

## RESEARCH IN MATHEMATICS EDUCATION FROM A PHENOMENOLOGICAL PERSPECTIVE: *CHANGE IN THE TEACHING PRACTICE OF THE MATHEMATICS TEACHER*

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**ABSTRACT.** The goal of this study was to investigate *change in the teaching practice of the mathematics teacher*, adopting a qualitative research approach from a phenomenological perspective. Our understanding of phenomenological research, and the fundamental ideas underlying it, is presented. The research is described, including the ideographic and nomothetic analyses, and the six invariants, or open categories that emerged. We present our interpretation of one of them, the *possibilities of going through the experience: loosening the ties to the past and an objective look at change*.

**Key words:** *qualitative research, phenomenological research, changes in the model of teaching practice.*

We begin the article by presenting our understanding regarding the meaning of *research*, and explaining the bases that support this understanding, to then focus on the research conducted on change in the teaching practice of the mathematics teacher.

To research is to investigate. It is: circling around an interrogation formulated as a consequence of perplexity in the face of that which exists around us; seeking answers, explanations, interpretations; persisting in the attempt to shed light on dim areas with clear-sightedness; walking the path constructed by the rigor that transcends momentary perceptions, subjective opinions, and categorical statements based on beliefs, ideologies and unquestioned theories. It is seeking the rationale that

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supports the articulation of the discourse, the possible clarity of the language that expresses comprehension. It is seeking meanings in the light of objectivity constructed in the space of inter-subjectivity, made possible by the socio-cultural-economic context. The meaning of research that makes sense in these statements is that which was mentioned innumerable times in the classes, talks, and conferences of Joel Martins.

The master tells us that *doing research* means *having an inquiry and circling around it, in every sense, always seeking its multiple dimensions, and going around again and yet again, in search of more meaning, more dimensions, and still more... The inquiry keeps itself alive, since the comprehension we inquire about never runs out.*

This comprehension leads us to think for a long time, and its meaning began to be perceived, when we focused on the meaning of the word *research*. In Latin, it has roots in the verb *perquiro, is, ere, sivi, situm*, whose translation<sup>3</sup> is presented as: 1. Seek everywhere, search carefully; 2. Inform oneself carefully, investigate well, ask, inquire. In Spanish, the common expression is *investigación*. In Portuguese, *pesquisar*. In French, *recherche*, where *re* means again, and *cherche*, search, look for. Thus, to search or look for something again. In English, the word *research* can be understood as having the same roots as the French word.

Note that the following words are highlighted in these meanings: *circle around, again and again; inquire, seek, search; carefully*. The word *problem* does not appear. Why? What does this mean? These questions invited us to search for the meanings of interrogate, and of problem, seeking to visualize the possible unfoldings that the meanings attributed to them bring to the investigative posture.

Interrogate<sup>4</sup> means to pose questions to someone or to yourself, to question or question yourself, to pose academic questions, and other meanings that are less relevant to this paper. The noun *interrogation* also has meanings related to doubt and uncertainty; it speaks of a question directed to something that one wants to know. It is the product of a doubt, of an uncertainty in relation to what is known, or is taken as a given, as certain. Or, it could be uncertainty in relation to one's everyday experience, when the organization placed, or the judgments held begin to no longer make sense. The germ of the interrogation lies in the discomfort felt. Borheim<sup>5</sup> speaks brilliantly about the passage from naive certainty to the state of doubt as being a crucial moment for the possibility of philosophical thought - *possibility*, since one can become stuck in skepticism, without transcending it, which is what leads one in the direction of comprehending what is doubted, opening up new horizons for interrogation.

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<sup>3</sup> DICIONÁRIO DE LATIM-PORTUGUÊS, segunda edição. Porto: Porto Editora, 2001.

<sup>4</sup> DICIONÁRIO HOUAISS DA LÍNGUA PORTUGUESA. Rio de Janeiro: editora Objetiva, 2001.

