

Socioepistemology and mathematical culture in the training and performance of high school math teachers

La socioepistemología y la cultura matemática en la formación y desempeño de los profesores de matemáticas en nivel superior

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Abstract

Identified antecedents and contributions made by several researchers are described to understand two undervalued foundations in relation to the training and academic performance of mathematics teachers at the higher level of studies. It starts from the concepts of the socio-epistemological approach and that of mathematical culture. Through the valued contributions, it is broken down little by little how the experiences of people who later become teachers, in this case at the professional level, form that mathematical culture and how social practices intervene in the entire training process. It is analyzed how knowledge in didactics moves between the scientific, technological and technical aspects through a characteristic factor: time, which also marks the changes in society. The ways of knowing social realities and how they are communicated by those who live them are described, a situation in which the narrative method that facilitates this process stands out. Finally, the information obtained is considered to support a project that considers knowing the mathematical culture of active teachers within an institution.

Resumen

Se describen antecedentes identificados y contribuciones realizadas por varios investigadores para comprender dos cimientos poco valorados con relación a la formación y desempeño académico de los profesores de matemáticas en el nivel superior de estudios. Se parte de los conceptos de la aproximación socioepistemológica y el de la cultura matemática. Por medio de las aportaciones valoradas se desglosa poco a poco como las vivencias y experiencias de las personas que luego son docentes, en este caso en el nivel profesional, forman esa cultura matemática y como las prácticas sociales intervienen en todo el proceso formativo. Se analiza como el conocimiento en las didácticas se mueve entre lo científico, tecnológico y técnico mediante un factor característico: el tiempo, que además marca los cambios en la sociedad. Se describen las maneras de conocer las realidades sociales y como son comunicadas por quienes las viven, situación en donde se destaca el método de la narrativa que facilita ese proceso. Por último, la información obtenida se considera para fundamentar un proyecto que considere conocer la cultura matemática de profesores activos dentro de una institución.

Socioepistemology, Mathematical culture, Practices

Socioepistemología, Cultura matemática, Prácticas

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Introduction

From the perspective of socio-epistemology, understood as a method of a systemic nature that deals with the phenomena of production and dissemination of knowledge from a multiple perspective, placing knowledge in three research components: social, historical and cultural (Cantoral, Montiel & Reyes-Gasperini, 2015, p. 8-9), with an approach that assumes the legitimacy of all types of knowledge.

Some few contributions found in the field of educational research that consider these research components (social, historical and cultural) that go hand in hand, since social practices, human history and the cultural aspect in which mathematical culture is generated, are not commonly analysed in a structural way, appear as a guide for the achievement of the intended objective, which is: "to understand the influence of socio-epistemology and mathematical culture in the training and performance of mathematics teachers at a higher level".

General aim

To understand the influence of socio-epistemology and mathematical culture on the training and performance of mathematics teachers at higher education level.

Type of research

Qualitative, longitudinal trend, analysing changes over time (Hernández, Fernández & Baptista, 2014, p. 160).

Research question

Are there significant contributions that allow us to understand the meaning of socio-epistemology within the functions of a teacher? How does mathematical culture present itself within the educational environment?

Content

Villa (2006), states that education is defined as the transmission of culture or enculturation. However, in this meaning it goes unnoticed that within the different disciplines this notion contains a history and a transcendence, in such a way that this concept of culture adapted over time has developed effects in pedagogical theories and practices.

It is common to use phrases such as: "she has a different culture", at which point the question arises: "whose culture? this situation is a clear example of the relevance not only of the word "culture" but also of its meaning. Again, it is Villa who, based on his analysis, provides comments where he points to culture as "the social inheritance", which would mean that the culture of a given group would be the product of that inheritance (2006).

The author comments on how at other times the same concept appears within the lifestyles of peoples and institutions, so that it is seen as an observer that retains the situations and problems of an identity. Thus the school is the transmitter of a "culture", of a heritage, and at the same time its protector.

As for the contribution of Mingüer (2006), the concept of mathematical culture is understood anthropologically as a "specialisation of culture, comprising a total of specifications of mathematical knowledge that a person can possess and master".

