

Phenomenological Approach and Bakhtinian Dialogism: Epistemological Tensions and Methodological Responses

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Abstract: In this article, I develop a methodological reflection based on research concerning the role of the history of mathematics in the context of pre-service teacher training. The purpose of the study was to describe the experience of six prospective secondary school mathematics teachers engaged in the reading of historical texts in a history of mathematics course. In the process of research, epistemological tensions emerged between, on the one hand, the need to account for a portion of the participants' intimate personal experience by deploying a phenomenological approach, and on the other hand, the convocation of a historical-cultural perspective of mathematics education focusing on social interaction and artifacts. The answers formulated in response to these epistemological tensions were methodological. I analyze in what way these tensions played a reflexive and emulator role developing both the research methodology and an innovative description adapted to the context of the study, i.e., a polyphonic narration.

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1. Introduction

The objective of this article is to reflect on, and discuss how, epistemological tensions, that were inherent to some theoretical and methodological aspects of a study conducted in mathematics education, were approached through the production of a polyphonic narration. More precisely, I examine how the latter satisfied both the requirements of the phenomenological approach and the teaching/learning perspective that underlies my position in mathematics education. I will begin by presenting a brief summary of the study, including its context, purpose, and research problem, as well as its conceptual and epistemological basis. I then attempt to describe more fully the methodological approach used. The special attention paid to methodology segues into a reflection on the polyphonic narration that was developed to describe the phenomenon being examined. [1]

2. Study Context and Summary

2.1 History and epistemological disorientation

Beginning mostly in the 1980s, a number of researchers were focused on the role and potential of the history of mathematics in teaching and learning (FAUVEL & VAN MAANEN, 2000). A range of avenues for action in the mathematics classroom were explored. In the last decade, however, the research community has lost momentum with regard to the production of teaching practice support. The interest of researchers has shifted to establishing the didactic and pedagogical grounds for better grasping the role and potential of history in mathematics education (KJELDSEN, 2012; SIU, 2006). [2]

Within this trend, BARBIN (1997, 2006, 2012) developed an important concept in the context of teacher education: *dépaysement épistémologique* [epistemological disorientation]. According to her, the history of mathematics has the ability to surprise. She reminded us that "history of mathematics has the virtue to astonish. It makes the common uncommon and disorients [...] The learner gets engaged in a process where he is forced to reclaim mathematical meaning" (BARBIN, 1997, p.21). Through the history of mathematics, and by encountering different ways of doing mathematics in other times and other cultures, teachers are encouraged to question their conceptions and experiences in relation to mathematics. [3]

A number of researchers have contributed to the discussion surrounding this key concept of *epistemological disorientation* (e.g., FURINGHETTI, 2007; JAHNKE et al., 2000; LAWRENCE, 2008) but few have engaged it in empirical research (JANKVIST, 2009; SIU, 2006). Empirical studies are usually presented in the

form of practice accounts that hardly improve our understanding of 1. the experience of this epistemological disorientation, 2. how this lived experience meshes with the presence of history in the classroom, and 3. the influence it might have on students' future teaching practice (GUILLEMETTE, 2011; JANKVIST, 2009). A review of a number of field studies has shown that qualitative research is underdeveloped and that the research community draws little from a comprehensive/interpretive paradigm (GUILLEMETTE, 2011). [4]

In addition, the need to connect empirical research with theoretical development is of paramount importance in this field. In this regard, GULIKERS and BLOM (2001) demonstrated the existence of a serious "gap" between theoretical and empirical research on the topic. They noted, on the one hand, key theoretical studies providing innovative conceptualizations, and on the other hand, empirical studies that attempt to challenge certain tools and ways to introduce the history of mathematics in the classroom without taking into account theoretical advancements. The two forms of research develop alongside each other while failing to provide mutual stimulation and orientations. My study aimed to avoid this gap and bridge these two lines of research in its deployment. [5]

2.2 Investigating the concept of epistemological disorientation

As mentioned above, BARBIN (2006) explained that, with the introduction of mathematics history in the classroom, the unusual takes the place of the habitual and disrupts students' common perspectives about mathematics. She stressed that the history of mathematics—perhaps its main draw—has the virtue of allowing us to find astonishing what otherwise goes without saying (BARBIN, 1997, p.21). Much like travelers in a foreign land, after a period of confusion and bewilderment, meaning is reconstructed. [6]

Developed in the specific context of teacher training (e.g., FURINGHETTI, 2007; LAWRENCE, 2008) and incorporated into reading activities involving historical texts (e.g., BARBIN, 1997, 2006, 2012; FRIED, 2007, 2008; JAHNKE et al., 2000), the concept of epistemological disorientation suggests that the history of mathematics astonishes because of the diverse ways in which mathematics developed throughout social cultures and history, prompting broad reflection on the form, nature, and use of mathematical objects. In other words, without undermining the development of an understanding of mathematics that history can provide in teacher training, epistemological disorientation mainly brings to light the historical and cultural dimension of the discipline and helps to develop students' critical thinking in relation to this social and cultural aspect of mathematics (BARBIN, 2012). In BARBIN's opinion, it is with regard to these issues that the history of mathematics is especially beneficial, to the extent that it involves a genuine *choc culturel* [culture shock] and becomes a source of *étonnement épistémologique* [epistemological wonder] (2006, p.26) by way of questioning knowledge and procedures that are considered to be evident. For BARBIN, the reading of historical texts is a good way to achieve these objectives, by questioning obvious knowledge, procedures, and motivations for studying and doing mathematics (ibid). [7]

