

Mathematics learning in secondary school textbooks of the New Mexican School: challenges for teaching

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Introduction

We are currently living in the context of the fourth industrial revolution, characterized by the proliferation of artificial intelligence, big data, robotics, 3D printing, connectivity, and more. There is no doubt that these technologies are redefining the way we work, live, and learn (Sánchez, 2019).

As a result, educational systems are compelled to design curricula that evolve at the pace of technology and promote subjects such as mathematics, which equip students with coherent competencies to respond effectively to this context. Mexico is no exception to this need, given that the results of the latest PISA test administered in 2022 revealed a serious decline in meaningful mathematics learning. The students faced difficulties in formulating, applying, and interpreting mathematics to solve problems in everyday contexts. According to the OECD (2023), students from top-performing countries in the PISA test outperform Mexican students by nine years in academic achievement in mathematics.

The importance of preparing citizens who are competent in the use and application of mathematics leads to understanding and utilizing new technological developments, formation of talent capable of developing cutting-edge technology and patents, which promotes the economic growth of any country. Examples include those countries that rank highest in PISA: Singapore, China, Japan, Estonia, South Korea, and others.

In 2019, the Mexican government promoted an educational reform that included strengthening mathematics learning subject, that has historically been a fundamental pillar in developing logical thinking, critical reasoning, and problem-solving skills. As a consequence, the "New Mexican School" (NEM for its acronym in Spanish) was introduced, a curricular proposal that led to new study plans and new textbooks for primary and secondary education (Osuna et al., 2024). Following the reform, the General Education Law mandates that curricula promote meaningful learning, critical thinking, and the development of life competencies (Diario Oficial de la Federación [DOF], 2019).

The New Mexican School (NEM)

The NEM proposal is not solely focused on transmitting content; rather, it promotes research and critical thinking (Tobón, 2024), encouraging students to deeply examine their community environment, ask questions, and propose actions that foster change and aims for students to face the challenges of the 21st. In 2022, the curricula underwent an update, structuring the study plans around *four formative fields*: a) Languages, b) Knowledge and Scientific Thinking, c) Ethics, Nature, and Societies, and d) Human and the Communal. According to the Secretariat of Public Education [SEP] (2024a), the purpose of this organization is to structure and connect the disciplines that underpin work at the basic education levels: preschool, primary, and secondary.

Seven *cross-cutting themes* were also incorporated, tailored to the students' developmental stage and their "real context," and integrated into the textbooks to strengthen the teaching-learning process in order to achieve the comprehensive education of students (SEP, 2024a). These themes are: 1. Inclusion: Ensures that all students have access to an equitable and high-quality education, as well as fostering their active participation in all stages of the educational process; 2. Critical Thinking: Develops students' ability to analyze, question, interpret, and evaluate information from diverse perspectives; 3. Critical Interculturality: Recognizes and values the country's cultural, ethnic, and linguistic diversity, promoting dialogue, respect, and harmonious coexistence among different cultures; 4. Gender Equality: Promotes the recognition of the rights of all individuals regardless of gender and the eradication of stereotypes and gender roles; 5. Healthy Living: Encourages the formation of behaviors and lifestyles aimed at strengthening the physical, mental, and social health of students; 6. Cultural Appropriation through Reading and Writing: Recognizes reading and writing not only as basic communication tools but as a means to access knowledge, understand the world, and express one's identity and 7. Arts and Aesthetic Experiences: Values artistic expression and aesthetic experiences as forms of knowledge and as connections to culture and the world. According to SEP (2024a), these themes are interwoven and articulated transversally across all formative fields and throughout the different grades and educational phases of the NEM.

Meaningful learning of Mathematics in the NEM

One of the main challenges in learning mathematics lies in avoiding the disconnect between abstract mathematics and students' lives, everyday reality. According to Palmer (2018), the teaching of this discipline has traditionally focused on the memorization of formulas and algorithms, which often leads to student disinterest and frustration.

According to Barriendos *et al.*, (2023), following the aforementioned curricular update, mathematics is no longer conceived as an independent subject but is now integrated into the formative field of *Knowledge and Scientific Thinking*, alongside Physics, Biology, and Chemistry. However, this integration raises concerns (Valenzuela & García, 2022), since the dispersion of mathematical content could reduce the time available for in-depth study. These risks relegating topics to superficial treatment and hindering the solid construction of internal knowledge structures, thereby compromising the intended benefits of interdisciplinary relevance.

