RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

Problem-based learning in higher education: foundations, diagnosis, and action plan at UNINBE

Problem-based mathematical learning in higher education: foundations, diagnosis and action plan at UNINBE

Óscar Mavungo Cumbo - University of Namibe - oscar.cumbo@uninbe.ao

Summary

This article discusses the potential of Problem-Based Learning (PBL) to transform the teaching and learning of mathematics in higher education, using the University of Namibe (UNINBE) in Angola as a case study. Based on exploratory research, the theoretical foundations of PBL in Mathematics Education are analyzed, and a diagnosis of teaching practices and the perceptions of teachers (N = 17) and students (N = 325) in STEM courses regarding this approach is presented. The data reveal a strongly transmissive scenario, centered on lectures and individual exercises, with low use of contextualized problems and collaborative work, although teachers and students express very favorable attitudes towards PBL and a "desire to offer" this methodology. Based on the diagnosis, an action plan articulated at different levels (teacher, student, institutional, curricular, and monitoring) is proposed, aiming at consolidating PBL as a structuring axis of mathematics teaching at UNINBE. Finally, the extent to which such a plan can contribute to bringing the local teaching culture closer to contemporary trends in Mathematics Education is discussed.

Keywords: Problem-Based Learning. Mathematics Education. Higher Education. Educational Innovation. Angola.

Abstract

This paper discusses the potential of Problem-Based Learning (PBL) to transform the teaching and learning of mathematics in higher education, using the University of Namibe (UNINBE), in Angola, as a case study. Based on exploratory research, it analyzes the theoretical foundations of PBL in Mathematics Education and presents a diagnosis of teaching practices and perceptions of lecturers (N = 17) and STEM students (N = 325) regarding this approach. The data reveals a strongly transmissive scenario, centered on lectures and individual exercises, with limited use of contextualized problems and collaborative work, although both lecturers and students show favorable attitudes towards PBL and express a clear “demand” for this methodology. Drawing on this diagnosis, a multi-level action plan (teacher, student, institutional, curricular and monitoring) is proposed, aiming to consolidate PBL as a structuring axis in mathematics teaching at UNINBE. Finally, we discuss how this plan may help to bring local didactic culture closer to contemporary trends in Mathematics Education.

Keywords: Problem-Based Learning. Mathematics Teaching. Higher Education. Pedagogical Innovation. Angola.

Summary

This article analyzes the potential of Problem-Based Learning (ABP) to transform mathematics teaching and learning in higher education, taking as a case study the University of Namibe (UNINBE), in Angola. From an exploratory investigation, the theoretical foundations of ABP in Mathematical Education are analyzed and a diagnosis of teaching practices and perceptions of teachers (N = 17) and students (N = 325) of STEM courses on this approach is presented. The data demonstrates a powerfully transmissive scenario, centered on expository classes and individual exercises, with little use of contextualized problems and collaborative work, although teachers and students demonstrate very diverse attitudes

favorable to the ABP and expressing a clear “demand” for this methodology. Based on the diagnosis, an action plan articulated at different levels (teaching, student, institutional, curricular and monitoring) is proposed, with the purpose of consolidating the ABP as a structuring element

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

of mathematics teaching at UNINBE. Finally, it is discussed to what extent this plan can contribute to bringing local didactic culture closer to contemporary trends in Mathematical Education.

Keywords: Problem-Based Learning. Mathematics Teaching. Higher Education. Pedagogical Innovation. Angola.

1- **Introduction**

Problem-Based Learning (PBL) has been highlighted in recent decades, as one of the active methodologies with the greatest potential to promote meaningful learning in mathematics, especially in higher-level vocational training contexts. In general terms, ABP organizes teaching around authentic, complex, and socially relevant problems, in which students are called upon to mobilize knowledge, formulate hypotheses, test strategies and justify solutions, instead of simply reproducing previously presented procedures. (Hmelo-Silver, 2004; Graaff; Kolmos, 2003).

In higher education, particularly in science, technology, engineering and In mathematics (STEM), PBL is seen as a way to articulate... formal content combined with situations from professional practice and daily life, developing modeling skills, decision-making in uncertain contexts, and problem-solving abilities. non-routine (Alpers et al., 2013; Gravemeijer et al., 2017). This perspective engages with classic contributions of Mathematics Education that advocate the centrality of problem-solving problems in the curriculum (Pólya, 1945; Schoenfeld, 1985).

