

REFLECTIONS AND PERSPECTIVES
ON THE EVALUATION OF MATHEMATICS LEARNING
IN MEXICAN HIGHER EDUCATION

Reflexiones y perspectivas sobre la evaluación
de los aprendizajes de matemáticas
en la educación media superior mexicana

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Abstract

The evaluation of mathematics learning in Higher Secondary Education constitutes a great challenge for teachers due to the complexity of their task, in order to achieve meaningful learning from the point of view of the learning subject, where it is considered important to revitalize the formative dimension of evaluation to transform their practices in light of contemporary curricular demands. It emphasizes the importance of promoting a culture of evaluation that ensures the development of a systematic, rigorous, critical, reflective, and academic decision-making process. The study was structured in two moments, the first considers the theoretical foundations that support the teacher's understanding of the formative dimension of the evaluation of student learning, the objective of which is aimed at analyzing evaluation practices in the field of math subjects. In the second, interviews and focus groups were applied, where the diversity of criteria issued by the teachers was considered, on the problems that affect the learning results. In this interpretive framework, some conclusions and implications are offered related to the need to promote a methodological change, as a mechanism that allows redirecting teaching strategies, which support the significance of knowledge in EMS; It emphasizes the need to strengthen spaces for collegial interaction, from where an exchange of experiences on evaluation forms is generated, as a viable alternative that conditions the understanding and improvement of teaching in high school.

Keywords

Evaluation of learning, formative evaluation, mathematical learning, assessment culture, evaluation practices, Upper Middle Education.

Resumen

La evaluación de los aprendizajes de matemáticas en la Educación Media Superior, constituye un gran desafío para los docentes por la complejidad de su tarea, en función de lograr un aprendizaje significativo desde el punto de vista del sujeto que aprende, donde se considera importante revitalizar la dimensión formativa de la evaluación para transformar sus prácticas a la luz de las exigencias curriculares contemporáneas. Se enfatiza en la importancia de promover una cultura de la evaluación que asegure el desarrollo de un proceso sistemático, riguroso, crítico, reflexivo y orientado a la toma de decisiones académicas. El estudio se estructuró en dos momentos, el primero considera los fundamentos teóricos que sustenta la comprensión del docente, sobre la dimensión formativa de la evaluación de los aprendizajes de los estudiantes, cuyo objetivo está orientado a analizar las prácticas de evaluación en el ámbito de las asignaturas de matemáticas. En el segundo, se aplicaron entrevistas y grupos focales, donde se consideraron la diversidad de criterios emitidos por los docentes, sobre las problemáticas que inciden en los resultados de aprendizajes. En este marco interpretativo se ofrecen algunas conclusiones e implicaciones relacionadas con la necesidad de promover un cambio metodológico, como mecanismo que permite redireccionar las estrategias de enseñanza, que sustentan la significatividad del saber en la EMS; se enfatiza en la necesidad de fortalecer espacios de interacción colegiada, desde donde se genere un intercambio de experiencias sobre las formas evaluación, como alternativa viable que condiciona la comprensión y mejora de la docencia en el bachillerato.

Palabras clave

Evaluación de los aprendizajes, evaluación formativa, prácticas de evaluación, aprendizaje matemático, cultura de la evaluación, Educación Media Superior.

278



Introduction

The evaluation of learning in the contemporary Mexican educational context must be critically understood for its contribution to the improvement and quality of learning, by providing the only guarantee that promotes the construction of knowledge and the intellectual growth of those who learn, in accordance with the intentions defined in the curriculum, where the teacher plays a fundamental role in integrating qualitative strategies in the teaching and learning process that support the understanding and construction of learning.

De acuerdo con Gimeno Sacristán (1992):

Evaluating refers to any process by which some or several characteristics of a student, a group of students, an educational environment, educational objects, materials, teachers, programs, etc. receive the attention of the evaluator, their characteristics and conditions are analyzed and evaluated on the basis of criteria or benchmarks for making a judgement relevant to education (p. 338).

279


All this makes it possible to assert that, through the evaluation of learning, inferences are constructed by the teacher on the level of achievement of what the students have learned, in order to effectively feedback each case according to the expected standards, to enable them to advance in their learning, to know what they have learnt, what they have yet to learn and how they can proceed to solve their learning problems, which requires that assessment practices take on their formative dimension, becoming a tool in the self-regulation of learning and as a differentiated care strategy from where the understanding of the actors involved is promoted as a factor for the improvement of teaching and learning.

For its part, De la Orden (2001), understands that:

The evaluation could be considered as the systematic collection process, analysis and interpretation of relevant and reliable information to describe any facet of education and to formulate a value judgement on its suitability for a criterion or pattern as a basis for decision-making on that facet (p. 16).

This means that the assessment of learning requires of the teacher a reflection exercise based on how to teach to learn and to evaluate, as a mechanism to redirect teaching strategies and activities or tasks, that sustain the significance of knowledge.

According to Álvarez Méndez (2003), through evaluation the teacher can change the complexity of his practice, in order to systematically

meet the needs of students, in the field of the alignment of various teaching strategies favoring the integration of the mathematical knowledge defined in the curriculum; it also states that “to evaluate is to know, it is to contrast, it is to converse, to inquire, to argue, to deliberate, to reason, it is to learn [thus, such activity must be] at the service of those who learn, that help them to grow and develop intellectually, affectively, morally and socially” (p. 51). Thus, evaluation is assumed as a systematic, rigorous, critical, reflective, flexible, appreciative and academic decision-making process and involves a research process, encompassing positions, theories and practices.

In Mexico, since 2008, the Comprehensive Reform of Higher Secondary Education (RIEMS) has been carried out, one of the main purposes of which is to promote a qualitative change in the management of academic processes at the baccalaureate level, with an emphasis on the development of competences in students and teachers, as a support for the quality of learning, which entails assuming an academic culture, which promotes the understanding of learning assessment and learning, for which secretarial agreements and guidelines have been published setting out the different methodologies that teachers must carry out in the process of evaluating students in the different subjects that make up the curriculum, generally, without emphasis on the area of mathematics and other areas of knowledge.

