Difficult topics in junior secondary school mathematics: practical aspect of teaching and learning trigonometry

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ABSTRACT

This paper presented the practical aspect of teaching and learning Trigonometry to serve as a guide to both teachers and students of Mathematics. It is aimed at reducing the level of difficulties teachers and students of mathematics are facing in terms of delivery and comprehension. The paper identifies Trigonometry as a difficult topic alongside simultaneous linear equation, word problems and change of subject of a formula that causes challenges to both Mathematics teachers and educators. Problems of teaching and learning as well as the strategies that could be employed in teaching and learning of Sine, Cosine and Tangent of a triangle were explicitly explained and discussed. The paper recommends that Mathematics teachers should endeavor to teach difficult topics concretely and explicitly.

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1. Introduction

Many teachers shy away from difficult topics such as trigonometric ratio; change of subject, statistic e.t.c ... and many students run away from Mathematics class on the traditional belief that it is an abstract and difficult
subject. Now the bottom line is why do teachers shy-away and why do students run away from Mathematics class. Since teachers of Mathematics are expected to teach with enthusiasm and the students are also expected to learn enthusiastically.

Previews researches confirmed that many students gave up, many lost hope, many lost the interest to learn and many hate Mathematician just because of their low performances. The writer’s view of the students low performances is a two side of a coin; one side is students problems and the other side being teacher’s problems.

The students problem could be attributed to many factors, these include:
1. Students' lack of readiness to learn and have success in Mathematics.
2. Students' beliefs about mathematics.
3. Students' lack of interest in Learning Mathematics.
4. Lack of Motivation from parents, teachers and colleagues.
5. Lack of Mathematics foundation.

However, the teacher’s problem being the contributing factor in students’ low performance include teachers’ content knowledge of Mathematics, strategy, method of presentation as well as method of evaluations. From 1960 to date the Nigerian’s school curriculum has gone through several reformations and fine turning all in the bid to improve academic excellence. Yet, the issue of difficulty in mathematics especially in junior secondary sections remains unsolved. This paves ways for several questions to be asked. i.e. (i) Why are some of the topics in JSS are perceived to be difficult by both the teachers and students (ii) Are the teachers and content knowledge adequate enough to tally with the reformation of fine turning of the curriculum? (iii) What are the challenges for Mathematics educators.

It is against this backdrop this paper seeks to look at these questions and proper a solution for the way forward by exposing participants to the practical aspect of teaching and learning of trigonometry.

2. Challenging topics in JSS mathematics

Various reasons have been given by Mathematics educators as why some topics in Junior Secondary Schools Mathematics are difficult or challenging. Chianson, Kurumeh and Obida (2010) opine that many students became miserable and disturbed in a Mathematics classroom after being taught a topic and they could not memorize or readily recall such concept(s) with ease. According to them the reason may not be far from the teaching method being used to teach and explain such topics. But Sesutho, Paul and Kgomotso (2006) see challenging or difficulty in Mathematics as “difficult and demanding mathematics” a mathematics that holds someone back and impedes one’s progress. The perennial low performance in mathematics has been attributed to inadequate teachers' content knowledge of the subject matter and poor instructional techniques (Salman, 2004). She also identified and confirmed that both the students and teachers dislike certain topics in Mathematics because of the belief that they are either difficult to learn or to teach (Salman, 2005).

The following topics were identified as challenging via a discussion among Mathematics teachers in a workshop organized by Sokoto State Universal Basic Education Board (SSUBEB) in conjunction with Mathematical Association of Nigeria (MAN) Sokoto State chapter in 1996. Trigonometry, simultaneous linear equation, word problems, change of subject of a formula, etc.

3. Challenges for mathematics educators

Part of the challenges for Mathematics educators is to design ways to reduce the difficulties encountered by both the teachers and students in teaching and learning identified difficult topics. For example, Mathematics teachers are expected to design and present their lessons as presented below: Teaching the concept of Trigonometric ratio.

**Definitions:** Consider a right-angled triangle
Trigonometric Ratio: - Are the ratios of the lengths of too sides of a right-angled triangle. A right-angled triangle (e.g \( \triangle ABC \)) is made up of three sides \( AB \), \( BC \), \( CA \), and three angles \( \angle A \), \( \angle B \), \( \angle C \) of which one ( \( \angle B \) in this case) is 90º or a right-angle. The other two angles ( \( \angle A \), \( \angle C \), ) are acute angles. There are three sides of the right-angled triangle and there are six different trigonometric ratios for the triangle. These are \( \frac{AB}{BC} \), \( \frac{AB}{CA} \), \( \frac{BC}{CA} \), \( \frac{BC}{AB} \), \( \frac{CA}{AB} \), \( \frac{CA}{BC} \).

