ISSN: 1815-7696 | RNPS: 2057 | MENDIVE Vol. 23 No. 2 e3895 (April-June)
Rojas Hernández, D.; Meléndez Ruiz, R.; Mazón Fabelo, A. M. "Management of the mathematical culture training process in Computer Engineering".
https://mendive.upr.edu.cu/index.php/MendiveUPR/article/view/3895
2025

Original article

Management of the mathematical culture training process in Computer Engineering

Gestión del proceso de formación de la cultura matemática en Ingeniería Informática

Gestão do processo de formação da cultura matemática em Engenharia da Computação

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Received: 8/06/2024
Accepted: 11/05/2025

ABSTRACT

This research addresses the need to manage the development of mathematical literacy as a key element for solving professional problems with a sustainable approach. The objective was to present a diagnosis of the research object in the context of the Computer Engineering program at the Hermanos Saíz Montes de Oca University of Pinar del Río. Methods such as surveys, observations, and documentary analysis were applied to students, teachers, and administrators. The main results were inadequacies in the treatment of educational management from the institutional, administrative, pedagogical, and community dimensions, evidencing a fragmented and limited approach to the teaching-learning process of mathematics, without integration into curricula, work

activities, or social outreach. Weaknesses were identified such as a lack of content sequencing, poor teacher preparation, and zero intra/extra-university promotion. The theoretical discussion highlights the importance of a comprehensive approach based on educational management principles (shared leadership, continuous improvement) and proposes a strategy for coordinating mathematical culture (description, thinking, methods, and mathematical language) with the substantive processes of the program. The research contributes to overcoming reductionist views by proposing a model that links mathematical education with the socioprofessional demands of computer engineers.

Keywords: mathematical culture; comprehensive education; management; computer science.

RESUMEN

La investigación aborda la necesidad de gestionar la formación de la cultura matemática, como elemento clave para la resolución de problemas profesionales con enfoque sostenible. El objetivo consistió en presentar un diagnóstico del objeto de investigación en el contexto de la carrera de Ingeniería Informática de la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca". Fueron utilizados métodos como: encuesta, observación y análisis documental aplicados a estudiantes, profesores y directivos. Los principales resultados estuvieron en las insuficiencias en el tratamiento desde las dimensiones institucional, administrativa, pedagógica y comunitaria de la gestión educativa, evidenciando un enfoque fragmentado y limitado al proceso de enseñanza-aprendizaje de la matemática, sin integración en los planes de estudio, actividades laborales o proyección social. Se identificaron debilidades como: la falta de secuenciación de contenidos, escasa preparación docente y nula promoción intra/extrauniversitaria. La discusión teórica destaca la importancia de un enfoque integral basado en principios de gestión educativa (liderazgo compartido, mejora continua) y propone una estrategia para articular la cultura matemática (descripción, pensamiento, métodos y lenguaje matemático) con los procesos sustantivos de la carrera. La investigación contribuye a superar visiones reduccionistas, proponiendo un modelo que vincula la formación matemática con las demandas socioprofesionales del ingeniero informático.

Palabras clave: cultura matemática; formación integral; gestión; ingeniero informático.

RESUMO

A pesquisa aborda a necessidade de gerir a formação da cultura matemática como elemento chave para a resolução de problemas profissionais com uma abordagem sustentável. O objetivo foi apresentar um diagnóstico do objeto de pesquisa no contexto do curso de Engenharia Informática da Universidade de Pinar del Río. Foram utilizados métodos como questionário, observação e análise documental aplicados a estudantes, professores e dirigentes. Os principais resultados evidenciaram insuficiências no tratamento das dimensões institucional, administrativa, pedagógica e comunitária da gestão educacional, revelando uma abordagem fragmentada e limitada ao processo de ensino-aprendizagem da matemática, sem integração nos planos de estudo, nas atividades laborais ou na projeção social. Foram identificadas fragilidades como a falta de sequenciamento dos conteúdos, escassa preparação docente e ausência de promoção intra/extrauniversitária. A discussão teórica destaca a importância de uma abordagem integral baseada em princípios de gestão educacional (liderança compartilhada, melhoria contínua) e propõe uma estratégia para articular a cultura matemática (descrição, pensamento, métodos e linguagem matemática) com os processos substantivos do curso. A pesquisa contribui para superar visões reducionistas, propondo um modelo que vincula a formação matemática às demandas socioprofissionais do engenheiro informático.

