

Un ejemplo de la aplicación del Modelo Didáctico de Instrucción Heurística

An example of the application of the Didactic Model of Heuristic Instruction

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Recibido: 21 de junio de 2024

Revisado: 15 de julio de 2024

Aceptado: 05 de septiembre de 2024

RESUMEN: Se presenta un ejemplo de la aplicación en la práctica pedagógica, de la metodología sustentada en un modelo didáctico de la superación profesional de los profesores de Matemática del Nivel Educativo Secundaria Básica en Cuba, para solucionar las insuficiencias en su preparación teórica y metodológica. El modelo aporta una lógica epistemológica en las relaciones dialécticas entre los componentes Concepción, Ejecución y Evaluación del tratamiento del contenido de la Instrucción Heurística de la Matemática asistida por las Tecnologías de la Información y las Comunicaciones que favorece, mediante un enfoque heurístico, que los profesores conciban, ejecuten, regulen y evalúen el procesamiento la asimilación y la aplicación de dicho contenido. En el ejemplo se trata de acercar la teoría expresada en una tesis doctoral realizada y en publicaciones realizadas sobre el tema, de manera que los interesados puedan tener un cómo aplicarlo en sus respectivos contextos.

Palabras clave: Tecnologías de la información y las comunicaciones; Secundaria básica; Instrucción heurística de la matemática; Superación de profesores

ABSTRACT: An example is presented of the application in the pedagogical practice, of the methodology supported by a didactic model of the professional improvement of Mathematics teachers of the Basic Secondary Education Level in Cuba, to solve the insufficiencies in their theoretical and methodological preparation. The model provides an epistemological logic in the dialectical relationships between the components Conception, Execution and Evaluation of the treatment of the content of Heuristic Instruction of Mathematics assisted by Information and Communication Technologies that favors, through a heuristic approach, that teachers conceive, execute, regulate and evaluate the processing, assimilation and application of such content. In this example, we try to approach the theory expressed in a doctoral thesis and in publications on the subject, so that those interested may have a way to apply it in their respective contexts.

Keywords: Information and communication technologies; Basic secondary education; Heuristic instruction of mathematics; Teacher training

Introduction

In the current times of development of the Basic Secondary Education Level (NESB), it is a necessity to conceive, execute and evaluate the improvement of teachers, in order to raise the quality of their preparation, it is necessary to improve their professional performance, to achieve an adequate development of professional skills, which facilitates the exposition of their ideas and arguments with coherence, with the use of mathematical terminology and symbology, as well as interpreting the language of the resources of the Information and Communication Technologies (TIC) and other sources with which they interact for heuristic purposes.

The application of the facto-perceptible diagnosis on the professional improvement of Mathematics teachers of the Basic Secondary Education Level, from the bibliographic review, the observation of the teachers' performance, the analysis of documents, inspection reports, methodological assistance, interviews and surveys to directors, teachers and students, review of lesson plans, methodological work and improvement, as well as the pedagogical experience accumulated by the researcher in his performance as a teacher at this level, allowed revealing insufficiencies among which are:

Predominance of the expository-illustrative method and the non-use of didactic strategies aimed at encouraging students to discover and search for reasonable solutions to the problems posed. Insufficient preparation to conceive and direct a teaching-learning process with a heuristic approach, as well as the non-use of Information and Communication Technologies, knowledge is transmitted limiting the possibility for students to think, reason and give their opinion, by restricting the impulses to the realization of questions whose answers are closed, regularly providing anticipated help in the treatment of exercises with texts and problems, to find and support the solution path.

These inadequacies in teachers result in students showing limitations such as: Tendency to study by repeating and memorizing concepts, theorems and properties or learning formulas and procedures to solve problems, showing little solidity and durability of knowledge. Limitations in the use of heuristic procedures, since most of them focus on the final answer, without realizing the error. Tendency to answer the questions asked by the teacher without previous reflection, very few investigate, assume or reach conclusions.

The main causes can be related to the following: Limited projection of strategies, methods and techniques that allow an adequate treatment of the heuristic instruction of Mathematics (IHM) with the use of Information and Communication Technologies (TIC). Limited use of heuristic resources assisted by TIC in the evaluation of learning of students at the Basic Secondary Education level during the teaching-learning process of the subject Mathematics.

Going into the analysis of the professional improvement of Mathematics teachers at the Basic Secondary Education level implies, first of all, considering the specialized literature of the authors who have studied this subject in different fields: Díaz (1993), Añorga (2014), Cabrera (2017), Madureira et al. (2017), Ávila et al. (2019), among others.