Therefore, when analyzing the results of mathematical learning in the baccalaureate, it is considered to be a problem of urgent attention in the context of Higher Secondary Education (EMS) in Mexico, since the results issued by external evaluation bodies, according to the Ministry of Public Education of Mexico (2017), the national evaluation results (2017), it is evident that in mathematics 6 out of 10 students is located in level I (66%) which have difficulty in performing operations with fractions and operations combining unknowns or variables (represented by letters) and in establishing and analyzing relationships between two variables; almost 2 out of 10 are located at level II (23%) who express in a mathematical language situations where a value or proportionality relations between two variables is unknown, and solve problems involving proportions between quantities (for example, calculation of percentages).

Also according to the results issued by the Ministry of Public Education of Mexico (2017), in level III, only 8 out of 100 students (8%), use mathematical language to solve problems that require the calculation of unknown values, and to analyze situations of proportionality; at level IV, almost 3 students out of 100 (2.5%), master the rules for transforming and operating with mathematical language (for example, the laws

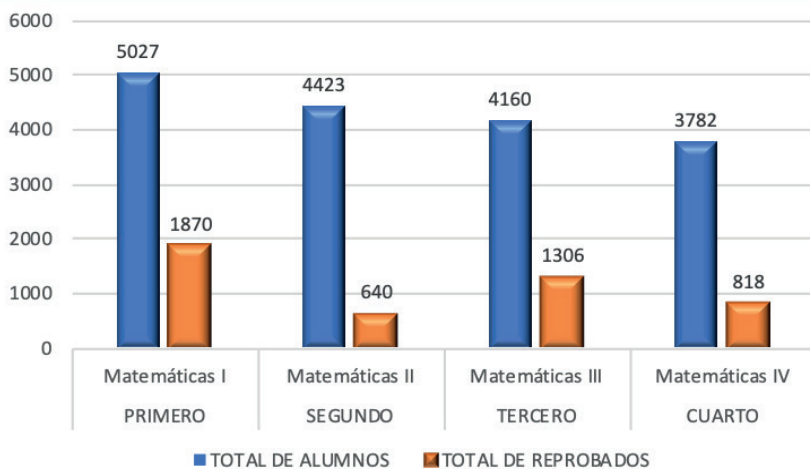


of signs); express in mathematical language the relationships that exist between two variables of a situation or phenomenon; and determine some of their characteristics (for example, they deduce the straight line equation from its graph) (2017).

Under these guidelines, the evaluation of learning constitutes the nucleus of the educational action from which “the learning needed to face the challenges of the 21st century” is based, as stated by the Mexican Ministry of Public Education (2017, p. 18). Which, as results of an external evaluation, allow to identify, prioritize and work with students in the field of the mathematics curriculum, since specific data are also generated by each of the students and school, which encourages differentiated academic decision-making.

Below is presented in Figure 1, the behavior of the failure in the subjects of Mathematics in the period July 2018, in the six high schools that support the study.

Figure 1
Behavior of the percentage of failure in mathematics
(July-December 2018)



Source: Compiled from the statistics from the studied higher secondary education institutions.

As can be seen in the statistics of the six schools under study, in the first semester 1870 students failed, in the second 640, in the third 1306 and in the fourth 818, the highest failure rate occurs in the first and third semester with 37% and 31% failure respectively, data that require the teacher to promote a learning evaluation process, with an emphasis

on understanding the main knowledge gaps, and emphasize the training dimension, in order to consolidate the knowledge of basic disciplinary competencies, defined in secretarial agreements; 444, 486 and 656 (Mexico, Ministry of Public Education, 2008, 2009, 2012).

According to the Under-Secretariat of Higher Secondary Education of Mexico (2018), these intentionalities are defined in the curricula of subjects in this disciplinary field whose main objective is to develop logical-mathematical thinking, to interpret real hypothetical situations that allow the student, to propose alternative solutions from different approaches, prioritizing the skills of thought, such as the search for patterns or principles that underlie everyday phenomena, the generation of various alternatives for problem-solving, information management, decision-making based on critical analysis of mathematical information, interpretation of tables, graphs, diagrams, texts with mathematical symbols that are found in their context will allow both the argumentation of solution proposals and the prediction of the behavior of a phenomenon from the analysis of its variables; all this requires an analytical-reflexive assessment of teachers in terms of decision-making towards improving the quality of learning.

In this regard, in informal discussions with the mathematics teachers of these schools, they report that the main difficulties presented by students in the first semester are: understanding of knowledge in order to be able to translate problems into algebraic models, based on equations representing unknown quantities and other data of the problem, according to explicit or implicit relationships in the statement of the task, solve problems with equations of first and second degree, maximum common divisor, minimum common multiple, division of polynomials, factoring of trinomials of the form $ax^2 + b x + c$, and also present limitations in solving linear equations by different methods.

The teachers of the third semester also report that the main problems affecting the learning of geometry can be framed in; the deduction of the equation of the ellipse and hyperbola, solving ellipse and hyperbola equations with center in the origin and out of the origin, solving exercises using equations and varying parameters.

In this sense, it is inferred that the learning problems described by mathematics teachers and minimize the students' failure, should generate a culture of evaluation, the same as according to De la Orden Hoz (2001); Mateo (2006); Castro, Martínez and Figueroa (2009); Capó Vicedo, Pla Rodríguez, and Capó Vicedo (2011); Alsina (2016), ensures the understanding and improvement of students' learning based on obtai-



ning, analyzing and interpreting evidence, which allow establishing the relationship between performance and the evaluation criteria established in the curriculum in mathematics courses at EMS, as a basis for decision-making in the face of the challenges of teaching to learn.

In considering the evaluation of learning and for learning, according to Moreno Olivos (2011, 2016); and Cáceres Mesa (2018), its formative understanding is resized as a process that compromises the learning of students. Problems in this area include: What theoretical references about the formative dimension of evaluation are present in the EMS curriculum? how to revitalize learning assessment practices in mathematics subjects in the EMS curriculum?

Theoretical references for the understanding of the evaluation of learning in the EMS

283



According to the contributions of Trillo Alonso and Porto Currás (2002), when teaching and evaluating mathematical learning in EMS students, a relevant line is generated in the study of educational quality, therefore, in the field of mathematics courses, this perspective should be analyzed in order to promote the development of logical, creative thinking, which stimulates operations, problem solving and data processing; all of them with an increasing character of the complexity of cognitive processes, in order to promote deep, meaningful and transferable learning in students, which implies that through the evaluation process the integration of knowledge is generated, as an educational response that directs the application of these to life situations.

