EMP Educação Matemática Pesquisa
ISSN 1983-3156
Qualis A1
http://dx.doi.org/10.23925/1983-3156.2024v26i4p005-034

Conceptualizing formative curriculum materials and discussing their crossing on teachers' professional knowledge

Conceptualizar los materiales curriculares formativos y discutir sus atravesamientos en el conocimiento profesional docente

Conceptualiser les matériels curriculaires formatifs et discuter de leurs traversées dans les connaissances professionnelles des enseignants

Conceituando materiais curriculares formativos e discutindo seus atravessamentos no conhecimento profissional docente

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Abstract

The production of curriculum materials has been influenced by the High School Reform and the approval of the *Base Nacional Comum Curricular*, especially the materials that are evaluated and made available by the *Programa Nacional do Livro e do Material Didático* (PNLD). The latest edition of the PNLD for secondary education brought innovations, such as: Continuing Education books. We call these books Formative Curriculum Materials, as they are designed to support teachers' learning in relation to the theories that underpin didactic, methodological, conceptual and evaluative options relating to mathematics and its teaching. The aim of this paper is to discuss teacher learning opportunities in Mathematics Formative Curriculum Materials. The methodological approach employed is qualitative and exploratory, and the procedures follow the outline of documentary analysis. The results show that the materials examined offer different learning opportunities for teachers, which can influence the planning and implementation of lessons. These materials are a source of learning for teachers, but they must be used critically and reflectively, respecting the freedom and autonomy of these professionals.

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Keywords: Formative curriculum materials, Learning opportunity, Professional teaching knowledge, TLO-Math.

Resumen

La producción de materiales curriculares ha sido influenciada por la Reforma de la Enseñanza Media y la aprobación de la *Base Nacional Comum Curricular*, especialmente los materiales que son evaluados y puestos a disposición por el *Programa Nacional do Livro e do Material Didático* (PNLD). La última edición del PNLD dirigido a la Enseñanza Media trajo innovaciones, como ejemplo podemos mencionar: obras de educación continua. Designamos estos trabajos como Materiales Curriculares Formativos, ya que están diseñados para apoyar el aprendizaje de los docentes en relación con las teorías que subyacen a las opciones didácticas, metodológicas, conceptuales y evaluativas relativas a la Matemática y su enseñanza. Este artículo está guiado por el objetivo de discutir oportunidades de aprendizaje para docentes en Materiales Curriculares Formativos de Matemática. El enfoque metodológico utilizado es cualitativo y exploratorio, cuyos procedimientos siguen el esquema del análisis documental. Los resultados revelan que los materiales examinados ofrecen diferentes oportunidades de aprendizaje para los docentes, lo que puede influir en la planificación e impartición de las clases. Estos materiales son una fuente de aprendizaje para los docentes, pero deben ser utilizados de manera crítica y reflexiva, respetando la libertad y autonomía de los docentes.

Palabras clave: Materiales curriculares formativos, Oportunidad de aprendizaje, Conocimiento profesional docente, TLO-Math.

Résumé

La production de matériel curriculaire a été influencée par la réforme du Lycée et l'approbation du *Base Nacional Comum Curricular*, en particulier le matériel évalué et mis à disposition par le *Programa Nacional do Livro e do Material Didático* (PNLD). La dernière édition du PNLD destinée au Lycée a apporté des innovations, à titre d'exemple on peut citer: la formation continue fonctionne. Nous désignons ces ouvrages comme Matériels Curriculaires Formatifs, car ils sont conçus pour soutenir l'apprentissage des enseignants en relation avec les théories qui sous-tendent les options didactiques, méthodologiques, conceptuelles et évaluatives relatives aux Mathématiques et à leur enseignement. Cet article est guidé par l'objectif de discuter des opportunités d'apprentissage pour les enseignants en matière de Matériels Curriculaires Formatifs en Mathématiques. L'approche méthodologique utilisée est qualitative

et exploratoire, dont les procédures suivent les grandes lignes de l'analyse documentaire. Les résultats révèlent que les matériels examinés offrent différentes opportunités d'apprentissage aux enseignants, ce qui peut influencer la planification et la prestation des cours. Ces matériels sont une source d'apprentissage pour les enseignants, mais ils doivent être utilisés de manière critique et réfléchie, dans le respect de la liberté et de l'autonomie des enseignants.

Mots-clés: Matériels curriculaires formatifs, Opportunité d'apprentissage, Enseigner des connaissances professionnelles, TLO-Math.

Resumo

A produção de materiais curriculares tem sido influenciada pela Reforma do Ensino Médio e pela homologação da Base Nacional Comum Curricular, especialmente os materiais que são avaliados e disponibilizados pelo Programa Nacional do Livro e do Material Didático (PNLD). A última edição do PNLD destinada ao Ensino Médio trouxe inovações, a título de exemplo podemos citar: obras de formação continuada. Designamos essas obras como Materiais Curriculares Formativos, pois são concebidas para apoiar as aprendizagens dos professores em relação às teorizações que fundamentam as opções didáticas, metodológicas, conceituais e avaliativas referentes à Matemática e seu ensino. Este artigo orienta-se pelo objetivo de discutir oportunidades de aprendizagem de professores em Materiais Curriculares Formativos de Matemática. A abordagem metodológica empregada é qualitativa e exploratória, cujos procedimentos seguem o delineamento da análise documental. Os resultados revelam que os materiais examinados oferecem diferentes oportunidades de aprendizagem para os professores, que podem influenciar o planejamento e a realização das aulas. Esses materiais são uma fonte de aprendizagem para os professores, mas que devem ser usados de forma crítica e reflexiva, respeitando a liberdade e a autonomia destes profissionais.

Palavras-chave: Materiais curriculares formativos, Oportunidade de aprendizagem, Conhecimento profissional docente, TLO-Math.

Conceptualizing formative curriculum materials and discussing their crossing on teachers' professional knowledge

Changes in Brazilian public curricular policies, such as the High School Reform and the approval of the *Base Nacional Comum Curricular* — BNCC (Brasil, 2018), have influenced the production of curricular materials, especially those evaluated and made available by the *Programa Nacional do Livro e do Material Didático* — PNLD.

Considered the largest program in terms of financial investment of all the Ministry of Education — MEC programs (Carvalho, 2018), it is through the PNLD that didactic, pedagogical and literary works, among other materials to support educational practice, can be found in public schools, guaranteeing students and teachers the constitutional right to access materials to support curriculum development (Brasil, 2017). Even with the advent of digital technologies, these materials are still central to teaching and learning processes and are often the only resource teachers have to plan their lessons and carry out pedagogical practices (Fernandes, 2005).

