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Teaching Perspectives on Trigonometric Functions in the Second Cycle of Secondary Education in Angola

Perspectivas de ensino nas funções trigonométricas no II Ciclo do Ensino Secundário em Angola

Perspectivas de enseñanza de las funciones trigonométricas en el segundo ciclo de la educación secundaria en Angola

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Abstract:
The present study highlights perspectives on teaching trigonometric functions to students in the Second Cycle of Secondary Education in Angola. This article aims to propose theoretical and practical foundations for teaching trigonometric functions in Mathematics classes. The methodology is based on the use of theoretical and empirical methods, which make it possible to analyse the perspectives offered by the scientific literature on the subject and determine which of them can be contextualised in the teaching and learning process of trigonometric functions. The study as a whole contributes to addressing the didactic difficulties involved in teaching trigonometric functions and applying them to everyday problems. In this regard, the proposed perspectives, supported by didactic activities, make it possible to solve problems

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arising in the classroom from the abstract nature of Mathematics, which often requires appropriate coping strategies, and thus contribute to developing a more critical view of the objects of knowledge related to the subject. Therefore, deepening the study of the trigonometric circle through appropriate teaching materials, technological resources, active methodologies and cognitive contextualisation facilitates student learning.

Keywords:
Trigonometric functions. Mathematics teaching. Didactic activities. Second Cycle. Angola.

Resumo:
O presente estudo evidencia perspectivas de ensino nas funções trigonométricas nos alunos do II Ciclo do Ensino Secundário em Angola. Este artigo tem como objectivo propor sustentos teórico-práticos perspectivados no ensino das funções trigonométricas nas aulas de Matemática. A metodologia está suportada na utilização de métodos do nível teórico e empírico, os quais permitem analisar que perspectivas oferece a literatura científica sobre o tema, e quais podem ser contextualizadas no processo de ensino-aprendizagem das funções trigonométricas. O trabalho, no seu conjunto, facilita a atenção das dificuldades didácticas no tratamento das funções trigonométricas, aplicáveis aos problemas da vida quotidiana. Neste sentido, as perspectivas propostas, sustentadas em actividades didácticas, permitem dar solução aos problemas levantados em sala de aula gerado pela abstracção da Matemática que muitas vezes requerem meios de enfrentamento e desse modo, contribuir para a constituição de um olhar mais crítico sobre os objectos do conhecimento a respeito do tema. Assim, aprofundar no ciclo trigonométrico, usando meios de ensino adequados, recursos tecnológicos, metodologias activas na contextualização cognitiva, facilita o seu aprendizado.

Palavras-chave:
Funções trigonométricas. Ensino de Matemática. Actividades didácticas. II Cíclo. Angola.

Resumen:
El presente estudio evidencia perspectivas para la enseñanza de las funciones trigonométricas a los estudiantes del segundo ciclo de la educación secundaria en Angola. Este artículo tiene como objetivo proponer fundamentos teórico-prácticos orientados a la enseñanza de las funciones trigonométricas en las clases de Matemáticas. La metodología se sustenta en la utilización de métodos de nivel teórico y empírico, los cuales permiten analizar qué perspectivas ofrece la literatura científica sobre el tema y cuáles pueden contextualizarse en el proceso de enseñanza-aprendizaje de las funciones trigonométricas. El trabajo, en su conjunto, contribuye a atender las dificultades didácticas presentes en el tratamiento de las funciones trigonométricas y en su aplicación a los problemas de la vida cotidiana. En este sentido, las perspectivas propuestas, sustentadas en actividades didácticas, permiten solucionar los problemas planteados en el aula como consecuencia de la abstracción de las Matemáticas, que muchas veces requieren medios adecuados para su enfrentamiento, y contribuir así a la constitución de una mirada más crítica sobre los objetos de conocimiento relacionados con el tema. Por lo tanto, profundizar en el ciclo trigonométrico mediante medios de enseñanza adecuados, recursos tecnológicos, metodologías activas y contextualización cognitiva facilita el aprendizaje de los estudiantes.

Palabras clave:
Funciones trigonométricas. Enseñanza de las Matemáticas. Actividades didácticas. Segundo ciclo. Angola.

