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Teachers' and Students' Perceptions of the Use of Instructional Materials and Students' Understanding of Mathematics Concepts in Senior Secondary Schools in Port Harcourt Metropolis, Rivers State, Nigeria

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Abstract **Original Research Article**

This study examined how mathematics teachers and Senior Secondary 2 (SS2) students in Port Harcourt metropolis, Rivers State, Nigeria, perceive the contribution of instructional materials to students' understanding of mathematics concepts. Three research questions and three null hypotheses guided the study, which used a descriptive survey design. The sample comprised 150 mathematics teachers (purposive sampling) and 320 SS2 students (stratified random sampling; sample size from the Taro Yamane formula). Data were collected with a 4-point rating scale on three areas: posters for teaching Pythagoras' theorem, improvised audio-visual aids (slide projector with audio-tape player) for revising trigonometric ratios and identities, and three-dimensional models for areas and volumes of plane and solid shapes. Data were analysed with means, standard deviations and the z-test at the 0.05 level. Both groups rated all three types of material above the criterion mean of 2.50, and no significant difference was found between teachers and students in any area. The study concludes that teachers and students share a positive view of these materials as aids to understanding mathematics and recommends instructional resource centres, training of teachers in improvisation, and combining materials with teacher explanation.

Keywords: instructional materials, mathematics education, teachers' perceptions, students' perceptions, senior secondary school, Nigeria.

Introduction

Mathematics underpins science, technology and everyday decision-making. It is a gateway subject for further study in Nigeria. Yet students' achievement in the subject has remained a concern for many years. Recent studies continue to describe poor performance in national examinations and low learning gains among secondary school students (Malik & Saddiq, 2024; Muraina et al., 2021). Part of the difficulty is that many mathematical ideas are abstract. When lessons rely mainly on talk and chalk, learners are asked to understand relationships that they cannot see, touch or link to familiar experience.

One widely recommended response is to make abstract ideas visible through instructional materials. Mainali (2021) argues that representations such as diagrams, pictures, objects and symbols are central to teaching and learning mathematics, and that understanding grows when learners move between different representations of the same idea. Concrete and virtual manipulatives have been reported to benefit pupils at different achievement levels (Ahmad & Siller, 2024). In Nigeria, studies in Ogun, Kwara and Cross River States link the use, and especially the improvisation, of instructional materials and activity-based methods with better learning in mathematics (Malik & Saddiq, 2024; Muraina et al., 2021; Oribhabor, 2020).

Three areas of the senior secondary mathematics curriculum make the case for instructional materials particularly clear. Pythagoras' theorem depends on seeing the relationship between the sides of a right-angled triangle. Trigonometric ratios and identities need repeated revision and recall. Areas and volumes of plane and solid shapes are difficult to grasp without three-dimensional objects. Posters, improvised audio-visual aids and models are low-cost options that match these three needs. Evidence on audio-visual media is encouraging but not uniform: video generally improves learning in higher education (Noetel et al., 2021), educational television has been associated with higher mathematics capability among Tanzanian children (Watson et al., 2021), but technology-based interventions in Africa as a whole show mixed results (Evans & Mendez Acosta, 2021).

Whether materials are actually used depends on what teachers and students think of them. Teachers decide what to bring into the classroom, and students' acceptance determines whether the materials engage them. Research shows that teachers' and students' perceptions of classroom practice often differ (Fitzgerald et al., 2020; Holzer et al., 2023). It is therefore useful to ask not only whether each group values instructional materials but also whether the two groups agree. This study does so for senior secondary schools in Port Harcourt metropolis.

Statement of the Problem

Senior secondary mathematics covers a wide content area, and several topics need visual or audio-visual support to become meaningful to learners. In Port Harcourt metropolis, many students who sit the senior school certificate mathematics examination do not achieve the results they need. Many classrooms depend mainly on explanation and chalkboard work, and facilities that help learners form mental pictures of abstract ideas are limited. What is not well documented is how teachers and students in this metropolis perceive specific, low-cost materials (posters, improvised audio-visual aids and models) and whether the two groups agree. Without such evidence, schools and education authorities lack a clear basis for deciding which materials to provide or improvise. This study was designed to fill that gap.