This view of history's potential in teacher training is shared by quite a large number of authors (see GUILLEMETTE, 2011). One of them, RADFORD, proposed the use of his *théorie de l'objectivation* [Theory of Objectification] (2011) to rethink mathematics teaching and learning through the concept of *alterity*. He drew, among others, on the ideas of the philosopher BAKHTIN, according to whom "meaning only reveals its depths once it has encountered and come into contact with another foreign meaning: they engage in a kind of dialogue, which surmounts the closedness and one sidedness of these particular meanings" (1986 [1979], p.7). [8]

RADFORD et al. underscored that the history of mathematics is "a place where it is possible to reconstruct and reinterpret the past in order to open new possibilities for learners and for future teachers" (2000, p.165). His didactic and pedagogical view is marked by a strong cultural, social, and historical dimension in the exploration of mathematics learning and teaching. In the following section, I summarize a number of key concepts of the theory of objectification and highlight the degree to which it underpins my reflection on the concept of epistemological disorientation. [9]

2.3 Theory of objectification

The theory of objectification, developed by RADFORD and colleagues, is a contemporary historical-cultural theory of mathematics teaching and learning that advocates a non-mentalist conception of the mind. Challenging the rationalist and idealist currents, it puts forward a conception of the mind that is both sensitive and historical. On the one hand, it is sensitive because it is grounded in the body, the senses, and feelings: the body, perception, and gestures and signs are considered an integral part of the mind. On the other hand, it is historical because it is equally rooted in history and culture and hence understood as a historically constructed social form of reflection and action. Mathematical thinking is therefore referred to as a *praxis cogitans* (RADFORD, 2011, p.67). As regards mathematical objects, the ontological position departs from the idealist discourse. Indeed, mathematical objects are not considered as independent from time and culture and transcending human activity. Based on this theory, they are "historically generated during the mathematical activity of individuals" and constitute "fixed patterns of reflective activities anchored in the changing world of social practice" (p.7)¹. [10]

In this context, learning is not a personal process of construction and reconstruction of knowledge. Learning results from our engagement in the world of cultural artifacts that surround us (objects, instruments, literary and scientific production, etc.) and social interactions. More specifically, learning mathematics, understood as objectification, is a social process of gradual coming-to-awareness of the Homeric *eidos*, in other words, of things that can be seen, a figure, a form, whose generality we continually perceive while attributing meaning to it in our social engagements. Objectification literally means an encounter with something,

1 All translations from French are mine.

something that objects itself, presents itself as Other, revealing itself little by little. RADFORD defined it as

"[the] perception that unfolds in the intention, itself expressed in the sign or action mediated by the artifact in the course of a practical sensory activity, something that can change form and become reproducible action, whose meaning belongs to this cultural eidetic pattern that is the conceptual object itself" (2011, p.68). [11]

This conception of learning as cultural objectification implies that learning mathematics is not limited to "doing math" (much less to solving so-called mathematical problems); rather, it is "being-in-mathematics-with-others," i.e., mathematical activity being nothing more than a way of "being-with-others" (RADFORD, 2008, p.229). This brings us to the ethical aspects of mathematics education in the theory of objectification, aspects that are discussed by RADFORD in relation to BAKHTIN's philosophy. In this regard, BAKHTIN stressed "that a properly ethical relationship to the Other and the acceptance of a genuine personal responsibility entail the display of a loving consciousness and the absence of a reifying or self-interested posture" (1997 [1975], p.40). In fact, learners' sociability is seen through their role which is to "learn-to-be-with-others" (RADFORD, 2008, p.229), a form of being whose essence is engagement as a participative act in the deep sense, an engagement that is consubstantial to learning. [12]

Furthermore, discussions around ethics and research itself in mathematics education have been developed in relation to BAKHTIN's perspective. For example, ROTH (2003, 2013) has stressed means for considering and going about making research in mathematics education in an ethically grounded way. For ROTH, coming to understand through research in mathematics education "has to be the result of contributing to the collective responsibility for teaching and learning" (MAHEUX & ROTH, 2012, §6). Discussing the idea of ethics in the making, and drawing on BAKHTIN's philosophy, ROTH contributed to the development of ways to assume a responsive attitude towards the Other in the course of research (ROTH, 2005; MAHEUX & ROTH, 2012). [13]

Within this perspective, the concept of epistemological disorientation takes on new meanings. For RADFORD, and more generally for cultural-historical thinkers, the history of mathematics offers opportunities for engagement with other ways of being-in-mathematics to the extent that they are historically and culturally removed. Insofar as epistemological disorientation articulates the question of learning around the concept of alterity developed by BAKHTIN (1986 [1979], 1997 [1975], 2003 [1986]), it can be understood as an experience of alterity in mathematics. The focus here is not on individuals facing possibilities for personal emancipation, but on learners having the possibility to engage, with others, in new ways of being-in-mathematics and to explore what is possible in mathematics through history. [14]

2.4 Research objective

Embedded in the epistemological reflections described above, the objective of the study was to describe the epistemological disorientation experienced by a group of future secondary mathematics teachers in the context of historical text reading activities, both in terms of engagements with other ways of "being-in-mathematics" and their experience of alterity in mathematics education. [15]