These authors agree that this process has a continuous character and although they base their studies on the need to update knowledge as a consequence of changes and advances in technology and sciences, they do not propose theoretical models that allow building strategies or methodologies that reveal a logic to address coherently and with sufficient depth the mentioned process at the Basic Secondary educational level.

Therefore, a scientific study was carried out to provide a methodology, based on a didactic model of treatment to the content of the IHM assisted by TIC, for Mathematics teachers of the Basic Secondary Education Level, to improve their professional performance.

Development

For the development of the research and the design of the methodology, the concept of pedagogical professional performance given by Santos (2005) is assumed, who defines it as:

The result of the behavior of the education professional and his performance in the fulfillment of the functions, as well as in the roles he assumes in the tasks proper to the profession during the development of the professional pedagogical activity he performs, for being the most generalizing, since it comprises the actual behavior or conduct of teachers in the professional and technical order, professional skills; as well as, their human and ethical values. (p. 14)

This research also assumes Ballester's (1992) definition of IHM, expressed as:

The conscious and planned teaching of general and special rules of heuristics for problem solving, for which it is necessary that, when they are first stated explicitly and their importance is emphasized until they are learned and used independently, the following is

achieved: cognitive independence; new and old knowledge are integrated; new ways of working and thinking are developed, the search for relationships and dependencies, considerations of analogy and the formation of mental capacities such as intuition, productivity, originality and creativity. (p. 225).

In this sense, the author deems it necessary to note that the treatment to the content of the IHM assisted by TIC is: the planned and conscious teaching-learning process of the Method and heuristic procedures, favoring the obtaining of the new knowledge through the use of TIC.

Analysis and discussion

With the aim of promoting understanding and comprehension by teachers, in order to improve the quality of the teaching-learning process, an example of the application in pedagogical practice of the methodology based on a didactic model of professional development of Mathematics teachers of the Basic Secondary Education Level (NESB) in Cuba is presented.

It is modeled a reconstruction of the NESB Mathematics teacher's professional development aimed at the heuristic preparation assisted by TIC. Therefore, the model consists of three components, the Conception of the TIC-assisted IHM, the Execution of the TIC-assisted IHM and the Evaluation of the TIC-assisted IHM, which has a systemic nature, evidenced in the structural-functional interrelationship established between the subsystems, ensuring the relevance and effectiveness of the process in its relational dynamics, establishing its organization and functions (Lahera et al., 2023, p. 421). (Lahera et al., 2023, p. 421)

The designed model constitutes the theoretical basis of a methodology based on a categorical theoretical body organized by stages and actions, which allows the construction of knowledge for the treatment of the content of the IHM assisted by TIC and its application in the professional development of the mathematics teacher at this educational level. (Lahera, 2024, p. 80).

According to the studies carried out and the application in pedagogical practice of the methodology that leads to de facto ways the model, the authors assume that:

It allows the improvement of the performance of the Mathematics teacher of the Basic Secondary Education Level during their professional development by favoring the treatment of the content of the IHM assisted by TIC, which allows them to achieve higher levels in the

development of professional development and evidences the social significance of the scientific proposal defined. (Lahera et al., 2023, p. 310).

Taking into account that publications have been made in high impact scientific journals, of pedagogical line, it is intended that readers and followers of the subject in question have an approach through this publication so that they can apply it in their respective educational centers, and also use them in their studies, serving as a basis for their work and as an element of criticism in the deepening of the subject.

As an example for department heads and teachers who intend to use the methodology resulting from this research, it is exposed.

Activity to be developed:

To propose a material in which the treatment of a mathematical concept of circumference chord is worked.

In the work with mathematical concepts, TIC as an auxiliary heuristic means (MHA) is directed especially to the recognition of the essential characteristics, the identification of the concept and the application in the resolution of exercises and problems in the educational practice and serves as support to determine the logic to follow for the formation of the concept and the methodological structuring of its definition.

Teachers, to develop this activity, use the mastery of the elements related to the use of the heuristic method, the elements of the content of the Heuristic Instruction of Mathematics (IHM), the skills and abilities for the use of technological resources to be used (videos, computers, software, cell phone applications, working with search engines (Google, Wikipedia), as well as the necessary elements to develop the concept of the circumference chord, among others that are required in the teaching of Mathematics assisted by Information and Communication Technologies (TIC).

For these reasons, it is convenient to prepare Basic Secondary Mathematics teachers in this regard, using a Methodology to develop the TIC-assisted IHM, which is why this process is exemplified by treating the STEM "Treatment of concepts and their definitions".