The Sine: - Is an acute included in a given right angled triangle, it is the ratio of the length of the opposite side to the Hypotenuse, in \( \triangle ABC \):

\[
\frac{AB}{BC}
\]

The Cosine: - Is an acute angle in a given right angled triangle, it is the ratio of the length of the adjacent side to the Hypotenuse, in \( \triangle ABC \):

\[
\frac{AC}{BC}
\]

The Cosine of angle \( \angle C \) = Adjacent / Hypotenuse = \( \frac{BC}{AC} \).

The Tangent: - Is an acute angle in a given right-angled triangle, it is the ratio of the lengths of the opposite side to the adjacent side of the triangle.

\[
\tan(\angle C) = \frac{AB}{BC}
\]

4. Problems of teaching and learning the sine cosine and tangent of a triangle

- Teachers’ inability to define appropriately the concepts; Sine, Cosine and Tangent.
- Teachers’ lack of basic challenges and techniques on how to calculate the Sine, Cosine and Tangent of an acute angle using a right-angled triangle.
- Students inability to use the Sine ratio of a given angle to solve a given problem.
- Lack of adequate teaching materials
- Lack of effective teaching methodology.
- Large class syndrome
- Lack of motivations
- Poor presentation of Instructions.

5. The Strategies of teaching and learning the sine, cosine and tangent of a triangle

The sine

5.1. Identify your objectives

What do you want to achieve after the lesson? Tell your students your objectives (i.e. At the end of this lesson you should be able to;
• Define the Sine of an acute angle
• Calculate the Sine of an acute angle using a right-angled triangle.
• Use the Sine ratio of a given angle to solve a given problem.

5.2. Select your teaching materials
• Readily available plastic/ Wooden or improvised right angled-triangle.
• Cardboard sheets
• Paper
• Scissors
• Markers
• A mathematical set
• Graph sheets

5.3. Identify the strategy to be used in teaching the concept
• Discovery
• Carefully guided Method
• Grouping (same ability, clustering, mixed ability, cooperative and cross-graded) etc.

5.4. Teaching the concept-sine
• Present/ Draw three (3) right angled-triangle in 3 different positions.

- Pick any of the acute angles and level the sides opposite and adjacent to that angle i.e

- Exemplify the sine of [G i.e from SOHCAHTOA
- Sine = opposite / Hypotenuse = EF / EG
- Assign values to the sides EF, FG, and EG and Simplify
i.e

\[
\text{Sine } [ G = \text{Opp} / \text{Hyp} = 3/5 = 0.6
\]

- Using a Graph sheet, draw X-axis and Y-axis. From point O. The Origin at an angle of 30° to the positive X-axis draw a straight line. On this line at interval of 2cm mark off points A, C, E, G … From these points draw perpendiculars to meet the X-axis at B, D, F, H, … respectively.

![Graph showing X and Y axes and points B, D, F, H with distances AB, CD, EF, GH marked vertically from the origin at 30°.]  

Measure the distances AB, CD, EF, GH and fill the table

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Practical application of sine ratio.</th>
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<tr>
<td>No of Opp</td>
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<tr>
<td>0.5</td>
<td>0.5</td>
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</table>

5.6. Teacher’s and students activities
• Step 1: Tell your students to draw a triangle \( \triangle H I J \) i.e \( \triangle A B C \).
• Step 2: Students to assign values to the triangle \( \triangle H I J \) such that
  \( H I = 2\text{cm}, \quad I J = 3\text{cm} \) and \( H J = 4\text{cm} \).
• Step 3: Tell students to find the sine of \( \angle J \) and \( \angle H \) respectively.

5.6. Evaluation

Teachers should always evaluate their students in terms of application, knowledge and understanding (AKU).
• To test knowledge; teachers should ask questions such as defined the SINE.
• To test understanding; teachers should ask students to draw a triangle \( \triangle PQR \) Show the sides i.e Adjacent, Opposite and Hypotenuse.
• To test application; teachers should ask students to draw a triangle \( \triangle A E F \) assign values 5, 6 and 7 in such that \( P Q = 5\text{cm} \), \( Q R = 6\text{cm} \) and \( P R = 7\text{cm} \) and find sine of \( \angle R \).

6. The Cosine

6.1. Identify your objectives

What you intend to achieve at the end of the lesson or topic. Tell your students your objective(s). i.e At the end of this lesson you should be able to;
• Define the cosine of an acute angle.
• Calculate the cosine of an acute angle using a right-angled triangle.
• Use the cosine ratio of a given angle to solve a given problem.

6.2 Select your teaching materials
• Readily available plastic/wooden or improvised right-angled triangle.
• Cardboard sheets
• Papers
• Scissors
• Markers
• A mathematical set
• Graph sheets.