In her work, the researcher emphasises that it is necessary to know these concepts and characteristics that each person develops in their daily and academic experience, as well as the environment and time in which they live, in order to understand how this has influenced the perception they now have of mathematics. And more specifically, if the person is an education professional, how is their knowledge transmitted to their students now?

The socio-epistemological approach in educational mathematics research is an instrument that allows us to analyse mathematical culture in a global way, where not only the quantity and quality of knowledge that a teacher can count on in his or her activity is transcendental, but also the strengths achieved and weaknesses not overcome that the teacher is acquiring and that, whether he or she wants to or not, have repercussions on his or her academic functions. In other words, this means approaching the phenomenon from a more human approach.

In her interventions, the author proposes that we should not lose sight of the socio-epistemological approach. It should be kept in mind that it is a research paradigm of theoretical approach that can be used in socio-cultural scenarios where mathematical knowledge is developed.

It firmly adds that the "mathematical culture" of an individual is "(The) succession of constructions of mathematical knowledge that comes from social practices linked to mathematics, its teaching and learning" (Mingüer, 2009, p. 1346) that the person carries out throughout his or her life.

A more detailed explanation appears, in which Mingüer (2006) develops and analyses that people become involved in mathematical activities from an early age, even without knowing it, while their mental functions develop and their reasoning abilities grow, and at the same time, everyday life with the family and society have an influence on the way in which knowledge is learnt. Thus, in the early ages a person is introduced into a social environment, which is called "natural mathematics", and in later ages another environment appears, called "formal mathematics".

It is emphasised that "natural mathematics" will appear in the course of a human being's life, and it is therefore necessary to analyse how the family in the first instance, the extract from society of the person's closest relationship, the particular environment, even geographical, the period in which he/she develops and the relationship that all these aspects have for mathematical activities and relationships, form a personal identity which, for our work, forms a teacher who will later contribute to the socio-cultural formation of other individuals.

Thus, his exploratory study is carried out on a sample of mathematics teachers at the higher level of studies, using qualitative information gathering strategies, and then making use of the data reduction method, which allowed him to group the information in a more comprehensible way in order to carry out an analysis of the teachers' accounts and to obtain results of the factors that have affected the training of mathematics teachers in a school and how this influence continues today in their teaching functions.

Cantoral (2001), states that the "socio-epistemological approach" in educational mathematics research is used in a concise way in the matter that exposes the social construction of social, cultural and historically situated mathematical knowledge, depending on how the situations of construction and dissemination are presented.

The socio-spistemological approach belongs to a paradigm of research corresponding to educational mathematics, where epistemological concepts and data that do not appear in a documentary manner can be sought and rescued by using this tool, which at the same time forms a methodology that can be used at all levels in very different events that deserve to be an object of study within educational mathematics.

The analysis of social practices within the phenomenon of mathematical culture that accompanies teachers and students according to Mingüer can help to obtain:

- 1) The nature and origin of these influences, i.e. where they come from and how they originate.
- 2) The action of socio-cultural influences, how they act and manifest themselves.
- 3) What are the effects of their action on the formation of the mathematical culture of a social group.
- 4) The identification of beliefs, practices of use and opinions and attitudes (human activity and social practice) that prevail in society, family, social environment and school environment, which strongly influence the conception that individuals have of mathematics, its teaching and learning (2006).

Cantoral (2013) analysed the procedures for the construction of mathematical knowledge and the construction of concepts, in an extensive text by evidencing the intervention of the didactic transposition that appears in the historical and contemporary analysis. Some of his developments within his research are:

The epistemological study of calculus, the relationships he discovers between epistemological data and the situations that were lived at the time when the data originated, even raising questions such as Why did the scholars of the subject make certain decisions at that time? Or why did they solve the problem in that way?

A concept is generated in the area of physics, of phenomena in movement and in space, which is called *Praediciere*, which consists of the practice understood by an epistemic subject about events that behave with a periodicity, which can be predicted according to the presence of other elements, such as culture and society, and the explanation of these events.