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INTRODUCTION

Mathematics is an essential curricular component in the education of secondary school students, both for its formative character and its applicability in scientific and technological contexts (D' Ambrosio , 2015). In Angola, the Mathematics Program for the second cycle of general secondary education establishes the study of Trigonometry as a cognitive core for understanding periodic phenomena, being worked on in the 10th and 11th grades after initial concepts of right-angled triangles in the first cycle (National Institute for Educational Research and Development [INIDE], 2013).

However, research and teaching practice reveal that students have difficulties mastering concepts, algorithmic procedures, and solving problems involving trigonometric functions (Mendes, 2019). These difficulties are associated with rote learning, excessive abstraction, and a lack of contextualization with local reality (Quintas, 2022). The Basic Law of the Angolan Education and Teaching System No. 32/20 highlights the need to adapt content to the current realities and conditions of students (National Assembly, 2020).

Given this scenario, the following research question arises: How do the theoretical and practical perspectives of teaching in activities... Can contextualized teaching methods contribute to the learning of trigonometric functions in students in the second cycle of secondary education in Angola?

Thus, this article aims to propose theoretical and practical supports for teaching trigonometric functions, through didactic activities that integrate the trigonometric circle, technological resources, and problem situations from daily life. It defends the thesis that active and contextualized approaches reduce abstraction and promote meaningful learning, according to the assumptions of Ausubel 's Theory of Meaningful Learning (Moreira, 2012).

Theoretical foundations for teaching trigonometric functions.

Trigonometry historically developed from the relationship between arcs and chords in Astronomy, integrating Algebra, Geometry, and Analysis (Boyer & Merzbach , 2019). In the school context, Costa (2017) argues that teaching should go beyond memorizing formulas and prioritize the graphical and conceptual understanding of sine, cosine, and tangent functions.

From a didactic perspective , the teacher assumes the role of mediator who organizes learning situations in which the student constructs knowledge through problematization and dialogue (Freire, 1996). Nacarato , Passos, and Mengali (2009) reinforce that "doing

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mathematics" implies formulating hypotheses, testing conjectures, and negotiating meanings in a communicative environment.

Difficulties identified in the Angolan context.

Analysis of INIDE programs (2013, 2014) and studies by Quintas (2022) point to three weaknesses: a) Limited didactic preparation of teachers in the methodological treatment of Trigonometry; b) Predominance of algorithmic exercises geared towards exams, without connection to practical applications; c) Disconnection between school mathematical knowledge and community knowledge, such as change calculations and measurements in agricultural and fishing activities . This gap generates rote learning, in which the student memorizes procedures without attributing meaning to mathematical objects (Moreira, 2012).

Didactic perspectives : contextualized activities .

activity are proposed, supported by both theoretical and practical foundations:

Construction and analysis of the trigonometric circle.

Objective: To understand the relationship between angles, coordinates, and trigonometric ratios.

Methodology: Group work using manipulatives and GeoGebra software .

Context: Use the roundabout at Parque Comandante Kussanje , in the city of Sumbe , as a model of a unit circle. The student measures angles from the point (1, 0) and associates coordinates x, y to the values of cosine and sine. It is defined that, for a point P(x, y) on the unit circle: $\sin \theta = y$; $\cos \theta = x$; $\tan \theta = y/x$, with $x \neq 0$.

Solving practical problems.

Objective : To apply trigonometric functions in real-world situations.

Example: Calculating wall height using a ladder placed 2 m from the base, forming a 70° angle with the ground.

Solution: $\tan 70° = h/2 \rightarrow h = 2 * \tan 70° \approx 5.49$ m.

$\cos 70° = 2/c \rightarrow c = 2/\cos 70° \approx 5.85$ m.

This type of problem connects mathematical algorithms to the student's experience, reducing abstraction .

Graphic design with technology

Objective : To visualize the period, amplitude, and displacement of functions.

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Methodology: Using GeoGebra / Desmos to plot f(x) = A· sin (Bx + C) + D. The student varies parameters A, B, C, D and observes graphical transformations, developing algebraic and visual reasoning simultaneously (Costa, 2017).

Algorithmic sequence for solving trigonometric problems.

To structure the thinking process, it is proposed to: 1) Identify data and unknown; 2) Choose the appropriate trigonometric function; 3) Verify if the value belongs to the function's image; 4) Determine the reference angle on the circle; 5) Identify the quadrant and sign; 6) Interpret the result in the context of the problem.