6.3. Identify The strategy to be used in teaching the concept i.e

• Heuristic method
• Discovery method
• Guided method
• Grouping method (same ability, clustering, mixed ability, cooperative and cross-graded) etc.

6.4. Teaching the concept – cosine
• Draw and present 3 right-angle Triangles in 3 different positions.

• Pick any of the acute angles and label the sides opposite and adjacent to that angle.
• Exemplify the cosine of \[ C \] i.e. from SOHCAHTOA
  \[
  \text{Cosine} = \frac{\text{Adjacent}}{\text{Hypotenuse}} = \frac{BC}{AC}
  \]
• Assign values to the sides \( AB \), \( BC \), and \( AC \) and simplify

Using a graph sheet draw \( X \)-axis and \( Y \)-axis. From point \( O \), the origin at an angle of 30 to the positive \( X \)-axis draw a straight line. On this line at an interval of 2cm mark off points \( A_1 \), \( A_2 \), \( A_3 \)...... From these points draw perpendiculars to meet the \( X \)-axis at \( B_1 \), \( B_2 \), \( B_3 \)...... respectively.
Measure the distances OB_2, OB_3, OB_4..... Fill in the table. The table will look like

<table>
<thead>
<tr>
<th></th>
<th>OB</th>
<th>OA</th>
<th>Cosine = ( \frac{OB}{OA} )</th>
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<td>OA</td>
<td>6.93</td>
<td>8</td>
<td>0.87</td>
</tr>
</tbody>
</table>

You will observe that the ratio is constant just like the Sine ratio in Table 1.

6.5. Teachers and students activities

Step 1 : Tell your students to draw a triangle \( \triangle ABC \) i.e 
Step 2 : Tell your students to assign values to the triangle \( \triangle ABC \) such that \( AB = 4cm \), \( BC = 5cm \), \( AC = 6cm \).
Step 3 : Tell your students to find the cosine of \( \angle A \) and \( \angle C \) respectively.

6.6 Evaluation: Teachers should always evaluate their students in terms of application, knowledge and understanding (AKU) i.e.

- To test knowledge; teachers should ask question such as define the cosine.
- To test understanding; teachers should ask students to draw a triangle \( \triangle HIJ \) and show the 3 side i.e adjacent, opposite and Hypotenuse.
- To test application, teachers should ask students to draw a triangle \( \triangle HIJ \) assign values 7 8 and 9cm such that \( HI = 7cm \), \( IJ = 8cm \) and \( HJ = 9cm \) and find the cosine of \( \angle J \).

7. The tangent

7.1. Identify your objectives

What you intend to achieve at the end of the lesson or topic. Tell your students your objective(s).

At the end of this lesson you should be able to;

- Define the Tangent of an acute angle.
- Calculate the Tangent of an acute angle using a right-angled triangle
- Use the Tangent ratio of a given angle to solve a given problem.

7.2. Select your teaching materials

- Readily available plastic/wooden or improvised right angled triangle.
- Cardboard sheets
- Papers
- Scissors
- Makers (Colour)
- Mathematical set
- Graph sheets.

7.3. Identify the strategy to be used in teaching the concept i.e

- Heuristic (problem solving) method
- Discovery method
- Guided method
- Grouping method (same ability, clustering, mixed ability, cooperative and cross-graded) etc
7.4. Teaching the concept - tangent

- Draw and present three (3) right angled triangles in three (3) different position.

- Select any of the acute angles and level sides opposite and adjacent to that angle.

- Exemplify the Tangent of \( \angle Z \) i.e from SOACAHTOA
  
  \[
  \text{Tangent} = \frac{\text{opposite}}{\text{adjacent}} = \frac{XY}{YZ}
  \]

- Assign values to the sides \( XY, YZ \) and \( XZ \). AND Simplify.

7.5. Teachers and student activities

Step 1: Tell your students to draw a triangle
Step 2: Tell your students to assign values to the triangle \( \triangle XYZ \) such that \( XY = 3\text{cm} \), \( YZ = 4\text{cm} \) and \( XZ = 5\text{cm} \).
Step 3: Tell your students to find the tangent of \( \angle X \) and \( \angle Z \) respectively.

7.6. Evaluation

Teachers should always evaluate their students based on application, knowledge and understanding (AKU) i.e

- To test knowledge; teachers should ask questions such as defined the tangent.
To test understanding; teachers show ask question such as draw a triangle LNM and show the three (3) sides.

![Triangle LNM](image)

To test application; teacher should ask students to draw a right-angled triangle LNM

Assign values 5, 6, 7 such that LN = 5cm, NM = 6cm LM = 7cm and finds the tangent of [M and [L.

