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The Teaching Perception of the Didactic Transposition of Mathematics in a Group of University Teachers

Hugo Hernando Mendoza Vargas

hugo.mendoza@uptc.edu.co@uptc.edu.co

2hsmendoza@gmail.com

Orcid https://orcid.org/0000-0003-3664-4505

Juan María Mendoza
juanmaria.mendoza@uptc.edu.co
soyjuanm@gmail.com
orcid https://orcid.org/0000.0003-1113844

Adriana Lucia Fonseca Murillo

Lucia.fonseca@uptc.edu.co

adrifonsecam@gmail.com

ORCID https://orcid.org/0000-00032206-8842

Abstract

This study aims to establish the perception of teachers who work in a university educational institution in the department of Boyacá. Therefore, it has a qualitative approach of systematic design. The participants were six male and female teachers, who teach mathematics classes in technological programs at UPTC. The collection instruments consisted of a semi-structured interview whose guiding questions focused on characteristics and aspects taken into account by teachers in the teaching and learning process when teaching mathematics classes. The analyzes were carried out through content analysis using the Atlas ti software. version 8. The results showed that teachers present a conceptual and practical deficit in relation to the aspects taken into account by the theory and pragmatics of didactic transposition.

Keywords: Teacher, process, transposition, didactics

Introduction

Didactic transposition was, the term introduced by Chevallard (1994) and determined by him, as a fundamental process in teaching, since it implies the transformation of scientific knowledge into teachable knowledge, adapted to the characteristics and needs of students. This process allows academic knowledge to be accessible in the classroom, as well as establishing a bridge between specialized knowledge and practical learning, ensuring that the contents are understandable and meaningful to students.

In the context of the formative process of mathematics, didactic transposition acquires special relevance, since this discipline requires a constant adaptation of abstract and complex concepts to concrete pedagogical situations. This process involves not only transmitting information, but also evaluating and adjusting teaching strategies to reduce the gap between the knowledge taught and the knowledge learned. In addition, it allows the epistemic basis of the content to be analyzed and evaluated, promoting a more reflective and grounded understanding (Bosch et al., 2021).

Studying didactic transposition is crucial to understand how teachers transform and adapt knowledge in the classroom, which impacts the quality and significance of student learning. This analysis not only contributes to understanding pedagogical practices, but also allows us to identify possible dysfunctions in the educational process, promoting a more effective mathematics education.

The above, articulated in the current educational panorama both globally and locally, shows that teaching faces challenges derived from social, technological and cultural changes, globalization, the advance of information and communication technologies (ICT), and the growing diversity of students and teachers in educational institutions. which have transformed the dynamics of this process, in the diversification of practices, strategies and methodologies implemented in the classroom. These factors have generated the need to rethink pedagogical ones, adapting them to more complex and diverse contexts.

Globally, one of the main challenges is to ensure inclusive and quality training, as set out in one of the UN Sustainable Development Goals (2020). However, educational inequalities persist, especially in resource-limited regions, where access to technological tools and adequate teacher training is insufficient. In addition, the COVID-19 pandemic accelerated the transition to hybrid and virtual teaching models, which evidenced both opportunities and gaps in the implementation of these modalities.

However, in Colombia, and according to the Ministry of National Education MEN (2022), it has shown how teaching faces specific challenges related to equity and institutional quality. According to recent studies, teachers must deal with contexts of high social vulnerability, which makes it difficult to implement effective and contextualized pedagogical strategies. In this sense, didactic transposition becomes a key process, since it allows academic content to be adapted to the realities of students, ensuring that their discernment is accessible and meaningful.

Therefore, the importance of transposition is due to the fact that it is a process of transformation of scientific knowledge into teachable knowledge and plays a crucial role in all educational contexts. This process not only involves selecting and organizing content, but also contextualizing and adapting it to the needs of students, considering factors such as their level of understanding, interests, and sociocultural environment (Palencia et al., 2022).

However, inadequate practices or the lack of teacher training in this area can hinder their effectiveness, especially in contexts far from the protection of the state, Villamizar (2016) states that the national government, although it has prioritized education as a key sector, allocating high budgets to guarantee access and permanence of children and young people in the training system, and trying to provide quality and equity in education, what it does is to move away from these pretensions due to lack of oversight, since when reviewing the statistics of the sector it is found that although educational coverage and quality has improved with respect to previous years, it is observed that compared to other nations, Colombia faces significant challenges in terms of educational quality.