Palavras-chave: cultura matemática; formação integral; gestão; engenheiro informático.

INTRODUCTION

Higher education institutions around the world are currently paying special attention to the comprehensive training of future generations of professionals, due to its decisive contribution to building sustainable human development. Its implementation requires agreed-upon policies, but above all, spaces for open and sincere reflection and debate, promoting a gradual transformation of the mindset and specific modes of action of managers, teachers, support workers, and students (Alarcón Ortiz *et al.*, 2019).

For this reason, among the priorities of higher education an institution worldwide is the comprehensive training of professionals who ensure sustainable development from a curricular sustainability perspective. In this regard, good educational practices are inspired by policies that

promote lifelong learning opportunities based on criteria of inclusivity and equity (Alarcón Ortiz *et al.*, 2019).

To achieve this aspiration, in the general case of engineering careers, authors such as Mena and Mena (2019) consider that their curricula must be designed with a "solid, sufficient, integrated and always updated scientific base that facilitates the use of established knowledge, its reconstruction and transfer to new socio-productive contexts" (p. 154).

This criterion also applies to Computer Engineering at an international level, whose graduates must possess a "broad and solid education, with a scientific and technological foundation, that allows them to address systems, applications, and products in all phases of their life cycle, applying the methods and techniques specific to engineering" (García Peñalvo, 2018, p. 26); to solve professional problems supported by knowledge of Logic, Mathematics, Computer Science, and Software Engineering.

Particularly in Cuba, the E Curriculum proposed by the Ministry of Higher Education (MES) envisions a Computer Engineer capable of developing processes related to IT solutions and systems in organizations, with the goal of increasing their effectiveness and efficiency. They apply techniques that allow for environmental analysis to define computational processes, the information to be processed, the corresponding interrelationships, and the professional management of IT projects. This requires solid scientific knowledge, particularly mathematics, as this is one of the basic sciences that most contributes to the training of this engineer.

Without a doubt, basic sciences in general play a crucial role in the comprehensive training of this professional. Mathematics, in particular, helps shape the logic of computer scientists' professional thinking, providing them with a language for interpreting, processing, and solving professional problems at the foundation of the profession, which accompanies them throughout their careers and beyond.

From this perspective, mathematical culture [Organization for Economic Cooperation and Development (OECD), 2004] becomes the greatest contribution of this science to the professional training of computer scientists (Sharhorodska *et al.*, 2018); resulting in an important manifestation of human education and a basic professional competence in engineering.

Such is its importance that the International Program for Student Assessment has investigated in 40 countries how mathematical literacy enables a population of 15-year-old students to solve everyday problems, and how it prepares them to master it. This is what Faustino *et al.* (2014) assert:

> The integration of inquiry, argumentation and analysis-synthesis, in the process of formation of mathematical-investigative thinking, intervene in mathematical training as a whole, which supports the formation of the transformative capacities of the subjects, through the systematization of the appropriation of mathematical culture, which is developed from the social environment and transcends to universal culture, where mathematical contents are deepened (p. 85).

At the national level, although studies on mathematical culture from the pedagogical sciences do not proliferate, the contributions of Sharhorodska *et al.* (2018) and Terry Leonard *et al.* (2019), Terry Leonard *et al.* (2021), are recognized, from the procedural nature of its training and as a result of the professionalization and the social dimension of the teaching-learning process (TLP) of mathematics.

Specifically, Sharhorodska *et al.* (2018) recognize the following as the main dimensions of mathematical culture: the mathematical description of the world, mathematical thinking, mathematical methods, and mathematical language; elements that, without a doubt, must accompany the training of computer scientists.

In this context, it is essential to foster, through the study of these areas of knowledge (those related to mathematics), a comprehensive mathematical education and modes of reasoning and behavior, based on the use of analytical mechanisms, techniques, multidisciplinary perspectives, methodologies and tools, both intellectual and cognitive self-regulation, together with a professional attitude in accordance with the foundations and standards of teaching ethics.