Research Questions

The following research questions guided the study:

1. To what extent do mathematics teachers and SS2 students perceive posters as contributing to students' understanding of Pythagoras' theorem?
2. To what extent do they perceive improvised audio-visual aids (a slide projector synchronised with an audio-tape player) as contributing to the revision, retention and recall of trigonometric ratios and identities?
3. To what extent do they perceive models such as cuboids, cones and cylinders as contributing to students' understanding of areas and volumes of plane and solid shapes?

Hypotheses

Three null hypotheses were tested at the 0.05 level of significance. They are:

H01. There is no significant difference between the mean ratings of mathematics teachers and SS2 students on the contribution of posters to students' understanding of Pythagoras' theorem.

H02. There is no significant difference between their mean ratings on the contribution of improvised audio-visual aids to the revision, retention and recall of trigonometric ratios and identities.

H03. There is no significant difference between their mean ratings on the contribution of models to students' understanding of areas and volumes of plane and solid shapes.

Review of Related Literature

Conceptual Review

Instructional materials and mathematical representation

Mathematics is largely the study of abstract ideas, and Mainali (2021) regards representation as the means by which these ideas become accessible to learners. In this view, a mathematical idea can be expressed through objects, pictures, diagrams, spoken or written words and symbols, and understanding is strengthened when a learner can move from one form to another. Instructional materials can therefore be seen as the carriers of representation in the classroom. They are not a substitute for the teacher's explanation; they give the explanation something concrete to refer to. In this study, instructional materials are the objects, images and sounds that a teacher uses to help students understand a mathematics topic.

Posters and visual displays

Mayer (2021) maintains that people learn better from words and pictures together than from words alone, provided the two are presented in a way that does not overload the learner. On this view, a poster that pairs a labelled right-angled triangle with a short statement of the rule serves a learner better than the rule on its own. Sweller et al. (2019) add that working memory can hold only a limited amount of new information at a time, so instruction should be designed to remove unnecessary effort. A poster that remains on the classroom wall can serve this purpose because learners can return to it during a lesson and during later revision without having to rebuild the figure in their heads.

Models and concrete objects

Mainali (2021) places concrete objects at the foundation of the range of representations, from which learners move to pictures and then to symbols. Three-dimensional models of cuboids, cones and cylinders fit this view well, because area and volume are properties of solid objects that are hard to appreciate from a flat diagram on the chalkboard. Handling a model allows the learner to link the formula to the shape it describes. Models can also be improvised from cardboard, paper and other cheap local materials, which makes them practical in schools where commercial equipment is scarce.

Audio-visual materials

Audio-visual materials combine pictures with sound. Mayer (2021) presents a modality principle, which holds that learners may do better when pictures are accompanied by spoken explanation than when the same pictures carry long printed text, since the eyes and ears each carry part of the load. For revision of trigonometric ratios and identities, a set of slides shown through a projector with a recorded explanation on an audio-tape player is an inexpensive way of putting this principle into practice. The same slides and recording can be repeated as often as needed, which suits topics that depend on frequent recall. Mayer (2021) also cautions that adding pictures or sound without regard to how learners process them can do more harm than good, so the materials need to be planned and linked to the teacher's lesson.

Theoretical Framework

The study rests on two connected theories. Cognitive load theory explains that learning is limited by the small capacity of working memory and that good instruction reduces effort that does not contribute to learning (Sweller et al., 2019). The cognitive theory of multimedia learning extends this idea to the combination of words, pictures and sound, and sets out principles for designing materials that help learners to select, organise and connect information (Mayer, 2021). Both theories lead to the expectation that clear posters, models and well-planned

audio-visual aids will be seen as helpful for understanding abstract mathematics, and that teachers and students who experience them will rate them favourably.

Empirical Review

Malik and Saddiq (2024) used a quasi-experimental design with 65 senior secondary students in Obafemi Owode Local Government Area, Ogun State. Students taught mensuration with instructional materials understood the concept better and recorded significantly greater mean gains than those taught by conventional methods. Muraina et al. (2021), in an ex post facto survey of 372 respondents from ten local government areas in Kwara State, reported that mathematics learning gains correlated significantly with teachers' improvisation (r = .863) and utilisation (r = .783) of instructional materials; together the two variables accounted for 74.5% of the variance in learning gains. Oribhabor (2020) studied activity-based teaching with 96 students in two senior secondary schools in Calabar and recommended that teachers be trained and retrained in activity-based methods to make learning more interesting. Malik et al. (2021) examined the usability of mathematics laboratory facilities in relation to junior secondary students' achievement in number and numeration. Watson et al. (2021) analysed data on 38,682 Tanzanian children and found that normal exposure to an educational television cartoon was significantly associated with mathematics capability.