According to international assessments such as PISA tests, Colombian students obtain below-average scores in areas such as mathematics, reading and science, which shows deficiencies in the education system, with lower percentages of investment in this sector of GDP compared to developed countries, which limits the system's ability to improve infrastructure. teacher training and pedagogical resources (Santamaría, 2020).

Díaz (2019) proposes that pedagogy as a science that studies the forms and manners of the pedagogical process, faces social debate by the members belonging to its noosphere, established by representatives of the scientific system of teaching, a system from which the understanding of what didactic transposition is, whose peak is produced by the "wear and tear" of the knowledge taught and that as a characteristic finds support in the contextualization of it, the de-incretization and depersonalization of knowledge.

For Murillo et al., (2023) education faces unique challenges that require innovative and adaptive approaches from teachers. Lack of adequate infrastructure and limited access to teaching materials complicate the teaching of abstract concepts, such as geometry, which are essential for the development of mathematical reasoning in students. This document explores the perception of university teachers regarding the use of didactic materials, lesson planning, evaluation and playful strategies in mathematics didactics, highlighting the need for educators to appropriate transposition to transform specialized knowledge into effective pedagogical practices.

Returning to the discursive process of the work and pointing to the development of the phenomenon of didactic transposition, Gómez (2005) reflects on the evolution of knowledge in academic disciplines, arguing that the use of the term was derived from various disciplines such as philosophy, physics, foreign languages and in particular, in the teaching of mathematics. where it had its beginnings. The transposition was developed from the anthropological perspective of knowledge, where there is a symbolic game between the teacher, the students and the understanding, forming a didactic system where this phenomenon is the passage from wise knowledge to taught knowledge.

Bosch et al., (2021) state that didactic transposition is a key concept in the teaching of geometry, which refers to the process by which specialized mathematical content is transformed into accessible and understandable content for students. This process is essential for educators to be able to adapt complex concepts to the realities and contexts of their students, especially in rural environments where teaching resources are limited. Geometry, as a mathematical discipline, presents particular challenges due to its abstract nature and its reliance on visualization and spatial reasoning.

In the sciences that involve numbers, it is found that the teacher focuses his attention on the development of key skills, such as logical reasoning, visualization and problem solving. These competencies are essential for students to be able to analyze and understand the properties and relationships of geometric figures, as well as apply this knowledge in everyday situations. However, traditional geometry teaching is often based on a rote approach, where students learn formulas and definitions without a deep understanding of the underlying concepts. This limits their ability to connect geometry with other areas, such as physics, art, or technology.

The analysis of transposition in the teaching of geometry reveals the need for a curricular reorganization that integrates geometry as a transversal axis in education from the early stages. This integration would allow students to develop critical and creative thinking, fostering skills that are essential for their academic and personal development. The lack of a systematic approach has led to many students failing to understand geometric concepts in a profound way, which affects their performance in mathematics in general.

Teacher training is another crucial aspect of didactic transposition. Many educators lack the necessary training to teach geometry effectively, resulting in pedagogical practices that are not conducive to meaningful learning. It is essential that teachers receive continuous training in specialized pedagogical techniques that allow them to approach geometry in a dynamic and contextualized way. This includes the use of manipulative teaching materials and digital resources that facilitate the understanding of geometric concepts (López & Pérez, 2022).

Using educational software, such as Cabri, can be a valuable tool in teaching geometry. These programs allow students to explore and manipulate geometric shapes in an interactive way, which favors the development of spatial reasoning and visualization skills. In addition, incorporating digital resources into the classroom can motivate students and make learning geometry more engaging and relevant to them (Kynigos, 2015).

For Jamilah et al., (2020) Didactic transposition also involves considering the characteristics and needs of students when designing learning activities. Teachers must be able to identify their students' prior knowledge and build on it to facilitate the understanding of new concepts. This requires careful planning and ongoing assessment of student progress, as well as a willingness to adjust pedagogical strategies as needed.

In the context of teaching mathematics and especially geometry, it is important to foster a collaborative learning environment where students can work together to solve problems and explore concepts. Group activities promote the exchange of ideas and the joint construction of knowledge, which enriches the learning experience. In addition, using problem situations that connect geometry to everyday life can help students see the relevance of what they are learning.