3. Approaches and Methodology Elements

In this section, I explain the methodological choices that were made. These choices involved epistemological tensions that will be highlighted before explaining in detail the methodological approach developed in order to describe the participants' experience and how they addressed these epistemological tensions. [16]

3.1 Epistemological tensions and methodological approaches

First, the need to clearly describe the meaning of the learners' experience and the emphasis placed on individuals' lived experience to describe the phenomenon motivated the use of a phenomenological approach (GIORGI, 1975, 1997; VAN MANEN, 1990, 1994). Second, the historical-cultural perspective in mathematics education and the problematization of teaching and learning from the perspective of Bakhtinian ethics prompted me to question the form, content, and production modalities of the phenomenological description of epistemological disorientation. Indeed, the conceptual and theoretical elements explained above underpin a particular view of the subject, of knowledge, and of learning. Drawing on BAKHTIN (1986 [1979], 2003 [1986]), this perspective brings to light the viewpoint of a subject that is in the process of becoming, one that is multilayered and divided, that is to say, an ethical subject constituted and revealed in its relation to the Other. Learning mathematics, as an inherently social process, implies in this perspective the development of an ethical subject and the development of knowledge that is "knowledge-with-others." [17]

Indeed, the epistemological assumptions underpinning the historical-cultural perspective in mathematics education may appear, at first, to be at odds with a phenomenological approach. The latter is centered on the participants' intimate experience and prioritizes subjectivity insofar as it is transcendental and a place of enclosure and recuperation in an immanence of the Self. On the other hand, with the historical-cultural approach, which posits that conscience is precisely (con)science, i.e., knowing-with-others, there is a radicalization of the transcendental pole of intentionality. In other words, it prioritizes the "world" over "subjectivity" by emphasizing the mediation of actions through cultural artifacts and social interactions. CRESSWELL and HAWN (2012) sought to develop an approach to the interpretation of human action that highlights phenomenologically immediate experience by evoking BAKHTIN's (1986 [1979], 2017 [1979]) discussion of the interpretation of art and avoiding, to some extent, the pitfalls associated with similar epistemological tensions. [18]

These tensions are echoed in the work of BAKHTIN itself. Indeed, BERNARD-DONALS accounted for the incongruities between "individual" and "social" analyses in the work of BAKHTIN and emphasized, in this sense, the following:

"The materialist or 'Marxist' component of his work, in which he discusses the ways in which various languages come into contact and reveal difficulties and contradictions in verbal material as well as other ideological material, seems to be at odds with the phenomenological component, in which he discusses the individual subject relations that construct utterances" (BERNARD-DONALS, 1995, p.16). [19]

That said, the work of BERNARD-DONALS related to the philosophical discussion between elements of Marxism and phenomenology in the work of BAKHTIN. Aware of the ambiguity of the Bakhtinian corpus, my discussion here will focus more on how to account, on a methodological level, for a phenomenological approach in human sciences and a historical-cultural perspective in mathematics education that draw on BAKHTIN's philosophy. [20]

In simple terms, whereas the phenomenological approach in human sciences focuses on participants' innermost experience, the historical-cultural approach to mathematics education focuses on joint acts of meaning that are rooted in culture and the world of artifacts. The purpose here is not to reconcile, on a theoretical level, the phenomenological approach and the historical-cultural approach in mathematics education. Rather, it is to articulate them in such a way that I could meet each of their methodological requirements within the research process. [21]

To this end, one manner to articulate these approaches was through a concrete methodological procedure such as adding a data collection step (group interview) and, in particular, working and reflecting specifically on the construction and form of the description of the phenomenon. This description was approached from BAKHTIN's dialogical perspective and the notion of polyphonic narration (1977 [1929], 1986 [1979], 1998 [1963]). Describing the phenomenological approach in human sciences and BAKHTIN's dialogical perspective and notion of polyphonic narration, along with their respective epistemological underpinnings, will help to better understand these methodological choices and how they enabled me to address the epistemological tensions described above. [22]

3.2 Phenomenological approach in the human sciences

In the late 1970s, the phenomenological tradition in philosophy, founded in the early 20th century by HUSSERL, led to the development of what is referred to as phenomenological approaches in the human sciences, notably, in psychology, mainly with the work of GIORGI (1975, 1997), and in education, with the work of VAN MANEN (1990, 1994). The former belongs to the eidetic tradition and the latter to hermeneutic. In Giorgian terms, investigating phenomena requires no more than the first movement of phenomenological reduction, i.e., *epoché*. The idea is to systematically return to subjectivity to describe its movement and the intentional modalities that tie it to the world. By dint of its scientific label, GIORGI's (1975, 1977) four-step method, adopted by DESCHAMPS (1993) and

LAMARRE (2004), for example, is a common point of entry to phenomenology in the human sciences in general (MEYOR, 2007). [23]

The approach that was put forward by VAN MANEN (1990, 1994) seems less systematic and prescriptive. Inspired from the hermeneutic tradition, with references to HEIDEGGER and MERLEAU-PONTY in particular, VAN MANEN (1990, 1994) laid out broad guidelines and topics that he considered essential to phenomenology-driven research. His reflection is general, and it contains no methodological prescription or claim of scientific nature. His areas of interest are the orientation toward a phenomenon by exploring the lived experience, the investigation of existence, phenomenological reflection, and phenomenological writing (VAN MANEN, 1994). [24]

