention on important information in Physics				
53	I am good at organizing information in Physics				
54	I think of several ways to solve a problem in Physics and choose the best one				
55	I ask others for help when I do not understand any concept in Physics				
56	I focus on overall meaning rather than specifics in Physics				
	CLUSTER 7: Planning	**A**	**U**	**S**	**NA**
57	I pace myself while I am learning Physics in order to have enough time				
58	I set my specific learning goals before I start learning Physics				
59	I ask myself questions about the learning materials I am going to use in Physics				
60	I organize my time to best accomplish my learning goals				
61	I define specific goals before my attempt to learn something				
62	I use the organization structure of the text to help me learn				
	CLUSTER 8: Information Management	**A**	**U**	**S**	**NA**
63	While I am solving a problem in Physics, I wonder whether if I answer its major questions				
64	Before I present the final solution of a problem in Physics, I try to find some other related solutions as well				
65	Whenever I encounter difficulty in Physics in my attempt to solve a problem I try to solve it again				
66	Whenever I try to solve a problem in Physics I pose questions to myself in order to concentrate on it				
67	Whenever I finish my work in Physics I wonder whether I have learnt new important things				
68	I know ways to remember knowledge I have learnt in Physics				
69	I stop and go back over new information that is not clear to me in Physics				
70	I use examples to make concepts in Physics clearer				
71	I draw picture or diagram while learning Physics to simplify it				
72	I try to translate new information into my own word in Physics				
73	I try to break topics in Physics down into sub-topics and learn in steps				
74	I think about several alternatives to a problem in Physics before I answer				
75	I create my own examples to make concepts in Physics more meaningful to me				