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A phenomenological methodology based on Husserl's work in the service of mathematics education research

Andonis Zagorianakos

Mathematics Department of the University of Athens; matheart7@math.uoa.gr

The paper introduces a phenomenological methodology based on Husserl's work and on Merleau-Ponty's radical extension of Husserl's work. The phenomenological reduction and bracketing (epochè) are introduced as the critical methodological instruments in exploring the emergence of mathematical understanding, by casting phenomenological light on the learner's intentional cognitive constitutions, from the passive to the active stage of her or his lived experience. An empirical example is used in order to showcase the impact of the researcher's methodological shifting, from the natural to the phenomenological attitude (the reduction and the epochè), and the methods and techniques that are used, in allowing the methodology to produce results. A summarising diagram and some notes for the usefulness of the methodology application for mathematics education research are included.

Keywords: Phenomenological methodology, Husserl, intentionality, reduction, bracketing, epochè, phenomenological attitude.

Introduction

The aim of this paper is to introduce a phenomenological methodology as a valuable frame for mathematics education research (MER). Examples of my use of this methodology have been published in *Educational Studies in Mathematics* (2015) and other international journals, as well as presented at CERME9, PME (2014, 2015) and BSRLM (2012, 2013) conferences. Critical distinctions emerge, between my use of phenomenology and that of other phenomenological or phenomenologically informed researchers in MER (e.g., Radford, Roth, Nemirovsky). The distinctions are concerned with the principal use of Husserl's work in my research—which is either taken for granted, critically disputed or scarce in the influential work of these scholars. Most importantly, the central difference in my work is the thematisation and application of Husserlian *methodological* concepts, such as the phenomenological reduction and the epochè. These concepts are used precisely for the purpose introduced by Husserl (i.e., phenomenology as methodology), and they are missing in the aforementioned researchers' phenomenological contributions. In my work, these concepts have been used in order to put in motion Husserl's mature work on the life-world (Lebenswelt) and the living present of learners. My conviction is that the same methodology could be applied to research with teachers, mathematical classrooms, curricula etc., each time providing critical distinctions. In this sense, the application of the phenomenological methodology presented here and as applied to learners suggests the viability of its application to other phenomena in mathematics education research.

The key concept of intentionality as a starting point for the application of the methodology

This paper follows Husserl's (1970, p. 168) conceptualisation of the central role of intentionality for the study of mathematical cognitive situations. The **intentional aspect** of conscious acts is

concerned with the fact that every conscious act is *about* something; I fear *something*, I hope *something*, I judge *something* (as true or false), I love *someone*, I hate *something*, and so on. Also, everything perceived is always perceived in a certain manner, with fear, hope, in shaping a judgement, with love, hate, etc. In the same respect the key feature of conscious acts, and in particular the cognitively motivated acts, are *about* something, present or absent, real or supposed as real, valid or not, but in any case, present for these acts. Husserl (1983) adopted Brentano's conception of intentionality as being the main feature of conscious acts and extended it critically. Mature Husserl (e.g. 1970, p. 168) thematised further the "uncover[ing] and the "clarification of what is accomplished" in the "intentional origins" region of lived experience. What does this mean in terms of the mathematics education research perspective? It means that by focusing on the region of intentional origins we could uncover and clarify what is accomplished in them, since, as he explains "every sort of intentional unity becomes a '*transcendental clue*' to guide constitutional 'analyses'...[which are] *uncoverings of intentional implications*" (Husserl, 1969, p. 245, italics in the original), particularly related to an operative, embodied sense on which abstract knowledge is grounded.

In order to explore the intentional aspect of the mathematical cognitive experience, the phenomenological reduction and the epochè (see the following sections) must be applied, as the two basic methodological instruments. The aim of the methodology is to open up the "currently constituted intentional unity" (1969, p. 245) of the learners' understandings, and thus to understand better how they *arrive* at their understandings, in their engagement with mathematical tasks and questions.

Epochè (bracketing) and phenomenological reduction—A first introduction

The methodology is supported by a phenomenological perspective that presents an intentional view of the cognitive life-world. This perspective approaches the mathematical lived experience as being intentionally supported; the researcher tries to study it without pre-conceptions on what it ought to be, but merely focuses on the intentionally emerging appearances, as they appear *for* the learner. The suspension of preconceptions is one of two basic methodological instruments. This suspension amounts to a two-fold task:

- To spot and put aside actions that are not relevant to the student's experience;
- To suspend the researcher's own intentions, and prevent him or her from interfering with the intentions running through the phenomenon of cognition under study.

In this sense all objectivity is *suspended*, as was introduced by Husserl (1983, p. 60), who used the term *epochè* for this process. Husserl employed *epochè* in order to combine it methodologically with his *phenomenological reduction*. This is the second basic methodological instrument. It is tantamount to the "leading back" from the natural targets of our concern, to "what seems to be a more restricted viewpoint, one that simply targets the intentionalities themselves" (ibid.).

So a combination of *epochè* (suspension or bracketing), and *phenomenological reduction*, shapes the core of the methodology. What are revealed through this combination are not the objects as such, but *as they are intended* (imaginatively, through remembering, judging, etc.), focusing on the

manners or modalities in which such objects are ‘given’. In other words, we look *at* what people normally look *through* (ibid.).