The PNLD has existed since 1985 and its latest edition for secondary education, PNLD 2021, has brought changes, such as the production of books by areas of knowledge and the increase in the types of materials made available (called Objects), which are certainly worrying the agents that make up the school space and impacting the ways in which these materials are chosen and used. It is possible to identify that these materials have the potential to enable the implementation of curricular changes, as happened with the *Parâmetros Curriculares Nacionais*, for example.

Gracin and Matić (2021) argue that curriculum changes bring new approaches to classroom practice and as they are implemented, teachers and students need to receive additional support from various sources, such as textbooks and other materials, because such resources that support reform can actively influence teachers' intentions and decisions at the stage of assessment, task selection and implementation. These resources can also induce student learning situations, and learning itself. And here we include that materials can impact teacher knowledge by also providing learning resources for teachers.

It is therefore important to analyze how curriculum materials can contribute to teachers' professional development, especially in contexts of educational reform. According to Remillard and Heck (2014), materials can be seen as tools that mediate the relationship between teachers and the curriculum, which can facilitate or hinder the implementation of proposed changes. In this sense, curriculum materials are not just resources that transmit content and guidelines, but also tools that interact with teachers and influence their conceptions, beliefs and practices, as

highlighted by Souza (2024) and Soares (2024) in their studies.

From this perspective, teacher learning mediated by curriculum materials can be understood as a dynamic and complex process involving different cognitive, affective and social dimensions. According to Ball and Cohen (1996), curriculum materials can serve as learning opportunities for teachers when they are challenged to reflect on their own conceptions and actions, compare different pedagogical approaches, evaluate student results and adapt resources to specific needs and contexts. Thus, curriculum materials can act as stimuli for teachers' continuous professional development, provided they are well-designed and used critically and creatively (Perovano, 2022).

The publication of new materials that translate curriculum prescriptions into classroom practice is seen as a relevant first step in implementing curriculum change (Keitel, Otte & Seeger, 1980), especially since promoting curriculum reform through textbooks aligned with the standards indicated in curriculum documents is relatively inexpensive and guarantees the implementation of those standards (Polikoff, 2015).

However and Howson (2013) points out that teachers need help to work with the proposed curriculum changes, and that these professionals find support for new approaches, for example, in the curriculum materials and in the guidelines that accompany these materials. Corroborating this reflection, Keitel, Otte and Seeger (1980) argue that teachers' dependence on curriculum materials during a period of reform is greater than at other times due to the role of this resource as educational material for teachers. This is because, “teachers' understanding of the material, their beliefs about what is important, and their ideas about students and the teacher’s role all strongly shape their practice” (Ball & Cohen, 1996, p. 6). Thus, materials can support teachers' learning through the presentation of content and its approach, serving as a source of professional development (Collopy, 2003).

The reform of secondary education has reconfigured the structure and curricular design of this stage of schooling. In response to this change, publishers have produced their books in an attempt to take account of the curricular innovations and meet the changes in the concept of secondary education, as well as aligning them with the BNCC and what was indicated in the PNLD Notice. The PNLD 2021 provided for five objects, as illustrated in Table 1.

An innovation took place in the 2021 PNLD, and for the first time in the program's history, space was opened up for *Continuing Education Books* aimed at teachers and management staff of public high schools. It is understood that these works are a reference for building teaching and learning practices in line with the New High School (Brasil, 2019).

Table 1.

Types of materials corresponding to the PNLD 2021 (Own elaboration based on Call Notice No. 03/2019, referring to the PNLD 2021 (Brazil, 2019))

	Characterization	Cycle
Object 1: Integrating Projects and Life Projects	Integrating Projects (for each area of knowledge) are didactic works that seek to make learning more meaningful by showing the relationship between different curricular components and areas of knowledge, relating students to situations they experience in their communities. They should contain a printed student book, a printed teacher's manual and digital teacher's material. Each area of knowledge will have six projects and the teacher's digital material.	4 years
	Life Projects are materials that focus on student protagonism. They should contain a printed student book, a printed teacher's manual and digital teacher's material (three video tutorials) and digital teacher's material.	
Object 2: Teaching Materials by Areas of Knowledge	All six volumes of the student's book should address, in a balanced way, all the general and specific competences and skills of each area of knowledge (except for English Language in the area of Languages and their Technologies). Areas of knowledge: Languages and their Technologies, Mathematics and its Technologies, Natural Sciences and their Technologies, and Applied Human and Social Sciences. The Specific Teaching Works may be submitted independently, for English Language and Applied Human and Social Sciences and Mathematics. They must contain a printed student book, digital student material, a printed teacher's manual and digital teacher material.	3 years
Object 3: Continuing Education Materials	The Continuing Education books include discussions on training teachers in their respective areas and the management team of public schools. The work, comprising a printed book and video tutorial, aimed at the management team, should help those responsible for school management to create experiences that integrate the school's various professionals so that they can work together to implement the New High School, developing diversified and efficient teaching practices. The book should contain a printed book and a video tutorial, and for teachers it should help and encourage them to face the challenge of working by area of knowledge based on interdisciplinary experiences.	3 years
Object 4: Digital educational resources	The books, which are related to Digital Learning Objects (ODA), cover areas of knowledge, instruments and themes that make up secondary education. The material is organized into video lessons, proposals for teaching tools, solved and commented assessment items. There are also development plans, didactic sequences and reports and indicators for monitoring learning, as well as online management tools.	Not determined by the call

	The literary materials include a printed student book, digital student material, a printed teacher's manual, digital teacher material and video tutorials.	
Object 5: Literary materials	Themes considered: the vulnerability of young people; youth protagonism; digital culture in young people's daily lives; youth concerns; fiction; mystery; fantasy; bullying; and respect for difference. It includes the following literary genres: short story, chronicle, novel, drama, diary, biography, autobiography, stories, memoirs, comic books, novels and picture books.	3 years

These books arose from the need to provide teachers and school administrators with support in facing the challenges of implementing the New High School, as well as building new teaching and learning relationships structured around areas of knowledge (Brazil, 2023). Proposals were drawn up for teachers from different fields of knowledge: Portuguese Language, English Language, Physical Education, Music, Theater, Dance, Visual Arts, Mathematics, Biology, Physics, Chemistry, Philosophy, Geography, History and Sociology. It should be noted that the state recognizes the role of these books in teaching practice, disseminating ways of conceiving teaching work and identity. We won't discuss the political and ideological dimension of the arrival of these materials in Brazilian public schools, as this is beyond the scope of the study presented here.

The *Continuing Education Books* aimed at teachers (Object 3) should support and encourage them to break away from the disciplinary logic, facing the challenges of working by area of knowledge based on experiences of curriculum integration. However, we disagree with the nomenclature of these materials, as it can give the impression that it is possible for a teacher to be trained from a textbook. We believe that textbooks, including these materials, are a vector for continuing education for mathematics teachers in basic education (Silva Júnior, 2010); they contain elements and aspects that can support or enhance teacher learning, but they do not replace the training itself.