In the Angolan context, educational policies emphasize the expansion and improvement of The quality of STEM courses, as well as the need to strengthen scientific research and... Technological innovation. However, recent studies have pointed to persistent weaknesses in mathematical learning of students, as well as a strong presence of transmission practices, poorly interactive and scarcely contextualized in higher education institutions (Chikulo, 2019; (Dias, 2023). Under these conditions, the implementation of PBL in mathematics teaching is configured as a promising strategy, but one that faces constraints related to conditions. Institutional factors, teacher training, evaluation culture, and available resources.

This article presents the results of an exploratory investigation carried out in The University of Namibe (UNINBE), with the general objective of analyzing the implementation process. The role of PBL in mathematics education at this institution. The guiding question of the research could be stated as follows: how to implement problem-based learning in education from mathematics to improving the performance and conceptual understanding of students of UNINBE?

To answer this question, we established the following specific objectives: a) to discuss theoretical foundations of PBL in dialogue with Mathematics Education; b) characterize the

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

teaching methodologies for mathematics currently used at UNINBE, based on the perception of teachers and students; c) analyze the attitudes and perceptions of both groups regarding PBL, including perceived obstacles and needs; and) propose an action plan, articulated in different levels, to guide the gradual implementation of PBL in the institution.

The text is organized into five sections, in addition to this introduction. In the next section, We present the theoretical framework, articulating the tradition of problem-solving, some models didactics and the perspective of Models and Modeling in PBL in mathematics. Next, we describe the methodological procedures of the research. In the following section, we present and discuss the The main empirical results of the study. In the fourth section, we systematized a multi-action plan. level for the implementation of PBL at UNINBE. We conclude with some final considerations. Regarding the contributions and limitations of the study.

2-Theoretical Framework

2.1 The tradition of problem-solving in Mathematics Education

The connection between PBL and Mathematics Education has its roots in the tradition of problem-solving. problems as a structuring axis of the curriculum. Pólya (1945) systematized a heuristic in four phases — understanding the problem, developing a plan, executing the plan, and reviewing it — that are It has become widely known as a model for teaching and learning problem-solving. Although Even though Pólya didn't talk about PBL as we understand it today, his proposal helped to shift the focus. from lists of routine exercises to reflection on strategies, representations, and monitoring of own resolution process.

Subsequent research has emphasized that, in addition to knowing these phases, it is necessary to create Classroom environments where students are actually challenged to formulate, test, and revise. their strategies. Schoenfeld (1985, 1992), for example, developed an analytical framework in which the Problem solving is described using four core components: resources, heuristics, control and beliefs. This chart shows that students with seemingly certain knowledge Similar individuals can exhibit very different performance in problem-solving tasks. depending on how they manage their time, monitor their progress, and interpret what it means to "do". mathematics".

2.2 Didactic models and the perspective of Models and Modeling

Other teaching models offer complementary lenses for thinking about learning in problem environments. Krutetskii (1976) investigated the structure of mathematical skills in students considered talented, identifying abilities such as perception of relationships. structural, generalization, abbreviation of thought, and pursuit of economy of effort. Instead of treating these abilities as innate gifts, more recent studies in Mathematics Education...

RCMOS – Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

They understand these as dimensions that can be developed through challenging, open-ended tasks and contextualized, characteristics present in PBL proposals.

Brousseau (1997), in turn, developed the theory of didactic situations, differentiating stages such as action, formulation, validation and institutionalization, and highlighting the importance of non-didactic situations, in which the environment and the problem regulate the students' activity before the The teacher's systematizing intervention. This theory inspires the idea that the teacher should create environments in which students take responsibility for exploring and validating solutions, which is consistent with ABP principles.

The Models and Modeling (MM) perspective consolidated by Lesh and colleagues (Lesh (Doerr, 2003; Lesh; Lehrer, 2003) is particularly fruitful for thinking about PBL in mathematics. Perspective, models are conceptual systems that people develop to interpret and deal with... with problematic situations, and modeling is an iterative process of building, testing, reviewing and refinement of these models. Mathematical learning is seen as a conceptual reorganization. progressive, in which more primitive level systems are restructured as they cease to be sufficient to interpret new experiences (Lesh; Lehrer, 2003).

2.3 Constructivist and socio-epistemological perspectives

The approaches mentioned engage with constructivist perspectives and socio-epistemological aspects of mathematical knowledge. Piaget (1970) emphasizes that the Cognitive development involves successive reorganizations of conceptual structures, and that Important properties of mathematical systems emerge from the overall organization, not from the overall structure itself. reducing to the sum of isolated elements. Vygotsky (1978), in turn, highlights the mediated character and social thought, emphasizing the role of cultural interactions and tools in shaping concepts.