Whether belonging to the eidetic or hermeneutic tradition, these different thinkers agree that the phenomenological researcher's question is essentially to explore how humans exist in and by their relationship with the world, in other words, to elucidate what this experience was like for the person who lived it and to grasp its incidence on the person's way of being in the world during and after the experience (LAMARRE, 2004, p.24). In this sense, I understand the phenomenological approach as a style of analysis focused on the description of the experience lived by participants. This experience is revealed in their concrete existence rather than classically through the lens of an explicative scientific position operating within an aprioristic perspective. In addition, the approach is rooted in research postures that are specific to the phenomenological tradition, while building on its results. [25]

As reported by a large number of researchers in the phenomenological tradition (see, e.g., MEYOR, 2007), the use of any kind of grid or procedural analysis would be a contradiction within such an approach. This type of research looks for maximum closeness to the object of study while paying attention to all dimensions of the research problem and the context of the study. It requires methodological creativity and genuine intellectual tools in order to do so. [26]

3.3 Bakhtinian dialogical perspective: Dialogism and polyphony

From his analyses of FREUD, DE SAUSSURE, and linguistics theories, BAKHTIN developed a critical mode of analysis based on the *dialogical principle*, which he applied to literary analysis and more generally to the analysis of ideology (TODOROV, 1981). Briefly, the dialogical principle stresses the idea that each utterance of a discourse is necessarily a response to other utterances in a given sphere of speech communication. Discourse is therefore understood as a dialogue, but one which is not a stream of utterances constituting a form of conversation or exchange. These aspects are simply a superficial manifestation of dialogism, which, as claimed by BAKHTIN, "exceeds by far the relationship between replies of a formally structured dialogue and, to the degree that it is universal and runs through all of human discourse in general, anything that has meaning and value" (1998 [1963], p.81). In a general sense, discourses are dialogues as much on the level of language as on the levels of ideas, ways-to-

engage-in-the world, forms of consummation, and ideology, and these levels are intrinsically tied. [27]

In other terms, for BAKHTIN, individual voices and understandings cannot make themselves heard without integrating themselves into the complex chorus of the already existing discourses. This simple but profound, dialogical perspective led BAKHTIN to develop a totally new way of interpreting human subjectivity and, therefore, the entire field of human sciences (TODOROV, 1981). As BRANDIST emphasized around Bakhtinian dialogism: "Intersection of horizons is precisely what characterises the dialogic relations between discourses: double-voiced or 'hybridised' discourses are its manifestation and as such, an index of the type of intersubjective interaction" (2002, p.101). Indeed, for BAKHTIN, (1986 [1979], 2003 [1986]) there is an architectonic of the Self, a kind of constant upsurge of the Other in our acts of consciousness. But what happens in concrete terms? How does this intersection of horizons occur? [28]

For BAKHTIN, when the listener understands the meaning of a discourse:

"He [or she] simultaneously takes on an active/responsive attitude toward it. He or she either agrees or disagrees (entirely or in part), augments it, applies it, prepares for its execution, and so on. And the listener adopts this responsive attitude for the entire duration of the process of listening and understanding" (1986 [1979], p.68). [29]

Standing across, the speaker also expects such an active/responsive relationship, BAKHTIN adds:

"Instead of a passive understanding that only duplicates his [or her] own idea in someone else's mind, the speaker too talks with an active expectation of a response, an agreement, sympathy, objection, execution, and so on. Each utterance is thus filled with a range of sensitive reactions to other utterances in a given sphere of communication" (p.91). [30]

Seen through the lens of this dialogical principle, a scientific, literary, or philosophical work is said to be *polyphonic* when it presents a substantial plurality of discourses and understandings of the world, but, above all, when the author presents these voices in their dialogical interactions. For BAKHTIN (1998 [1963]), DOSTOEVSKY's novel "The Brothers Karamazov" (1992 [1880]) is the archetype of the polyphonic novel. The author depicts numerous characters having singular personalities embodying finely established roles (the aristocrat, the liberal, the intellectual, and so on). These characters act as spokespersons for various forms of consummation and ideology, and DOSTOEVSKY makes them engage in a dialogue. For BAKHTIN, what highlights the polyphonic aspect of the work is as follows:

"Dostoevsky never leaves anything essential outside the consciousness of his main characters [...] he leads them into dialogical contact with the important elements that enter into the constitution of the world of the novel. Each other's 'truth' is necessarily

introduced into the dialogical field of vision of all the other protagonists" (1998 [1963], p.121). [31]

The confrontation between these protagonists, gifted with a strong ipseity and, in the course of the narration, emancipating themselves from the author as they embed themselves in the dialogical web of the narration, highlights the existential, ideological, and sociohistorical multi-layeredness of the time. According to BAKHTIN (1998 [1963]), the polyphonic aspect of this work of fiction captures the author's reality, in this case, Russia in the wake of the 1860s reforms. Within this dialogical perspective, the work of the author/researcher is to reveal the "broad ideas" and "representations of men who speak of their ideological universe" (BAKHTIN, 1997 [1975], p.182). By giving a polyphonic dimension to his work, the author makes "reality lose its statism, its naturalism [...] the future begins to penetrate it as trends, possibilities, anticipations" (BAKHTIN, 1982 [1965], p.129). Such a work "contains essential views on freedom, overcomes determinism and narrow mechanism" (*ibid.*). As BRANDIST pointed out: "As the dialogic form *par excellence*, the novel is now engaged in the systematic debunking of the pretensions of 'authoritative discourse'" (2002, p.127). [32]