We will therefore refer to these materials as *Formative Curriculum Materials*. The variety of terms at first glance may seem to cloud the debate on curriculum materials, but an understanding of the expressions is necessary to justify our characterization/conceptualization of this material as formative.

Curriculum Materials are those developed to support student learning. *Curriculum Educational Materials* (MCE) are those that present specific resources to support teacher learning, incorporating features and structure that contribute to teachers' professional knowledge, be it about content, teaching, classroom situations or the curriculum (Davis & Krajcik, 2005). MCE enable teachers to make decisions about how best to adapt teaching

proposals to meet their learning objectives and strategies. The Teacher's Manual, which is evaluated and distributed by the PNLD, can be considered an example of an MCE.

We consider *Formative Curriculum Materials* to be those designed and conceived with the aim of helping to support or enhance teaching practice; which can be seen as a tool for developing professional teaching knowledge; which help to deepen certain teaching contents and approaches — conceptual aspects, methodological strategies, didactic options, conceptions and assessment proposals.

In this context, the post-doctoral study — developed in the Research Group on Curriculum in Mathematics Education (GPCEEM), within the Graduate Program in Education at the Universidade Estadual de Montes Claros — focuses on books intended for mathematics teachers. The study presented in this article is guided by the objective of discussing teacher learning opportunities in Formative Curriculum Materials for Mathematics[3]. It is justified to look at these books in view of their singularities; they are an innovation within the PNLD, still little known, and because of the learning opportunities they can provide for teachers based on the relationship between these professionals and such materials.

Teachers and curriculum materials: learning opportunities

Ball and Cohen (1996) state that curriculum materials influence what content is taught and what approaches are used to teach the content. In addition, they play an important role because they can impact not only student learning, but also teacher learning. These materials can offer potential learning opportunities for the teacher when planning, modifying, implementing and evaluating what they present in the form of teaching guidelines and tasks (Davis & Krajcik, 2005). They are potential because teachers can make different uses of textbooks, influenced by their individual preferences and circumstances (Charalambous *et al.* 2010; Remillard, 2005). In other words, the materials can be transformed or modified according to the knowledge, beliefs, tendencies and experiences of the teachers who use them, especially when these professionals, when planning their lessons, consider the tasks or actions that can enhance students' learning and interpret how they influence students' mathematical thinking, whether it is necessary to plan several tasks, whether there will be any misunderstandings or difficulties.

Remillard and Bryans (2004) described learning opportunities as events or tasks that have the potential to challenge or expand teachers' existing ideas and practices, offering them

[3] The study was carried out as part of the first author's post-doctoral internship, under the supervision of the second author.

new perspectives or experiences. In previous texts, Remillard (1999, 2000) argues that teacher learning occurs when teachers need to make decisions about the specific activities they will carry out with students; Collopy (2003) associates learning with the changes in beliefs that teachers manifest in their everyday teaching and learning practices. She suggests that curriculum materials developed for educational purposes should provide explicit opportunities for teachers to make decisions about planning classroom events, highlighting the dynamic and diverse nature of the opportunities for teachers to learn by reading, interpreting, evaluating and selecting materials and carrying out lessons. Corroborating this idea, Land, Tyminski and Drake (2015) point out that it is important for creators of educational curriculum materials to "strongly communicate their intent" (p. 26), because educational features cannot always be read in an educational way, especially for early career teachers.

It is during the use of materials that teachers interpret the authors' intentions loaded with their subjectivity, i.e. teachers' beliefs and experiences influence the way they read and use the materials, bringing their own meanings to relate to the materials, influenced by their knowledge (Remillard & Kim, 2020; Perovano, 2022). The interpretation of curriculum materials can be understood as the teacher's interaction with them when reflecting on the classroom context (Sherin & Drake, 2009).

Before carrying out lessons, teachers plan them by analyzing the information presented in the curriculum materials, understand them based on their knowledge, and try to align the authors' intentions with their context. In this process, knowledge of the content to be taught and pedagogical knowledge are involved. This interaction is dynamic; by interpreting the underlying messages in the materials, the teacher can alter the intentions of the material's developers, while on the other hand, the materials can influence the teacher's beliefs or knowledge about teaching (Collopy, 2003). In this way, curriculum materials can and need to be used in such a way as to provide opportunities for professional development (Ball & Cohen, 1996), especially when they bring with them curricular innovations.

Fuentes and Ma (2018) conducted a comprehensive literature review of educational curriculum materials. As a result, they developed a framework for designing and evaluating mathematics materials based on their educational characteristics, the *Teacher Learning Opportunities in Mathematics Curriculum Materials* (TLO-Math).

The authors state that teacher knowledge is multifaceted, that the focus on educational curriculum materials has increased and that the framework presented was created from a thorough synthesis of existing empirical and theoretical literature on educational curriculum materials that included descriptions of the material, guidelines for developing or evaluating

them with regard to their educational characteristics, comparisons or evaluations of educational curriculum materials, examinations of how teachers make use of them and investigations into how such materials can support teacher learning.

From the perspective of Fuentes and Ma (2018), TLO-Math can serve as a guide for developing educational features in curriculum materials that promote teacher development in terms of implementing effective practices and can be used to identify and evaluate the type and focus of educational features, or lack thereof, in existing materials.

Thus, in addition to being used to evaluate existing curriculum materials, the TLO-Math framework can also be used by curriculum developers and curriculum material designers to include opportunities for teachers to expand what they know and build other knowledge, since this framework "supports the use of curriculum materials as sites for teacher learning" (Fuentes & Ma, 2018, p. 375). Teachers are professionals; their continuous learning and the learning of their students are closely related.

By using TLO-Math, teachers and teacher educators can identify the learning opportunities that the curriculum materials offer, as well as the gaps or limitations they present. They can then select, adapt or supplement the curriculum materials according to their needs and pedagogical objectives. In addition, TLO-Math can stimulate critical reflection and dialog about pedagogical practice in mathematics, contributing to teachers' ongoing professional development.

It is understood that this structure makes it possible to identify opportunities for teacher learning. For example, if a particular material incorporates guidelines on how it can be used, what is the logic behind the choices made by the material's developers in relation to the sequencing of content, suggestions for methodologies and adaptations. Figure 1 illustrates the seven dimensions of TLO-Math.

According to Fuentes and Ma (2018), this framework was generated from a review of the literature on educational curriculum materials, evaluates the educational characteristics of mathematics curriculum materials and can assist in the analysis of how such materials can meet teachers' learning objectives. TLO-Math has seven dimensions, as illustrated in Figure 1.