Therefore, according to Jorba y Sanmartí (1993), the teacher of mathematics at this level of education must have didactic references that allow him to conceive evaluation as the axis, from which all the school work revolves, not only conditions what, when and how it is taught, but also the adjustments that must be made to meet the diversity of needs generated in the classroom, in order to promote differentiated care capable of meeting the needs and interests of all students.

From another perspective according to Godino (2013), the evaluation of learning can be seen as a process in cognitive suitability (Assessment of Didactic Suitability) of students, since it is a necessary indicator that measures achievement in the appropriation of the knowledge thought in the classroom. In other words, evaluation is the adaptation of the implemented and intended meanings with respect to the students'

initial and final personal meanings, through the practices developed in the class, which conditions that the teacher reflexively values the didactic strategies that he applies during his practice, in the field of teaching and learning processes in mathematics.

Likewise, it is important to return to the contributions of Moreno Olivos (2009), when he argues that the evaluation of learning has a direct impact on the training of students. Therefore, teachers are required to professionally and rigorously carry out their practice in order to evaluate the learning of their students from a formative dimension, with the ethical commitment that this type of activity compromises, because throughout the experiences constructed in the scope of their practice, preconceptions are generated that allow them to place themselves in an effective theoretical-methodological framework for decision-making on evaluation strategies.

284



In this area, Jorba and Sanmartí (2000) argue that all the practices of evaluation of learning, must be immersed in an adequate articulation between the “how it is taught”, “how it is learned” and “how it is evaluated”, a space in which the subject who learns is recognized as the protagonist of this process, in which motivational elements that stimulate the achievement of the knowledge defined in the curriculum, where the strengths and weaknesses of learning are rescued, rather than merely considering what the results are; a scenario in which the role of the regulatory function of evaluation is valued, which allows each student to construct an autonomous, gradual and progressive personal learning system, which shapes and develops mental structures that favor logical-mathematical thinking.

In this same order of ideas, Moreno Olivos (2011) points out that it is desirable for teachers to become aware, as part of the culture of evaluation implicit in their practices, to assume formative evaluation, as a systematic discourse and action where a differentiated and group interaction with all the members of the class is revitalized, since self-regulation processes are activated in each subject that learns and the feedback is strengthened and systematized, whose impact is reflected in academic performance and the improvement of learning.

On the other hand, Moreno Olivos (2016) highlights the role of the evaluation of learning and for learning, basing, from different perspectives, the conception of the evaluation of learning from its formative dimension, as an inescapable process of contemporary educational practices, as these are immersed in reforms that condition the integration of knowledge aligned to the formation and development of competencies, as is the case of the curriculum of the current Mexican EMS. In this

sense, the formative evaluation allows to understand and transform the teaching and learning processes, and to identify problems that limit the achievement of the expected knowledge, by participating in a constant change according to the demands and needs of the students.

For its part, Cáceres Mesa (2018) argues that formative evaluation should be considered as a process that activates the ways of teaching and learning, as it invites valuable reflection as a basis for academic decision-making in each class group, where the didactic work of the academies is resized, as a space for collegial interaction that allows to analyze the curricular requirements, the learning activities that must be designed and the methodological strategies that support the evaluation. Here is important the role of feedback, as an effective process that impacts on the nearby development zone in the subjects who learn, all in function of contributing to pedagogical regulation, the management of errors and the improvement of learnings during the learning journey of students.

In this area, Bordas and Cabrera (2001), emphasize the transition from training evaluation to formative evaluation, where reflection on one's own mistakes is considered as the starting point of the learning process, from where internal forces are generated in students to continue learning consciously, autonomously and independently, as it promotes a positive personal assessment towards learning. At the same time, they state that strategies should be used in which students:

Feel active in their own assessment, learn to evaluate their own actions and learning, use self-assessment techniques and be able to transfer them in a variety of situations and contexts, be able to adapt and/or define self-assessment models based on values, contexts, social realities, moments, etc. (p. 36).

For which the formative evaluation promotes a space of reflection, feedback and permanent interaction between the teacher and the students, which favors a progressive understanding of the knowledge and differentiated supports as strategic reinforcements, to diversify different levels of support for students in the internalization and personalization of learning.

Evaluation of Learning in the Mathematics Curriculum in Upper Secondary Education

In this area when analyzing the theoretical references that support the formative evaluation in the curriculum of the mathematics programs of



the EMS, the Undersecretary of Higher Secondary Education of Mexico (2018), argues that the processes of evaluation of learning are based on Agreement 8 of the Steering Committee of the National High School System in Mexico (2009), which describes the integration of the types of evaluation, according to their purpose and time: Diagnostic, formative and summative and according to the agent involved in this process: self-evaluation, co-evaluation and hetero-evaluation.

In this regard, it is considered that the *diagnostic evaluation* is the one that is developed at the beginning of training to estimate the previous knowledge of the students, which then helps to guide the educational process, has a predictive function of the learning potential, where the diagnosis and prognosis of each student and/or group comes into play; is an evaluation that not only needs to be done at the beginning, but is embedded in every step of the learning process.

It is interested in recognizing whether students, before starting a cycle or a long educational process, possess or not a series of previous knowledge, as prerequisites to be able to significantly assimilate and/or understand the new and according to Jorba and Sanmartí (1993); and Sanmartí (2007), diagnostic evaluation makes it possible to identify the cognitive abilities of students in relation to the curriculum, in terms of generating differentiated individual and group strategies; therefore constitutes an important moment for the design of teaching, learning and evaluation strategies.

For its part, *formative evaluation* is carried out in the course of the teaching and learning process. Enables teachers to design relevant and adapted teaching strategies that support students as an opportunity to explore new knowledge and continue learning; is a long journey through which the subject who learns, restructures his knowledge from the activities he carries out, which favor the appropriation of knowledge of greater level of complexity, thus it makes it possible to pinpoint the progress made by each student and, in particular, to identify the difficulties encountered during learning; to identify problems, show alternatives, detect the obstacles to overcome them, in short, to perfect the learning process, where everything learned is put into play, in a located know-how (Díaz Barriga, 2006).