On a more general level, for BAKHTIN (1986 [1979], 2003 [1986]), the duality between the world of objects and the Self that is thinking, perceived as an isolated atom, an ahistorical I, permeates the philosophy of his time. Conversely, BAKHTIN (2003 [1986]) argued that the constraining dualism of Cartesian rationalism is to be challenged by repudiating the abstractions of the idealist philosophy in order to better grasp the nature of action or the concrete act that constitutes the central value of human existence. The subject here is a dynamic, corporeal, and creative entity. In this sense, BAKHTIN attempted to formulate a phenomenology of the act of creation and participation (2003 [1986], 2017 [1979]), a phenomenology that is centered on the activities that we carry out as corporeal and historical beings in a world that pre-existed our abstract constructs. [33]

3.4 A polyphonic narration of the epistemological disorientation

In light of these fundamental critical elements, I decided that the proposed description of the epistemological disorientation should take the form of a polyphonic narration. The idea of writing a polyphonic narration was in line with the need to account for a multitude of experiences of epistemological disorientation. Such multiplicity is not merely a juxtaposition of the participants' experiences but is genuinely the common world that emerged in the course of reading activities; it is a shared world that could take unexpected directions, overlapping and interwoven with descriptive elements that respond to and echo one another. The intent was also to account for my own voice through those of the participants as well as those of mathematicians in history who, as I will discuss, were convoked during the readings of historical texts, and to render all these voices within their dialogical interaction. In this respect, BAKHTIN would say that any movement of consciousness is itself dialogical, penetrated by and in dialogue with the consciousness of others; thus, it cannot be addressed outside of movements of consciousness to which it responds and that it allows in the form

of responses. I felt that a polyphonic narration, as a methodological way to engage with the participants' testimonies, was able to provide a description that could meet, on the one hand, the requirements of the historical-cultural perspective on mathematics education by restoring the interactions and mediations that guarantee the knowledge-with-others which emerged, and on the other hand, the requirements of the phenomenological approach by keeping the participants' subjectivity and the description of their experience concrete and alive. [34]

In sum, from the phenomenological approach in social science, the study took an exploratory look at the research object and the openness toward the participants who are revealed within their concrete existence. Far from rejecting either GIORGI's "methodology" (1975, 1997) or VAN MANEN's (1990, 1994) reflection on phenomenological writing, the study draws inspiration from them to structure the stages of analysis. As such, the phenomenological approach used in this study is situated between GIORGI's systematic framework and VAN MANEN's literary openings. [35]

To this end, I borrowed the notions of dialogism and polyphony from BAKHTIN's (1977 [1929], 1986 [1979], 1998 [1963]) dialogical perspective. It allowed me to find the necessary means to create a description of the epistemological disorientation that is in tune with the historical-cultural purview. By virtue of the dialogical interactions, the description is hinged on the concepts of the theory of objectification that are used in my own discourse on the phenomenon and my own appreciative orientation in mathematics education. [36]

4. Operationalization and Instrumentalization

4.1 Data context and sources

The participants were selected among secondary-school-teacher candidates who attended a history of mathematics course given in the final year of a four-year undergraduate program at the Université du Québec à Montréal (UQAM) in Quebec, Canada. Given the chosen methodological approach and the depth of the analysis required, four to six participants were anticipated (DESCHAMPS, 1993). Within the group of 40 students, six participants volunteered and were all recruited, including two males (Aliocha and Mitia) and four females (Grouchenka, Katia, Martha, and Ninotchka).² The participants were all approximately twenty-five years old and were registered full time in the program. [37]

Over the term, each of the classes, which were led by an experienced professor, was divided into two 75-minute sections. The first section focused on the evolution of mathematics in the Western world with a concern for relating the development of mathematics to the history of Western societies. In the second section, students were engaged in reading historical texts. Seven activities were planned for the course and related to the writings of mathematicians associated

² Pseudonyms are used for the purpose of anonymity.

with the stages of history studied (A'HMOSE, EUCLID, ARCHIMEDES, AL-KHWARIZMI, CHUQUET, ROBERVAL, and FERMAT). The reading activity included a presentation of the author of the text, a period for individual or small group reading, and final group discussion. [38]

As explained earlier, reading of historical texts was the approach chosen to elicit the epistemological disorientation in the students (BARBIN, 1997, 2006, 2012; FRIED, 2007, 2008; JAHNKE et al., 2000). Following FRIED's recommendations (2007, 2008), reading activities continuously articulated two poles: one that we may qualify as "translational," which essentially aimed at extrapolating content and working with the mathematics in the texts, and a second more "interpretative" one that aimed at better understanding the authors by "welcoming" and "engaging" with them without removing their work from its sociohistorical and cultural context. This reflection about epistemological disorientation and modalities of reading historical text guided me as researcher/trainer but was not discussed explicitly with the pre-service teachers. [39]

4.2 Data collection

Drawing on the phenomenological investigations of DESCHAMPS (1993) and LAMARRE (2004), three data collection tools were used: video recordings of classroom activities, individual interviews conducted at the end of the term, and a group discussion held after the interviews. The data used in the study consisted of videotapes and written transcripts of one-on-one and group discussions. More specifically, two cameras recorded the work of each team of two to three participants during the reading activities. One-on-one discussions lasted approximately 75 minutes and were recorded as digital audio files. They addressed three topics: the participants' general course experience, their historical text reading experience, and their epistemological disorientation experience. [40]

