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Axiological implications of a didactic strategy for mathematical knowledge management in pre-university heterogeneous groups

Implicaciones axiológicas de una estrategia didáctica de gestión del conocimiento matemático en grupos heterogéneos preuniversitarios

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Abstract

Introduction: Mathematics teaching at the Cuban pre-university level has traditionally prioritized cognitive aspects over axiological ones. However, knowledge management in heterogeneous groups inevitably involves the value dimension, bringing into play solidarity, intellectual honesty, respect for diversity, and shared responsibility.
Objective: To analyze the axiological implications derived from applying a didactic knowledge management strategy in tenth-grade students with different starting levels.
Methods: A pre-experiment (pretest-posttest) was conducted with 60 students and 8 teachers in Granma, Cuba, during the 2024-2025 academic year. Theoretical (analysis-synthesis, systemic-structural-functional) and empirical methods (survey, participant observation, group interviews, reflective portfolio analysis) were used.
Results: A significant improvement was evidenced in the four value dimensions. Qualitative triangulation revealed that mutual help, peer assessment, and error valuation actions transformed the classroom climate.
Conclusion: Knowledge management, by structuring collaborative interaction and metacognitive reflection, fosters an environment conducive to internalizing values that transcend mathematical learning.

Key words: Values education; knowledge management; heterogeneity; mathematics teaching; pre-university education.

Resumen

Introducción: La enseñanza de la Matemática en el nivel Preuniversitario cubano ha priorizado los aspectos cognitivos en detrimento de los axiológicos. No obstante, la gestión del conocimiento en grupos heterogéneos implica ineludiblemente la dimensión valorativa,

poniendo en juego la solidaridad, la honestidad intelectual, el respeto por la diversidad y la responsabilidad compartida.

Objetivo: Analizar las implicaciones axiológicas derivadas de la aplicación de una estrategia didáctica de gestión del conocimiento en estudiantes de décimo grado con diferentes niveles de asimilación.

Métodos: Se realizó un pre-experimento (pretest-postest) con 60 estudiantes y 8 profesores en Granma, Cuba, durante el curso 2024-2025. Se emplearon métodos teóricos (análisis-síntesis, sistémico-estructural-funcional) y empíricos (encuesta, observación participante, entrevistas grupales, análisis de portafolios reflexivos).

Resultados: Se evidenció una mejora significativa en las cuatro dimensiones valorativas. La triangulación cualitativa reveló que las acciones de ayuda mutua, coevaluación y valoración del error transformaron el clima del aula.

Conclusión: La gestión del conocimiento, al estructurar la interacción colaborativa y la reflexión metacognitiva, genera un entorno propicio para la internalización de valores que trascienden el aprendizaje matemático.

Palabras clave: Educación en valores; gestión del conocimiento; heterogeneidad; enseñanza de la matemática; educación preuniversitaria.

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Introduction

The teaching of Mathematics at the Pre-University educational level faces the challenge of serving classrooms characterized by marked heterogeneity. Students enter with different levels of prior knowledge, interests, and self-confidence. Historically, the teaching of this science has prioritized the assimilation of concepts and the resolution of exercises, relegating training in values - such as solidarity, honesty and respect - to a secondary level.

From the perspective of pedagogical axiology, values do not constitute abstract entities, but are configured and manifested in human activity. Authors such as Frondizi (1972) and Buxarrais (2023) maintain that the evaluative dimension is built in social interaction and in the resolution of real conflicts. In this sense, knowledge management - understood as the process through which students search, select, organize, apply and share information - becomes an ideal scenario for axiological training (Dalkir, 2023).

When knowledge management is implemented in the classroom, evaluative dilemmas inherent to the process emerge: which sources to trust? How to react to one's own or another's error? How is merit distributed? How is collective responsibility assumed? (Nonaka & Takeuchi, 1995; Rodríguez et al., 2024).

Recent international research has shown that collaborative learning and knowledge management foster respect and solidarity **(Almeida & Aportela, 2024; Gutiérrez et al., 2025; Vera *et al*., 2025)**. However, a theoretical gap persists regarding how these dynamics operate specifically in heterogeneous groups, where the coexistence of different cognitive levels can generate both tensions and invaluable opportunities for empathy.

The initial diagnosis carried out at the **"Silberto Álvarez Aroche" Vocational Pre-University Institute of Exact Sciences (IPVCE)** in Granma revealed poor academic performance accompanied by a classroom climate where competition took precedence over cooperation and the concealment of errors. In response, a didactic knowledge management strategy focused on the axiological dimension was designed and implemented.

The objective of this article is to analyze the axiological implications derived from the application of said strategy in tenth grade students, evidencing how the management of mathematical knowledge can act as a vehicle for the internalization of values.

Methods

Research design

A pre-experimental pretest-posttest design was used with a single group (Campbell & Stanley, 1963), complemented by a mixed data triangulation approach. This design allowed us to evaluate the evolution of the evaluative indicators before and after the didactic intervention.