It is Cantoral who also adds to the theory called socio-epistemological approach how images describe a subject, exposed by different authors at different times and moments (2013) and the analysis by questioning How did it occur to them to illustrate this? or why did they analyse it in this way? in other words, investigating the ways in which knowledge was generated, and the conclusions reached by the researcher, increase the contributions of the social and cultural within the research in educational mathematics.

... we will assume social practice as normative of human activity, rather than as reflexive human activity or reflection on a practice. Social practice is not what the individual or group does per se, but what makes them do what they do, even without acquiring awareness of their actions (Cantoral, 2013, p. 152).

Additionally, Cantoral (2001) formulates and numbers a process of six phases and follows them one by one in everyday teaching practice, in the activity of teacher training and updating, which supports the theory of educational mathematics. These phases occur in socio-cultural contexts inside and outside a classroom or an institution, and at different educational moments:

- 1) Historical genesis: it considers studying the constructed concepts not only as epistemological knowledge, but going deep into knowing the socio-cultural and scientific situations that marked the development of that knowledge in history.
 - 2) Intrinsic phenomenology: it raises the possibility of designing a didactic phenomenology of mathematical concepts, where the intention is to take up the elements that established the different meanings that a subject had in different periods. Practising intrinsic phenomenology entails searching in the dark, i.e. culture numbs reason, therefore, the intuition factor is sometimes necessary in this phase.
 - 3) Characteristic constructs: Mathematical concepts are not usually simple; the ease of constructing them lies in the cognitive structure acquired by the subject, learning styles, inductive processes and ways of thinking are some of the resources that facilitate this construction.
- This construction in formation little by little, with the resources obtained, strengthens the human cognitive structure and also allows the mathematical culture to be moulded. The author also shares with us that this culture is singular, it is different for each subject, according to the previous constructs, in itself, it depends on the internal and external factors that have been presented, that give experience and that make up the socio-cultural environment.
- 4) Didactics of yesteryear: The purpose of this phase is to analyse the ideas that were held in the past about the way or methods of teaching a mathematical subject, and their relationship with other sciences or fields of work. However, these ways have changed over time, have not changed or have been lost. It is necessary to keep in mind that knowledge is a cultural product.
 - 5) Reconstruction of the associated meanings: in order to be able to carry out this phase it is necessary to have all the previous ones, the researcher proposes the result that could be obtained by knowing each of the stages, which in conventional mathematics education do not exist, the past and its fruits are not considered in the new mathematical constructions.

- 6) Educational practice: the analysis of the degree of relationship that currently exists and that which should exist between mathematical educational research and teaching practice in order to improve the main objective, which we know is that students learn mathematics.

Mingüer (2006) among the instruments she applied were in-depth interviews with teachers specialised in the mathematics teaching process. The author conceives the "academic trajectory" of the teacher as "a set of training and experience". It is the constant experience and training, sometimes unnoticed in the institutional context, which forms the figure of the teacher with all that this implies. Among other results, the researcher reveals the impact of the didactic approach of the teacher on the teaching and learning process of his or her students.

From the point of view of another researcher, "knowledge in didactics moves between the scientific, technological and technical, since it creates scientific knowledge about its object of study, to control the teaching-learning processes, and designs strategies to carry out better didactic transpositions in the classroom" (Rodríguez, 2020, p. 190); the author emphasises that it is necessary for this work to have standards that guide the teaching processes.

The knowledge acquired leads the researcher to take a step towards transforming the existing reality (Rodríguez, 2020). She adds that with didactic interventions the researcher purposely seeks to improve teaching practices and the ways in which students learn.

The same researcher points out that the surrounding truths that at some point are captured or recorded and account for social facts, in this case in the educational process, are related to time, method and the object of study. He adds in his contributions that "language is not only a condition of possibility for knowledge, but also for the construction of social reality" and accepts the possibility of a subjective margin to reality due to the qualitative characteristic of social phenomena, but justifies the procedures that make the information more objective.