<sup>5</sup> BORHEIM, Gerd. Introdução ao Filosofar. Porto Alegre: Globo, 1973.

The path that leads from the *discomfort felt* to the *interrogation* is long. Therefore, it is necessary to stay with it, questioning, seeking to clarify what is perceived as conflicting. One must proceed to studies and analyses of that which one perceives until the interrogation takes form and emerges, amazingly clear.

Then place the interrogation in focus, and seek to comprehend what the interrogation is interrogating. Heidegger, in *Introdução à Metafísica*<sup>6</sup>, writes profoundly about what is interrogated in an interrogation, placing in focus the interrogation *Why is there simply the being, and not before the Nothing?* This **why** questions the basis on which the freedom of the questioned/interrogated, and the manner in which it is interrogated, move.

This is a crucial exercise for the investigator: placing the interrogation in evidence, attentive and in a lucid manner, seeking for what is being asked, for what one wants to know, for what is being interrogated. This is a movement that helps one to foresee the path to be taken in the investigation, i.e., to visualize the procedures appropriate for what is being questioned, and its modalities of contextualization and cultural exposition.

The investigator circles around this interrogation, returning to it time and time again, with new foci, visualizing new dimensions and awaiting new investigations. This process of searching, which, being scientific, calls for rigor, exposes clearings that unveil themselves, are discovered, aspects heretofore obscure of the reality constructed in mundane relations. Underlying this idea, one encounters the conception of *truth* as evidence and as manifestation.

The interrogation is different from the notion of *problem*. This, taken in the context of scientific research, is exposed in such a way that it anticipates a possible solution, albeit not specific or determinate, as it is about to ask logically-connected studies and reasoning that lead to possible answers. It is known that a problem resolved does not mean that it is solved once and for all, since its solutions are alternatives. Underlying the idea of problem is that which is an approximation of reality, which brings with it a conception of truth as accommodation, and as correspondence; accommodation between what is found, through rigorous investigation, and reality, presumed to be objectively given.

The enunciation of a problem defines what is sought. The rationales unleashed follow the rigor present in contemporary theories of logic, in such a way that, together with the truth sought, the criteria for truth are found. Alfred Tarski, for example, upon explaining the meaning of the enunciation, said: *an enunciation is true if it designates a state of something that exists.*

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<sup>6</sup> HEIDEGGER, Martins. *Introdução à Metafísica* (translated by Emmanuel Carneiro Leão). Rio de Janeiro: Tempo Brasileiro, 1987.

- ***The question of rigor in research***

Rigor, in the realm of the meanings present in our everyday lives, leads to the idea of severity of principles; persistence and determination in carrying out undertakings, in making decisions; exactitude. In the context of research according to positivist philosophy, *rigor* carries with it the meaning of ***exactitude*** and the strict observance of the values of ***neutrality*** and ***objectivity***.

These values – exactitude, neutrality, and objectivity – are at the core of modern scientific thought, which, from an historical point of view, can be understood as originating with Galileo, when he lays the foundations for physics. This science becomes the model for the exact, biological, and human sciences.

Rigor was taken immediately as exactitude, without reflexive analysis of the possible meanings that this word brings with it as part of its tradition. Exactitude was understood as quantification and the calculations that can be performed with it. In response to situations in which quantification and measurement became problematic, because the object of quantification was not defined in an objective manner, showing itself in its concrete reality, modern science developed the notion of *statistic probability*, assuring a probable exactness, still measurable, from which the response obtained would be statistically acceptable within numerically-defined parameters.

The human sciences sought to follow this model. The educational sciences also sought exactitude, neutrality and objectivity. When, in contemporary times, specifically after the 1960's, there is a critique of *scientific rigor*, and the human and educational sciences, and later, of mathematics education, and alternative modes of research are sought, there is a movement to renounce rigor. Those who accept this criticism begin to conduct non-quantitative research, again without questioning *What is this rigor?* What are we talking about when we talk about rigor?