Socio-epistemology, as elaborated in works such as those by Cantoral and Farfán. (2003) considers that mathematical knowledge is produced, legitimized, and used in practices. specific social skills, such as solving problems in a community, arguing, justifying, and negotiating. meanings. From this perspective, well-planned PBL environments create conditions for students participate in epistemic practices typical of mathematics, involving the formulation of conjectures, use multiple representations, strategy testing, and argument-based defense of solutions.

Problem-based learning (PBL) in higher education mathematics

In higher education, especially in engineering and science courses, the approaches Problem-based learning gains meaning by allowing students to address situations that... They approach professional problems, requiring the mobilization of knowledge from different areas. areas, dealing with incomplete data and making decisions under uncertainty (Graaff; Kolmos, 2003; Alpers et (al., 2013). Recent studies indicate that PBL, when carefully implemented, can

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

to contribute to the development of conceptual understanding, mathematical reasoning and skills of solving complex problems (Hmelo-Silver, 2004; Gravemeijer et al., 2017).

However, research also indicates that the adoption of PBL in teaching contexts higher education, especially in countries of the Global South, faces obstacles related to the massification of teaching, resource scarcity, teacher training, and an assessment culture that still prioritizes tests. Traditional writing and the memorization of procedures (McCowan, 2018). The investigation developed at UNINBE is part of this debate, seeking to understand how teachers and Students become aware of PBL and the conditions necessary for its consolidation.

3 Methodology

The research is exploratory in nature, with an articulated quantitative-qualitative approach, and It was held at the University of Namibe (UNINBE) in Angola, a public institution with a strong The presence of courses in the STEM field. The specific focus of the investigation is curricular units of mathematics and related areas, in which conceptual and practical learning challenges are identified. performance, as well as an institutional discourse favorable to pedagogical innovation.

3.1 Participants

The teaching staff considered consists of 25 teachers who teach mathematics. or subjects with strong mathematical content at UNINBE. In an exploratory phase, data was collected 19 questionnaires, of which 2 were discarded due to insufficiently discriminating responses. (tendency to always mark the same option), resulting in a sample of 17 teachers. On the side of Students, 325 students enrolled in different STEM courses at the institution participated, They responded to a survey administered in a classroom setting, with the authorization of the coordinators of course.

3.2 Instruments

Two structured questionnaires were developed, inspired by the literature on PBL in mathematics education and studies on mathematics teaching practices in higher education courses. The questionnaire for teachers contains sections on teaching practices (types of activities, frequency of activities, etc.). use, role of the teacher), attitudes towards PBL, perceived obstacles to its implementation and Previous experiences with similar approaches. The student questionnaire includes items about perceived teaching methods, self-assessment of conceptual understanding and performance, attitudes and Perceptions about ABP, perceived obstacles, and suggestions for improvement.

Both instruments predominantly use items on a five-point Likert scale. points (from strongly disagree to fully agree), supplemented by open-ended questions that They allow participants to provide examples, suggestions, and comments.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

3.3 Data collection and analysis procedures

Data collection was carried out over one academic semester, with support from department heads.

The questionnaires were completed by the department and course coordinators. The faculty members filled out the questionnaires at various times.

previously agreed upon with the research team, and the students responded in classrooms, after clarification regarding the objectives of the investigation and guarantee of anonymity and confidentiality of the answers.

The quantitative data were processed using simple descriptive statistics, with Calculation of absolute and relative frequencies for each item. In the analysis, special attention was given to... to the percentages of agreement (sum of categories 4 and 5 on the scale), since such values They allow us to identify prevailing trends. The open-ended responses were analyzed. qualitatively, seeking emerging categories related to perceptions of obstacles, Needs and suggestions from teachers and students.

3.4 Ethical aspects

The research respected fundamental ethical principles, including informed consent. The right to refuse and the guarantee of anonymity. Participants were informed that the data They would be used exclusively for research purposes and to support improvement processes.

pedagogical approach within the institution.

4. Results and Discussion

4.1 Teachers: teaching practices and perceptions about PBL

The data relating to teachers reveal the predominance of a teacher-centered teaching model. in the presentation of content and in solving individual exercises. Most report using lectures or lectures as the main method, with high frequency, and also refers to the use A systematic approach of exercises solved individually by students in class. In contrast, only A relatively small percentage report frequently using group work to solve problems. mathematical or activities based on real problems or contextualized in Angolan reality.

and university student.