The methodology consists of four stages: Diagnosis for the treatment to the content of the TIC-assisted IHM, Planning of the necessary conditions, Appropriation and application of the content

of the TIC-assisted IHM, Evaluation of the treatment to the content of the TIC-assisted IHM, which favors:

- To perform mental operations and logical procedures such as generalizing, completing, concretizing, comparing, characterizing, among others.
- To consciously apply induction and deduction, methods and means of rational work, and heuristic resources that stimulate the search for solutions.
- To reveal aspects of the origin and historical genetic development of the teaching of Mathematics.
- To use a symbolic language, and to show its potentialities to solve problems.

First stage: Diagnosis for the treatment of the content of the IHM assisted by TIC in the professional development of mathematics teachers.

For this treatment we start from the treatment of the mathematical concept, circumference chord by means of the deductive way in which TIC are used as means to support the IHM, in this stage the training of each teacher is analyzed, this can be individual or group depending on the characteristics of the faculty that is chosen as a sample, The mediator of the improvement (methodologist or experienced Mathematics teacher) and the Mathematics teacher are diagnosed to know the previous knowledge of the elements corresponding to the content of the concept to be treated, such as (concept and definition of segment, point, straight line, diameter of the circumference, circumference, ends of a segment, among others), as content of the concept.

In this stage, actions are carried out such as:

- To diagnose the mastery of the elements of the IHM by Mathematics teachers.
- To diagnose the infotechnological skills of mathematics teachers to use TIC as an IHM.
- To identify the strengths and weaknesses of Mathematics teachers to plan activities.
- To analyze the teachers' training models to develop the treatment of concepts.
- To analyze the incidence of the professional improvement process based on knowledge, skills, habits, modes of action and norms for the treatment of concepts.
- To determine the possible technological resources to be used for the diagnosis.

At this stage, the initial training of teachers is taken into consideration, since not all of them have the same training and some lack the necessary elements (knowledge, skills, habits and modes of action) to work on the subject.

To achieve this purpose, among other heuristic resources, rules are used, such as: substituting the concept for its definition, determining common and uncommon characteristics of the content, specifying essential characteristics based on elements that they gather according to their extension, as well as the analysis of particular and special cases.

It is taken into account that in order to deal with mathematical concepts and their definitions, there are insufficiencies such as: the recognition of the essential characteristics and elements of the concept, it does not always materialize in the determination of the logical path and its steps for its formation and the lack of a logical and orderly sequence for the realization of questions and impulses according to the heuristic principles and rules.

Second stage: planning of the necessary conditions for the development of TIC-assisted treatment of the content of the IHM

At this stage, work is done with the mediators of overcoming on how to plan and organize the treatment of the concept of circumference chord, to avoid the most frequent errors, how to ask questions for its effective development of the concept and ways to introduce it.

For this purpose, materials are prepared, brochures with the elements of the IHM, the elements to be worked on for the treatment of the concept, the review of MEM books is oriented, topics are prepared for them to search in Google or another search engine for the mentioned elements, a guide is provided for the development of the work, and the use of impulse questions is also planned.

This stage ensures the determination of the heuristic resources to be used in the Video to be played, their possible distracters, how to introduce them, how to introduce another (if possible) for the treatment of the content of the IHM assisted by the TIC, as well as the technological resources that can be used to develop the content of the concept to be treated, in addition to establishing the methods and techniques to evaluate the effectiveness of the treatment of the concept.

In this stage, actions are also developed in order to develop information, communication and knowledge search skills guaranteed through the use of TIC, as well as the development of the skills they possess in order to create the capacity for the analysis of images, animations, text, voice, sound and videos, thus shaping their thinking and professional performance.

Third stage: Appropriation and application of the content of the TIC-assisted IHM during professional development.

In this stage we proceed to the realization of the improvement actions designed from the organizational forms of the postgraduate for the implementation of the activities, courses, trainings, scientific debates, workshops, seminars, consultations, self-preparation in addition to others that are integrated in the networking as support of educational agencies in which the treatment to the content of the IHM that was determined to impart is planned and applied, as well as the technological tools and resources to be used, then we take advantage of the forms of work both individual and collective as part of the overcoming organized by mediators such as the Technical Council, the Grade Council and Subject Collective as part of the methodological work, the media are placed on digital platforms created from WhatsApp, Telegram, mobile applications such as Google meet, search engines (Google, Wikipedia), the use of educational software such as (Mathematical Elements, Geogebra), among others that make possible the appropriation of the content by the teacher in a heuristic virtual environment because in it are organized and achieved activities that are supported by TIC as MHA.