Research in mathematics didactics has shown that transposition is a dynamic process that requires the active participation of teachers in the transformation of what is taught. Educators must be thoughtful and critical in their practice, constantly evaluating the effectiveness of their pedagogical approaches and looking for new ways to improve the teaching of geometry. This implies being open to innovation and the incorporation of new technologies and methodologies in the classroom.

Atalar and Ergun (2018) analyzed the factors that affect the transposition of the knowledge to be taught into "learned knowledge" among science teachers in Turkey, finding that the previous training of teachers influenced the delivery of knowledge; The more experienced teachers offered more understandable examples. Students felt that the teaching of chemistry was better than that of other subjects.

As a result of the research, Atalar and Ergun (2018) were able to conclude that the qualifications and experience of the teacher have a significant impact on the effectiveness of teaching in science education. Factors influencing the transformation of knowledge from teachers to students in science education include:

Teacher Training: Teachers' educational qualifications and areas of study significantly affect how they convey content.

Professional Experience: Teachers with more experience tend to offer more understandable examples and repeat key concepts, improving students' understanding.

Consideration of the Curriculum: Teachers take into account the prescribed curriculum when transforming knowledge, which can influence the depth and focus of how it is taught.

It was also found that didactic transposition is significant in science education because:

Facilitates Content Transformation: Describes the process of converting academic scientific knowledge into curricular content, then into taught knowledge, and finally into knowledge learned by students.

Improves Teaching Effectiveness: By understanding the differences between types of knowledge, teachers can better tailor their instruction to meet students' learning needs.

Promotes Curriculum Development: Provides a framework for analyzing and improving the way scientific concepts are presented in educational settings, ensuring that the curriculum is aligned with scientific rigor and pedagogical effectiveness.

Likewise, Otero et al., (2015) discuss the evolution of research in mathematics education, focusing on cognitive and epistemological programs, Highlighting the role of the Anthropological Theory of Didactics (SDT) in improving the epistemological program, finding key contributions including; the emphasis on institutional and ecological perspectives in didactic analysis, as well as the development of epistemological reference models (MER) for various mathematical fields, the exploration of macrodidactic phenomena and their impact on learning processes, seeking to clarify the conditions that promote or hinder effective study modalities in education.

The three stages of the algebrization process described by Otero et al., (2015) are the mathematical praxeologies that build on and extend each previous stage. Each stage is generated from a specific type of problem characterized by a general structure. This process supports a new modality of study with different purposes and didactic means.

Didactic paradigms characterize and govern specific types of study processes within a field in educational institutions. They help define the interactions between students and teachers, forming a didactic system that influences how mathematical knowledge is taught and learned. By analyzing these paradigms, researchers can better understand the conditions that affect the effectiveness of mathematics education.

Modernism reacts against the traditional modalities of studying the numerical sciences, such as theoreticalism and technicality, by promoting the idea that the learning of mathematics should involve the free exploration of non-trivial problems. It emphasizes creativity and problem-solving over machine learning and algorithmic procedures. This approach seeks to make these sciences more relevant and attractive to students, moving away from the rigid structures of traditional education.

Similarly, Putra (2020) examines the didactic transposition of rational numbers to students, focusing on how this mathematical knowledge adapts from its scientific form to a form that can be taught in the classroom. The study combines an analysis of textbooks with the evaluation of the mathematical and didactic knowledge of future primary school teachers. The main goal is to investigate how future teachers understand and teach rational numbers, a concept that presents significant challenges due to the conceptual transition from natural numbers. The article highlights that many future teachers have limited knowledge of both mathematical content and pedagogical strategies to teach this topic. This underscores the need to strengthen their training in both aspects to improve the teaching of rational numbers.

Methodology

The methodology of this study was designed to explore and describe the perception of teachers of the Pedagogical and Technological University of Colombia (UPTC) about didactic transposition in mathematics classes. This approach is based on a qualitative paradigm of a descriptive type, which allows understanding the experiences and perspectives of the participants in relation to the phenomenon studied. The key methodological aspects are detailed below:

Research Design

The study is framed in a descriptive qualitative approach, which, according to Hernández, (Hernández et al., 2014) It is suitable for analyzing phenomena in depth from the perspective of the participants, allowing their perceptions and experiences to be interpreted in specific contexts.

Participants

The research involved the participation of six UPTC professors who teach subjects related to mathematics. These teachers were selected through purposive sampling, considering their experience in teaching mathematical content and their willingness to participate in the study.