Regarding the role of the teacher, the results indicate that few teachers perceive themselves as clearly as facilitators of learning, in the sense of organizing situations in which the Students take a leading role in the investigation, discussion, and validation of ideas. This self-image This aligns with the strong presence of lectures and the limited use of discussion strategies.

and the exploration of reasoning in plenary sessions.

Despite this, attitudes towards ABP are markedly positive. Most of the Teachers agree that PBL can promote deeper conceptual understanding and increase... motivating students and encouraging active participation and collaboration. When asked about

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

The feasibility of regularly implementing PBL at UNINBE, however, is becoming more complex.
cautious, highlighting the perception of significant contextual barriers.

Among the most frequently cited obstacles are: class size,
which makes managing groups and mediating discussions difficult; the lack of time to plan activities.
of ABP, considering the teaching workload; the scarcity of material and technological resources;
and the need for specific pedagogical training to design and evaluate problem-solving tasks.
Few teachers report more systematic experiences with PBL, suggesting that knowledge
The approach is often indirect, based on literature or reports, rather than on...
Consolidated practices within the institution.

4.2 Students: perceived teaching methods and conceptual understanding

From the students' point of view, the portrayal of teaching practices confirms and deepens the...
Diagnosis made from teacher data. A large majority consider that the classes of
Mathematics lessons are dominated by teacher explanations, followed by solving exercises.
Individuals. In contrast, working in small groups to solve problems is perceived.
as it is infrequent, and few students state that the problems proposed in class are, with
frequency, linked to real situations or contexts that they recognize from their daily lives.

Perceptions about active participation also reveal a scenario with little interaction: a
A minority of students report that the professor frequently asks them to discuss and
to explain the reasoning to colleagues. In this context, the teacher's role is seen more as that of a holder of knowledge or understanding.
and as a transmitter of knowledge rather than a mediator of research and discussion processes.

Regarding conceptual understanding, less than a third of students claim to have...
a clear understanding of the main concepts of the course, being able to explain them using one's own words.
words, establish relationships between different themes, and apply what you have learned to new problems or
unknown. Many rate their own performance on math tests as only
moderately satisfactory, and almost half consider the content too difficult for their level.
This set of perceptions suggests weaknesses in the construction of meaning and knowledge.
fragmented and low self-efficacy in mathematics.

4.3 Attitudes towards PBL and obstacles perceived by students

When it comes to attitudes towards ABP, the picture changes significantly. One
The vast majority of students agree that working with real-life problems or
Contextualized explanations help them understand mathematics better, and group work contributes to this.
to clarify doubts and learn from colleagues. Many say they feel more involved in
learning occurs when the lesson begins with a problem and only then addresses the underlying theory, in
In contrast to the traditional "theory-exercises" sequence.

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

Students also attribute to ABP the potential to increase interest in mathematics.
and to improve performance in assessments, even though a significant portion remains neutral in these.
items, possibly due to limited practical experience with the approach. One of
Stronger evidence of this appreciation is the fact that a large majority stated that they would like to have
more opportunities to learn math through problem-based activities in
UNINBE.

When asked about obstacles to participating in such activities, the
Students highlight the lack of time to work on complex problems in groups, the size
of the classes and the feeling of not being sufficiently prepared to participate actively in
ABP contexts. In questions about desired changes, the most frequent responses include
requests for clearer and more transparent evaluation, greater teacher guidance, more class time
dedicated to working with problems and organizing smaller groups, as well as assigning tasks.
linked to Angolan reality and professional contexts.

4.4 Interpretive Synthesis

A coordinated analysis of data from teachers and students allows for the identification of a
Misalignment between an ideal of active, problem-oriented learning and the practices
effectively carried out at the institution. On one hand, there is a strong presence of expository teaching,
individual exercises and assessment focused on traditional tests; on the other hand, there is recognition
widespread awareness of the potential of PBL and a desire, especially on the part of students, to
to experience richer problem-solving experiences in meaningful contexts.

From the perspective of the theories discussed in the previous section, this scenario can be interpreted
as it is not very conducive to the development of robust and flexible conceptual systems, to the type of
investigative thinking and participation in epistemic practices characteristic of approaches of
Models and Modeling and socio-epistemological perspectives. The absence of tasks that require
Modeling, argumentation, and decision-making in authentic contexts tend to restrict the
students' mathematical knowledge is reduced to isolated procedures, strengthening the sense of
difficulty and lack of meaning in the subject.