The concept of epistemological disorientation was not discussed with the participants; indeed, no element of research was discussed explicitly with them. That said, the phenomenological investigation had an object and the interviews had to point to it. To respect the phenomenological stance, the participants were questioned more generally about their experience of disorientation. The following specific questions were asked: During the reading activities, did you ever feel lost, struggling, or disoriented? Can you tell me about these experiences? What particular elements during these activities can explain this? Similarly, the phenomenological discussion protocol included a few open and broad questions with emphasis on explaining the experience and what was felt or perceived. [41]

As for the group discussion, it was held with the six participants in the study two weeks after the end of the individual meetings and lasted 90 minutes. All the topics discussed in the one-on-one encounters were covered during the group discussion so that the participants could share their experiences and understanding. They were instructed not to seek consensus necessarily but rather to fine-tune the description of their own experience by listening to the

descriptions of the others. The discussion was filmed and recorded on digital audio tape. [42]

5. Data Processing and Analysis

5.1 Processing and analysis of video recordings

Video recording analysis aimed to account for how the activities affected the participants and to obtain immediate descriptive elements of epistemological disorientation. These could be dialogues, gestures, or particular expressions that emerged during the activities. To this end, the recordings of each session and each team were thoroughly viewed, and a descriptive text was produced for each team's reading activity. Screen shots were included to provide snapshots of the encounters between participants and the historical texts. For example, in the first excerpt, Katia attempts a new geometric approach.



Figure 1: Team Grouchenka, Katia, Mitia [43]

She explains her solution strategy for the layout of the geometrical figure, which differs from that presented in the first excerpt. She highlights a passage that she has difficulty understanding but continues her explanation. Mitia has lost track of her explanation and returns to reading on his own. He expresses impatience and looks around the room with increasing frequency. With resignation, *they* return to reading the text for a few minutes longer. Katia tries to continue despite failing to understand a number of passages.



Figure 2: Team Grouchenka, Katia, Mitia [44]

5.2 Processing and analysis of one-on-one discussions

Six specific descriptions were provided by analyzing the transcripts of individual interviews. The purpose was to describe each participant's experience of epistemological disorientation, based on phenomenological analysis. Drawing on DESCHAMPS (1993) and LAMARRE (2004), the following approach was applied.

1. During the initial stage, units of meaning were extracted and analyzed. They were divided into one or several small text extracts containing a certain degree of unity of meaning.
2. For each of these text extracts, a unit of meaning was drawn, i.e., a simpler and more articulate sentence that summarized the comments.
3. To the unit of meaning were then attributed one or several topic categories that enabled the final stage of processing. These categories emerged in the course of processing without prior preparation and oriented the phenomenological reduction process.
4. Extraction of the phenomenological experience was carried out, i.e., a description of the participant's experience was produced as it was received by the researcher's sensitive consciousness. [45]

In the second stage of analysis, the set of phenomenological experiences obtained was carefully read several times. A short summary was produced based on the meanings that identified each reading of phenomenological experience. This text represented the specific description of epistemological disorientation experienced by the participant. Descriptions were validated with the participants. [46]

5.3 Processing and analysis of the group discussion: Toward a polyphonic narration

For this stage of the research, I distanced myself from a mechanistic and systematic approach, seeking instead to tell and evoke (VAN MANEN, 1994). The objective was to go farther by bringing to light, through writing, the common world that emerged from these learning activities—a world that I, as the researcher, also shared—no longer describing, but writing instead. Plus, building on the prior stages of analysis was required. [47]

The objective was to produce *free indirect speech* to reflect the polyphonic aspect of the narration. Through this style, protagonist and author speak jointly, and the accents of two different voices can be heard: "[...] the hero and the author express themselves jointly [...] we then hear accents of two different voices resonate. [The discourse] works openly, double-faced, like Janus" (BAKHTIN, 1977 [1929], p.198). Moreover, "the author participates from the inside in acts and words of his heroes, he comes across as their agent and defender" (p.207). The protagonist becomes emancipated from the author, even though the latter participates in the former's words and gestures:

"We identify reported discourse not so much through the isolated meaning, but above all through the intonations and accentuations proper to the hero, through the appreciative orientation of the discourse. We seize how these accents coming from outside interfere with the author's accents and intonations" (p.214). [48]

I thus noted the emergence of a new avenue for analysis in the course of writing this polyphonic narration—a new avenue that would lead me toward an encounter with the "participants," not only with each participant but also with "them" and toward "us." A number of stages paved the way for this style of writing. Prior to this, however, a careful transcription of the group discussion had to be carried out, followed by several readings of the transcript, which enabled me to extract the passages that were particularly replete with reflections and stood out by the depth of the commentaries. Twelve extracts were chosen and processed one by one, following four stages of writing. [49]

The first stage consisted in reworking the dialogue. It was presented in a format designed to make it more legible by adding indentation and spacing. Furthermore, each time the speaker changed, it was identified while avoiding redundancies. The initial traces of narration appeared with the addition of interpolated phrases, such as "she said casually," "Aliocha replied while fidgeting in his seat," or "I thought." These interpolated phrases marked and qualified the dialogue by highlighting manner and attitude. To respect the temporal distance separating the narration and the account made during the group discussion, the narration was written in the past tense. [50]