The arguments presented by Barriendos *et al.*, (2023) and Valenzuela & García (2022) should not be overlooked, especially considering that, according to SEP (2024a), the formative goals of the NEM include strengthening the teaching and learning process to equip students with competencies to face the challenges of the 21st century. Clearly, learning mathematics is not simply about memorizing formulas to pass exams, but rather about understanding how mathematics helps explain the world and solve real problems from different perspectives. This paradigm shift requires offering students instructional materials that provide meaningful and practical learning experiences—resources that allow them to sequentially organize the acquired knowledge, thus supporting the process of learning how to learn (Pimienta, 2008), while also fostering abstract thinking (Valenzuela & García, 2022).

According to Ausubel (1963), meaningful learning occurs when new information is connected to the learner's existing cognitive structure. Achieving this requires a consideration of the following aspects: 1. Identifying students' prior knowledge, 2. Establishing connections between new and existing knowledge, 3. Offering challenging activities that spark interest, 4. Creating a supportive learning environment, 5. Involving students in experiences that foster discussion and idea exchange so they can interpret reality through their conceptual frameworks, 6. Explaining content through examples to contextualize learning, 7. Monitoring the learning process, and 8. Promoting situated learning that relates to the student's sociocultural environment (Ausubel, 1963; Baque & Portilla, 2021).

In line with these ideas, the objectives of this study were, first, to document the presence or absence of didactic and methodological elements that support meaningful learning in the third-grade secondary school textbook *Knowledge and Scientific Thinking* (mathematics section), and second, to identify its alignment with the approach proposed by the NEM. It is worth noting that this grade level was selected for analysis because students at this stage are those who participate in the PISA assessment—an international benchmark for academic achievement in mathematics and other subjects.

To address the previously stated objectives, the analytical search categories were based on elements identified in the literature as characteristics that enhance the potential of educational materials to foster meaningful learning (Ausubel, 1983, 1963; Pimienta, 2008) (Table 1).

Table 1. *Analytical Search Categories in the Mathematics Textbook Content.* Source: Prepared by the author based on Ausubel (1983, 1963) and Pimienta (2008).

Element	Nature (Didactic or Methodological)	Definition
Focus on knowledge construction	on Didactic	Content goes beyond the mere transmission of information, promoting inquiry, reflection, and critical discussion.
Contextual relevance	Didactic	Topics and content relate to students' daily lives, culture, and community, encouraging connections with their environment.
Active collaborative learning	and Methodological	Promotes student participation through activities that encourage dialogue, group work, and problem-solving.
Integration of New Mexican School principles	Methodological	Reflects the principles of the New Mexican School: the 7 cross-cutting themes and the 4 formative fields.
Ongoing formative assessment	and Didactic	Incorporates tools to evaluate student learning continuously and formatively, not just summatively.
Project-based learning	Didactic	Includes projects that engage students in solving problems within their communities, promoting project-based learning.
Dialogic reflective activities	and Didactic	Includes activities that foster debate, critical thinking, and reflection on topics relevant to society.
Use of digital resources	Methodological	Integrates the use of digital resources (videos, audio, or simulations) to enrich the learning process.

The methodology falls within the qualitative paradigm and is framed by an exploratory documentary research design which involves analyzing information

from documents to identify main and subordinate elements of a topic, establish connections between the previously defined analytical categories, determine their presence and relevance in the analyzed text, and draw conclusions (Cazares *et al.*, 2020).

Document analyzed

The textbook analyzed was the third-grade secondary school book *Knowledge and Scientific Thinking (Saberes y Pensamiento Científico* in Spanish), published by the Secretariat of Public Education (SEP, 2024b). The book is structured in two parts: the first includes 18 mathematics lessons, and the second, 28 chemistry lessons no related to math lessons. In this study only the mathematics lessons were considered. Each lesson was reviewed with attention to its didactic and methodological structure accompanying the content—in other words, the focus was not on the mathematical content itself, but rather on the presence or absence of the analytical categories that promote meaningful learning, as previously described in Table 1.

Procedure

In each mathematics lesson, the objective, planned didactic strategies, proposed methodological activities, and supporting resources were examined. This information made it possible to identify the presence—or document the absence—of the analytical search categories. The results of the analysis were recorded in a table with the following columns: 1. Analytical category, 2. Is the category present? (Yes/No/Partially), 3. A concrete example from the textbook that applies to this criterion, and 4. A column for comments or observations.

The integrated results for each category are presented in the following lines. As a general finding, it is noteworthy that none of the mathematics lessons includes a description of the learning objectives intended for each lesson.

Focus on knowledge construction

This dimension was present only in the 45% of reviewed lessons, and just 45% of lessons had concrete examples from the textbook that applies this criterion. As shown, no didactic strategies were identified to activate prior knowledge or promote critical thinking. Most lessons focus on the transmission of concepts rather than their construction, and only a few provide concrete examples to support knowledge acquisition in a didactic way.