*Rigor* expresses the care one takes when proceeding to seek the interrogated or the solution to the problem posed. This is not a subjective care, loaded with emotional aspects. Rather, it is care that seeks the researcher's constant attention to proceed in a lucid manner, analyzing the steps taken, obtaining clarity regarding his/her why's and how's, about what it means, of the bases of his/her mode of investigation and vision of the mode of knowledge regarding the object in question that is being constructed and upon proceeding in the way that the investigation is being conducted. ***Rigor*** can carry with it different criteria, but there are always criteria that can be explained and justified in the context of the tradition of scientific/philosophical and artistic thinking. These criteria, in turn, are not circumscribed only by the epistemological and methodological realm, but carry visions of the world and of reality, and thus, conceptions of knowledge and truth.

According to this understanding, this has gone unnoticed by many researchers that distance themselves from the positivistic model of doing research and seek other modalities of research, generally of a qualitative nature.

- ***Qualitative research: procedures and the view of the world and of knowledge that underlie them***

Remaining at the level of procedures, the investigation, taken to term by the sciences of the spirit, can assume an historical focus, in the man-world dialectic and its determining aspects, in the linguistic expressions, in the context where the man-world-man and man-man interrelations occur, and in the way in which they occur, seeking appropriate ways to investigate them. This is the case of, for example, content analyses, hermeneutic analyses, ethnographic studies, and studies of symbolic representations, among others. The point of interrogation that is formulated, showing some doubt regarding these modes of investigation, is relative to how the data obtained will be analyzed, applying rigor in the process. Many continue to appeal to the resources offered by statistics, others work with narrative accounts, using them as a basis for important assertions made in the course of the research.

The values considered to be positive by this science are participation, engagement, proceeding from the assumption that history and culture are important.

However, beyond the questions of *how to proceed* and *what to focus on*, there is a basic question that concerns the underlying ontological aspects regarding the way the object of study is conceived of in the sciences of the spirit. It is the question of the subject, and the nexus established between the subject, world, and object.

Object of knowledge? How to understand it? Subject of knowledge? How is it to be understood? Cognitive psychology has made a great effort to understand the cognitive processes through which the subject of knowledge generates knowledge. Sociology, of knowledge in particular, has focused on knowledge as a social, cultural, and historical product. Dialectic historical materialism has shown how the subject of knowledge is determined by the historical context, which is materially constituted by cultural products. This is at the center of the web that involves the question of the nexus of *reality*, or the real, and *the subject*. Are they distinct, separate aspects? In the research carried out in the sciences of the spirit that have gradually come to be called Human Sciences, including the arts and philosophy, the separation between the *subject that is known* and *reality* persists. The bridge uniting them is the concept. With it, it becomes difficult to comprehend the question of history, of life, of the man-world nexus, because the concept is the product of relations established

cognitively, although the processes may be explained taking the socio-cultural context into account. Or, if one looks from another perspective, that of the historical-social context, and admits that this determines cognitive processes; the link between both continues to demand explanation. The knot is in the separation, and thus, in the world view that assumes a separation between man and the world.

Husserl, upon developing phenomenology, understood as a science of rigor<sup>7</sup>, calls into question the constitution of the *I* that thinks, and with this, approaches a dimension of the Hegelian subjective spirit. However, unlike what many contemporary authors affirm, through the processes of reduction that he carries out, in the first reduction, which is of the world, and in the second reduction, which is of the subject<sup>8</sup>, he doesn't fall into the trap of the solipsistic subject or the universal subject, as is the case of the absolute subject of the romantic idealism of Hegel, but rather establishes the immediate man-world link. He seeks the subjective-intersubjective-objective nexus, and elucidates it, in his work, through the conception of the *life-world, perception, expression of what is perceived through the language, empathy, intersubjectivity, community, linguistic structure, tradition, history*.<sup>9</sup>