Context and participants

El The study was carried out at the IPVCE "Silberto Álvarez Aroche" (Granma, Cuba) during the 2024-2025 academic year. The population was 126 tenth grade students. A non-probabilistic intentional sample of 60 students (47.6%) was selected, with an average age of 14.8 years (62% female, 38% male). The 8 Mathematics teachers of the level also participated.

Ethical considerations

The research was governed by the ethical principles of educational research. Written informed consent was obtained from the parents or legal guardians of the students, as well as approval from the institutional ethics committee of the educational center. The anonymity of the participants was guaranteed by coding their responses (e.g. Student 1, Teacher 1) and the confidentiality of the data, used exclusively for scientific purposes.

Data collection instruments

Questionnaire of values in mathematical learning (CVAM): Instrument with 20 items on a 5-level Likert scale. It evaluates four dimensions: solidarity/mutual help, intellectual honesty, respect for the diversity of rhythms and shared responsibility.

Validation: The CVAM was subjected to a content validation process through the judgment of 5 experts (doctors in pedagogical and mathematical sciences), who evaluated the relevance, clarity and coherence. Subsequently, a pilot test was carried out with 20 students not belonging to the sample, which allowed the wording of the items to be adjusted. Internal consistency was calculated using Cronbach's Alpha coefficient, obtaining a value of α=0.89 in the pretest and α=0.93 in the posttest, which indicates high reliability.

Observation guide for evaluative behaviors: 10 observations of 45 minutes each were carried out, recording frequencies of positive behaviors.

Group interviews with students: 4 focus groups of 5 students each were carried out.

Reflective Portfolios: Individual documents where students reflected on evaluative dilemmas.

Procedure

The teaching strategy was implemented for 10 months (September 2024 - June 2025) in three stages:

1. Stage 1: Diagnosis and creation of the evaluative climate (2 weeks). Application of the pretest. Awareness-raising activities through discussion of moral dilemmas. Negotiation of coexistence rules.

2. Stage 2: Development of knowledge management with axiological emphasis (8 months). Integration of evaluative actions in the management phases. Mutual help, respectful co-evaluation, appreciation of error, and honesty in attributing sources were emphasized.

3. Stage 3: Consolidation and value transfer (2 months). Carrying out integrative projects and a Knowledge Fair. Socialization of reflective portfolios.

Data analysis

Quantitative data were processed with SPSS. Means, standard deviations and percentages were calculated. To compare the pretest and posttest measurements, the Wilcoxon signed rank test was used ($p<0.05$) and the effect size was calculated using Cohen's d. Qualitative data (interviews, observations, portfolios) were analyzed using content analysis and triangulation of sources.

Results

Improvement of evaluative indicators

Table 1 shows the evolution of the four evaluative dimensions. All improved highly significantly ($p<0.001$) with large effect sizes.

Table 1. *Evolution of evaluative indicators*

Evaluative dimension	Pretest (mean)	Postest (mean)	*p*-value	*Cohen´s d*
Solidarity and mutual help	2,5	4,6	<0,001	1,28
Intelectual honesty	2,6	4,5	<0,001	1,22
Respect for the diversity of rhythms	2,4	4,3	<0,001	1,18
Shared responsibility	2,7	4,4	<0,001	1,15
Overall rating	2,6	4,5	<0,001	1,21

Note: Own elaboration

In the pretest, only 18% of the students claimed to offer spontaneous help; In the posttest, this percentage rose to 88%. Public recognition of the error went from 12% to 82%, and respect for the different rhythms went from 22% to 86%

Observed behaviors

Table 2 shows the increase in evaluative behaviors recorded during the systematic observations.

Table 2. Observed evaluative behaviors *(average frequency per class)*

Observed behavior	Pretest	Postest	Increase
Offering help without being requested	2,1	8,4	+300%
Public recognition of own error	1,2	7,6	+533%
Attribution of credit to ideas of others	0,8	6,9	+763%
Expressions of respect for different rhythms	1,5	7,2	+380%
Compliance with assigned responsibilities	3,2	9,1	+184%

Note: Own elaboration

Qualitative Results

The content analysis revealed a transformation in the students' perception. The most representative quotes were selected:

- Solidarity and error: "Before I was ashamed to ask for help. When the teacher said that error is interesting and my classmates explained it to me without making fun, I learned that being supportive is also knowing how to receive" (Student 7).
- Intellectual honesty: "I learned that honesty is recognizing when I don't know something.

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Before I copied the homework; now I prefer to say 'I didn't understand, explain to me'" (Portfolio 15).

- Shared responsibility: "Responsibility is not just doing my job, it's making sure the team works. If someone doesn't understand, I stop and help them" (Portfolio 59).

The teachers corroborated these changes. Teacher 3 noted: "The most profound change was in the classroom climate. They went from competing to collaborating; even the most arrogant became humble."

Relationship between values and knowledge management

Table 3 shows positive and significant correlations (Spearman's r) between the evaluative dimensions and knowledge management.