Paradoxically, phenomenological observation of the professional training process for Computer Science Engineers at the University of Pinar del Río reveals certain external manifestations worth highlighting: the program lacks a deliberate and sequenced approach to mathematical literacy content in each training cycle; teaching departments do not conduct scientific activities aimed at applying mathematical literacy to professional problem-solving; mathematics teachers do not promote the development of mathematical literacy in the program; mathematical literacy content is

not systematized in the work component developed within the business system, nor is it part of the intra- and extra-university promotion of the program content.

These criteria are, in essence, elements that inform the social problem of this research, recognized as the need to manage the comprehensive training of a Computer Engineer who is capable of solving socio-professional problems based on the mathematical culture of the field.

In a first approximation to the theory, it is recognized that a comprehensive approach to the importance of managing the mathematical literacy process in the professional training of computer engineers requires going beyond the limits imposed by training processes, which are limited solely to the mathematics PEA. In contrast, a comprehensive analysis is desirable from the institutional, administrative, pedagogical, and community dimensions of educational management, as recognized by the United Nations Educational, Scientific, and Cultural Organization.

In this way, it is agreed with Tristá (2001): "The fundamental challenge of Higher Education Institutions (HEIs) in the 21st century is the need for change in the management model of Higher Education Institutions due to the changes in context that have occurred both internally and in the institutional environment" (p. 60).

Along these lines, authors such as Terry Leonard *et al.* (2021) consider that among the main contributions of managing the mathematical culture training process in the career is considering it as a complex and multidimensional process that favors the completion, deepening, and updating of mathematical content, assumed as professional content.

On the other hand, other researchers (Sampedro *et al.*, 2009) recognize the following as fundamental theoretical gaps: the lack of emphasis on the development of mathematical culture in students at the higher education level, from educational management processes; the management of the process of formation of mathematical culture is reduced to the treatment of its history, applicability and its contents; the management of the process of formation of mathematical culture is conceived from a didactic approach that is fragmented, decontextualized and limited only to the PEA of mathematics; it does not specify ways for the management of the process of formation of mathematical culture in Higher Education and the management of the process of formation of mathematical culture is worked on in an anecdotal manner and without didactic orientations to develop it.

The above analyses served as a starting point for developing the initial exploratory study aimed at finding the causes that originate the research problem, and at identifying the strengths and weaknesses of the process in the Computer Science Engineering program at the University of Pinar del Río. Program documents and reports were analyzed, training activities were observed, surveys and interviews were conducted, and the experience of the graduate researchers of this program was taken into account.

The strengths identified are that the mathematics program has an adequate scientific level and its objectives are geared toward the comprehensive training of future professionals.

The main weaknesses of the process are identified as: insufficient use of the management of the mathematical culture formation process from the substantive processes of the degree, weak treatment of the sequencing and continuity of the components of mathematical culture in the methodological preparation meetings in the departments of the degree, insufficient leadership and preparation of the pedagogical group to promote mathematical culture in the degree, and the components of mathematical culture are not promoted in the intra and extra-university community.

Thus, the aforementioned problematic situations reveal the following general contradiction: on the one hand, the real limitations of the Computer Science Engineering program at the University of Pinar del Río in managing the process of developing mathematical literacy from its institutional, administrative, pedagogical, and community dimensions; and on the other, the need for a well-rounded professional with a solid mathematical background, capable of solving professional problems with a transformative perspective at the grassroots level once they begin practicing their profession.

In this sense, the following research aims to present a diagnosis of the research object in the context of the Computer Engineering degree at the University of Pinar del Río "Hermanos Saíz Montes de Oca".

MATERIALS AND METHODS

A diagnosis was made of the management of the mathematical literacy training process in Computer Science Engineering, revealing the little attention that has been and is being paid to the management of the mathematical literacy training process for Computer Science Engineers at the University of Pinar del Río. Despite the fact, that all stakeholders involved in the process (professors, students, and administrators) recognize its importance for the comprehensive training of future Computer

Science Engineers. Based on this diagnosis, a strategy was developed that offers a solution to the needs for improving the management of the mathematical literacy training process in the Computer Science Engineering program at the University of Pinar del Río, through a set of theoretical and practical components that contribute to improving professional training from the different dimensions of educational management.

The research followed a mixed approach, explanatory, correlational, with a cross-sectional design, because the phenomenon was studied at two points in time. In addition, it is considered social, because it addresses a transcendent professional problem that involves pedagogical and student groups. It was intentionally worked with two sample groups composed of all first- to fourth-year students (120), 10 professors from the Mathematics Department, 20 professors from the Computer Science Department, six department heads, six discipline heads, three Vice Deans, one Dean, and five tutors in the period from September 2021 to September 2022.