The dimension of *mathematical content knowledge for teaching* refers to whether the material provides resources for developing mathematical content knowledge for teaching. This is the type of knowledge that teachers need to mobilize in order to effectively implement the tasks associated with teaching mathematics, i.e. knowledge about the objectives, relationships and connections between mathematical content, and ways of representing and communicating mathematical concepts. According to Fuentes and Ma (2018), curriculum materials can offer

support and opportunities to help teachers develop this knowledge if they provide explanations, justifications and activities about mathematical content.

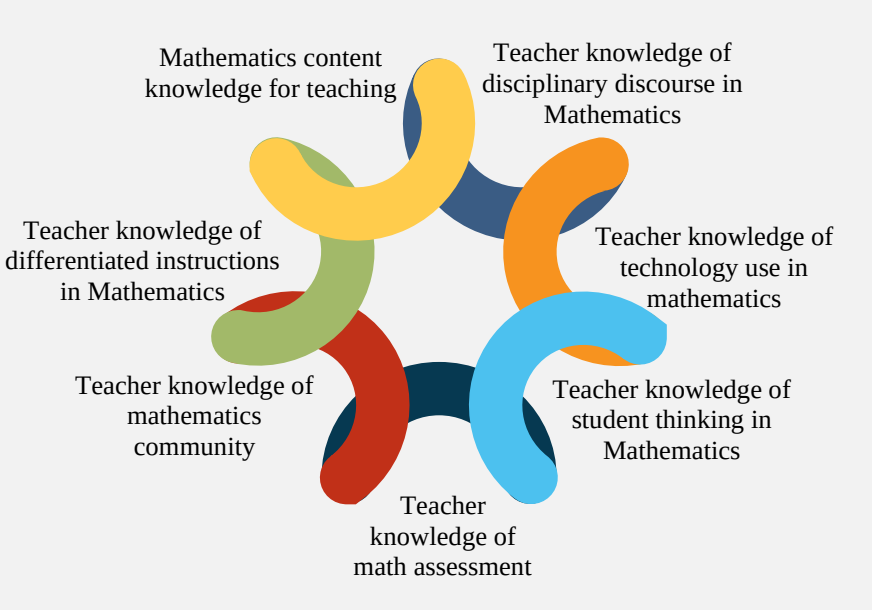

Figure 1.

Framework that analyzes Teacher Learning Opportunities in Mathematics Curriculum Materials (Own elaboration based on Fuentes & Ma (2018))

The dimension *teacher knowledge of student thinking in mathematics* takes into account whether the materials support the development of teacher knowledge in anticipating and understanding students' thinking. This is the knowledge that teachers mobilize about students' ideas, difficulties, strategies and ways of learning mathematics. In order to stimulate students' thinking, teachers need to know how students reason about mathematics and, in this case, curriculum materials can support the development of teachers' knowledge in anticipating and understanding students' thinking, and by providing recommendations on ways to address students' difficulties.

The third dimension, *teacher knowledge of disciplinary discourse in mathematics*, considers whether the materials support the development of teachers' knowledge in promoting disciplinary discourse in mathematics. This is the knowledge that teachers develop about language, communication, argumentation and mathematical justification, both in oral and written form. Curricular educational materials can provide guidance on how to conduct a productive classroom discussion, indicating the mathematical and pedagogical objective, clarifying the relationship with the mathematical topic of a given unit, proposing ways to organize it, offering initial and follow-up questions to stimulate interaction on students' ideas, suggesting ways to encourage their participation, showing possible ways forward and

presenting examples of discussions.

Fuentes and Ma (2018) point out that a risk can occur when providing examples of conversations, they can be seen as a script. For example, in a case study on the use of educational curriculum materials by two female teachers, Collopy (2003) observed that one of them thought that the sample dialogues should be followed word for word in the classroom. In contrast, the other teacher used them to prepare lessons, understanding how students could think and talk about mathematics. To avoid this misconception, the examples of classroom discussions should be seen as illustrations of possible ways of conducting a productive conversation, rather than as ready-made recipes, highlighting the flexibility and adaptation of what is being presented to different realities and educational contexts.

The *teacher knowledge dimension of mathematics assessment* analyzes whether the materials support the development of teachers' knowledge in the use of mathematics assessments to make instructional decisions. It refers to the knowledge that teachers mobilize about the objectives, criteria, instruments and practices of assessing students' mathematical learning. In order to provide learning opportunities for teachers in this area, curriculum materials need to offer guidelines for different assessment instruments, samples of student output, criteria for examining student work, guidelines on how to use student work to assess, and also ways of giving feedback to students, such as reasons for the various forms of support.

The fourth dimension, *teacher knowledge of differentiated instruction in mathematics*, looks at whether the curriculum materials support the development of teacher knowledge in the use of differentiated teaching to meet the mathematical needs of all students. It refers to the knowledge that teachers mobilize/manifest about ways to adapt and diversify teaching to meet the needs, interests and characteristics of different students. According to Fuentes and Ma (2018), in order to guarantee equitable opportunities, teaching must be adjusted, or personalized, to suit the different demands of students. In this sense, curriculum materials can provide learning opportunities for teachers with regard to differentiated teaching, offering equitable possibilities to their students.

Teacher *teacher knowledge of technology use in mathematics* is the dimension that addresses whether the materials support the development of teachers' knowledge in the strategic use of technology in mathematics. This dimension involves the advantages, limitations, possibilities and implications of using technological resources in the teaching and learning of mathematics - such as calculators, computers, software. Curriculum materials can contribute to the development of this knowledge by including information and providing guidance for integrating, for example, digital videos into lessons.

From Moje's perspective (2008), learning a subject is not only about developing content knowledge, but also about developing an insight into how content knowledge is produced in a specific area. In this context, the dimension of *teacher knowledge of mathematical community* refers to whether curriculum materials support the development of teacher knowledge in building a mathematical community that establishes norms for a productive learning environment. It encompasses the knowledge that teachers mobilize of mathematics as a science, as a human activity, and of mathematics' relationships with other areas of knowledge and with society. Thus, in this dimension of knowledge it is necessary for the teacher to build a classroom community, or an environment, in which disciplinary practices are eventually established norms for engagement. Likewise, mathematics learning could clearly explain the type of community sought, as well as offer the rationale and support for creating this type of mathematical community, presenting clear and appropriate justifications or implementation guidelines to support students in engaging in disciplinary practices. Fuentes and Ma (2018) identified, among the materials they analyzed, a proposal to create a mathematical community in which the teacher values discussions about errors as valuable learning opportunities.

Thus, the seven dimensions of mathematics teacher knowledge presented here highlight the complexity and importance of teacher training. They also show how educational curriculum materials can contribute to teachers' professional development.