The second stage of writing consisted in adding details about the participants' comments in the extract. These added paragraphs, called *intercessions*, enabled defending and underscoring the participants' comments by stressing their

thoughts and evaluative orientation. In this regard, BAKHTIN observed that in a polyphonic narration:

"[The author] never keeps an essential interpretive surplus for himself, but only a minimal, informative pragmatic surplus, necessary for the conduct of the narrative. The interpretive surplus would in fact transform the novel's grand dialogue into an objectified and completed dialogue, a rhetorical game" (1998 [1963], p.121). [51]

In making these intercessions, I acted as the participants' agent or spokesperson. The intercessions were drawn from, and justified by, descriptions obtained during the previous stages of analysis. When I felt the need to intercede, I consulted the phenomenological analysis descriptions to find the necessary material to clarify the excerpt. Usually, one intercession warranted another. This emulation added depth to the narration while sustaining its polyphonic aspect. This stage was considered complete when the extract was saturated and could absorb no more additions. [52]

Personal reflections were added at the third stage; the purpose was to make myself heard as the author/researcher. In general, one or several paragraphs were added to the beginning of the extract, whereby I was able to express my emerging reflection and use the moment of writing to think with the participants, to be close to them, and among them. Consequently, the present tense was used in this part of the narration. This interpolated narration allowed me to bring to light the temporal distance between the time of the personal reflection and the time of the account. [53]

The fourth and last stage of writing consisted in refining the narration. It was done with regard to the free indirect speech used. Tense agreement and narration speed were also adjusted. The twelve processed extracts were combined to make up the final polyphonic narration describing the epistemological disorientation experienced by future mathematics teachers. The following excerpt illustrates the resulting written text:

I watch what students do and I hear what they say, but it's hard for me to perceive what they "are" in mathematics. A relationship with an infinitely distant being, in other words, one who outstretches the idea thereof, like the one that arises when you are face-to-face with the Other, is such that any question "about" the meaning of this being is futile. It is natural for me to ask myself questions "about" the students and much harder to ask them questions face-to-face. I forget that this questioning, this Telling the Other, this relationship to the Other as an interlocutor offering themselves, precedes any "speech about" anything "said." In other words, it is difficult for a teacher to look at a class, to be present. Strangely, this difficulty seemed to arise for each one of us.

"What can you say about your experience and the specific experience of feeling disoriented?" I asked the group.

"You relate this experience of disorientation to a change that you have experienced in the past," said Aliocha to Grouchenka. "I, on the other hand, relate it more to a future

disorientation, that which I will impose on my students, who will have to build knowledge on things that they have never heard of, or mainly heard negative things about..."

"Algebra! Ah!" exclaimed Martha with a terrified look on her face.

"They'll experience emotions like mine," continued Aliocha. "They'll feel things that I'm only realizing now, holding this historical text in my hand. We make them experience something of a historical nature as well, because why does math, its history, have such an important place in school?"

"I see," I said.

"What image will the student picture? What meaning will they attribute? What will they do when they make a mistake? What will they do when they are stuck? I look for my terms of reference and my own tools when I experience disorientation like this. What are they? What in my personal life can I relate this to? How can I relate it to what I already know? So, when the student experiences disorientation, it is kind of the same thing. What do I already know that can help me in this? How can I connect this to something I know? It is one big math question they will have to solve..."

These readings allowed Aliocha to rediscover, in a new way, concepts he had studied in high school, and thus relive and recognize what the student is experiencing in a learning situation. He drew parallels between the helplessness and exasperation experienced by the future teachers confronted with these texts, and the experience of students exploring new mathematical objects and processes. [54]

6. Study Results and Conclusion

6.1 On epistemological disorientation: Otherness, empathy, and violence

Overall, two interrelated elements stand out in the narration: the experience of otherness and empathy. The future secondary mathematics teachers made considerable effort to understand the texts without removing them from the context in which they were produced. This interpretive work faced a number of challenges, including type of language, annotations, implicit theorems, strange style, new definitions, peculiar argument, unusual typography, and so on. The students literally endured these texts and, in the context of teacher training, the readings seemed like painful exercises in hermeneutics. [55]

In this experience of otherness related to epistemological disorientation, students can sometimes respond with violence. Violence is understood here as the "thematization of the Other," a reification of the Other. Empathy can be understood as an effort to establish a non-violent relationship with the Other. In the experience of otherness, empathy is the modality of being that attempts to keep the Other's subjectivity free and alive, to preserve its mystery and indeterminate nature. BAKHTIN would say in this sense:

"I actively identify with an individuality and therefore not for a moment do I lose myself or my place outside. It is not the object that unexpectedly takes possession of me, passive, but it is me who actively identify with it. The act of empathy is my act, and

that is where its productivity and novelty lie. [...] Empathy achieves something which is neither in the object of empathy, nor in me before the act of empathy, and the event-being is enriched by this something which is realized, he does not remain equal to himself" (2003 [1986], p.35). [56]