In this area, Gimeno Sacristán (1991), points out that evaluation is a systematic and rigorous process of data collection, incorporated into the educational process from the beginning, so that it is possible to acquire continuous and meaningful information to know the situation, to form value judgements with respect to it and to take the appropriate decisions,



in order to continue the educational activity, progressively improving it. He points out that the assessment refers to any process in which the characteristics of one or a group of students, educational objectives, teaching materials, teachers, programmes, educational environment, among others, are analyzed and assessed on the basis of criteria or benchmarks to make a judgment that is relevant to education, referents that support the formative understanding of evaluation in the curriculum.

It is also specified that the *summative evaluation* must be carried out at the end of a process or educational cycle, considering the set of evidence generated by each student, which validate the achieved learnings, aims to establish reliable balance of learning outcomes, supported by Jorba and Sanmartí (1993, 1994); and Moreno (2016), where they stress the importance that teachers consider, in the development of assessment instruments, their reliability and that they ensure the knowledge that students must integrate into their learning, as a basis for valuing what is learned and how it is learned.

According to Jorba and Sanmartí (1993), it is noteworthy that summative assessment has a formative function, by providing information on the learnings acquired by students and consequently whether they have the necessary prerequisites for further learning, or to identify those aspects that should be modified in the context of teaching and learning processes, where their qualitative understanding recovers.

It should be pointed out that the self-evaluation and co-evaluation activities give a participatory character to the evaluation process, which promotes the personal awareness of students of their academic strengths and weaknesses. In addition, the practice of heteroevaluation should be included in the concept of the assessment that the teacher or external agent makes of the performance of students, pointing out the strengths and aspects to improve, based on the achieved learnings, where feedback strategies are activated from evidence of learning.

Curriculum content in mathematics in Upper Secondary Education

As established in the Undersecretary of Higher Secondary Education of Mexico (2018), in the curricular organization of the curriculum of the EMS, is composed of four subjects from the first to the fourth semester; in Mathematics I, the purpose is to:

To develop logical-mathematical thinking in students, through the use of arithmetic, algebra, probability and statistics, allowing them to propose alternative solutions to problems taken from their daily lives, taking into account that knowledge is not the end of education, but a tool for the student to develop the competences that define the graduation profile (p. 6).

In the previous document it is specified that, within the contents to be developed, “the Basic Numbers and Operations, Reasons and Proportions, Probability and Statistical Models, Algebraic Operations, Linear Equations and Quadratic Equations” are delimited (Mexico, Subsecretaría de Educación Media Superior, 2018, p. 7).

In this sense, the teacher must design learning activities that promote the development of a mathematical thought in students, which must be based on reasoning, the formulation of conjectures, the resolution of problems, the connection of mathematical ideas and their applications in real situations linked to the lives of students; all this in function of the didactic treatment of mathematical contents, discarding the emphasis on the mechanical, simple and memoristic search for answers.

For its part, as established by the Undersecretary of Higher Secondary Education of Mexico (2018), the subject of Mathematics II, has the purpose of:

Develop logical-mathematical thinking, by using Plane Geometry and Trigonometry that allow the student to propose alternative solutions to real situations or hypotheses from various approaches, bearing in mind that knowledge is not the end, but a tool for the student to develop the competences that define the graduate profile of Higher Secondary Education (p. 8).

At the same time, the document states that “the contents to be developed are the Angles and Triangles, the Properties of Polygons, Elements of the Circumference, Reasons and Trigonometric Functions and Oblique Triangles” (Mexico, Subsecretaría de Educación Media Superior, 2018, p. 8). Contents that must be addressed through teaching strategies that stimulate the resolution of problems that are significant for students, that promote the search for patterns or principles that underlie everyday phenomena; All this depends on the fact that the student is immersed in the active construction of new knowledge based on experience, previous knowledge and the level of reasoning that they may have on this topic. This process stimulates students’ interest in learning this science and pro-



motes the development of imaginative and creative skills through work with different geometric shapes.

Likewise, the Undersecretary of Higher Secondary Education of Mexico (2018), points out that in the subject of Mathematics III, through the use of Analytical Geometry, has the purpose of:

Develop logical-mathematical thinking, as well as the capacities to propose alternative solutions to various problems present in their environment from different approaches. It is from the application of Analytical Geometry and the proposed contents for the development of this program; geometric places in the plane, straight line, Circumference, Parabola and Ellipse, where students are introduced to concepts such as those related to the coordinate system, straight line or conical, through the solution of problems that allow them to perceive and interpret the spatial environment from the geometric analytical approach (p. 8).

Therefore, the contents of Analytic Geometry, require that the teacher of mathematics, provide an opportunity for students to explore, observe and know the environment around them, in which they will find diversity of geometric elements; all this through didactic situations that stimulate the development of skills that allow them to use representation systems to achieve spatial localization; apply transformations to analyze mathematical situations; make use of spatial visualization and reasoning for the construction of geometric models with which to explain real phenomena. All this in order to favor, in an ascending and gradual way, the advance of the students in the level of geometric reasoning in which they are.

For its part, the Undersecretary of Higher Secondary Education of Mexico (2018), establishes that in the subject of Mathematics IV, through the use of the Theory of Functions, has the purpose of:

To promote both the development of logical-mathematical and variational thinking, in order to generate critical and reflective elements in the student that allow him to propose alternative solutions to human actions that impact on his environment from different approaches. It is from the application of the Theory of Functions and the proposed contents for this program; Relations and Functions, Polynomial Functions, Rational Functions and Transcendent Functions, where the student is introduced to concepts such as the use of applications of special, algebraic and transcendent functions, through the solution of problems that allow him to perceive and interpret his environment through functions (p. 9).

As stated in the previous references, the purpose of learning mathematics in EMS in the Mexican educational context is aimed at students



developing a way of thinking that allows them to mathematically express situations of everyday life, which occur in different socio-cultural environments, as well as using appropriate techniques to recognize, pose and solve problems; at the same time, it is intended that through the study of this discipline, they assume a critical, collaborative, civic, and ethical conscience in life, developing a respectful attitude towards interculturality, that they learn autonomously and that they assume responsibility for their learning, among others.