8. The use of trigonometric tables

Trigonometric ratios were found by drawing, measuring and dividing the corresponding sides of the right-angled triangle. From such the three trigonometric ratios namely sine, cosine and tangents. The tables are for ready used purpose they give values of the ratio correct to four significant figures. Teachers should teach their students how to take readings from these tables and apply them to solve problem. Those with a zero in the denominator are undefined. They are included solely to demonstrate the pattern.

8.1. Unit of measurement

Angles are usually measured to the nearest degree. The symbol for degree is (°) for example 10° for ten degree. Similarly, fractions of degree can be expressed as decimals or expressed in minutes. There are 60 minutes in one (1°) degree. The symbol for minute is (‘) for example 30° (for thirty minutes), Angles can therefore be written in degrees and minutes or expressed as decimals of degrees. Degree can be converted to minutes by multiplying by 60 just as minutes can be converted to degrees by dividing by 60.

8.2. The sine cosine and tangent

Identify your objectives. What you intend to achieve with your students.

- Read the Sine or Cosine or Tangent Table
- Use the Sine or Cosine or Tangent table to solve right angled triangles.

8.3. Reading the sine table

The Sine Table gives the values of angles 0° to 89.99°. see table 3.

- Using the Sine table, calculate Sin 13°.
- Solution: From the table 3 under the O column look for 13°. Along the now containing 13° take the reading under 0 column.
  The reading is 0.2250.
- Use Sine table to find the angle whose Sine is 0.24
Solution: In table 3 look for the reading whose values is nearest to lent less than or equal to 0.24. The reading nearest to but less than 0.24 in value is 0.2385. This is the reading for 13.8°. This is between 0.385 and 0.24 is 0.0015. Look for 15 along 13° row in difference Columns. It appears under 9 which is the same as 0.09° to 13.8° to get 13.89°. There, the angle whose Sine is 0.24 is 13.89°. This may be written as Sin-1 or anti-Sin or arc-Sin i.e Sin-1 0.24 = 13.89° (pronounced as Sine Zero point two four).

8.4. Reading the cosine table
The cosine table gives the values of the cosine of angles 0 to 89.99. See table 3.
- Using the cosine table, calculate Cos 16°
- Solution: From the table 3 Look for 16°
  - Trace along the column for O, the row of 16° to the column of 0. Take the reading at their point of meeting.
  - The reading is 0.9613.
Solution: In table 3 look for the reading whose value is nearest to but not more than or equal to 0.9. The nearest reading in the table is 0.8996. This reading is at the meeting point of the row for 25° and the Column for 0.9, this means that the angle whose Cosine is 0.8996 is 25° and the Column for 0.9.
  - Look for 4 in the difference column along the row for 25° is 5 same as 0.05°. The angle whose Cosine is 0.9 is 25.9° – 0.05° = 25.85°.
  - NOTE: Always take values nearest to but less than what you want to solve.

8.5. Reading the tangent table
The tangent table gives accurate values of tangents of angels 0° to 89.99°. See table 3.
- Use the tangent table to find tan 15°
Solution: In table 3 along the column for O look for 15° look at where the row for 15° meets the column for 0.0° and take the reading there. [Note that 15° = 15.0°].
  - The reading is 0.2679
  - Tan 15° = 0.2679.
  - i. Find the angle whose tangent is 0.24.
Solution:
Let the angles be O
Tan O = 0.24
In table 3 look at the reading whose value is equal to 0.24 or nearest in value to but less than it. There is a reading of the value 0.2400. This value is at the meeting point of the row of 13.5° and the column of 0.5°.
  - 0.24 is the tangent of angle 13.5°.
  - O = 13.5°.

9. Recommendation
- Teachers should always endeavor to re-strategies in methodology, use of instructional materials and method of delivery in teaching difficult topics such as Trigonometry, word problems etc. to teach concretely and explicitly.
Table 3
Table for determining the values of trigonometric ratios.
$\pi = 3.141592...$ (approximately $\frac{22}{7} = 3.1428$)

Radians = degrees x $\pi / 180$ (deg to rad conversion)

Degress = radians x $180 / \pi$ (rad to deg conversion)

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Source: http://math2.org/math/trig/tables.htm

Cos Sin Cot Sec Csc Tan Deg Rad
Table 4
Table of common angles in trigonometry.

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<th>Angle (degrees)</th>
<th>0</th>
<th>30</th>
<th>45</th>
<th>60</th>
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<th>120</th>
<th>135</th>
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<th>210</th>
<th>225</th>
<th>240</th>
<th>270</th>
<th>300</th>
<th>315</th>
<th>330</th>
<th>360 = 0</th>
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<td>PI/4</td>
<td>PI/3</td>
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<td>3/4PI</td>
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References