Study Methodology

The study area focused on the municipality of Gangula , specifically the Quibaúla Centrality High School . This school, established under Executive Decree No. 312/2022 of April 21st , is a permanent state-owned institution located 19 kilometers from the capital city of Cuanza Sul Province, north of the municipality of Gangula .

For the development of this research, the criterion of simple random sampling was used, since the samples were chosen through the researchers' criteria taking into account the treatment of the subject matter. In this perspective, the following sample was obtained: Management body (2), being thus: Director (1), Pedagogical Deputy Director (1), Teachers (3) and 11th Grade students (27), as shown in the following table.

(Table No. 1).

COMPONENTS	POPULATION	SAMPLE	PERCENTAGE %
Governing Body	2	2	100
Mathematics teachers	4	3	75
11th Grade Students	56	27	48

Table No. 1. Population and sample

Among the main existing techniques, classroom observation, interviews, document analysis, and visual materials were used to infer certain research results. Regarding data collection instruments, we used a questionnaire administered to students during the teaching assessment, a classroom observation form containing various indicators that allowed for a brief

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assessment of the teacher's competence in their noble mission, and a questionnaire directed to the teachers, whose characteristics were inventoried and systematized.

Results and discussion

In all the classes observed, it was proven that the teachers have mastery of the subject matter, developing their cognitive and communicative skills.

The procedures employed do not always favor the treatment and development of trigonometric functions.

- There are limited activities aimed at developing and integrating the topic of trigonometric functions with the aspects and data of the locality and its potential.

The three (3) representatives of the sample, 75%, are male and female, have professional training and have mastery of the content they teach. However, 100% of the teachers have mastery of the subject matter and the methodologies for its treatment, but claim not to have sufficient conditions for meaningful learning in students, due to poor working conditions, lack of training on the use of technology in mathematics teaching and systematicity at other times in the process.

The pre-test was applied with the purpose of diagnosing prior knowledge, conceptual difficulties, and practical application skills at the moment of the beginning of direct contact with the field of action , with the intention of identifying the errors made by the students and the causes associated with these errors, to allow the adoption of a strategy for action in subsequent didactic -methodological work, in order to overcome the identified errors.

A test was thus applied to 27 of the 55 students in the 11th grade of the application school, Liceu da Quibaúla / Gangula , with two parts, the first consisting of three theoretical questions and one practical question with two free-response options where each student could apply the method of their choice, the results of which are presented in the table below:

Table 2 - Overall results of the pre-test

Ques-tions	**Answers**				
	Certain		Wrong		Total
	No.	%	No.	%	
Q_1	01	04	26	96	27
Q_2	27	100	00	00	27

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Q_3	10	37	17	63	27
Q_4	13	44	15	56	27

As can be seen, of the 27 students who took the test:

1. Have you ever heard of a function? If so, can you define the concept?

01 (4%) got the first question right, compared to 26 (96%) who did not get it right;

2. What are the fundamental trigonometric relationships you know?

27 (100%) answered the second question correctly;

3. What are the values of the following trigonometric ratios?

Only 10 (37%) answered the third question correctly, compared to 17 (63%) who did not answer it correctly;

4. The Nova Estrela agricultural farm, located in the municipality of Quilenda , in the statistical record map of the Mathematical analysis referring to the first quarter of the year 2025, the company's finance department determined that the level of production (yield) was related to the analysis of the following trigonometric function.$Y = 2senx$:

a) Sketch the graph of the function, identify its range and period.

b) Within what range are the farm's earnings?

13 (48%) answered the fourth question correctly, compared to 14 (52%) who did not.

In short, the test applied to the students, reflected in the table and its respective graph, shows that out of the 27 students evaluated, 1 answered the first question correctly (4%), and 26 answered incorrectly (96%). On the second question, 27 students answered correctly (100%), with zero incorrect answers (0%). On the third question, 10 answered correctly (37%), with 17 incorrect answers (63%). On the fourth question, 13 answered correctly (48%), with 14 incorrect answers (52%). This indicates significant difficulty with the subject matter, particularly in the formation, interpretation, and application of concepts, as well as the understanding of procedures and algorithms for solving trigonometric functions.

From this perspective, it can be concluded that the activities Teaching methods with theoretical and practical foundations that serve as a basis for addressing trigonometric functions still need to be explored to ensure better results in students' cognitive development. Based on the indicators in the table and graphs above, which include the entire sample, it is considered that despite the efforts made, difficulties remain in this area.