For Husserl, man and world are intrinsically connected, without conceiving of a separation between them, but rather, seeing a continuous line between subject/world/subject/world... where world is always understood as life-world. In other words, it is always understood as the *where* in which one is with others, all immersed in the historical and cultural context that renews them, and which is concomitantly renewed through what is perceived - the perceived that is expressed by talking, understood by the co-subjects with whom one exists in the world, layered with the linguistic expressions that, in turn, carry with them other historically-structured understandings present in the life-world.<sup>10</sup>

Husserl effects a profound modification in the attitude assumed when one looks upon the world. And, according to our understanding, it is this modification that opens up paths for carrying out non-positivist research that are coherent with the conceptions of the world assumed. It is the differentiation between a *natural attitude* and a *phenomenological attitude*.

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<sup>7</sup> HUSSERL, Edmund. *Phenomenology and Crisis of Philosophy*. New York: Harper Torchbooks, 1965.

<sup>8</sup> BICUDO, Maria Ap. Viggiani. "A contribuição da fenomenologia à educação", in Bicudo, M.ªV. & Cappelletti, I. (Orgs.) São Paulo: Olho D'Água, 1999.

<sup>9</sup> HUSSERL, Edmund. *The Crisis of European Sciences and transcendental phenomenology*. Evanston: Northwestern University Press, 1965.

<sup>10</sup> Idem. *Cartesian Meditations: an introduction to phenomenology*. Netherlands: Martinus Nyhoff, 1977.

In the natural attitude, that which becomes the object for the subject, as well as the consciousness that operates the relations of this knowledge, are considered to be objects. This means that the *I* and its subjective experiences are assumed as *things in themselves, as part of the objective world*. In this natural world, things are understood as distinct positive concepts, on principle, of phenomena or manifestations.<sup>11</sup> It is represented by images or signs. The language is taken, in this view, as being objectively given.

In the phenomenological attitude, the thing is not taken as being in itself, since: a) it is not beyond its manifestation, and is therefore relative to perception and dependent on consciousness; b) consciousness is not a thing in itself, but is an absolute whole that comprises everything. As it embraces: in its own movement of extending toward, once it is understood as intentionality whose meaning is to head in a direction, extend, tend toward, open, become attentive.

The meaning commonly attributed to consciousness, in the magnitude of the natural attitude, is that of a thing, recipient, shaper, part of the world. For phenomenology, consciousness is a key concept, and is understood as intentionality, as the movement of extending to something ... and of embracing it in the vision of the attentive look that leads to perception. Phenomenological research investigates the manifestations of the thing as it occurs in the perception of he/she who perceives and explains this feeling (perceiving) through talking and language. Language is understood as expression of the perceived and articulated in intelligibility, organizing the perceived for the subject, so that the meaning is made for him/her, and communicating the perceived meaning to the other co-subjects, partners of a community. The investigation aims for the manifestation of the perceived, which is explained by the language, capable of being comprehended by the co-subject partner of the community, thus constituting a zone of intersubjectivity. From the repetition of the success of communications between subjects, replete with meaning, and through the use of mundane, and hence historical, language, zones of objectivity are constituted; speaking now of objectivity whose origins reside in subjectivity, but that transcended it to the extent that the initial perceptions were expressed.

Qualitative research, conducted according to a phenomenological approach, conceives of the man-world as always connected. There is no man without the world, and not world without man. This is because world is not understood as recipient, but as the *natural medium and the field of all my thoughts and all my explicit perceptions*.<sup>12</sup>

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<sup>11</sup> MOURA, C.ªR. *Crítica da Razão Fenomenológica*. São Paulo: Nova Stella-EDUSP, 1989.

<sup>12</sup> MERLEAU-PONTY, Maurice. *Fenomenologia da Percepção*. Translated by Carlos Alberto Ribeiro de Moura. São Paulo: Martins Fontes, 1994, p.6.