Data Collection Instrument

A structured interview was used as the main instrument for data collection. This instrument was validated by expert peers, following the recommendations of Hernández, Fernández, and Baptista (2014), to ensure its relevance and clarity. The interviews were designed to address the following categories of analysis:

Processes and procedures that teachers consider when planning and developing mathematics classes.

Perception of the planning of mathematics classes.

Teaching practices used by teachers.

Structure for the evaluation of mathematical content.

Data Analysis

The analysis of the collected data was carried out using the content analysis method, which allows identifying patterns, categories and meanings in the participants' discourses. To facilitate this process, the Atlas.ti version 7 software was used, which allowed the answers to be organized and coded in a systematic way. This approach made it possible to identify the perceptions and practices related to didactic transposition in mathematics classes.

Procedure

Data collection: Structured interviews were conducted with the six participating teachers, which were recorded and transcribed for later analysis.

Codification

The transcripts were analyzed using Atlas. You, identifying emerging codes and categories related to the previously defined dimensions of analysis.

Interpretation

The coded data were interpreted in the light of the theoretical framework and the objectives of the study, allowing us to understand the teachers' perceptions about didactic transposition.

Ethical Considerations

The confidentiality and anonymity of the participants were guaranteed, obtaining their informed consent before conducting the interviews. In addition, the ethical principles of qualitative research were respected, ensuring that the data were used exclusively for academic purposes.

This methodology allowed to rigorously and systematically explore teachers' perceptions of didactic transposition, providing a solid basis for the interpretation of the results and the formulation of conclusions.

Results

Illustration 1

Word Cloud

Note. The word cloud is based on the perceptions of UPTC professors who teach subjects associated with mathematics.

The previous one is the word cloud made from the answers obtained from the participants of the research, mounting on their answers that great attention is paid to the didactic transposition of mathematics in front of what is done in the class, to the structure of the students' training, to the way of learning mathematics itself, to the content that is implemented, the exercises that are generated in the educational spaces, as well as to the strategies, the contents and the evaluation, all focused on the students.

After this analysis, the following semantic network was carried out, which expresses what was stated by the study participants regarding the following categories of analysis:

Mathematics teaching practices.

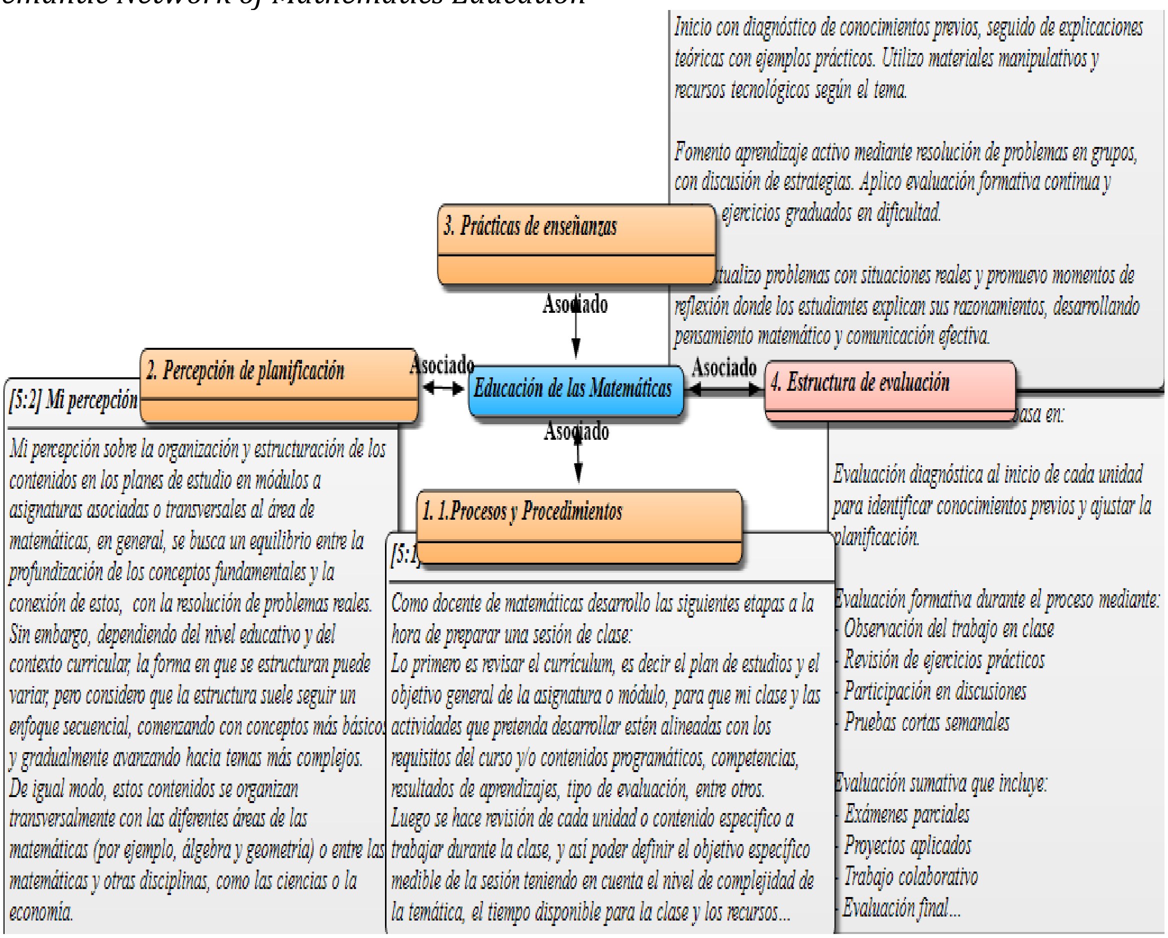
Structure of evaluation of subjects associated with mathematics.