Mathematical learning is based on the integration and application of knowledge and the progressive construction of new knowledge, as a basis for a relevant and deep learning founded on the generation of flexible problematizing learning environments, where students formulate and validate conjectures, ask questions, use their own procedures and acquire socially established mathematical tools and knowledge, while communicating, analyzing and interpreting resolution ideas and procedures¹.

Indeed, according to Morales Maure, Durán González, Pérez Maya, and Bustamante (2019), this mathematical learning is based on the skills developed from solving mathematical tasks where the mathematical activity, that is carried out, is evaluated. The teacher proposes a task to the student, then the teacher analyzes it and finds evidence of a certain degree of development of one or more mathematical competences through an evaluation.

290



Method

This study is based on a qualitative approach to information, where a diversity of criteria issued by mathematics teachers about their personal experiences regarding the learning outcomes of students intersect. All this supported by the contributions of Denzin and Lincoln (2012), as a framework that supports inferences in interpretations on the problems that affect learning outcomes in mathematics subjects in EMS.

The techniques used were the in-depth interview and focus groups, through which the diversity of criteria issued by mathematics teachers about their personal experiences around the learning outcomes of students intersect, All this supported by the contributions of Denzin and Lincoln (2012), as a framework that supports inferences in interpretations on the problems that affect learning outcomes in mathematics subjects in the EMS, in the six studied schools.

This work is structured in two moments; in the first moment, it was based on documentary and bibliographic research on the concept of eva-

uation, its formative dimension, generalities of the EMS curriculum and the evaluation of student learning in mathematics, For this purpose, the contributions by Bordas and Cabrera (2001); Perrenoud (2008); Moreno Olivos (2009, 2016); and Cáceres Mesa (2018) were used as reference theorists who support the high school teacher's understanding of how to evaluate student learning, all with the intention of analyzing What theoretical framework on the educational dimension of evaluation, are present in the curriculum of the EMS? How to revitalize the practices of evaluation of learning in the subjects of the EMS mathematics curriculum? Whose aim is oriented towards analyzing the evaluation practices of learning in the EMS, considering the inferences in interpretations on issues that affect learning outcomes in the subjects of mathematics at this level.

In the second moment, the criteria issued by the mathematics teachers, on the results of the students' learning, were analyzed. We held meetings with an interview and focus group modality with teachers of mathematics, where they attempted to analyze and discuss from their personal experience on the learning evaluation practices in each class group.

This process is based on a qualitative analysis of the information based on this interpretative framework. Some conclusions and implications are offered related to the need to promote a methodological change in the evaluation practices of learning in the EMS and the need for strengthening collegial interaction spaces from where an exchange of experiences on evaluation is generated, as a viable alternative that conditions academic decision-making.

For the analysis of results, ATLAS Ti was used as tools that supported qualitative analysis and helped organize, regroup, and manage the study results, and the following categories were considered:

- First Category of Analysis: The conception that mathematics teachers have of the concept of learning evaluation.
- Second Category of Analysis: Mathematical content in the curriculum.

Results

With the intention of assessing the understanding of mathematics teachers on the concept of evaluation of learning, a space of dialogue was promoted in the field of interviews and focus groups, where some criteria were rescued, those that refer to aspects of their conception of evaluation, the time and purpose of evaluation:



The evaluation of learning is a process through which the student is graded, is planned in each subject program and is structured in three moments, first and midterm and final evaluation (Teacher 1, 3/12/2018).

I consider the evaluation of learning as the component that allows me to assess the achievements of my students, so each student has a portfolio of evidence, I am sure that through personal monitoring the results are improving (Teacher 2, 3/12/2018).

Through the evaluation of learning is how I can know the mastery of the students of certain knowledge and adjust teaching and learning strategies, is aimed at progressively improving (Teacher 3, 3/12/2018).

“Learning evaluation has a diagnostic and formative function, in my class students develop the exercises and problems that appear in the textbook” (Teacher 4, 3/12/2018).

Through the evaluation of learning I can know the achievements and weaknesses of the students and thus be able to support them to pass the class (Teacher 5, 3/12/2018).

The evaluation of the learning allows me to reflect on the teaching I imparted and therefore work in a personalized way with some students that I perceive do not understand the content treated in class, but my priority is the midterm and final exams (Teacher 6, 3/12/2018).

It is through the evaluation of the learning that I can improve the results of the students, as they develop complementary exercises and problems as part of the independent work (Teacher 7, 3/12/2018).

I consider that the evaluation is a process for improvement, but the truth is that they require time and dedication to attend students, but I have four groups that demand a lot of attention and time exceeds me, I apply the midterms and final exams (Teacher 8, 3/12/2018).

For me the evaluation of learning is very complicated because it requires a continuous process, which allows us to clarify the doubts of all students, personally I pay more attention to those who are failing, because I do not have time to attend to all (Teacher 9, 3/12/2018).

These educational reforms consider the diagnostic and formative dimension, in practice we continue to evaluate the learning of students and we stick to the problems and exercises of the textbooks and apply the three tests established in the program (Teacher 3/12/2018).

Considering the testimonies of the teachers, we can affirm that some privilege evaluation as a final product and in some cases as a pro-



cess to improve results. It is identified that they do not visualize their understanding from the formative dimension of it with an emphasis on learning, therefore a traditional vision of said concept prevails since they state that they are attached to the criteria established in the subject program and the textbook, which limits the teacher from thinking and reflecting on the evaluation of learning from mathematical processes.

Likewise, it is important to highlight that if teachers do not have a concept of learning evaluation in correspondence with contemporary curricular demands, their teaching strategies do not stimulate the development of logical-mathematical thinking in students.

According to the interviewed teachers, the problems with the highest incidence of failure for students are:

Formulate and explain arithmetic problems, factorization of polynomials by grouping of terms, factorization of trinomials of the form $x^2 + bx + c$, factorization of a perfect square trinomial, factorization of a sum and difference of cubes, solution of simultaneous equations, for the methods of reduction, substitution and graph, solution of second degree equations, complete and incomplete; by factoring methods, decompose a polynomial using the different cases of factoring, calculate the value of the trigonometric ratios, solve exercises and problems involving calculating the slope, angle of inclination and angle between two lines, solve exercises and problems involving parabola and ellipse equations, in their different vertex positions at the origin and outside it, solve exercises and problems involving equations of the hyperbola and its asymptotes in their different vertex positions at the origin and outside it, solve exercises and problems involving the graphical construction of a function, solve exponential and logarithmic equations.