That said, the participants in this study hardly maintained an empathetic relationship with the authors studied. Their subjectivity was hard to preserve. In the throes of epistemological disorientation, reaction is often violent. The authors were deprived of their singularity, translated, summarized, and reified. Henceforth, from the perspective of teacher training, the need to have the students establish a relationship of empathy (i.e., non-violent) with the author seemed crucial. This is because, on one hand, such empathy allows for receptiveness to the mathematician's experience, which is the first step in epistemological reflection, and a new perspective on the discipline; on the other hand, it appears that empathy can subsequently shift to the classroom. It is indeed toward their future classrooms that the prospective teachers directed their reflections on the epistemological disorientation experience. Furthermore, they take on a new responsibility in the context of the mathematics activity that will be carried out in the classroom—welcoming their students and their reasoning in a non-violent manner—hence my suggestion that by inducing epistemological disorientation, historical text reading may support nonviolent mathematics education (GUILLEMETTE, 2017, 2018). [57]

6.2 Study contribution and limitations

A sample as small as the one used in this study is unable to provide generalizable conclusions. However, predictability, falsifiability, and reproducibility are clearly not expected in this type of exploratory study underpinned by an interpretive and comprehensive paradigm. That said, the study has allowed constructing a rich and fertile description that refines my thinking and does so on new, ethical grounds in relation to a key concept in my field of research. [58]

More concretely for the mathematics classroom, it is difficult to recognize in what ways the epistemological disorientation experience can reach the students' practice and possibly affect the secondary school mathematics classroom. The scope of this study is limited to the context of teacher training and can provide a reflection about practices and the role of history of mathematics in this context (GUILLEMETTE, 2017). It would be interesting to extend this research and recognize how the epistemological disorientation experience can play a role in teaching practices, orient the relationship of teachers to the learning of their pupils, or ultimately, influence the relationship of their pupils with mathematical knowledge. [59]

This has to do with the results of the study. In the next section, I will discuss the very objective of this article, that is, to reflect on how epistemological tensions that are inherent to some of the study's theoretical and methodological aspects were approached through the production of a polyphonic narration. For further elements regarding the results of the study, see GUILLEMETTE (2017, 2018). [60]

7. Discussion

It seems important to stress from the outset that providing conclusions on epistemological disorientation is impossible. The difficulty resides not so much in synthesizing and summarizing elements, but rather in the possibility of doing so while upholding the objective of keeping the description open and alive. In one sense, the polyphonic narration is sufficient as a conclusion since it is itself a "research result" insofar as it presents itself as an opportunity for the reader to better understand the phenomenon studied. Consequently, the narration is not accompanied by a call for preservation and does not require "things" to be "maintained." In other words, the narration does not come with prescribed thought or custom but merely an openness to new possibilities in the *parousia* of the beings that are part of it. [61]

That said, the writing technique used left room for the emergence of tensions, differences, and convergence between the participants' points of view. Views drifted apart, came closer, interpenetrated, and mutually influenced each other to form a kind of siphonophore, both singular and plural. Moreover, it must be noted that researchers in phenomenology have commonly stressed the importance of developing discursive means to account for a phenomenon (BALLEUX, 2007; DEPRAZ, 2010; PAILLÉ & MUCCHIELLI, 2010). In this regard, the study makes a contribution to the extent that it develops an adapted phenomenological research and writing protocol without falling victim to sterile mechanics and descriptive diluting (BALLEUX, 2007). [62]

It should be mentioned that the object of this study, epistemological disorientation, is a human experience and, as such, is ambiguous. Effectively grasping, and ultimately expressing absolutely with language, the participants' intimate experience is out of reach; lived experience and language cannot "coincide." However, aware of the mediating effect of language as opposed to the immediate nature of intentional relationship, it was my concern to avoid betraying participants by putting forward reifying conclusions and to keep their subjectivity intact by way of polyphonic narration, which allows readers to access their presence and voice. In other words, insofar as this research is language, including the participants' accounts, I had to establish writing techniques and hence work within language itself. This allowed rendering their movement of consciousness, to do so without uprooting them from the movements of consciousness that they responded to or allowed as a response, and with the objective of remaining as close as possible to their lived experience and the manner in which it was made explicit. [63]

Indeed, one of the core questions regarding phenomenological research in the social sciences is the place of *epoché* (or phenomenological reduction) in the research process. This study contributes to elucidating this question partly by extending the deployment of reduction and more generally the phenomenological style beyond the analysis of transcripts, in order to incorporate it at each stage of the research into writing in particular. In addition, the polyphonic narration used allowed me to comply with the phenomenological requirement to keep the

participants' subjectivity alive and maintain the historical-cultural dimension of the study object. Supported by a literary perspective in line with the initial theoretical and conceptual reflection, this study contributes novel ways of conducting qualitative research that allows sharing the voices and experience of all participants, including the researcher's, as well as their dialogical interaction. [64]

8. Conclusion

In this article, I developed a methodological reflection around a study seeking to describe the epistemological disorientation experienced by future secondary mathematics teachers in the context of historical text reading activities. The theoretical framework in mathematics education was briefly presented before engaging in a more elaborate description of the methodological elements that were deployed to describe the phenomenon investigated. In this article, I aimed to shed light on how developing a polyphonic narration from free indirect speech helped, in the context of this study, to contend with epistemological tensions between the phenomenological approach and the historical-cultural perspective of mathematics education, in which the issue of teaching-learning is formulated in ethical terms and articulated around the concept of alterity as developed by BAKHTIN (1986 [1979], 1997 [1975], 2003 [1986]), I hope that this reflection will prove to be a useful reference in terms of epistemology and methodology, BAKHTIN's dialogical perspective with regard to the phenomenological approach in human science, and historical-cultural approaches in education. I also hope that this study will bolster and inspire research, especially in phenomenological, narrative, and participative approaches. [65]

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