Methodological procedure

The methodological approach adopted in this study is qualitative, which values description, meanings and inductive data analysis (Creswell, 2010). It is an exploratory study that provides greater familiarity with the problem, seeking to make it explicit (Gil, 2008), addressing information or guidelines presented in continuing education books. In terms of procedures, it is based on documentary analysis. This choice is justified by the fact that the object of study under investigation (curricular materials) is considered to be documents that have not yet received a more careful analytical treatment in relation to the subject under study (Cellard, 2012).

For Le Goff (1996, p. 545), “a document is not something that remains in the past, it is a product of the society that made it according to the power relations that held power there”. Contributing to the reflection on this issue, Alves-Mazzotti (1998) states that any written record can be considered a document if it is used as a source of information.

In the case of the study reported here, we considered two materials that were approved in the PNLD 2021. These materials were the only ones approved out of the five proposals

submitted to the call (Brazil, 2023). They are the object of our analysis. Figure 2 shows the covers of the selected books.

Figure 2.

Covers of the books aimed at training mathematics teachers to be analyzed (available on the websites of the respective publishers)

The analysis procedures were inspired by the textbook analysis scheme proposed by Charalambous *et al.* (2010), which consists of three dimensions: horizontal, vertical and contextual. The first dimension focuses on general characteristics, which provides a descriptive overview and data on the production of the curricular material; the second concerns the topics covered in the material and their organization; and the third dimension addresses aspects of the use of the material. Due to the objective set for the study, the contextual dimension will not be explored. To examine the second dimension, we used the TLO-Math framework to identify and evaluate the type and focus of the educational characteristics, or lack thereof, in the materials under analysis.

We chose to use the TLO-Math framework to analyze mathematics formative curriculum materials because it was developed with the aim of evaluating the professional learning opportunities for teachers that such materials can offer. Although there are no specific texts in the literature that discuss and evaluate *Formative Curriculum Materials*, we believe that this framework is suitable for the stated purpose, as it covers seven dimensions of mathematics teacher knowledge. Table 2 shows the items in the analysis proposal.

Table 2.

Analysis proposal (Own elaboration adapted from Charalambous et al. (2010) and Fuentes & Ma (2018))

Horizontal Analysis	
Basic Information:	**General Structure:**
Title	Number of chapters and/or units per chapter
Number of volumes	Subjects covered by chapter
Pages	Sequencing of topics
Author profile	
Publisher and year of publication	
Accompanying materials	
Vertical Analysis	
Knowledge of mathematics content for teaching;	
Teacher knowledge of student thinking in mathematics	
Teacher knowledge of disciplinary discourse in mathematics	
Teacher knowledge of assessment in mathematics	
Teacher knowledge of differentiated teaching in mathematics	
Teacher knowledge of the use of technology in mathematics	
Teacher knowledge of the mathematical community	

For documentary analysis, we used the steps outlined by Cellard (2012), the first stage of which is preliminary analysis, in which a critical look is taken at the documents, divided into five dimensions: the context, the authors, the authenticity and reliability of the text, the nature of the text and the key concepts and internal logic of the text.

Subsequently, by bringing these parts together, the theoretical lens is used in which an interpretation can be presented by the researcher, in which the choice of clues presented in the document must be made in the light of the initial questioning. However, in the course of the analysis, it is possible that discoveries and surprises will lead us to modify or enrich this questioning (Cellard, 2012). This understanding is in line with the view of Sampieri, Collado and Lucio (2013) who point out that, initially, the researcher, in the research environment, needs to observe everything they can and, during the research, focus their attention on the aspects linked to the formulation of the problem.

Presentation and discussion of data

The renewal of secondary education has brought innovations to the PNLD books and represents a challenge for which teachers have had to rethink their relationship with the

curricular materials made available for this stage of education. Curriculum materials are an important resource that teachers use in their teaching practice. These professionals can learn from such materials by using them in their practice, as Forbes and Davis (2008) recognize. These authors state that curriculum materials can be seen as a source of professional knowledge for teachers, who can appropriate them in a critical and reflective way.

In order to identify and discuss teacher learning opportunities in *Formative Curriculum Materials for Mathematics*, we analyzed the digital versions available for teachers to choose from in the Textbook Guide. Table 3 presents the basic information from the horizontal analysis of these materials.

Table 3.

Basic information from the horizontal analysis (Own elaboration)

Basic Information		
Title	New Practices for Secondary Schools	New Training Paths
Number of volumes	single volume	single volume
Pages	192	192
Author profile	The four authors hold master's degrees in Teaching, Mathematics Education, Mathematics and Technology Education and Mathematics.	A doctor in Mathematics Education, a specialist in Computer Science and Distance Learning Management, and two masters in Mathematics Education
Publisher	Editora do Brasil	FTD
Year of publication	2020	2021
Accompanying materials	video tutorial	video tutorial

This basic information provides an overview of the materials analyzed. Both books are unique and have the same number of pages and authors. The authors of both materials have a degree in Mathematics or Mathematics Education and are primary school teachers. One of these materials also shows the length of experience of these professionals, which may indicate that they are familiar with school reality and have incorporated the experiences they have had and validated over time into their repertoires of actions.

The PNLD Notice considered that in order to support teachers in this New High School scenario, it is necessary to take into account the continuing education of these professionals in four dimensions: i) Knowledge of self, the other and us (mini-project of life for teachers); ii)

Disciplinary knowledge in check (problematization of disciplinary isolation); iii) Area of knowledge in focus (problematization of curricular integration); and iv) Rethinking assessment (mapping of new assessment processes) (Brazil, 2019). In this context, the authors of the *Formative Curriculum Materials* prepared their books according to their interpretation of what would be an appropriate work for the PNLD, in compliance with the Public Notice. It should be noted that one of the books used the same names for its units as those specified in the public notice, as can be seen in Table 4, which shows the general structure of the horizontal analysis of the formative curriculum materials analyzed.

Table 4.