Table 3. *Correlations between values and knowledge management (postest)*

Evaluative Dimension	Correlation with knowledge management (Spearman´s *r*)
Solidarity	0,71
Intelectual honesty	0,68
Respect for diversity	0,65
Responsability	0,69

Note: Own elaboration

Discussion

The results confirm that the strategy has profound axiological implications. The dimensions evaluated improved significantly and were strongly correlated with knowledge management, which dialogues with the postulates of pedagogical axiology on the unity between the cognitive and the affective-volitional (Buxarrais, 2023).

Solidarity showed the highest improvement. Coinciding with Vera et al. (2025), structured collaborative learning encourages cooperation; However, our study adds that this did not emerge spontaneously, but as a result of an intentional design of roles and explicit reflection. The students internalized that explaining to others is a learning strategy (Almeida & Aportela, 2024).

Intellectual honesty improved significantly. Traditionally, an error in Mathematics is experienced as failure (Taveras, 2024). The strategy transformed this culture by institutionalizing error as an opportunity for collective learning, a fundamental change for knowledge management, which requires transparency (Dalkir, 2023).

Respect for diversity is a key outcome in heterogeneous groups. The intentional formation of

teams and the explicit rule of respecting times ensured that the advanced students did not despise the slower ones. This coincides with Gutiérrez et al. (2025), who point out emotional management as a key to respect.

Shared responsibility was manifested in concern for the functioning of the team. The students understood that individual success is not enough if the group does not achieve the objectives (Rodríguez *et al*., 2024).

Limitations of the study: As it is a pre-experimental design with a single group and in a specific context, the results cannot be generalized to the entire pre-university population. Likewise, self-perception instruments may be biased by social desirability, although triangulation with observations and portfolios mitigated this bias. Future research should explore the sustainability of these changes through longitudinal studies.

Conclusions

The application of the didactic strategy of mathematical knowledge management in heterogeneous groups generated significant axiological implications. The specific actions of the strategy —heterogeneous teams with rotating roles, structured co-evaluation, error assessment, and metacognitive reflection —acted as mediators for the internalization of values such as solidarity, intellectual honesty, respect for diversity, and shared responsibility.

The specific actions of the strategy —formation of heterogeneous teams with rotating roles, structured co-evaluation, assessment of error as an opportunity, metacognitive reflection in portfolios —acted as mediators for the internalization of values. The students not only learned to manage mathematical knowledge, but they transformed their relationship with error, mutual help, and diversity.

Students not only optimized their management of mathematical knowledge, but also transformed their relationship with error, mutual help, and diversity. The interdependence found demonstrates that a teaching of Mathematics that neglects the axiological dimension is incomplete. Knowledge management constitutes an authentic scenario for the formation of values, while training in values provides meaning and sustainability to the construction of mathematical knowledge.

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Conflict of interests:

It is declared that there are no conflicts of interest that may have influenced the results obtained or the proposed interpretations.

Curricular synthesis:

Edel Ernesto Pérez Almarales: Graduate in Education specializing in Mathematics and Computing. Master in Educational Sciences. He has held the positions of Municipal Methodologist of Mathematics in Pilón (2008–2013), Deputy Director of Labor Training, Head of the Department of Exact Sciences of the IPVCE and Deputy Director of Teaching (8 years). He has supervised 17 master's theses. Delegate to the international conferences Science Didactics 2024 and Pedagogy 2025. His lines of research include knowledge management, use of didactic games, Mathematics teaching and attention to heterogeneity at the pre-university level.

Eduardo Miguel Pérez Almarales: He has a Doctor in Pedagogical Sciences, a Master in Educational Sciences and a Bachelor of Education, specializing in Mathematics. He is the **2025 Pablo Miquel National Mathematics Award**, the highest recognition granted by the Cuban Society of Mathematics and Computing (SCMC) to lifelong work in mathematics education in Cuba. He works as Assistant Professor at the University of Granma, Professor of Mathematics at the IPVCE "Silberto Álvarez Aroche" and Main Trainer of the Provincial Training Center for Mathematics Olympiads in Granma. He is also President of the Cuban Society of Mathematics and Computing in the Granma province. He has an extensive career as a coach of the Cuban team at the International Mathematics Olympiads (2000-2017), he has achieved that his students obtain 14 gold, 41 silver and 54 bronze medals in international events. He has received numerous recognitions, including the Juan Tomás Roig Distinction (2024), the Rafael María de Mendive Distinction (2023) and has been selected as an expert by the Curaçao Accreditation Agency for Higher Education (2021). His lines of research focus on knowledge management in the teaching-learning process of Mathematics, the preparation of talented students and the resolution of mathematical problems. He is the author of multiple scientific articles published in national and international indexed journals.

Declaration of author´s responsibility:

Edel Ernesto Pérez Almarales: Participated in the conceptualization of the study, the design of the didactic knowledge management strategy, the implementation of the intervention in the classroom, the collection and analysis of quantitative and qualitative data (including the application of instruments and triangulation of sources), as well as the writing of the original draft and the final revision of the manuscript.

Eduardo Miguel Pérez Almarales: Participated in the general supervision of the research, the theoretical validation of the didactic model and the derived axiological implications, advice on the statistical processing of the data (Wilcoxon test, Cohen's d) and the critical review of the scientific content, also contributing to the editing and style correction of the article.

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