To characterize the initial state of the variable, empirical methods and instruments were applied (Table 1).

Table 1. Empirical methods and instruments applied

Methods	Tools	Strata	Sample	*Fr* (%)	Exhibit
Content analysis	Guide	Governing documents	10	100	3
Survey	Questionnaire	Managers	16	100	4
Survey	Questionnaire	Teachers	30	45	5
Survey	Questionnaire	Tutors	5	50	6
Survey	Questionnaire	Students	115	95.6	7
Scientific observation	Guide	Teaching activities	29	15	8

Legend: *Fr* = Relative frequency

The dialectical-materialist method was adopted as the general method, and based on this, the following theoretical methods were employed: historical-logical analysis, modeling, and systemic-structural analysis; the empirical methods were surveys, scientific observation, expert consultation,

and documentary analysis; and the statistical-mathematical methods were statistical, descriptive, and inferential techniques.

To evaluate the management of the mathematical culture training process in Computer Engineering, four dimensions and their indicators were defined.

Institutional dimension for the management of the training process of mathematical culture

Understood as the system of organizational activities within the Faculty and the Computer Engineering program, for the formation of working groups, communication channels, and the establishment of times and spaces for managing the research process in each academic year, and at the University of Pinar del Río.

Indicators:

- Dissemination, at the level of the pedagogical-student community, of the foundations that govern the management of the mathematical culture training process in Computer Engineering.
- Formation of working groups to manage the development of mathematical literacy in Computer Engineering and at the university.
- Establishment of communication channels to promote the management of the mathematical culture training process in Computer Engineering and at the university.
- Establishing time periods and spaces for managing the mathematical culture development process in Computer Engineering and at the university.

Administrative dimension for the management of the mathematical culture formation process

It was understood as the system of organizational activities within the departments of education, collective year and discipline for the efficient use of economic and financial resources, preparation of work teams and evaluation of their professional performance, in terms of managing the process of training mathematics culture in each academic year, and its generalization in the university context.

Indicators:

- Establishment of economic and financial resources for the management of the mathematical culture training process in Computer Engineering and at the university.
- Establishment of the functions of working groups for the management of the process of developing mathematical culture in Computer Engineering and at the university.
- Evaluation of the professional performance of working groups for managing the mathematical culture development process in Computer Engineering and at the university.

Pedagogical dimension for the management of the mathematical culture formation process

Understood as the system of organizational activities of the program's teaching staff, designed to update, deepen, and complete their knowledge of mathematical culture and its implementation in the teaching-learning process (TLP) and in the teaching, extracurricular, and extracurricular activities carried out in the program and at the university.

Indicators:

- Frequency at which the teaching staff of the program updates, deepens, and completes their knowledge of mathematical culture.
- Frequency in which the pedagogical group of the degree carries out teaching, extracurricular and extracurricular activities aimed at managing the process of developing mathematical culture in Computer Engineering.
- Frequency at which the teaching community resolves professional problems in their PEAs to enhance the appropriation of mathematical culture.
- Frequency at which the pedagogical group evaluates the appropriation of mathematical culture in the PEA.

Community dimension for the management of the training process of mathematical culture

Understood as the system of organizational activities of the institution, the administration, and the pedagogical-student groups, aimed at managing mathematical culture in the university and non-university community (organizations, companies, non-state sector).

Indicators:

- Establishment of social and local projection projects, both within and outside the university, for the promotion of mathematical culture.
- Establishing relationships between social networks (local governments, agencies, organizations, businesses, and the non-governmental sector) to manage the mathematical literacy training process in Computer Engineering, as part of the computerization of Pinar del Río society.
- Carrying out community activities to promote mathematical culture.

The percentage technique is used to quantify the results. The following percentage ranges were taken to classify the results of the indicators, dimensions, and the variable "management of the mathematical culture formation process in Computer Science Engineering." These ranges were: very adequate level of management of the mathematical culture formation process in Computer Science Engineering, over 95%; fairly adequate level of management of the mathematical culture formation process in Computer Science Engineering, between 85% and 94.9%; adequate level of management of the mathematical culture formation process in Computer Science Engineering, between 75% and 84.9%; not very adequate level of management of the mathematical culture formation process in Computer Science Engineering, between 65% and 74.9%; and inadequate level, not exceeding 65%.