General structure of the Formative Curriculum Materials (Own elaboration)

New Practices for Secondary Schools			**New Training Paths**		
Unit Name	**Number of pages**	**Topics covered**	**Unit Name**	**Number of pages**	**Topics covered**
Get to know your book	23	Units Sections Icons Tables of some activities and experiences Commented references	Prelude	23	Letter to the teacher Theoretical and methodological orientation
Unit 1 Knowledge of self, others and us	43	The life project; Getting to know yourself; Relationships; Projecting myself; Comments on the activities.	Unit 1 Life Project: what's yours?	20	The 21st century educator Teachers and socio-emotional skills Planning for the present and future of the professional
Unit 2 Disciplinary knowledge in check	55	Multiple perspectives on the objects of knowledge The BNCC and the objects of knowledge concerning the teaching of mathematics in secondary education Building bridges: possible organizations and linkages of knowledge objects. Comments on the activities.	Unit 2 Mathematics: what the BNCC proposes for secondary education	58	Structure and organization of the BNCC Establishing the objects of secondary school knowledge Learning progression Computational thinking and its tools
Unit 3 Area of Knowledge in focus	37	Problematizing interdisciplinarity The organization of knowledge	Unit 3 Inter, Multi and Transdisciplinarity	52	New training paths Exploring mathematics from a new perspective

		Mathematics and context Case studies: How to develop projects with mathematics Comments on the activities			Inter, Multi and Transdisciplinary The UN agenda Pedagogical strategies
Unit 4 Rethinking assessment	22	Mapping new assessment processes Necessary dialogues between learning and assessment Planning, evaluating, communicating, replanning Comments on the activities.	Unit 4 Assessment proposals	33	The role of assessment Types and strategies Monitoring the learning process

As Davis and Krajcik (2005) and Fuentes and Ma (2018) point out, current curriculum materials seek to promote teachers' understanding of content and pedagogical practice, with resources to support this process. Thus, in both books, as is the case with current PNLD books, there are pages for presenting the book, indicating how it is divided; which sections and icons are used; the theoretical-methodological orientation employed; and the indication of commented bibliographical references, containing indications of books, papers and websites that express national and international knowledge in the area of Mathematics Education, so that teachers can get to know sources for expanding their knowledge.

It should be noted in this initial section that the books present tables with some of the activities proposed in the units, explaining the objectives, justification, resources and suggested time for development, as can be seen in the excerpts in Tables 5 and 6.

These tables, illustrated in Figures 5 and 6, are a resource that supports the teacher's work, as they facilitate planning; provide an overview of the activities, the aims and the resources required; and make it possible to analyze and check the results achieved. The fact that the *Formative Curriculum Materials* present these frameworks does not mean that they restrict the teacher's autonomy and creativity, as they can use them as a reference, modify them, complement them or create them according to their context and the school's pedagogical project, as Remillard and Kim (2020) point out.

The first unit of both books deals with reflections on the teacher's Life Project. According to Leão, Dayrell and Reis (2011, p. 1071), the idea of a life project refers to “a plan

of action that an individual proposes to carry out in relation to some sphere of their life (professional, educational, affective, etc.) over a more or less long period of time". This action plan always depends on a field of possibilities given by the socio-economic and cultural context in which the subject is inserted and which limits their experiences.

Table 5.

Excerpts from the books analyzed illustrating proposed activity frameworks (New Training Paths, 2021, p. 15)

Activity	Objectives	Justification	Resources	Time organization
A case study. Intersectionality.	Investigate, debate, interpret information and develop hypotheses, arguments and possible solutions for the community.	Enable the student to develop a vision that goes beyond the development of mathematical skills and make learning more meaningful.	Water paper and pen. If computers or cell phones can be used, research can be carried out using specific applications.	3 lessons.

Table 6.

Excerpts from the books analyzed illustrating proposed activity frameworks (New Practices for Secondary Education, 2020, p. 24)

	Objectives	Justification	Materials	Suggested time
Page 168	• Create hypotheses about what assessment is and what it is used for. • Compare different conceptions of assessment between teachers and students. • Aligning teachers' and students' expectations of the assessment process.	Assessment is a very controversial topic in schools. Often understood as a synonym for "test", assessment generates fear and anxiety in students, as well as being a cause of stress and frustration for teachers. Promoting a learning community in which assessment is understood in the same way by everyone can reduce these feelings.	• Board to be filled in (real or virtual)	• 15 minutes for exchanges between teachers • 20 minutes for exchange with the students • 20 minutes for systematization.

Specifically in the first unit, the two books invite teachers to think about or experience situations by mobilizing different strategies, such as recording personal and professional memories, carrying out research, discussing films, recommending books and promoting debates

on topics linked to the BNCC and current teaching trends, in order to broaden their knowledge of themselves and their relationships with students, colleagues and knowledge in the school environment, as illustrated in Figure 3.

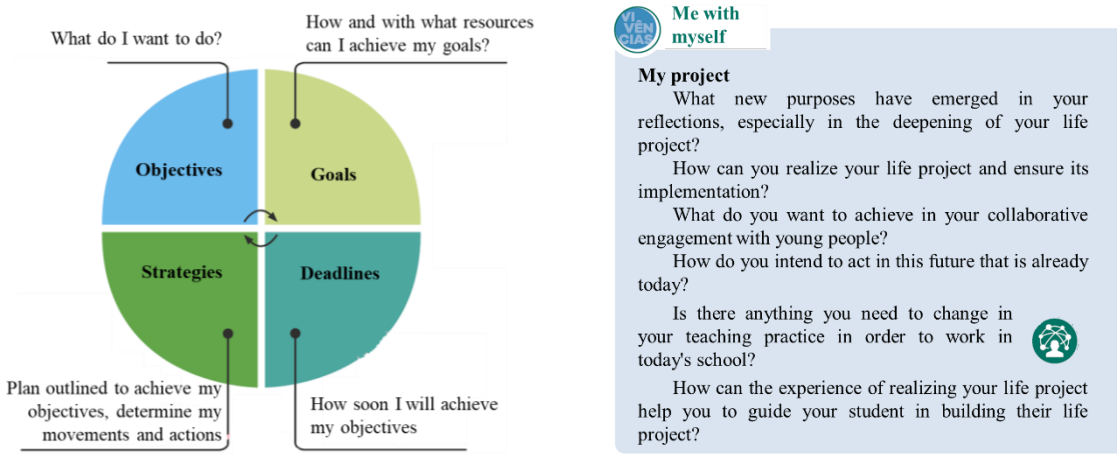

Figure 3.

Resource for teachers to think about or experience situations (New Training Paths (2021, p. 44) and New Practices for Secondary Education (2020, p. 68))

In this unit, we strongly identified ideas incorporated into both materials that activate what we call the *teacher knowledge of the school community*. We would point out that this dimension was not mentioned in TLO-Math (Fuentes & Ma, 2018). From our perspective, *teacher knowledge of the school community* are the resources in the books that are intentionally presented so that teachers can expand their knowledge of the characteristics, needs, expectations and potential of students, parents, colleagues, managers and other members of the school community. This knowledge can help teachers to plan, develop and evaluate their pedagogical work in order to meet the diversity and specificity of their school context. This knowledge also enables critical reflection on teaching practice and the teacher's role in the school community.

Discussions related to the teaching life project are pertinent because they allow teachers to reflect more systematically on their role in the school and on their expectations. This reflection can contribute to the teacher's professional and personal development, given that this project involves planning goals, actions and strategies to achieve objectives related to the teacher's training, career, interests and values. The teaching life project also involves recognizing the potential, difficulties, opportunities and challenges that teachers face in their

school and social context.