Landín & Sánchez comment that the language that expresses social reality must have certain qualities (2019), and it is here where the narrative biographical method is useful in qualitative research, including in the educational area. "...we work with the subjects through the narrative that travels through memory to bring to light those experiences, those images, those memories, feelings, ideals, learning and meanings contextualised in a certain time and space (p. 229).

The authors promote a term that they have called historicity of the person, where the relationship that they establish with their world and other people is revealed, and how they develop it, in each of the feasible spaces of deployment, their way of obtaining experiences that produce learning, feelings and different anecdotes.

A contribution of the work of the researchers is in relation to the phenomenological plane of memory (Landín & Sánchez, 2019, p. 233) "by understanding the exercise of memory as a memorising and recalling of interwoven factors" between passages, memories, images, comments of others when narrating a circumstance, where two factors: time and forgetting, influence what they call the game of consciousness, which is indicated as the subjectivity or degree of error that may exist in a story by the person who tells it.

Added to this game is the perspective or particularity of that same person who narrates the situation from the angle from which he or she experienced it, where the researcher is aware that other participants will have another experience of the same event, which could be very similar between two or more interviewees, or very different in discourse between them.

Another contribution of Landín & Sánchez's (2019) approach is the analysis of the biographical-narrative method applied in social research, to then propose several strategies that when applied are considered successful for gathering relevant information through narrative in qualitative research, such as: in-depth interviews, family stories, focus groups, and if possible, using photographs, autobiographical writings, letters, field notes and other resources when having conversations with the people involved in the research.

In particular, the focus group interview as a strategy is a suitable and practical research alternative for obtaining the information required. It should be taken into account that in the educational process, most of the data that we want to find out from the interviewees have generally been forgotten or the teachers never related that several of their experiences are linked to the formation of their mathematical culture, so resorting to the enquiry through the focus group interview facilitates the exposure of a part of the life history of the teachers.

In this interview model, the interviewer has authority over the subject matter and focuses the discussion on the point of interest. In a focus group, communication channels are developed by the members who, during a session and with the help of an interview guide, make it possible to raise and discuss a social phenomenon in which they are involved (Rodas & Pacheco, 2020).

For Landín & Sánchez (2019), educational research is necessary to understand the events that have happened from within a school and how the people involved have experienced them, to the scope and repercussions they have had on the external environment, be it community, region or country:

Narrative in the field of education becomes an excellent strategy by which teachers can document their practice in order to share with other colleagues those strategies that have been more or less successful for them, with the purpose of learning from others and learning from themselves (p. 235).

Among the particularities of the application of narrative methods is that a person is shaped by the situation and in turn shapes the situation, which makes a story real and in a story the experience is generated (Clandinin & Connely, 1989). In such a way that, with this method and its qualities, the previous experiences that influence the sense of belonging that teachers have, the phases of the life cycle of those who dedicate themselves to teaching and the histories of the institutions in which they work that enhance that teaching identity, what is sought is to highlight aspects such as feelings, perceptions, criteria and desires, which are not usually considered by other research methods (Huchim & Reyes, 2013).

Conclusions

A number of authors have analysed teacher training and the influence this has on their teaching practice. In these studies, they have not only considered their teaching preparation, but also their experiences from early stages, as students at basic levels, family, economic situation, geographical area, among other living conditions.

They have also taken into account their experiences during their years of teaching, the school in which they work, the facilities for professional updating and contact with certain technologies and the availability of the use of the latter.

The contributions that could be collected and analysed made it possible to understand that several of the researchers propose and explain certain steps that favour the understanding of socio-epistemology and mathematical culture. Teachers develop specific situations within their functions, hence the development of the two foundations addressed that study these characteristics.

By exposing the above aspects and their breakdown, the objective of the study is achieved: to understand the influence of socio-epistemology and mathematical culture in the training and performance of mathematics teachers at higher education level. In this way, the present document will be a reference to continue with a project with currently active university professors, in order to know the social realities and the mathematical culture that they have formed over time within a specific educational institution and how these aspects have an impact on their daily educational work.

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