In this regard, in the context of interviews, teachers state that:

The main difficulties are due to the fact that students have poor prior knowledge (Teacher 2, 3/12/2018).

There is no systematic academic accompaniment with students who have learning problems (Teacher 3, 3/12/2018).

There is coherence between what the program establishes and what is evaluated, but there is not enough time in the program to exercise exercises and algebra problems, they are oriented for independent work, but we can only develop in the classroom a model example, as time is short (Teacher 5, 3/12/2018).

The excessive hourly load that students have in each school cycle, limits their time of dedication to independent study to the mathematical contents (Teacher 7, 3/12/2018).



Most students with learning problems in mathematics have a lack of study habits and spend very little time solving exercises that are oriented to them as tasks (Teacher 10, 3/12/2018).

I almost always rely on the use of linear equations as algebraic models of problem-situations of an elementary complexity level (Teacher 2, 3/12/2018).

When analyzing the criteria issued by the teachers, it is inferred that the majority assumes a traditional concept of evaluation of learning, they assume it as concrete actions in the semester, they think that learning is evaluated through three moments, two partial exams and a final exam, and they do not rescue the diagnostic, formative and summative dimension; as a process that would allow them to understand the progress of the students and establish differentiated feedback actions.

At the same time, three of the teachers participating in the sample, consider that through the evaluation they can assess the learning achievements of the students, understand how they learn and adjust the teaching strategies, depending on the personalization and application of the On-site mathematical knowledge, however, six teachers emphasize that in order to select the problem situations to be solved by the students in the exams, they focus on the textbook (Moreno Tapia, Parada & Hernández, 2016).

They also say that they do not have enough time to design didactic situations related to the context and limit themselves to developing the exercises and problems that appear in the textbook, which limits the development of logical-mathematical thinking, in addition, the limitations in the application of the formative function of the evaluation are revealed, since they do not implement systematic feedback and differentiated follow-up actions.

Likewise, in the scope of the focus groups, they report that the essential purpose of the entire evaluation process is aimed at students building a portfolio of evidence, as a strategy that allows them to account for their learning, but when reviewing them, it is identified: that there are no notes and suggestions from the teachers as part of the feedback process, with the purpose of making the pertinent observations and corrections so that the student recognizes the successes and errors in the development of an exercise or mathematical problem.

Similarly, it was found that teachers lack documented evidence of student learning results, as they do not have a qualitative report that reflects learning problems in a personalized way because, when they inquired about it, they referred to the control of qualifications.



Only two teachers recognize the influence of evaluation in improving learning, and the majority emphasize that they do not have time to attend to students in a differentiated way or to exchange experiences and criteria about student learning problems with other teachers. Because they have multiple groups. These references allow us to infer that the evaluation of learning is a control mechanism at the service of the demands of the curriculum and not of the demands and needs of the students, which influences on their low academic performance.

Likewise, in the interviews carried out with these teachers, they report that they apply strategies aimed at self-evaluation and co-evaluation, in accordance with the provisions of their program, since they adhere to what is established in the regulations, but they do not they give credibility to these strategies because the students lack a critical conscience and, in most cases, they issue the highest grade.

Discussion

The results coincide with what was proposed by Trillo Alonso and Porto Currás (2002), who consider that when teaching and evaluating mathematics learning in EMS students, a relevant line is generated in the study of educational quality, therefore, in the field of mathematics, this view is analyzed in terms of encouraging the development of logical, creative thinking, the realization of operations, problem solving, data processing; all of them with an increasing complexity of cognitive processes, in order to promote meaningful, deep and transferable learning. This implies that through the evaluation process the integration of knowledge and the application of knowledge to life situations in students is generated.

In the context of these reflections, it is important to note that the teacher of mathematics at this educational level according to Jorba and Sanmartí (2000), must have didactic references that allow him to conceive of evaluation as the axis, from which all school work turns, that not only conditions what, when and how is taught, but also the adjustments that must be made to meet the diversity of needs that arise in the classroom and, at the same time, promote differentiated care that meets the needs of all students.

In this context it is important to take up the contributions of Moreno Olivos (2011); and Cáceres Mesa, Gómez Meléndez and Zúñiga Rodríguez (2018), when they argue that the evaluation of learning has a direct impact on the training of students, therefore it is necessary for tea-

chers to undertake their practice professionally and rigorously in order to evaluate learning, because throughout the experiences built up in the field of their work in teaching, preconceptions are generated that influence decision-making on the strategies to be applied in this process.

Likewise, William (2009), argues that all practices of evaluation of learning, should be immersed in an adequate articulation between how it is taught, how it is learned and how it is evaluated, where students are recognized as protagonists of that process, where motivational elements that encourage the incorporation of learning arise, rather than considering what the results are; where it considers the role of the regulatory function of evaluation, which, in the words of Jorba and Sanmarti (2000), enables each student to build an autonomous, gradual and progressive personal learning system, which shapes and develops mental structures that favor logical-mathematical thinking.

In light of these ideas, says Moreno Olivos (2011, 2016), that teachers should assume formative evaluation, as part of the culture that revitalizes a differentiated and group interaction with all members of the class, Self-regulation processes are activated in each subject that learns and feedback is strengthened and systematized, whose impact is reflected in academic performance and improvement of learning. In this sense, the formative evaluation transforms the teaching and learning processes, being immense in a constant change according to the demands and needs of the students.

For his part Godino (2013), emphasizes that formative evaluation should be considered as a process that activates the ways of teaching and learning, since it invites to the evaluative reflection for the taking of academic decisions in each class group, where the educational work of the academies is resized as spaces for collegial interaction that allow the analysis of curricular requirements; the learning activities to be designed and the methodological strategies underpinning the evaluation, the role of feedback is highlighted as an effective process that impacts on the levels of support for learners. All this in order to contribute to the pedagogical regulation, the management of errors and the improvement of the learnings during the formative journey of the students.