Contextual relevance

This category was present only in the 28% of reviewed lessons, and just 55% of lessons had concrete examples from the textbook that applies this criterion. Only slightly more than half of the lessons are connected to the students' cultural and

community context. Few lessons include examples that are applicable to the students' reality, so most content does not strongly encourage the resolution of real-world problems.

Active and collaborative learning

It was present only in 9% of the reviewed lessons. And just 20% of lessons had concrete examples from the textbook that applies this criterion, no examples were found in the other lessons. There is a significant lack of methodological strategies that promote active participation or teamwork. No collaborative problem-solving activities are included, nor are there clear guidelines for teachers to encourage interaction and the joint construction of knowledge in the classroom.

Principles of the New Mexican School

This category was found partially only in 20% of the lessons, and 80% of the other lessons were not found. In addition, there was no concrete example in the book that applied this criterion. Therefore, the book does not explicitly or implicitly reflect the integration of the seven cross-cutting themes of the New Mexican School (NEM). (Inclusion, Critical Thinking, Critical Interculturality, Gender Equality, Healthy Living, Cultural Appropriation through Reading and Writing, and Arts and Aesthetic Experiences). So, no symbols or references to these principles were observed, nor any evident articulation with them, therefore not achieve full alignment with the principles promoted by the NEM.

Ongoing and formative assessment

As in the previous case, it was found partially only in 20% of the lessons and 80% of the other lessons were not found. And just 28% of lessons had concrete examples from the textbook that applies this criterion. There is no reference to evaluation strategies or tools, nor are processes of self-assessment or peer assessment defined. This limits the ability to monitor learning in a continuous, formative, or even summative way, which hinders the identification of knowledge progression.

Project-Based Learning

There was no presence of this category in the lessons analyzed, nor any concrete example. The focus remains largely on reviewing theoretical content. No methodological proposals for project-based work (individual or interdisciplinary) or problem-based learning were identified. This limits active learning, community engagement, and the development of competencies through meaningful or collaborative experiences.

Dialogue and reflection

This analytical category was only partially present in 28% of the lessons, in the rest, no evidence was found. Regarding concrete examples of this category in the lessons, it was only found in 28% of them. No didactic strategies were identified that promote ethical, environmental, or social discussion. There is no encouragement of debate or critical thinking about the usefulness of the content analyzed, which does not contribute to the development of critical judgment through dialogue and reflection

Use of digital resources

This category was not present in any of the lessons, nor were any concrete examples of it presented. The textbook lacks digital tools or technological resources such as videos, interactive simulations, links, or QR codes to access complementary information that could enrich the learning experience. The potential of technology is categorically underutilized —despite being in the midst of the Fourth Industrial Revolution.

Conclusions

The textbook does not present a didactic sequence for mathematics learning. Content is addressed mostly in a conceptual manner and, in some cases, is accompanied by specific examples that lack contextual relevance. As a result, there is a disconnect between the discipline of mathematics and the students' everyday reality. This may contribute to a lack of interest in learning, as noted by Palmer (2018).

No didactic or methodological evidence was found to support the promotion of critical thinking or reflection, which contradicts the assertions of Tobón (2024). There is no indication that the knowledge generated can be used to solve problems or applied in new situations. This supports Moreira's (2017) observation that contemporary schooling tends to train more than it educates, producing mechanical rather than meaningful learning.

The fact that the book is divided into two sections (mathematics and chemistry) may limit in-depth study of mathematics (Valenzuela & García, 2022). Furthermore, mathematics lessons are not related to chemistry lessons, so interdisciplinarity is not encouraged.

Adding to this the presence of decontextualized concepts with no apparent usefulness, the sequential construction of logically meaningful knowledge may be hindered, disrupting continuity and progress in learning (Ausubel, 1983).

Furthermore, the textbook's design does not meet the requirements set forth by

the General Education Law, which mandates the promotion of meaningful learning, critical thinking, and the development of life competencies (DOF, 2019). Nor is there evidence of any mechanism to monitor learning progression, as none of the lessons include evaluation processes or tools.

According to the principles of the New Mexican School (NEM), there is no clear evidence of the presence of cross-cutting themes or their transversal integration with other formative fields. Likewise, there is no deliberate promotion of interdisciplinarity (Barriendos *et al.*, 2023), which contradicts statements made by the educational authorities (SEP, 2024a). It is worth mentioning that in the book chemistry lessons are not interdisciplinarily related to mathematics lessons.

These findings suggest that the development of competencies needed to face current challenges will be difficult to achieve in students. The formative goals of the NEM (SEP, 2024a) do not appear to be within reach, making it unlikely that, in the medium term, Mexican adolescents will narrow the gap in mathematical competencies that currently separates them from their international peers participating in the PISA assessment. It is therefore recommended that the didactic and methodological structure of the textbooks be updated in order to achieve meaningful and lasting learning in this subject.

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