The evidence on audio-visual media is positive but depends on how the media are used, and teachers and students do not always see classroom practice in the same way. The Nigerian studies reviewed focus on achievement in one or two topics, and none compares teachers' and students' perceptions of several specific materials. This study addresses that gap for three curriculum areas in Port Harcourt metropolis.

Methodology

A descriptive survey design was used because the aim was to describe and compare the opinions of two groups, teachers and students, without manipulating any variable. The study therefore measures the perceived contribution of instructional materials; it does not measure achievement. It was carried out in Port Harcourt metropolis, made up of Port Harcourt and Obio/Akpor Local Government Areas of Rivers State. Records obtained from the Rivers State Secondary School Board (personal communication, 2020) showed 80 mathematics teachers in 20 senior secondary schools in Obio/Akpor and 70 mathematics teachers in 18 senior secondary schools in Port Harcourt Local Government Area, together with 1,601 SS2 students (837 in Port Harcourt and 764 in Obio/Akpor). All 150 teachers were included through purposive sampling. For students, the Taro Yamane formula, $n = N / (1 + Ne^2)$, with a margin of error of 0.05, gave a sample of 320 from 1,601, selected by stratified random sampling with local government area and school location as strata as shown in table 1.

Table 1: *Population and Sample of the Study*

Group	Port Harcourt LGA	Obio/Akpor LGA	Population	Sample
Mathematics teachers	70	80	150	150
SS2 students	837	764	1,601	320

Data were collected with a researcher-designed rating scale that had parallel teacher and student versions. Section A collected background information. Sections B to D contained 15 items on the three areas of the study, five items each: posters and Pythagoras' theorem, improvised audio-visual aids and trigonometric ratios and identities,

and models and areas and volumes. Responses were Strongly Agree (4), Agree (3), Disagree (2) and Strongly Disagree (1). Face and content validity were confirmed by two supervisors and two senior lecturers in the Department of Curriculum Studies and Instructional Technology. Reliability was established with the split-half method on 10 teachers and 10 students outside the sample. For teachers, the correlation between the two halves was .79, and the Spearman–Brown correction gave a coefficient of .88. For students, the coefficient was 0.80.

The researcher explained the purpose of the study to the respondents, administered the scale personally and collected it immediately. Item means and standard deviations were computed from response frequencies. The criterion mean was 2.50, so an item with a mean of 2.50 or above was read as "Agree", and an item below 2.50 as "Disagree". Cluster means and standard deviations were obtained by averaging the item values within each area. The hypotheses were tested with an independent-samples z-test at the 0.05 level (critical z = 1.96, two-tailed), and Cohen's d was calculated as an indication of effect size.

Results

Research Question 1: To what extent do mathematics teachers and SS2 students perceive posters as contributing to students' understanding of Pythagoras' theorem?

Table 2: *Teachers' and Students' Ratings of the Contribution of Posters to Understanding Pythagoras' Theorem*

Item	Teachers M	Teachers SD	Students M	Students SD	Decision
Drawing right-angled triangle	3.17	0.81	3.17	0.83	Agree
Identifying the hypotenuse, opposite and adjacent sides of a right-angled triangle.	3.21	0.84	3.16	0.84	Agree
Recall of relevant formula in calculating the missing sides and angles of a given triangle.	3.07	0.92	3.14	0.86	Agree
Solving problems on applications of Pythagoras theorem	3.05	0.88	3.23	0.78	Agree
Demonstrating that the square of the hypotenuse side is equal to the sum of square of the other two sides.	3.07	0.83	3.11	0.87	Agree
Cluster mean	**3.11**	**0.86**	**3.16**	**0.84**	**Agree**

Table 2 shows that teachers' item means ranged from 3.05 to 3.21 and students' from 3.11 to 3.23. All items were above the criterion mean of 2.50, so both groups agreed that posters contribute to students' understanding of drawing right-angled triangles, identifying sides, recalling formulae, solving problems and demonstrating the theorem. The cluster means were 3.11 for teachers and 3.16 for students.