In this regard, Alsina (2016), emphasizes the transition from training evaluation to formative evaluation, which considers the reflection on own mistakes as a starting point of learning, from where internal forces are generated in students to continue learning consciously, autonomously and independently, as it promotes a positive personal assessment towards learning.



According to the Undersecretary of Higher Secondary Education of Mexico (2018), the theoretical references that support the formative evaluation in the curriculum of the programs of the subject of mathematics of the EMS, are supported in the integration of the types of evaluation, according to its purpose and time: According to the Undersecretary of Higher Secondary Education of Mexico (2018), the theoretical references that support the formative evaluation in the curriculum of the programs of subject of mathematics of the EMS, are supported in the integration of the types of evaluation, according to their purpose and time: diagnostic, formative and summative and according to the agent involved in this process: self-evaluation, co-evaluation and heteroevaluation, which is established Agreement 8 of the Steering Committee of the National Baccalaureate System in Mexico.

In this area, it is important to point out that the mathematics curriculum in Mexican Upper Secondary Education aims to enable students to express mathematically situations in their daily lives, which requires teachers to design teaching strategies based on problem formulation and resolution. All this in order to promote the formation of a critical, collaborative, reflective and ethical conscience in life, that they learn autonomously and that they take responsibility for their learning, among others.

Mathematical learning should be promoted through independent activities that require a significant effort, where students exercise and systematize knowledge individually and in collaborative interaction with others. All this in order to consolidate lasting knowledge throughout life.



Conclusions

Based on the contributions made by the teachers who participated in the study, it is considered that a culture of evaluation should be installed that ensures the educational quality in Upper Secondary Education, where its formative dimension is designed with a focus on understanding and improving students' learning, which requires promoting the renewal of teaching practice, in function of consolidating mathematical logical thinking and generating strategies that condition differentiated attention, in correspondence with the demands and learning needs of students in each class-group.

In this area it is important to specify that teachers, through their contributions to the interview, consider self-evaluation and co-evaluation as processes that stimulate the self-evaluation and management and

regulation of learnings in students, where students develop skills and initiatives for progressive self-evaluation in the field of peer interaction, as a procedure promoted by Jorba and Sanmarti (2000), “the issuance of a judgment on the work done by him or his colleagues, according to criteria negotiated with the teacher and having as reference the learning objectives” (p. 6). However, they specify that students always give themselves and peers the highest grade, so it is not for them an indicator of progress; they emphasize the importance of these processes in their training to help them raise awareness of the construction of their knowledge.

Consequently, the teaching, learning and evaluation strategies that the teacher designs in order to carry out his educational intervention, to cover subjects that make up the disciplinary field of mathematics in Upper Secondary Education, should revolve around significant problems for the lives of students, that is, they must not be repetitive or resolved by applying a procedure or mathematical model that has no meaning for students, such situations should be aimed at stimulating the mobilization of various resources for the design of an evaluation-based methodology for learning, all of which are essential means of achieving mathematical knowledge, which constitutes a training potential for students throughout their school career in the baccalaureate.

One of the ideas that is beginning to expand relates to the transformation of the sense of evaluation to stop conceiving it only as an instrument of approval or reprobation and start seeing it as a complex practice that needs to be reviewed and renewed in the light of contemporary curricular requirements, for their contribution to student learning.

The evaluation of learning should constitute a process of reflection based on how to teach and how to learn mathematics, where reasoning and demonstration are essential components in the exercise of analysis and reflection by teachers, which, at the level of the academies, should promote the reflection and exchange of criteria on the methodologies they apply in their teaching practice and, at the same time, should assume a culture of evaluation based on understanding and improvement, as a strategy that promotes and activates effective feedback processes based on the demands and needs of students in each class-group and, at the same, time stimulates lifelong mathematical learning.

For all of the above, in Upper Secondary Education, mathematics teachers should consider the constructive alignment of learning and consider various didactic strategies that integrate the formative dimension of evaluation, to support the qualitative transformation of their educational practices, in order to promote the knowledge defined in the curriculum.



It is therefore a reflective, rigorous and systematic process of inquiry that globally considers the situations in context, which addresses the explicit and implicit in favor of a sustained improvement of students' learning.

In this sense, one of the ideas that is beginning to expand relates to the transformation of the sense of the evaluation of learning, to stop conceiving it only as an instrument of approval or reprobation and begin to see it as a complex practice that promotes learning through it, which requires the mathematics teacher to reflect and analyze his practice from a didactic-discipline perspective, with emphasis on rigor, strategies that promote how to teach how to learn and evaluate.

The main findings in the study, point out the need for the mathematics teachers of the baccalaureate, to assume the challenges of formative evaluation, to transform their educational practices and generate strategies that help in the learning process of their students, which gives them the possibility to internalize mathematical knowledge and apply it in life situations.

It is therefore of vital importance to revitalize the collegial work of mathematics teachers in terms of exchanging reflections, experiences, strategies that promote the reasoning of mathematical problems based on experience and previous knowledge, analyze the assessment of learning and its results, in terms of their understanding for the improvement of students and teachers, all in terms of their classes becoming learning communities; as a strategy that conditions the professionalization of their teaching practice.



Note

- 1 These foundations are some of the contributions given by the mathematics teachers of the schools under study (Academy Meeting 03/12/2018).

Bibliography

ALSINA, Ángel

2016 Diseño, gestión y evaluación de actividades matemáticas competenciales en el aula. *Épsilon, Revista de Educación Matemática*, 33(1), 7-29.

ÁLVAREZ MÉNDEZ, Juan Manuel

2003 *Evaluar para conocer, examinar para excluir*. Madrid: Morata.