RESULTS

Results of the application of the instruments

The instruments used it was allowed to obtain the regularities that characterize the current status of each indicator and dimension. Their sequential execution linked the qualitative phase (obtaining criteria) with the quantitative stage (measuring the frequency of occurrence of said criteria). Finally, a methodological triangulation of data was performed in sequential designs, which revealed the main diagnostic regularities of the variable studied.

Results of the content analysis of governing documents using a guide

In order to characterize the current state of the research object, an analysis of governing documents was conducted. The base document for the design of the E plans emphasizes the importance of mathematical knowledge, but does not provide ways to manage mathematical culture.

The Higher Mathematics program clearly defines the importance of the subjects that comprise the discipline for the comprehensive training of Computer Engineers; however, they do not consider their contribution to mathematical culture as an essential element. The content of mathematical culture is not addressed in the diploma dissertations.

Results of the survey of managers of the Faculty of Technical Sciences

Sixteen executives were interviewed. The questionnaire sought criteria regarding the management of the mathematical literacy training process in the Computer Engineering program and its impact on the quality of professional training for this engineer.

The results reflect the poor compliance with the indicators corresponding to the institutional dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 2), with an arithmetic mean value of 0.58, which represents 57.8% of the total subjects investigated.

On the other hand, the same thing happens with the indicators corresponding to the administrative dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 2), with an arithmetic mean value of 0.56, which represents 56.3% of the total number of subjects.

Table 2. Results of the survey of 16 Faculty of Technical Sciences executives

Dimensiones	Indicadores	Escala Evaluativa					Evaluación (%)		
							Indicadores	Dimensiones	Variable
		MA	BA	A	PA	NA			
Dimensión institucional para la GPFCMII	1.1	0	1	3	2	10	NA (62.5%)	No Adecuada (57.8%)	EVALUADA DE NO ADECUADA (57.1%)
	1.2	1	1	2	3	9	NA (56.3%)		
	1.3	0	1	3	2	10	NA (62.5%)		
	1.4	2	1	1	4	8	NA (50%)		
Media aritmética (%)		**0.05**	**0.06**	**0.14**	**0.17**	**0.58**	**NA**		
Dimensión administrativa para la GPFCMII.	2.1	0	2	1	5	8	NA (50%)	No Adecuada (56.3%)	
	2.2	1	0	3	3	9	NA (56.3%)		
	2.3	0	2	1	3	10	NA (62.5%)		
Media aritmética (%)		**0.02**	**0.08**	**0.10**	**0.23**	**0.56**	**NA**		

Results of the survey of mathematics and computer science teachers

Ten professors from the Mathematics Department and 20 professors from the Computer Science Department were surveyed. The questionnaire sought criteria for managing the mathematical literacy development process in the Computer Science program, from both pedagogical and community perspectives.

The results reflect the poor compliance with the indicators corresponding to the pedagogical dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 3), with an arithmetic mean value of 0.43, which represents 42.5% of the total subjects investigated. The same occurred with the community dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 3), with an arithmetic mean value of 0.6, which represents 60% of the total subjects investigated.

Table 3. Results of the survey of 10 Mathematics teachers and 20 Computer Science teachers

Dimensiones	Indicadores	Escala Evaluativa					Evaluación (%)		
							Indicadores	Dimensiones	Variable
		MA	BA	A	PA	NA			
Dimensión pedagógica para la GPFCMII.	3.1	2	3	6	9	10	NA (33.3%)	No Adecuada (42.5%)	EVALUADA DE NO ADECUADA (51.3%)
	3.2	0	4	2	9	15	NA (50%)		
	3.3	3	2	5	8	12	NA (40%)		
	3.4	1	3	3	9	14	NA (46.7%)		
Media aritmética (%)		**0.05**	**0.1**	**0.13**	**0.29**	**0.43**	**NA**		
Dimensión comunitaria para la GPFCMII.	4.1	0	3	2	5	20	NA (66.6%)	No Adecuada (60%)	
	4.2	2	0	2	10	16	NA (53.3%)		
	4.3	0	1	3	8	18	NA (60%)		
Media aritmética (%)		**0.02**	**0.04**	**0.08**	**0.26**	**0.6**	**NA**		

Survey results for tutors from companies associated with the Computer Engineering program

Five tutors from the following companies were interviewed: Software Development Companies, Pinar del Río; Cuban Cultural Assets Fund, Pinar del Río Branch; and TRD Caribe Currency Collection Stores, Pinar del Río. The questionnaire sought criteria for the mastery of mathematical skills among

Computer Science graduates from the University of Pinar del Río, as a fundamental part of mathematical culture.