Processes and procedures carried out by mathematics teachers.

Perception of the planning carried out to carry out the teaching-learning process.

Illustration 2

Semantic Network of Mathematics Education



Note. The semantic network is based on the perceptions of UPTC professors who teach subjects associated with mathematics. In original Spanish language

The semantic network establishes Mathematics Education as the central axis, which groups all the practices and concepts related to the didactic transposition of the discipline. As a category associated with teaching are the Processes and Procedures: It includes the planning of the class and the teaching strategy that in the words of the study participants is established:

> The first thing is to review the curriculum, that is, the curriculum and the general objective of the subject or module, so that my class and the activities I intend to develop are aligned with the requirements of the course and/or programmatic contents, competencies, learning outcomes, type of evaluation, among others.
> Then each unit or specific content to be worked on during the class is reviewed, and thus be able to define the specific measurable objective of the session taking into account the level of complexity of the topic, the time available for the class and the digital and/or analog technological resources to be used, among other aspects.
> Subsequently, the appropriate didactic strategies and methods are designed to achieve the objectives proposed for the class session, for which I work in a masterful way to explain concepts and theories related to the topic to be addressed, likewise, I apply problem-based learning so that students implement or transfer what they have learned in real situations. from collaborative work, where students can solve problems in groups and make use of mathematical software (GeoGebra, WolframAlpha, etc.) or interactive simulators (PhET Simulators), which can help visualize abstract concepts, among other strategies. Planning responds to the development of the following moments: Prior knowledge or pre-knowledge, structuring, practice, transfer, evaluation and closure. Finally, he prepared the materials and/or resources necessary to work on each of the planned pedagogical actions (p.5).

Likewise, it can be established that the lesson plan consists of defining learning objectives, answering the question of what is expected to be achieved at the end of the class and in which the students' previous knowledge is evaluated.

Another pre-designed category for this work was that of teaching practices, methods and styles used in the classroom, to which the interviewees responded that the methods they implement the most are those that face a wide variety of strategies that can be adopted, problem-based teaching, which is a specific approach that is frequently mentioned, and collaborative education. which is the joint work between students, the above was evidenced in:

> In my classes I implement the following practices:
>
> Beginning with a diagnosis of previous knowledge, followed by theoretical explanations with practical examples. I use manipulative materials and technological resources depending on the topic.
>
> Promotion of active learning through group problem solving, with discussion of strategies. I apply continuous formative assessment and assign graded exercises in difficulty.
>
> I contextualize problems with real situations and promote moments of reflection where students explain their reasoning, developing mathematical thinking and effective communication (p.4).

Regarding the evaluation structure, it is evident that it is based on the conception that it is the way in which learning is evaluated and in which types of evaluation related to the following were found; the diagnostic evaluation applied at the beginning of a module to identify previous knowledge. Formative assessment that is implemented in the course of learning to adjust teaching and summative assessment implemented at the end of a training process to measure the knowledge acquired.