BORDAS, Inmaculada & CABRERA, Flor

2001 Estrategias de evaluación de los aprendizajes centrados en el proceso. *Revista Española de Pedagogía*, 25-48.

- CÁCERES MESA, Maritza Librada
 2018 Reflexiones sobre la evaluación formativa en el aprendizaje de los estudiantes de la Licenciatura en Ciencias de la Educación de la UAEH. *Internacional de Educación e Investigación sobre Innovación*, 6(12), 53-63. <https://doi.org/10.31686/ijier.Vol6.Iss12.1251>
- CÁCERES MESA, Maritza Librada, GÓMEZ MELÉNDEZ, Laura Elizabeth & ZÚÑIGA RODRÍGUEZ, Maricela
 2018 El papel del docente en la evaluación del aprendizaje. *Revista Conrado*, 14(63), 219-230. Recuperado de: <https://bit.ly/3cx6BLv>
- CAPÓ VICEDO, Jordi, PLA RODRÍGUEZ, Consuelo & CAPÓ VICEDO, Josep
 2011 La evaluación como elemento de mejora y enriquecimiento del sistema educativo. *Revista Latinoamericana de Estudios Educativos*, XLI(3-4), 139-150. Recuperado de: <https://bit.ly/3gXvtzK>
- CASTRO, Heublyn, MARTÍNEZ, Edgar & FIGUEROA, Yonar
 2009 *Evaluación del aprendizaje y promoción de los estudiantes en los niveles de educación básica y media*. Ministerio de Educación Nacional. Bogotá, Colombia. Obtenido de: <https://bit.ly/3dFJnV8>
- COMITÉ DIRECTIVO DEL SISTEMA NACIONAL DE BACHILLERATO
 2009 Acuerdo número 8/CD/2009 del Comité Directivo del Sistema Nacional de... orientaciones sobre la evaluación del aprendizaje. México: Secretaría de Educación Pública. Recuperado de: <https://bit.ly/3723FFK> (14.05.2019).
- DE LA ORDEN HOZ, Arturo
 2001 Reflexiones en torno a las competencias como objeto de evaluación en el ámbito educativo. *Revista Electrónica de Investigación Educativa*, 13(2), 1-21.
- DENZIN, Norman K., & LINCOLN, Yvonna
 2012 *Manual de investigación cualitativa*. Madrid: Gedisa.
- DÍAZ BARRIGA, Frida
 2006 *Enseñanza situada*. México: McGraw Hill.
- GIMENO SACRISTAN, José
 1991 *El currículum: una reflexión sobre la práctica*. Madrid: Morata.
- GODINO, Juan
 2013 Indicadores de la idoneidad didáctica de procesos de enseñanza y aprendizaje de las matemáticas. *Cuadernos de Investigación y Formación en Educación Matemática*, 8(11), 111-132. Costa Rica.
- JORBA, Jaume & SANMARTÍ, Neus
 1993 La función pedagógica de la evaluación. *Aula de Innovación Educativa*, 20, 1-7.
 1994 *Enseñar aprender y evaluar; un proceso de regulación continua. Propuesta didáctica para el análisis de Ciencias Sociales y Matemáticas*. Barcelona: Raycar Impresores.
 2000 *La función pedagógica de la evaluación*. Barcelona: Grao.
- MATEO, Joan
 2006 Claves para el diseño de un nuevo marco conceptual para la medición y evaluación. *Revista de Investigación Educativa*, 24(1), 199-218.
- MORALES MAURE, Luisa, DURÁN GONZÁLEZ, Rosa Elena, PÉREZ MAYA, Coralia Juana & BUSTAMANTE, Migdalia
 2019 Hallazgos en la formación de profesores para la enseñanza de la matemática desde la idoneidad didáctica. Experiencia en cinco regiones educativas de Panamá. *Revista Inclusiones* 6(2), 142-162.



MORENO OLIVOS, Tiburcio

2009 La evaluación del aprendizaje en la universidad. Tensiones, contradicciones y desafíos. *Revista Mexicana de Investigación Educativa*, 14(41), 563-591. Recuperado de: <https://bit.ly/2UdUYmA>

2011 La cultura de la evaluación y la mejora de la escuela. *Perfiles Educativos*, XXXIII(131), 116-130. Recuperado de: <https://bit.ly/3dFnjtB>

2016 *Evaluación del aprendizaje y para el aprendizaje*. Ciudad de México: UAM.

MORENO TAPIA, Javier, PARADA, Elideth, HERNÁNDEZ & LIBRET, Jazmín

2016 La actividad situada como estrategia para la enseñanza y aprendizaje de las matemáticas en un grupo de niños de primaria. *Eureka* 8(1), 55-67, en línea. Recuperado de: <https://bit.ly/30j6LE5>

PERRENOUD, Philippe

2008 *La evaluación de los alumnos. De la producción de la excelencia a la regulación de los aprendizajes. Entre dos lógicas*. Buenos Aires: Colihue. Alternativa Pedagógica

SANMARTÍ, Neus

2007 *10 ideas clave. Evaluar para aprender*. Barcelona: Graó.

SECRETARÍA DE EDUCACIÓN PÚBLICA

2008 Acuerdo Secretarial 444, por el que se establecen las competencias que constituyen el Marco Curricular Común. México: Secretaría de Educación Pública. Recuperado de: <https://bit.ly/2Ufr9Nz> (14.05.2019).

2009 Acuerdo Secretarial 486 por el que se establecen las competencias disciplinares extendidas del Bachillerato General. México: Secretaría de Educación Pública. Recuperado de: <https://bit.ly/2Mx0In7> (14.05.2019).

2012 Acuerdo Secretarial 656, por el que se reforma el Acuerdo Secretarial 444. México: Secretaría de Educación Pública. Recuperado de: <https://bit.ly/3dAKUf6>. (14.05.2019).

SUBSECRETARÍA DE EDUCACIÓN MEDIA SUPERIOR

2017 Planes de Estudio de Referencia al Componente Básico del Marco Curricular Común de la Educación Media Superior. México: Secretaría de Educación Pública. Recuperado de: <https://bit.ly/2AGqa6X> (14.05.2019).

2018 Programas de Asignatura de Matemáticas I, II, III y IV. México: Secretaría de Educación Pública. Recuperado de: <https://bit.ly/2AEV0wW> (14.05.2019).

TRILLO ALONSO, Felipe, & PORTO CURRÁS, Mónica

2002 La evaluación de los estudiantes en el marco de la evaluación de la calidad universitaria. *Revista de Educación*, 283-301.

WILIAM, Dylan

2009 *Una síntesis integradora de investigación e implicancias para una nueva teoría de la evaluación formativa*. Argentina: Universidad de la Plata. Recuperado de: <https://bit.ly/2XAWTDz> (14.05.2019).



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