In data processing (Table 4), the acceptance coefficient was calculated by the specialists, adjusting it to the present research. The formula used was: where K is the Acceptance Coefficient; PA are the accumulated points; TPA is the total points to be accumulated; N is the maximum points per question (N=5). The processing resulted in an Overall Acceptance Index of 2.24, considering the mastery of mathematical skills by Computer Engineering graduates as unfavorable. The indicator that obtained the lowest score (1.4) was the third.

These results confirm that students, upon graduation, have a little grasp of mathematical culture, highlighting the need for comprehensive management of mathematics throughout their studies.

Table 4. Results of the survey application to company tutors

Indicadores	Tutores					PA	K
	1	2	3	4	5		
1	1	2	1	1	3	8	1.6
2	4	5	5	3	5	22	4.4
3	2	1	2	1	1	7	1.4
4	3	2	2	3	1	11	2.2
5	1	1	1	3	2	8	1.6
	Total					56	2.24

$$K = \frac{PA}{TPA} \times N$$

Where **K** is the acceptance coefficient; **PA** is the accumulated points; **TPA** is the total points to be accumulated; **N** is the maximum number of points per question (N = 5); **E** is the sum of the points.

Results of the survey of Computer Engineering students

A total of 120 (100%) students from across the program were surveyed (45 from first year; 27 from second year; 26 from third year; and 22 from fourth year). The questionnaire focused on identifying criteria for managing the development of mathematical literacy in the Computer Science program, based on the experiences of students across the program.

The results reflect the poor compliance with the indicators corresponding to the institutional dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 5), with an arithmetic mean value of 0.819, which represents 62.8% of the total subjects investigated. The same occurs with the three indicators corresponding to the administrative dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 5), with an arithmetic mean value of 0.855, which represents 65.6% of the total subjects investigated.

On the other hand, the results reflect the poor compliance of the four indicators corresponding to the pedagogical dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (Table 5), with an arithmetic mean value of 0.839, which represents 64.3% of the total subjects investigated.

The same occurs with the community dimension for the management of the mathematical culture formation process, manifested in the Not Adequate category (table 5), with an arithmetic mean value of 0.869, which represents 66.7% of the total subjects investigated.

Table 5. Results of the interview with 115 Computer Engineering students

Dimensiones	Indicadores	Escala Evaluativa					Evaluación (%)		
							Indicadores	Dimensiones	Variable
		MA	BA	A	PA	NA			
Dimensión institucional para la GPFCMII.	1.1	0	2	5	8	100	NA (66.7%)	NA (62.8%)	EVALUADA DE NO ADECUADA (64.9%)
	1.2	1	3	11	10	90	NA (60%)		
	1.3	2	4	8	9	92	NA (61.3%)		
	1.4	0	2	11	7	95	NA (63.3%)		
Media aritmética (%)		**0.007**	**0.024**	**0.076**	**0.074**	**0.819**	**NA**		
Dimensión administrativa para la GPFCMII.	2.1	0	1	1	3	110	NA (73.3%)	NA (65.6%)	
	2.2	1	2	6	15	91	NA (60.7%)		
	2.3	2	5	5	9	94	NA (62.7%)		
Media aritmética (%)		**0.009**	**0.023**	**0.035**	**0.078**	**0.855**	**NA**		
Dimensión pedagógica para la GPFCMII.	3.1	0	2	5	8	100	NA (66.7%)	NA (64.3%)	
	3.2	0	1	3	9	102	NA (68%)		
	3.3	1	2	8	15	89	NA (59.3%)		
	3.4	1	4	5	10	95	NA (63.3%)		
Media aritmética (%)		**0.004**	**0.020**	**0.046**	**0.091**	**0.839**	**NA**		
Dimensión comunitaria para la GPFCMII.	4.1	0	1	1	3	110	NA (73.3%)	NA (66.7%)	
	4.2	2	3	5	5	100	NA (66.7%)		
	4.3	1	3	6	15	90	NA (60%)		
Media aritmética (%)		**0.009**	**0.020**	**0.035**	**0.067**	**0.869**	**NA**		

Results of participant observation of vocational training activities

29 activities were observed that cover the four dimensions studied, with the aim of verify the level of achievement of the indicators of each dimension, evidencing impacts in all dimensions and indicators of the variable, reflected in the Not Adequate category: institutional dimension (43.5%); administrative dimension (41.4%); pedagogical dimension (48.1%); community dimension (31.6%).