Research Question 2: To what extent do they perceive improvised audio-visual aids (a slide projector synchronised with an audio-tape player) as contributing to the revision, retention and recall of

trigonometric ratios and identities?

Table 4: *Ratings of the Contribution of Improvised Audio-Visual Aids to Revision, Retention and Recall of Trigonometric Ratios and Identities*

Item	Teachers M	Teachers SD	Students M	Students SD	Decision
Audio-visual item 1	3.05	0.85	3.13	0.88	Agree
Audio-visual item 2	3.17	0.84	3.10	0.89	Agree
Audio-visual item 3	3.08	0.87	3.23	0.78	Agree
Audio-visual item 4	3.09	0.84	3.12	0.92	Agree
Audio-visual item 5	3.11	0.83	3.02	1.00	Agree
Cluster mean	**3.10**	**0.84**	**3.12**	**0.89**	**Agree**

As shown in Table 4, teachers' item means ranged from 3.05 to 3.17 and students' from 3.02 to 3.23. Both groups agreed that synchronising slides with an audio-tape player supports revision, retention and recall of trigonometric ratios and identities. The cluster means were 3.10 (teachers) and 3.12 (students).

Research Question 3: To what extent do they perceive models such as cuboids, cones and cylinders as contributing to students' understanding of areas and volumes of plane and solid shapes?

Table 6: *Ratings of the Contribution of Models to Understanding Plane and Solid Shapes*

Item	Teachers M	Teachers SD	Students M	Students SD	Decision
Area of rectangle	3.28	0.65	3.27	0.82	Agree
Volume of a cuboid	3.21	0.61	3.20	0.83	Agree
Volume of a cylinder	3.12	0.60	3.26	0.75	Agree
Volume of a cone	3.06	0.77	3.33	0.80	Agree
Surface area of a cylinder	3.33	0.83	3.36	0.66	Agree
Cluster mean	**3.20**	**0.69**	**3.28**	**0.77**	**Agree**

Table 6 shows that teachers' item means ranged from 3.06 to 3.33 and students' from 3.20 to 3.36. Both groups agreed that models help students to understand the area of a rectangle, the volumes of a cuboid, cylinder and cone, and the surface area of a cylinder. The cluster means (3.20 for teachers and 3.28 for students) were the highest of the three areas.

Hypotheses

Hypothesis 1 (H01): There is no significant difference between the mean ratings of mathematics teachers and SS2 students on the contribution of posters to students' understanding of Pythagoras' theorem.

Table 3: *Z-Test of the Difference between Teachers' and Students' Mean Ratings on Posters*

Group	N	M	SD	SE	z-cal	z-crit	p	Decision
Teachers	150	3.11	0.86	0.084	0.58	1.96	.56	Not rejected
Students	320	3.16	0.84					

Table 3 shows that the calculated *z* of 0.58 is smaller than the critical *z* of 1.96 at the .05 level ($p = .56$). The null hypothesis is therefore not rejected which means that there is no significant difference between the mean ratings of mathematics teachers and SS2 students on the contribution of posters to students' understanding of Pythagoras' theorem.

Hypothesis 2 (H02): There is no significant difference between the mean ratings of mathematics teachers and SS2 students on the contribution of improvised audio-visual aids to the revision, retention and recall of trigonometric ratios and identities.

Table 5: *Z-Test of the Difference between Teachers' and Students' Mean Ratings on Improvised Audio-Visual Aids*

Group	N	M	SD	SE	z-cal	z-crit	p	Decision
Teachers	150	3.10	0.84	0.085	0.24	1.96	.81	Not rejected
Students	320	3.12	0.89					

Table 5 shows that the calculated *z* of 0.24 is smaller than the critical *z* of 1.96 ($p = .81$), so the null hypothesis is not rejected. Teachers and students do not differ significantly in their ratings of improvised audio-visual aids.

Hypothesis 3 (H03): There is no significant difference between the mean ratings of mathematics teachers and SS2 students on the contribution of models to students' understanding of areas and volumes of plane and solid shapes.

Table 7: *Z-Test of the Difference between Teachers' and Students' Mean Ratings on Models*

Group	N	M	SD	SE	z-cal	z-crit	p	Decision
Teachers	150	3.20	0.69	0.071	1.21	1.96	.23	Not rejected
Students	320	3.28	0.77					

Table 7 shows that the calculated *z* of 1.21 is smaller than the critical *z* of 1.96 ($p = .23$), so the null hypothesis is not rejected. Students' mean rating was slightly higher than teachers', but the difference is not significant.