At the time of appropriation it is suggested to work with defined indicators such as:

- Familiarization with the problem situation.
- Establishment of relationships and dependencies between the elements given and those sought.
- To identify and to establish the mathematical relations necessary to define the concept.
- To apply the most convenient heuristic procedures to solve the activity.
- To check the solution and evaluate the solution path employed.

Actions to develop:

Activities to carry out with materials:

- To use of concrete objects.
- Base models for concrete and direct visualization.
- The construction of figures of analysis (circles, straight lines, segments and their elements), for the understanding of the concept in Geogebra software, in Paint, PowerPoint, as well as the creation of elements of the concept.

- The realization of concept maps using Word, PowerPoint.

Oral activities:

- Conducting discussions on the characteristics observed in the constructions made and of the concept to be developed.
- Describing the characteristics of the content of the concept.
- To make partial summaries of the treated elements that are part of the concept.
- Activities to be developed mentally:
- To perform observations, comparisons, the analysis and synthesis of what has been observed to project the characteristics of the concept and define which are essential for the formation of the concept to be dealt with.

In this way, higher requirements of mental activity are generated and cognitive independence is achieved, after performing the analysis of the essential characteristics of the concept, one can ask what would happen if one of these were removed.

Then comes the moment of applying the assimilated content, which is carried out through the development of class visits, the realization of instructive and demonstrative classes in the preparation of subjects, in the subject groups, so that an adequate treatment of the concept worked on is achieved.

For the application of the concept the following actions of the general heuristic program are suggested as a way of working:

- To start from the known concepts (segment, diameter of the circumference, ends of the segment, points), to arrive at the essential characteristics. In this case, the elements worked on can be sent to be constructed in Geogebra, in Paint, in PowerPoint. In this case you can ask: What is given, what is asked (separate what is given from what is sought), Compare what is given with what is asked, What concepts can be applied in the search for the idea of solution (replace the concept by its definition), What properties, rules, do you know that are related to what is asked?
- To propose as motivation a situation in which it is necessary to determine the name of the searched element, so that its exact explanation of the concept becomes necessary. Then, you can send to trace a segment that has its ends in the circumference and another of the same

characteristic that passes through the center and compare, as well as others that do not meet these requirements, from there you get the subordinate concept of diameter as a chord of the circumference. For this action it is suggested to ask, what methods do you know to solve the exercise? What are its main characteristics?

- To find a way or strategy to achieve the search for the common and uncommon characteristics of the exposed elements. Perform the analysis of the elements that provide common and uncommon characteristics, where are the extremes, what happens with this segment, what limits them, can others be traced. In this case it is possible to ask, will it be necessary to make a figure of analysis, will it be necessary to draw lines or auxiliary figures, will it be possible to sketch a figure of analysis that can represent the situation raised, is it possible to establish some mathematical relation between the given elements, is it possible to establish some mathematical relation between the given elements, is it possible to establish some mathematical relation between the given elements?
- To group the segments that meet the requirements to be considered chords of the circumference and separate them from those that do not meet the condition. At this point it is possible to ask, what is the knowledge about the given concept that allows to affirm elements for its definition, under what conditions can the found elements be affirmed, what mathematical knowledge allows to relate the found elements, and what mathematical knowledge allows to relate the found elements?
- With the help of these common characteristics elaborate the concept. For this part you can use the following question, what are the essential characteristics of the concept?
- To take into account a similar procedure for working with other elements of the circumference such as radius, tangent to the circumference, among others. In this one you can operate with the following questions, Do you compare characteristics of a representative of the concept with a representative of another concept (subordinate or of a higher degree of generality)?

Actions to develop the heuristic method and its procedures with the use of TIC:

At this point, the following can be used as questions to develop the procedures and heuristic method:

What heuristic procedures would you use, do you consider it to be the most optimal, can it be done in another way, as you would have done it?

It is possible to search in Search Engines, terms to summarize, the teaching of a topic through the Google Meet application in which discussions are produced that enrich the teacher's preparation and develop professional performance.

In this way, learning is achieved through a heuristic virtual environment, since activities are organized to achieve support and control of the actions to be carried out that ensure that teachers with the support of TIC as MHA:

- Teachers work on real problems and solutions in their professional performance either individually or in teams.
- They achieve constant and uninterrupted interaction with mediators and other teachers.
- Activities that privilege cognitive skills such as analysis, synthesis (not memorization).
- The activities can also be proposed by the teachers.
- Feedback (before and after) from teachers and between mediators and teachers. Mediators should be involved in the search for materials and not only in the contents.
- Mechanisms are foreseen to meet the didactic and methodological needs of teachers.
- They explore and interact by putting into practice the new knowledge with the knowledge they already have, being able to define the concept under study.
- They strengthen the application of TIC as an MHA from their interaction with them.
- They interact and are able to navigate easily with the use of the Internet.