The second unit of the books emphasizes what the BNCC proposes for secondary education in mathematics. This unit highlights the teacher's knowledge of: differentiated teaching in mathematics*; the use of technology in mathematics; and the mathematical community*.

We have identified guidelines and situations in the materials that can induce *the teacher knowledge of differentiated instruction in mathematics,* for example:

> In the table, there is a lot of data to analyze, including percentages. Some questions can be "low floor" and others "high ceiling". Many questions can be asked to enlighten the students, such as:
>
> - Do you understand all the information in the table? What does it mean?
> - What attributes do you think are most important when analyzing the choice of health insurance? Please explain. (New Practices for Secondary Education, 2020, p. 97).

In this passage, we identify guidance on adapting the level of complexity of the activity to meet the different levels of student performance, in other words, it sheds light on the teacher's view of adapting to the different demands of their students, taking into account their prior knowledge, difficulties, abilities, rhythms, learning styles and preferences. Curriculum materials can help teachers to develop this knowledge by offering equal opportunities to their students, by presenting tasks that involve different forms of representation, expression and interaction, which can cater to students' different learning styles and preferences; and teaching guidelines that suggest ways of grouping students, managing time and space, and assessing results, to cater to the diversity of the classroom. These resources can contribute to meaningful student learning, motivation and engagement, and equity and inclusion in the classroom.

We have highlighted teaching guidelines and suggestions for activities that activate the *teacher knowledge of technology use in mathematics*, for example:

> [...] it is important to point out how the use of videos, podcasts and other digital resources can make the work proposal more interesting and closer to the technology used by the students. (New Practices for Secondary Education, 2020, p. 128).
>
> You could propose performing the calculations using apps (which can be found on the internet), using spreadsheets or by hand. This activity helps develop skill EM13MAT203 (New Training Paths, 2021, p. 66).

By identifying the resources that mobilize the *teacher knowledge of technology use in mathematics*, the teacher can plan and develop their lessons taking advantage of the possibilities and implications of the use of technological resources in their practice: enriching the mathematical content covered by presenting various ways of visualizing, exploring and communicating mathematical ideas; stimulating mathematical thinking by promoting the elaboration and resolution of problems, investigation and experimentation, and being able to offer different levels of challenge; bringing mathematics closer to digital culture, which is a form of culture based on the use of digital devices, social networks, digital media and other forms of information production and consumption in contemporary society.

Resources that mobilize *teacher knowledge of the mathematical community* are identified and these support teachers in engaging students in disciplinary practices, in the case of research, in mathematical practices, such as solving and designing problems; collecting and analyzing data; designing investigations and making explanations based on evidence; knowing how to argue and counter-argue; discussions about errors as learning opportunities.

> In this methodology [Problem-Based Learning], based on information from the real case, the students, organized in working groups, take ownership of the problems, investigating, debating, interpreting the information, raising and validating hypotheses, in other words, they create arguments with justifications for possible solutions or recommendations (New Training Paths, 2021, p. 133).
>
> Argumentation and proof
>
> - Recognize arguments and proofs as fundamental aspects of mathematics.
> - Elaborate and investigate mathematical conjectures.
> - Develop and evaluate mathematical arguments and proofs.
> - Select and use various types of reasoning and proof methods (New Practices for Secondary Education, 2020, p. 111).

As they read, interpret and plan with these materials, teachers mobilize knowledge that can help them create a learning environment and engage students in the practices of thinking, doing and communicating mathematics. By identifying these resources in curriculum materials, teachers can reflect on the curricular vision of these books and whether it aligns with mathematical practices.

The resources that mobilize the *mathematics content knowledge for teaching; teacher*

knowledge of student thinking in mathematic; and the teacher knowledge of disciplinary discourse in Mathematics are dealt with more clearly and directly in the third unit of the books analyzed, whose emphasis is on the area of knowledge (Mathematics) and curriculum integration.

In the material *New Practices for Secondary Education* (2020), a project is identified entitled *The connection between different axes of Mathematics*, which articulates the units: Algebra and Operations; Probability and Statistics; and Geometry and Measures. To this end, it proposes a study of the straight line, understood as a geometric object that can represent both graphs of polynomial functions of the 1st degree and the correlation between some statistical variables, and then chose a practice that was part of the students' social context, namely the use of transportation apps. This was the scenario in which the project was developed, guided by the triggering question: What variables influence the price of an app ride and how does this influence it?

Identifying the relationship between contents is important for teachers because it allows them to explore different mathematical concepts in an integrated way. In this case, in addition to the teacher planning tasks involving the use of the straight line, polynomial functions of the 1st degree, statistical correlation, graphical interpretation and problem solving, it is possible to show students that these concepts are useful in different areas of knowledge and in everyday life.

> The problem with the turkey breast slices
>
> This situation seems quite simple, but in Jo Boaler's (2018) experiment, even adults found it difficult to think about and record their solutions. The students could think that 1/3 of 1 kg represents 3 slices, so 1 kg is 9 slices. Eating 1/4 of 9 means eating 2 slices and 1/4 of another (i.e. eating 2 whole slices and half of the half of the last slice). They could algebraize the situation, which would also result in x =9/4, but it remains to be seen whether they know in practice what it would mean to eat 9/4 of the total of 3 slices. That's the challenge (New Practices for Secondary Education, 2020, p. 123).

In relation to the resources that induce the *teacher knowledge of disciplinary discourse in Mathematics*, we can mention the conduction of productive discussions in the classroom, as can be glimpsed in:

> [...] “many questions can be raised and many proposals for activities can be discussed, such as:
>
> - What is the relationship present in participation in productive activities considering the variables gender and race? Is it possible to propose a mathematical model that establishes this relationship? [...]
> - All the discussion promoted by working on the analysis of the infographics can serve as a platform for a new statistical survey, involving the investigative cycle. Students might want to know: “What are the professional prospects of women in the community?” or “How do black women fare professionally in my community?” (New Practices for Secondary Education, 2020, p. 112).

The teacher has an important role, which is to coordinate the students' discourse and the disciplinary discourse in mathematics, which is the way it is communicated, its norms, symbols, concepts and arguments. It is therefore essential for teachers to recognize the characteristics, purposes and implications of the disciplinary discourse in mathematics, as well as students' difficulties and potential in relation to it. In this context, as they read, interpret and plan with these materials, teachers mobilize knowledge by recognizing the disciplinary discourse in mathematics. This knowledge allows teachers to plan and develop tasks that enable them to analyze the interactions between students and mathematical knowledge, identifying errors, conceptions and strategies, and proposing interventions to promote learning. *Teacher knowledge of disciplinary discourse in mathematics* contributes to their professional development as it challenges them to broaden and deepen their mathematical knowledge, as well as to reflect on their teaching practice.