Board1

Diagnostic Evaluation Strategies

<table>
<tr><td rowspan="3">Category/Evaluation Structure</td><td colspan="2">Diagnostic evaluation at the beginning of each unit to identify prior knowledge and adjust planning.</td></tr>
<tr><td>Formative assessment during the process by</td><td>Observation of classwork
Review of practical exercises
Participation in discussions
Weekly Short Tests</td></tr>
<tr><td>Summative assessment including</td><td>Midterm exams
Applied projects
Collaborative work
Final Evaluation</td></tr>
</table>

	I give constant feedback and adjust strategies according to results. I maintain clear rubrics and evaluation criteria known to students (p.3).

Note. Own elaboration.

Finally, the perception of planning of mathematics classes responded to how the organization of content is perceived by teachers and in which the importance of updating content is considered considering the need to make the materials relevant and current. The basic levels of content that reflect the adequacy of the content to the level of the students and the logical progression of content that is the organization of the content in such a way that it is built on what has already been learned.

> My perception of the organization and structuring of the contents in the curricula in modules to subjects associated or transversal to the area of mathematics, in general, seeks a balance between the deepening of the fundamental concepts and the connection of these, with the resolution of real problems. However, depending on the educational level and curricular context, the way they are structured may vary, but I consider that the structure usually follows a sequential approach, starting with more basic concepts and gradually moving towards more complex topics.
>
> In the same way, these contents are organized transversally with the different areas of mathematics (for example, algebra and geometry) or between mathematics and other disciplines, such as science or economics (p.5).

Discussion

After the categorical analysis of what was established by the UPTC teachers, it was possible to conclude against the process carried out by them from the phenomenon of the didactic transposition of the subjects associated with mathematics that planning is the central axis of their teaching, observed as a structured process that allows the teacher to align the learning objectives with the curricular contents and pedagogical strategies. According to the results analyzed, this process includes the revision of the curriculum, the definition of specific and measurable objectives, and the selection of appropriate technological and didactic resources. This approach ensures that activities are aligned with course requirements and expected competencies.

Planning is organized in key moments such as the students' previous knowledge, structuring, practice, transfer, evaluation and closure, which allows a progressive and logical development of the contents. This approach reflects the importance of sequentiality in teaching, starting with basic concepts and moving on to more complex topics, as suggested by authors such as Chevallard (1994) and Bosch et al. (2021). In addition, the integration of technological tools such as GeoGebra and interactive simulators is highlighted, which facilitate the visualization of abstract concepts and promote active learning.

Regarding the methods and practices of mathematics content, the centrality of active and collaborative strategies, such as problem solving and project-based learning, was observed. These practices allow students to apply the concepts learned in real situations, encouraging teamwork and the use of technological tools. For example, activities such as the diagnosis of prior knowledge, theoretical explanations with practical examples, and the contextualization of real situational problems are mentioned. Collaborative teaching, which involves interaction between students to solve problems in groups, is a recurring practice. This approach was not only considered to develop mathematical skills, but also transversal competencies such as communication and critical thinking, aligning with the proposals of authors such as Villamizar (2016) and Putra (2020).

In view of the evaluation carried out by mathematics teachers, it was considered that it is structured in three main types: diagnostic, formative and summative. The diagnostic evaluation is carried out at the beginning of each unit to identify previous knowledge and adjust the planning. Formative assessment, on the other hand, is carried out during the learning process through observation, review of exercises and short tests, allowing continuous adjustments in teaching strategies. Finally, summative assessment measures the knowledge acquired at the end of a module or course, using exams, projects and collaborative work. This comprehensive approach to evaluation reflects the importance of constant feedback and clarity in evaluation criteria, aspects highlighted by authors such as Díaz (2019) and López and Pérez (2022). In addition, assessment encourages reflection and the development of mathematical thinking, promoting a deeper understanding of concepts.

Finally, the teachers' perception established that the organization of mathematics content was understood as a process that seeks to balance the deepening of fundamental concepts with their application in real problems. This involves a logical progression that connects areas such as algebra and geometry, as well as the integration of mathematics with other disciplines, such as science and economics. This transversal and sequential approach ensures that students build on previous knowledge, as suggested by authors such as Santamaría (2020) and Murillo et al. (2023).

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