Action plan for implementing PBL at UNINBE

Teaching level

At the teaching level, a key recommendation is that PBL (Project-Based Learning) be introduced gradually.
and strategic, instead of trying to immediately replace the exhibition model. One possibility is to
Implementation of "mini-PBL," that is, contextualized problems that take between 20 and 30 minutes.
classroom activities, around which moments of understanding and discussion in small groups are structured.
and validation of solutions, maintaining, in an initial phase, a part of the class organized in the following format

RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026
more traditional.

Another important measure concerns the reorganization of the lecture format, in order to Interspersing explanations with periods of work in pairs or small groups, in which students They can discuss ideas, test procedures, and present strategies. In this reorganization, the The teacher can start with small variations, such as proposing a problem before the presentation. collect different solution schemes produced by the students and only then present a synthesis.

It is also recommended that a portion of the assessment be explicitly dedicated to tasks. based on problems, albeit with limited weight at the beginning (for example, between 15% and 30% of (Note): This incorporation helps to signal to students that participation in activities of Problem-solving, teamwork, and the ability to justify solutions are dimensions. valued in the course, thus aligning the assessment tools with the training objectives. announced.

Student level

At the student level, the focus should be on preparing for collaborative work. and for active participation in PBL activities. One proposal is to hold initial workshops, Each semester, covering topics such as group organization, time management, and the creation of... Basic study reports and procedures in the context of problems. This type of guidance can to be developed in partnership between faculty, student support services, and student groups.

Another strategy involves developing simple support materials, such as paper guides. and responsibilities in work groups, examples of brief problem-solving reports and review sheets for prerequisites related to the tasks to be worked on. These "bridge" sheets They can help reduce conceptual gaps that hinder engagement in PBL activities.

Promoting written self-explanation — small tasks in which the student explains, in A few sentences, a concept to an imaginary colleague — this can also contribute to consolidating meanings and develop its own mathematical language. Furthermore, it is important to clarify that the ABP is not a "permanent exam," but an opportunity for supported learning, where error... It is a tool for reflection, aimed at reducing anxiety and feelings of overexposure.

Institutional level

At the institutional level, the need to adjust classroom and space conditions stands out. to facilitate, as far as possible, group work and discussions. In a classroom setting. Given the large number of people, a viable measure is to organize stable subgroups and make the furniture more flexible so that... students can interact face-to-face. Whenever possible, reserve rooms with movable furniture or Alternative spaces for more intensive PBL sessions.

Another important institutional dimension is the continuing education of teachers in PBL and in...

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

Problem-based mathematics teaching. The provision of internal workshops, study cycles and working groups on designing contextualized problems, mediating discussions, and evaluation. In PBL (Project-Based Learning), one can contribute to building a community of practice around this approach. creation of mechanisms for institutional recognition — such as accounting for time served preparing PBL activities within the teaching hours and offering calls for proposals for pedagogical innovation — tends to strengthen teacher engagement.

Curriculum level

At the curriculum level, it is recommended that the objectives of the mathematics curricular units They clearly state the training in problem-solving, modeling, and communication. mathematics, going beyond simply listing the contents. This explanation must be accompanied by definition of curricular moments in which PBL is planned, for example, in the form of 1 or 2 Modules for each subject, with a defined workload and clear evaluation criteria.

It is equally relevant to consider the vertical articulation of PBL experiences throughout the In the early years of the course, students may be offered more guided tasks, with strong teacher support and a focus on problems relevant to their daily lives. As they progress through the course, students... They may be challenged with more open-ended problems, involving professional and other contexts. investigation, requiring greater autonomy and modeling capabilities.

Monitoring and investigation

Finally, it is desirable that the implementation of PBL be accompanied by processes. Systematic monitoring and research methods. Periodically reapply questionnaires to teachers and students, produce internal reports on the experiments conducted and disseminate results in Academic events and publications can constitute a virtuous cycle of reflection and improvement. These processes can even contribute to the formulation of research projects in Education. Mathematics, increasing UNINBE's visibility in the scientific field.

5. Final Considerations

This article sought to discuss the theoretical foundations, the diagnosis of practices, and perceptions. and a set of proposals for the implementation of problem-based learning in mathematics teaching at an Angolan public university. The data analyzed show a a scenario in which the transmission model still predominates, with a strong presence of expository classes and Individual exercises, and little room for contextualized problems and group work.