The ideas incorporated into the fourth unit of the materials analyzed activate the *teacher knowledge of assessment in mathematics*. Initially, the books present the concept of assessment based on recognized authors such as Jussara Hofman and Cipriano Luckesi, and present three types of assessment with well-defined purposes and characteristics, as can be seen in Figures 4 and 5.

Diagnostic assessment consists of collecting and analyzing individual samples of the knowledge that each student has at the beginning of a teaching and learning stage in order to check whether their prior knowledge is sufficient to start the teaching sequence or whether they need to take a step back. To do this, it should prioritize **personal records** of the students and the teacher about each of them.

Formative assessment consists of observing and analyzing students' development throughout the learning process in order to direct the interventions the teacher should make to get them to the proposed objectives, as well as allowing students to plan their efforts in order to actively participate in the pursuit of these objectives. To this end, it should include classroom observation, active listening, recording behaviour and interpersonal relationships, recording activities or reflections produced by the class, monitoring the student's notebook, etc., prioritizing not only personal records but also the **feedback** that will be given to each student so that everyone can reflect on their learning.

Summative assessment consists of the collection and individual analysis of learning samples at the end of a stage with the function of verifying whether the planned objectives have been fully or partially achieved, as well as assessing whether the teacher's plan has been effective and what level of success has been achieved by each individual student, in comparison with the results of the diagnostic assessment. To this end, it should include exams, formal tests and objective work, with well-defined assessment criteria and individualized data collection, prioritizing, in addition to personal records and feedback, the **grade** (or **concept**) given to each student.

Figure 4.

Types of assessment and their purposes (New Practices for Secondary Education, 2020, p. 176)

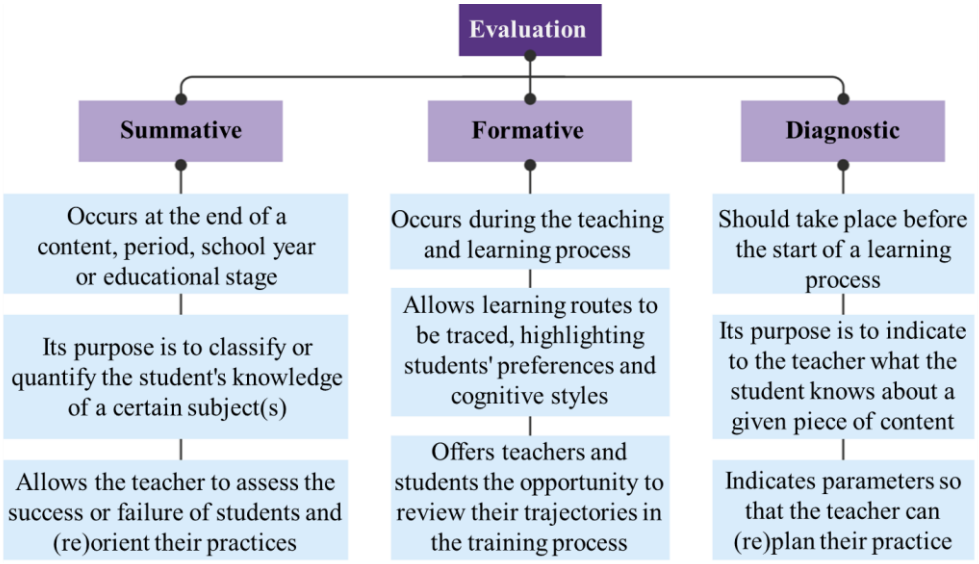

Figure 5.

Types of assessment and their purposes (New Training Paths, 2021, p. 170)

Assessment is an essential component of teaching and learning processes, which can influence both student development and the teacher's pedagogical practice. Guidelines and suggestions in the fourth unit of the materials analyzed activate the *teacher knowledge of assessment in mathematics* and enable them to use different assessment tools and strategies, involving not just written tests, but tasks that stimulate investigation, problem-solving,

argumentation and mathematical communication.

Through assessment, the teacher can identify students' progress, difficulties, errors and conceptions of mathematical concepts, and propose appropriate interventions to promote learning. In addition, assessment allows the teacher to give feedback to students, guiding them on their strengths and weaknesses, recognizing their efforts and encouraging them to overcome their challenges. Assessment also enables teachers to reflect on their own practice, assessing the effectiveness of their pedagogical actions, identifying their training needs and seeking to improve their mathematical, curricular and didactic knowledge.

Final considerations

This paper seeks to contribute to the debate on curriculum materials by providing an insight into the possibilities and limitations of materials as a tool for teacher learning.

In order to discuss teacher learning opportunities in *Formative Curriculum Materials* for Mathematics, we developed a qualitative research, documentary approach, using the TLO-Math framework. This framework assesses how different areas of teacher knowledge are addressed in curriculum materials. Using this framework can help determine whether the material is meeting teachers' learning needs, which is in line with the PNLD's idea that the book would help with the continuing education of mathematics teachers.

The *Formative Curriculum Materials* analyzed present different learning opportunities for teachers and these can affect lesson planning, reverberating in the learning of their students, in other words, the content and approach presented in the materials can broaden or restrict the experiences that allow them to attribute meaning to that content.

We stress that the analysis of the *Formative Curriculum Material* can reveal nuances and perceptions about what is made available to teachers and how this content is made available, i.e. it can identify elements in the books that are intentionally offered so that teachers can deepen their knowledge, create and (re)interpret those already used and mobilized in their teaching practices, but it is not possible to conclude how such materials will influence teachers' beliefs and practices.

Despite their limitations and weaknesses, *Formative Curriculum Materials* are a source

of learning for teachers, helping to update pedagogical trends and advances. However, teachers need to choose and use these materials in a critical and reflective way.

In this context, these materials can have a substantial impact on the instructional practices used in schools; they have the potential to help teachers develop their teaching skills and knowledge. It is also important that these educational characteristics are not only present, but that they are transparent, clearly explained to teachers.

We must emphasize the freedom of choice and autonomy of use by the teacher in the midst of the rigid regulation of curricular prescriptions and the PNLD notice. Especially since the teacher is the one who makes the connections between what is in the book and the realities of their students.

The presence of curricular materials containing new information and ideas in the classroom is not enough to promote changes in teacher learning. In the same way, the presence of *Formative Curriculum Materials* in schools is expected to be a support that enables teachers to make the choices that best favor their work and professional development. These materials embody the struggle of human knowledge, full of perspectives that need to be understood and explored. Although it contains concrete truths and invisible aspects, it should not be used as the only source of information in schools. Instead, it should contribute to the diversity of voices that guide pedagogical practices.

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