The management of the mathematical culture training process for Computer Engineers demonstrates a lack of involvement from the educational management dimensions, which would allow attention to be paid to the improvement of the professional performance of the teaching and student community, and to professional training in general, from the substantive processes.

The diagnostic study conducted shows evidence of the little attention that has been and is being paid to the management of the mathematical culture training process for Computer Science Engineers at the University of Pinar del Río, despite the fact that all stakeholders involved in the process (professors, students, and administrators) recognize its importance for the comprehensive training of future Computer Science Engineers.

DISCUSSION

The scientific research process developed reveals the low level of development in the management of the mathematical literacy development process in the Computer Science Engineering program at the University of Pinar del Río. This work reveals that the management of the mathematical literacy development process must extend beyond the teaching and curricular processes of the Mathematics discipline.

Authors such as Camarena Gallardo *et al.* (2022) emphasize that mathematics is not only a support tool and a formative subject, but also fulfills specific functions at the higher education level. These authors emphasize the importance of integrating mathematical knowledge and ensuring that students are able to transfer it to other areas that require it. However, in the context of the University of Pinar del Río, the results show that this transfer and integration are not effectively achieved, which is reflected in the poor mastery of mathematical skills by graduates, as evidenced by the tutors of the partner companies.

The research shows that a lack of shared pedagogical leadership and poor communication of mathematical learning objectives and strategies are factors that contribute to the low level of mathematical literacy development among students.

Sharhorodska *et al.* (2018) recognize the mathematical description of the world, mathematical thinking, mathematical methods, and mathematical language as key dimensions of mathematical literacy. These elements are fundamental to the training of computer engineers. However, our assessment shows that these components are not systematically and sequentially addressed in the program, which limits students' ability to apply them to professional problem-solving.

Manifestations and regularities of the problem

The results of the survey of managers, teachers, tutors and students, as well as participant observation of vocational training activities, reveal several regularities and manifestations of the problem:

Institutional dimension

Socialization: the lack of socialization at the level of the pedagogical-student collective of the foundations that govern the management of the process of developing mathematical culture.

Working groups: the lack of working groups dedicated to the management of mathematical culture.

Communication channels: the absence of effective communication channels to promote process management.

Time and space: insufficient allocation of time and space for process management.

Administrative dimension

Economic and financial resources: the scarcity of resources allocated to process management.

Working group functions: lack of clear definition of working group functions

Performance evaluation: insufficient evaluation of the professional performance of work groups.

Pedagogical dimension

Knowledge updating: the low frequency of updating, deepening, and completing knowledge about mathematical culture by the teaching community.

Teaching activities: the limited implementation of teaching, extracurricular and extracurricular activities aimed at developing mathematical culture.

Problem-solving: the limited incorporation of professional problems in the PEA to enhance the appropriation of mathematical culture.

Assessment: Insufficient assessment of the appropriation of mathematical culture in the PEA.

Community dimension

Social outreach projects: the lack of projects that promote mathematical culture in the community.

Community Relations: The weak relationships between the university and organizations, businesses, and the non-state sector in the management of mathematical culture.

Community activities: the limited implementation of community activities to promote mathematical culture.

Therefore, the management of the mathematical literacy development process in the Computer Science program at the University of Pinar del Río is affected by significant institutional, administrative, pedagogical, and community limitations. These limitations are reflected in the poor mastery of mathematical skills among graduates, which highlights the need for comprehensive and ongoing management.

To address this problem, a strategy is proposed that includes a system of specific strategic actions aimed at perfecting the research process. This strategy seeks to regulate and guide the process by establishing links between the dimensions of educational management and the components of mathematical culture, ensuring comprehensive training that prepares students to solve professional problems at the foundation level of their profession.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.