Upon making the meanings of *my explicit perceptions* explicit, we are lead toward the ontological comprehension of the reality comprehended as *created/constructed*<sup>13</sup>, where participation and engagement are considered as foundations, and where the language is always expression and communication of the perceived, comprehended, and articulated by historically-situated subjects. As reality is created/constructed by subjects engaged and participating in historical contexts and this subject are always in the movement of this creation and of what is already traditionally present in the world, we are then faced with the impossibility of investigation being separate from the world and its movement, from the creating acts and their manifestations. Thus, one must be attentive to the cultural expressions and proceed to the hermeneutic analysis. Language is assumed to be the expression of understandings at the same time it carries with it modes of expression and uses of this that were expressed, revealing meanings present in the tradition of a people, the characteristics of a culture, the history of its trajectory. These aspects should be considered in qualitative investigation that assumes a natural attitude.

This brings us to the question of the need to pay attention to the ontological and epistemological aspects of qualitative research, seeking to go beyond the broad categories present in qualitative methodologies, such as description, intersubjectivity, discourse, language, and history, among others.

- ***Investigation in Mathematics Education: explaining the modes of research upon privileging an interrogation***

The interrogation we privilege in the research under focus is: *what is this, living the experience of change in the teaching practice of mathematics?*; the phenomenon we seek to understand is: *the experience of change in teaching practice*, focalized based on the interpretation of the meanings that were gradually unveiled as we penetrated the different interwoven layers, covering and constituting themselves in a whole that, little by little, began to make sense.

As we, the researchers, were already familiar with the life-world of mathematics teachers, the subjects of the research, who wish to change their teaching practice due to their lack of satisfaction with what they do, we were able to pose some questions to guide our research, as they made sense to us: *How does a teacher choose to change his/her practice? What feelings are present when one goes through*

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<sup>13</sup> BICUDO, Maria Aparecida Viggiani Bicudo. Fenomenologia: Confrontos e Avanços. São Paulo: Cortez Editora, 2000.



*the experience of change? Is the willingness to change sufficient for the change to occur? How does the time lived by the teacher take place when going through the experience of change?*

Upon focusing attentively on the phenomenon under focus, we saw that some teachers, with whom we interact daily as researchers and as teachers, explained conceptions of the teaching of mathematics that differed from those present in the so-called *traditional paradigm*, indicating that they had passed through the experience of change placed in evidence. From these teachers, who were the subjects of our research, we selected seven to interview who we considered significant in terms of our interrogation and its manifestations regarding the questions raised. The interviews conducted were *inter-views*, where the subject-investigator dialogue was established; obtaining the discourse of each subject regarding the experience they had gone through in the practice of change in their way of teaching mathematics. Discourse is understood here as the comprehension, articulated and explained in intelligible language, of what he/she experienced.

These discourses, taken now as texts composed of data from the investigation, were analyzed at two different moments. Initially, an *ideographic analysis* of each deposition was conducted, when *Units of Meaning* were taken, and an explicative hermeneutic was elaborated of what was said in the subject's language, and a transformation of the former, into *Articulated Assertions*. A summary was presented, at the end of each ideographic analysis, of the understanding regarding the discourse articulated by the subject. We then moved on to the second moment of the analysis, concerning the *nomothetic analysis*, which characterizes research that seeks convergences and divergences between discourses. The convergences point to the invariants, which in the phenomenological view, characterize the structure of the phenomenon under investigation.

- ***Presenting the research***

We now present some excerpts from the ideographic analysis of one interview selected<sup>14</sup>, that of subject *E*, the summary of our understanding of the subject's discourse, a list of convergences obtained or of the broad, open categories, and finally, the analysis of these categories, attempting to show clearly the work involved in transcending the particular data, and exemplifying the interpretation carried out regarding one of the structural aspects of the phenomenon.

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<sup>14</sup> Hiratsuka, Paulo Isamo. *A vivência da experiência da mudança da prática de ensino de Matemática*. Rio Claro, UNESP, Tese de Doutorado (orientadora Dra. Maria Aparecida Viggiani Bicudo), 2003.