CONCLUSION

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The implementation of the proposal leads to the conclusion that teaching trigonometric functions in the second cycle of secondary education in Angola requires overcoming the algorithmic and rote learning approach. Didactic perspectives based on contextualized activities , the use of the trigonometric circle, and technological resources are presented as ways to reduce abstraction and give meaning to the content .

Contextualization with elements of local reality, such as urban architecture and measurement problems, aligns with Law No. 32/20 and promotes the development of critical thinking and the applicability of mathematical knowledge (National Assembly, 2020).

It is recommended that future studies develop empirical research with the application and quantitative/qualitative evaluation of these activities in Angolan schools, measuring their impact on learning.

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APPENDICES

Appendix No. 1
INTERVIEW FOR TEACHERS
Objective : The interview aims to understand the pedagogical practices, difficulties, and strategies used by teachers, seeking to identify challenges and possible solutions to improve the teaching of trigonometric functions.
Estimated duration: 30 to 45 minutes
Instructions: The interview will be recorded/note-taken (with permission) for later academic analysis, guaranteeing anonymity and confidentiality.
Section 1 - Interviewee Identification

1. Name (optional):_____
2. Academic background:_____
3. Years of experience teaching Mathematics: _____ years
4. Grade(s) or level(s) of education taught: _____

Section 2 - Teaching Planning and Methodology

1. teaching strategies are used to teach trigonometric functions? (Check all the ones you use and explain them)
   a) ( ) Expository teaching with blackboard and chalk
   b) ( ) Solving exercises in class
   c) ( ) Use of concrete or manipulative materials
   d) ( ) Application of mathematical software (GeoGebra , Desmos , etc.)
   e) ( ) Contextualization with everyday examples
   f) ( ) Project -based or problem- based learning
   g) ( ) Use of videos and multimedia resources
   ( ) Other. Which one? _____
2. Do you believe that trigonometric functions are taught in a contextualized and meaningful way for students?

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3. Do you usually relate this topic to other subjects or to real-life practical applications?
4. How do you assess students' interest and motivation when learning trigonometric functions, and what do you do to increase that interest?

Section 3 - Difficulties and challenges in teaching trigonometric functions

5. What are the main difficulties students face when learning trigonometric functions?
   a) ( ) Understanding of basic concepts
   b) ( ) Algebraic manipulation of functions
   c) ( ) Interpretation of trigonometric graphs
   d) ( ) Application to real-world problems
   e) ( ) Lack of interest/motivation
   ( ) Others. Which ones? _____
6. How do you deal with students' difficulties with this content?
7. Do you believe that trigonometric functions are taught in a contextualized and meaningful way for students?
8. What challenges do you face as a teacher when teaching this topic?

Section 4 - Use of technology and teaching resources

9. Do you use technological resources in teaching trigonometric functions? If so, which ones?
10. Have you participated in training courses on the use of technology in mathematics education? Do you think these training courses are sufficient?

Section 5 - Teacher training and professional development

11. During your initial training, did you receive sufficient preparation to teach trigonometric functions in a didactic and effective manner?
12. Have you participated in any courses or continuing education programs on teaching trigonometry? If so, what were the main takeaways?
13. What do you think could be done to improve teacher training on this topic?

Section 6 - Suggestions and improvements

14. What changes or innovations do you believe could make the teaching of trigonometric functions more effective?

Appendix No. 2

QUESTIONNAIRE FOR STUDENTS

Objective : To identify aspects related to students' perceptions, difficulties, and suggestions regarding the teaching and learning of trigonometric functions in the second cycle of secondary education.

Section 1- Student identification

Sex: ( ) Male ( ) Female

Age range: 12 – 15 ( ) ; 16 – 19 ( ) ; Over 20 ( )

1- Do you enjoy studying mathematics?
   a) ( ) Yes a lot
   b) ( ) Systematically
   c) ( ) No

2- How would you rate your overall performance in mathematics?
( ) Excellent ( ) Good ( ) Average ( ) Poor

3- Have you studied trigonometric functions before? ( ) Yes ( ) No

Section 2 - Knowledge and difficulties

4- How would you rate your understanding of trigonometric functions?