Discussion of Findings

Posters and Pythagoras' theorem

Teachers and students agreed that posters help learners to understand Pythagoras' theorem. This matches the conceptual position that pairing pictures with words serves learners better than words alone and that visual representations make relationships between the sides of a triangle easier to see and translate into symbols (Mayer, 2021; Mainali, 2021). It also fits the expectation from cognitive load theory that a display which stays in view reduces the effort of holding a figure in mind (Sweller et al., 2019). Malik and Saddiq (2024) also found that students taught with instructional materials understood mensuration better than those taught conventionally.

Furthermore, the hypothesis tested revealed that there was no significant difference between the mean ratings of mathematics teachers and SS2 students on the contribution of posters to students' understanding of Pythagoras' theorem, since the calculated z-value of 0.58 was less than the critical value of 1.96, with a p-value of .56. Consequently, the first null hypothesis was not rejected. This suggests that teachers and students hold similar views about the usefulness of posters in making the relationships and principles underlying Pythagoras' theorem more accessible. This finding differs from studies in which teachers and students perceived classroom practices differently (Fitzgerald et al., 2020; Holzer et al., 2023).

Improvised audio-visual aids

Both groups agreed that synchronised slides and audio support revision, retention and recall of trigonometric ratios and identities. This agrees with the modality principle of Mayer (2021) and the finding of Muraina et al. (2021) that teachers' improvisation of materials was strongly related to mathematics learning gains. Noetel et al. (2021) found that adding video to existing teaching produced larger gains than replacing it, while Watson et al. (2021) found a positive association between educational television and mathematics capability. Together, these findings suggest that audio-visual aids work best as a complement to the teacher's explanation. The mixed record of technology in Africa is a reminder that such aids must be properly planned and used for their benefits to be realised (Evans & Mendez Acosta, 2021).

The hypothesis test further established that the difference between teachers' and students' mean ratings of improvised audio-visual aids was not statistically significant. The calculated z-value of 0.24 was below the critical value of 1.96, with a p-value of .81. Therefore, the second null hypothesis was not rejected. This indicates that both groups share similar perceptions of the contribution of improvised audio-visual aids to the revision, retention and recall of trigonometric ratios and identities.

Models of plane and solid shapes

Models received the highest ratings from both groups. This agrees with the view of Mainali (2021) that concrete objects are important in mathematical representation because area and volume are properties of solid objects. It also matches the report that manipulatives benefit learners at different achievement levels (Ahmad & Siller, 2024) and the attention given to mathematics laboratory facilities in Nigerian studies (Malik et al., 2021). The relatively high ratings suggest that teachers and students recognise the value of physical representations in connecting mathematical formulae with the shapes and objects they describe.

The corresponding hypothesis test showed that the difference between teachers' and students' mean ratings was not statistically significant. The calculated z-value of 1.21 was lower than the critical value of 1.96, with a p-value of .23. Consequently, the third null hypothesis was not rejected. Although students recorded a slightly higher mean rating than teachers, the difference was insufficient to establish a statistically significant variation in their perceptions.

Conclusion

The effective teaching of mathematics requires more than the presentation of formulae and procedures; it requires instructional experiences that enable learners to connect abstract mathematical ideas with representations they can see, interpret and relate to their immediate environment. Instructional materials therefore have an important place in creating meaningful mathematics learning experiences, particularly in topics that depend on visualisation, repeated practice and concrete understanding.

Mathematics instruction should therefore, not be limited to explaining what mathematical concepts mean but should also provide learners with opportunities to see, explore and understand how they work. The purposeful use of instructional materials, supported by teachers' professional competence and adequate institutional provision, offers a practical pathway towards making mathematics more accessible, meaningful and engaging for senior secondary school students.

Recommendations

Based on the findings, the following recommendations are made:

1. Mathematics teachers should use relevant posters, models and audio-visual aids when teaching Pythagoras' theorem, trigonometry and mensuration.
2. Teachers should improvise low-cost materials where standard equipment is not available, for example charts, cut-out shapes and cardboard models.
3. School authorities and professional bodies should organise workshops on the design and use of instructional materials, with attention to how the materials are combined with teacher explanation.
4. Government should provide well-equipped instructional resource centres in senior secondary schools.

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