**Example of the procedure followed for ideographic analysis 1**

<b>Discourse E</b>		
<b>Units of Meaning</b>	<b>Explanation of the Subject's Language</b>	<b>Statements Articulated</b>
After becoming a professor at the university, I had a contact with Professor ... One day, he came to us and made the following proposal: Why don't you guys have a meeting with the calculus teachers to see what they are doing?	Contact: The meanings that appear on the language of the subject are: An action of being in touch with other person. A relationship of influence or of proximity.	E2- As a university professor, the subject began to relate to Professor ..., who proposed to him and some colleagues that they meet with calculus teachers to acquaint themselves with their practices/conceptions.

**Example of the procedure followed for ideographic analysis 2**

<b>Discourse E</b>		
<b>Units of Meaning</b>	<b>Explanation of the Subject's Language</b>	<b>Assertions articulated</b>
Then we organized a meeting to talk about (BATER PAPO) ... calculus on an informal way... I think that this meeting was the "turning point" to me; it was when I began to change the way I use to understand my conceptions about teaching.	"Bater papo" was the expression used by the subject. It has a special meaning in Portuguese from Brazil. It means to talk about some subject matter with other person, just to talk, without an objective purpose. It means: to talk, to exchange ideas. The expression in Portuguese from Brazil means "conversar, pappear, bater um papo, levar um papo, trocar uma idéia". To change: it means an act or an effect of changing. a. It is an act by which the proper subject modify itself or it can mean the effect of the subject be modified in some own characteristics; b. It mean transformation of something in other thing. To change in Portuguese from Brazil can mean, also, to move. That means "to put in other place, to organize the space of other way, to remove, to substitute, to modify, to vary, to combine, to transform.	E3 - The subject understands that the meeting, which he helped organize discuss the teaching of calculus, marks the beginning of his experience of change.

The articulated discourse presented below is a product of the analysis of all the Units of Meaning concerning Subject *E*, written in a text that we, the researchers, elaborated according to the meaning that the hermeneutic analysis had for us, in view of the interrogation that guided the whole investigation.

### **Articulated Discourse of Subject *E***

*Subject E graduated from a traditional university where students are expected to work hard within the traditional model of teaching mathematics, which is common in teacher education programs.*

*He understands that his experience of change in his mathematics teaching practice began when he participated in a meeting with teachers that had the objective of discussing the teaching of calculus. When the participants were asked to create a calculus problem, even about a simple subject, it was perceived that the problems presented were identical to those in the textbooks, that is, the teachers lacked creativity. This perception led to reflections about issues related to teaching - the first moment he felt his conceptions had been "touched".*

*Another moment of questioning his conceptions occurred during a Specialization Course, in the city of Guarapuava. When he realized he would be giving a course to teachers from various levels, with diverse educational backgrounds and interests, he adopted an approach, unheard of at the time, using mathematical modeling, which was an incredible experience for him, as he accomplished it by applying great will power, without having planned it in advance.*

*This experience allowed him to understand that working with mathematical modeling made it possible to create problems, and stimulated him to change his way of teaching. He was no longer afraid to face the problems that might arise in the process of change. He understood that one does not change an habitual practice, it being much easier to follow a path to which one is accustomed than another that, despite appearing to be more promising, may present unknown problems.*

*Working with modeling, he saw himself inserted in situations that involved mathematical knowledge, the application of mathematics, and that could be explored didactically. This experience had an important reflection in his professional life, as he then began to work in the field of Pure Mathematics, of Applied Mathematics, and Mathematics Education.*

*Beginning with this experience, he feels that his relationship with mathematics improved, having a better comprehension of its meanings when carrying out activities related to it. He then began to have a conception of mathematics teaching that differed from traditional teaching, and teaching became an activity that gave him great pleasure.*