Fourth Stage: Evaluation of the treatment of the content of the IHM assisted by TIC during professional development.

In this stage the form of evaluation is established, the categories, scales are proposed to measure it such as: oral, written, the delivery of a work as closing of a topic, which will be evaluated qualitatively (B, R, M), (A, M, B), quantitatively (scales of 1-5), which allow knowing with greater certainty and precision the development achieved by the teacher during his professional development and as improvement of the professional performance.

In this way, an evaluation of the process is developed that allows the assessment of the fulfillment of the proposed objectives, their redesign and reformulation during their performance both in the

improvement and in their performance, from the judgments issued by the mediators through the heteroevaluation being able to assess the performance of teachers, as well as the use of the content of the IHM assisted by TIC, evaluate the actions of the methodology and its effect, as well as the selection of the content, creating a criterion of what was done by the teachers, in a second moment of the evaluation, The group of teachers is encouraged to be able to evaluate their peers (Co-evaluation), assessing their actions and performances being evaluators and evaluated, which allows the development of personal and group achievements as well as the determination of solutions through critical reflection, finally, self-evaluation is encouraged, where the teacher himself is able to make a judgment of his own performance, recognizes his possibilities transforming his professional performance, is capable of critical feedback in the construction of his knowledge, in this way, the process becomes dynamic and problemic with the participation of all members of the professional improvement.

Through the use of this methodology it has been possible to transform in a positive way the preparation of teachers, which has allowed the improvement of the quality of the teaching-learning process in the Basic Secondary Education Level, as well as the knowledge and academic performance of the student.

Conclusions

An example is described on how to apply in the pedagogical practice, the methodology based on a didactic model of the professional improvement of Mathematics teachers of the Basic Secondary Education Level in Cuba; which allows a better understanding of the studies and results obtained on this subject.

It is illustrated in a clear and simple way, with a clear accessibility, how to apply the methodology in the pedagogical practice, which allows teachers and department heads, with their creativity, to contribute with new examples for the development of their professional development and the improvement of the quality of the teaching-learning process.

Bibliographic references

Añorga, J. (2014). La Educación Avanzada y el mejoramiento profesional y humano. *Revista Varona*, (58), 19-31.

- Ávila, M. E., Santos, I., Mederos, M. y Espert, B. (2019). La superación del maestro primario: vía para el mejoramiento de su desempeño profesional pedagógico ambiental. *Revista Universidad y Sociedad*, 11(5), 89-98.
- Ballester, S. (1992). *Metodología de la Enseñanza de la Matemática*, tomo 1. Pueblo y Educación.
- Cabrera, G. M. (2017). *La superación profesional del docente de la Especialidad Agropecuaria en la orientación profesional pedagógica*. (Tesis presentada en opción al grado científico de Doctor en Ciencias Pedagógicas, Universidad de Santa Clara).
- Díaz, M. D. (1993). *El desarrollo profesional docente y las resistencias a la innovación educativa*. Asturias: Servicio de Publicaciones. Universidad de Oviedo.
- Lahera, Y. (2023). *La instrucción heurística asistida por las tecnologías de la información y las comunicaciones para los profesores de matemática del nivel educativo secundaria básica*. (Tesis inédita doctorado, Universidad de Granma).
- Lahera, Y., Fernández, R.A. y Bello, G. (2023). Modelo Didáctico de instrucción Heurística asistido por las tecnologías de la Información y las comunicaciones. *Revista Edusol*, 23(Número Especial), 419-432.
- Lahera, Y., Fernández, R.A. y Bello, G. (2023). Una mirada actualizada a la superación de los profesores de Matemática de Secundaria Básica. *Revista Roca*, 19(2), 296-311.
- Madureira, H., Pérez-Almaguer, R. y Garcés-Cecilio, W. (2018). La profesionalización pedagógica del profesorado de matemática: comprensión y concreción desde la superación. *Revista Maestro y Sociedad*, 15(1), 103-113.
- Santos, J. (2005). *Modelo pedagógico para el mejoramiento del desempeño pedagógico profesional de los profesores de agronomía de los institutos politécnicos agropecuarios*. (Tesis en opción al grado científico de Doctor en Ciencias Pedagógicas. La Habana: Instituto Central de Ciencias Pedagógicas).