At the same time, teachers and students express very favorable attitudes towards PBL. recognizing its potential to promote conceptual understanding, motivation, participation and collaboration. Students, in particular, express a clear desire to have more opportunities to

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

Learning mathematics through problems linked to Angolan reality and professional contexts.
although they acknowledge obstacles such as lack of time, large class sizes, and gaps in their own
preparation.

In light of this context, we argue that the implementation of PBL at UNINBE should be...
understood as a gradual transformation process, involving changes in teaching practices,
in the role of students, institutional conditions, and curriculum. The action plan presented here
It offers a set of possibilities articulated at different levels, which can be adapted to...
specific reality of each course and curricular unit.

We acknowledge that the study has limitations, especially since it is an investigation.
exploratory, based on self-reports from teachers and students and within an institutional context.
Specifically, future investigations could delve deeper into the analysis of concrete experiences with PBL.
accompanying specific classes, observing lessons, analyzing student assignments and products,
in order to build a more detailed picture of the impacts of the approach on learning.
mathematics.

Nevertheless, we believe that the reflections developed contribute to the debate on the
Implementation of active learning methodologies in contexts of expansion and massification of higher education.
especially in Portuguese-speaking African countries, and which can engage in dialogue with discussions.
present in Brazilian literature on Mathematics Education, including publications from the author herself.
REMat.

References

ALPERS, Burkhard et al. A framework for mathematics curricula in engineering education. Brussels: European Society for Engineering Education, 2013.

CANTORAL, Ricardo; FARFÁN, Rosa María. Mathematics and didactics: from epistemology to socioepistemology. Latin American Journal of Research in Educational Mathematics, v. 6, no. 3, p. 247-265, 2003.

CHIKULO, Bornwell C. Higher education reforms in post-conflict Angola: Challenges and prospects. African Journal of Political Science and International Relations, vol. 13, no. 2, p. 16-26, 2019.

CUMBO, Oscar Mavungo. Problem-based learning using spreadsheets. 2018. Doctoral thesis (Education) – University of Beira Interior, Covilhã, 2018.

DIAS, Efilione Noez. State and public educational policy: advances and limitations in the implementation of educational policies in Angola. 2023. Dissertation (Master's in Education) – University of International Integration of Afro-Brazilian Lusophony, 2023.

GRAAFF, Erik de; KOLMOS, Anette. Characteristics of problem-based learning. International Journal of Engineering Education, vol. 19, no. 5, p. 657-662, 2003.

GRAVEMEIJER, Koeno et al. What mathematics education can prepare students for the society of

Year VI, v.1 2026 | Submission: 03/16/2026 | Accepted: 03/18/2026 | Publication: 03/20/2026

the future? International Journal of Science and Mathematics Education, vol. 15, suppl. 1, p. 105-123, 2017.

HMELO-SILVER, Cindy E. Problem-based learning: What and how do students learn? Educational Psychology Review, vol. 16, no. 3, p. 235-266, 2004.

KRUTETSKII, VA The psychology of mathematical abilities in schoolchildren. Chicago: University of Chicago Press, 1976.

LESH, Richard; DOERR, Helen M. (Org.). Beyond constructivism: Models and modeling perspectives on mathematical problem solving, learning, and teaching. Mahwah: Lawrence Erlbaum Associates, 2003.

LESH, Richard; LEHRER, Richard. Models and modeling perspectives on the development of students and teachers. Mathematical Thinking and Learning, vol. 5, no. 2-3, p. 109-129, 2003.

MCCOWAN, Tristan. Quality of higher education in Kenya, Tanzania, Uganda and South Africa: A comparative analysis. Compare, v. 48, n. 1, p. 92-109, 2018.

MENEZES, Ana; PINTO, Paulo. Role of industry in developing the educational system. International Journal of Scientific Research and Modern Education, vol. 1, no. 1, p. 385-390, 2016.

POLYA, George. How to solve it: A new aspect of mathematical method. Princeton: Princeton University Press, 1945.

PIAGET, Jean. Genetic epistemology. New York: Columbia University Press, 1970.

SCHOENFELD, Alan H. Mathematical problem solving. Orlando: Academic Press, 1985.

SCHOENFELD, Alan H. Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In: GROUWS, Douglas A. (Org.). Handbook of research on mathematics teaching and learning. New York: Macmillan, 1992. p. 334-370.

VYGOTSKY, Lev S. Mind in society: The development of higher psychological processes. Cambridge: Harvard University Press, 1978.