*He understands that the teaching of mathematics should be an activity that pleases people, since if this occurs, learning will take place; if not, people will reject the teaching. The student will enjoy learning mathematics when he/she works to create the elements of mathematics, and not when a topic is simply transmitted, finished, via mechanized procedures, as in traditional teaching.*

*Thus, for him, the goal of mathematics education is to give pleasure to those who are involved in the teaching and learning of mathematics, pleasure that is not currently perceived in the schools.*

It is important to point out that the construction of the invariants is an exhaustive task, requiring close attention to the rigor of the steps taken in the elaboration of the articulations carried out between the statements. This work is characteristic of phenomenological reduction. Initially, 18 convergences were outlined, which, following one more reductions of the assertions articulated, to which letters and numbers were assigned, representing the subject's deposition and a specific assertion from the deposition, respectively, were articulated to the following *open categories* or the invariants that comprise the invariants of the phenomenon under investigation: *the lived time in the experience of change: the manifestation of the past-present-future; the experience of contradiction between what was expected and what was encountered; from admiration to the resolution to change that reveals the presence of the future; the experience of the I-other relation: from the simple individual to the existential individual; the teacher concerned with the student: the presence of the teacher and the poet; the choice to change: the decision taken by free men; possibilities of the living the experience: loosening the ties with the past and looking objectively at the change.*

We will now present the summarized interpretation of the category, *possibilities of the living the experience: loosening the ties with the past and looking objectively at the change*, as a case to exemplify the above statement.

The subjects of this research, at certain moments in their accounts of their experience of change in the practice of teaching mathematics, make moves to synthesize, addressing the theme of *change* in a directly objective manner, meaning not as an expression of a theoretical construct, but as comprehension of their own experience of change. Subject A, in articulated assertion 1, A1, stated that *change is a trajectory you are following, in which transformations occur little by little*. These subjects comprehend change as a trajectory, as a path to be followed. Upon going through the experience of negating the traditional paradigm of teaching mathematics, they make the decision to change. But the change is slow and demands that they walk the entire path, carrying out activities, taking courses. Change is *lived time*. In articulated assertion G-23, we found the following statement: *the subject did not*

*premeditate his change; rather, the change occurred throughout his existence, beginning with the perceptions and happenings of his life, and the need to overcome difficult moments that presented themselves to him.*

According to our comprehension, change is characterized as a process that is experienced in its meaningful aspects. It is a process of continual learning that involves reflection and criticism of one's own practice, meta-comprehension of the "real" as it is experienced.

To change is to experience the solution to the problem posed by the subjects themselves regarding how to change this practice. According to statements by Watzlawick et al<sup>15</sup> regarding changes of first and second order, we understand that first-order changes are those that modify some practices, while the parameters of the system remain, whereas second-order changes cause a change in the system. The subjects we interviewed claimed as significant for themselves the search for an approach to teaching that differed from the traditional, seeking new teaching practices and different ways of being with their students. Subject B, in articulated assertion 29, states that what he *considers remarkable was the possibility of establishing dialogue between the teacher and the student.* In articulated statement 27, he said that he *strives to integrate mathematics with other disciplines in a single course, seeking to make the student perceive that what is important is human knowledge as a whole, of which mathematics is a part.* The accounts point to a comprehension of mathematics as being part of human culture. The conceptions they express, and the practice that we perceive as being consonant with them, reveal a loosening of ties with the past. It has to do, as we understand it, with going beyond the traditional way of conceiving of mathematics and how it is taught, which took place as they experienced the process of perceiving themselves as dissatisfied, and negated the lived reality, refusing to accept it, formulated the problem, and sought a solution, without be satisfied with first-level changes, overcoming the difficulties, uncertainties, and fears encountered along the way.

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<sup>15</sup> Cf. Watzlawick, P.; Weakland, J.; Fish, R. *Mudança: princípios de formação e resolução de problemas.* São Paulo, Cultrix, 1997.

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