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( ) Very good ( ) Good ( ) Average ( ) Bad

5- Which of the trigonometric function concepts do you find most difficult? (Check all that apply)

a) ( ) Definition and meaning of the sine, cosine , and tangent functions
b) ( ) Graphical transformations of trigonometric functions
c) ( ) Practical and contextualized applications of trigonometric functions
d) ( ) Relationships between trigonometric functions
e) ( ) Use of trigonometry in real-world problems

6- Which of the following difficulties have you encountered while studying trigonometric functions?

a) ( ) Lack of adequate teaching materials
b) ( ) Quick or unclear explanation from the teacher
c) ( ) Lack of practical examples and real-world applications
d) ( ) Difficulty in the algebraic manipulation of functions
e) ( ) Little motivation to learn this content

Section 3 - Suggestions and improvements

7- What aspects could be improved to make learning trigonometric functions easier?

a) ( ) More practical examples from everyday life
b) ( ) Use of more technologies and interactive resources
c) ( ) More detailed and paused explanations
d) ( ) Greater number of exercises solved
e) ( ) Other suggestions: _____

8- How much time do you dedicate each week to studying trigonometry outside of the classroom?

a) ( ) None
b) ( ) Less than 2 hours
c) ( ) Between 2 and 4 hours
d) ( ) More than 4 hours

Teaching strategies and resources

9- Which teaching methods are most helpful in learning trigonometric functions?

a) ( ) Traditional lecture-based classes with blackboard and chalk
b) ( ) Solving practical exercises
c) ( ) Use of mathematical software and simulators
d) ( ) Learning based on real-world problems
e) ( ) Group studies and discussion with colleagues
f) ( ) Use of videos and interactive materials

10- Does the teacher use technological resources to teach trigonometric functions?

( ) Yes ( ) Sometimes ( ) No

11- Have you ever used apps or online platforms to study trigonometry? If so, which ones?

_____

Instructions for students:

- Your answers are confidential and will not be shared individually.
- Please answer honestly so that we can better understand how to improve the teaching of trigonometry;
- If you have any questions about the questions, you can ask the researcher.

Appendix No. 3
PRE-TEST FOR STUDENTS

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Objective : To diagnose students' prior knowledge, conceptual difficulties, and practical application skills regarding trigonometric functions, with an emphasis on their theoretical foundations.

Note: Your answers are confidential and will not be shared individually; if you have any questions about the questions, you can ask the researcher.

Personal data

Sex: ( ) M ( ) F

Age range: 12-15 ( ) 16-19 ( ) Over 20 ( )

1- Have you ever heard of a function? ( )yes ( ) No, does it define the concept?

_____

_____

_____

2- What are the fundamental trigonometric relationships you know?

_____

_____

_____

3- Specify the value of:

a) $cos\frac{\pi}{2} =$

b) $sen\frac{5\pi}{2} =$

c) $\cos\pi =$

d) $tg\frac{3\pi}{2} =$

4- The Nova Estrela agricultural farm, located in the municipality of Quilenda , according to the statistical record of the Mathematical Analysis for the first quarter of 2025, was determined by the company's finance department to have its production level related to the analysis of the following trigonometric function.$Y = 2senx$:

a) Sketch the graph of the function, identify its range and period.

b) Within what range are the farm's earnings?

Possible solutions from the pre -test

1R: At the student's discretion, a function is a rule that relates each element of one set (represented by the variable x) to a single element of another set (represented by the variable y); that is, given two non-empty sets A and B, a function (or mapping) from A to B is a correspondence that associates each element x ∈ A with one and only one element y ∈ B.

2 R: The fundamental trigonometric relationships I know are: sine, cosine , and tangent.

3R: Indicate the value of:

a) $cos\frac{\pi}{2} = 0$

b) $sen\frac{5\pi}{2} = 0.1$

c) $\cos\pi = -1$

d) $tg\frac{3\pi}{2} = \nexists$

4 R: a) We constructed the table and transferred the values to the axes:

x	sen x	y = 2 sen x
0	0	$y = 2\,.\,0 = 0$

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$\frac{\pi}{2}$	1	$y = 2 \,.\, 1 = 2$
π	0	$y = 2 \,.\, 0 = 0$
$\frac{3\pi}{2}$	-1	$y = 2 \,.\, (-1) = -2$
2π	0	$y = 2 \,.\, 0 = 0$