The application of the phenomenological methodological lens in a designed experiment

Here I present an experiment that is phenomenologically analysed, and organised in accordance with phenomenological investigations. It was an experiment in which the teacher allowed all possible interactions between the students, usually working in groups, but he did not provide any guidance to his students, concerning the open tasks that he introduced. I present the case of Mary (pseudonym), one of 13 students, i.e. prospective teachers of mathematics for secondary education, in a course entitled *The nature of mathematics* (NoM). As the teacher’s part in the collective or individual thought processes of the students’ treatments of the tasks was bracketed (epochè, in Husserl’s terms) the thinking strategies themselves came to the fore; the research field was enriched by the various approaches to the tasks, by different or by the same students. *Reflective* and *pre-reflective intentional layers* were thus traced as such (see the following section), as they were grounding the students’ constitution of the mathematical objects.

As soon as the intentional layers¹ of the students’ engagement in the task are exclusively targeted the researcher enters the *phenomenological attitude*, which guides her or him to further analytical reflections, followed by new findings (cf. the *unit of phenomenological knowledge production* component of the diagram in Figure1). With the use of the *phenomenological reduction* and the *bracketing*—considered as a single methodological instrument by the mature Husserl—we are entering the study of the *natural attitude*, which is “our straightforward involvement with things and the world” (Audi, 1999, p. 405), by describing it with the *phenomenological attitude*. The *phenomenological attitude* is “the reflective point of view from which we carry out philosophical analysis of the intentions exercised in the natural attitude and the objective correlates of these intentions”. Further, “the process by which we move to the phenomenological attitude is called the phenomenological reduction, a ‘leading back’ from natural beliefs to the reflective consideration of intentions and their objects” (ibid.).

The application of the phenomenological methodology in this case had the effect that, what were before *brilliant ideas* that suddenly possessed the students, or *desperate efforts* to ‘survive’ by acquiring some sense of the task, now became telling appearances of the operative affordances that each student brought and was able to release actively, either in the team in which the student was working, or individually, during and/or after the sessions.

The transformation of the working field of research was the result of (a) the focusing on the intentional acts that brought the learners’ objects to the surface, in a regressive analysis that starts from the ‘final’ objects and goes back to their genetic appearances, and (b) the neutralising/bracketing (epochè) of factors that played no part in the perception of the objects that were chosen to be activated by the students. From this analysis it occurred that it is the double

¹ The intentional layers are the layers of intentions of the learner, as he or she is devising an object for a mathematical enquiry.

application of the phenomenological reduction (a) and the epochè (b) that allows the transformation of the cognitive event into a *phenomenon*—in the Husserlian sense that this methodology suggests.

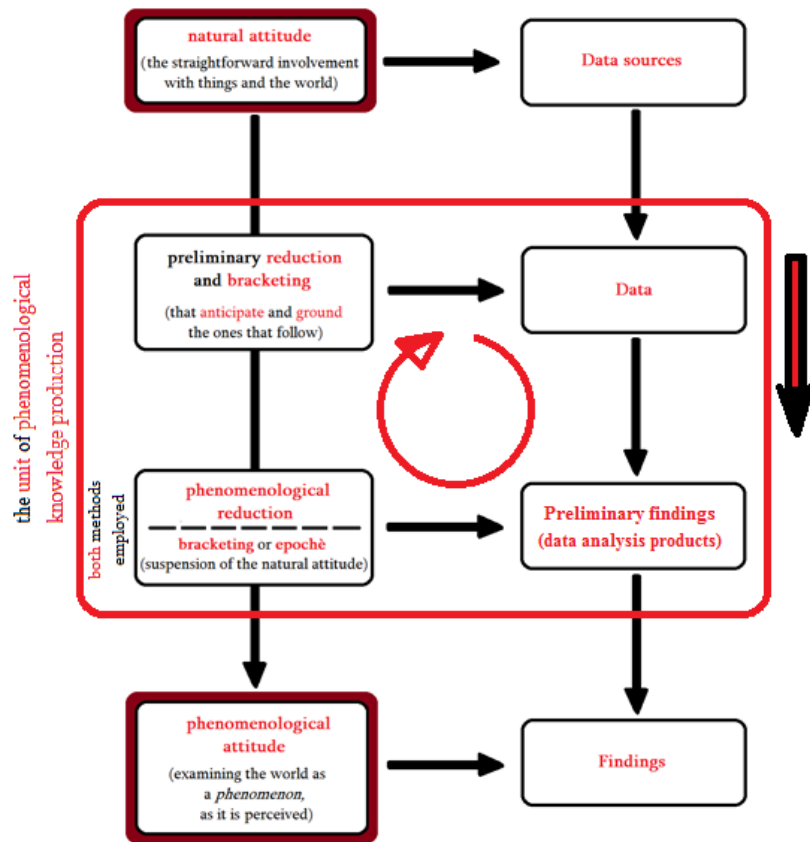


Figure 1: Methodology diagram

Methodological affordances and results

The transformation of the data sources' natural appearances into a phenomenon affords us, as researchers, with the following: (a) the ability to discern *structures* that the students' strategies follow, which could be helpful in teaching design (Zagorianakos, 2016; Zagorianakos & Shvarts, 2015); (b) better understanding of the students' learning horizons, which may also entail further phenomenological analysis, e.g., of a student's change of attitude (Zagorianakos, in press).

Description of the illustrative example—The use of the methodology

The bird's-eye view empirical intuition, as triggering a series of abstract intuitions.

Mary (pseudonym) was a prospective teacher of mathematics in English secondary education. During the NoM course (see previous section) a task was introduced that was required to be solved in teams of three or four students by involving bodily experience. One of each team actualised a fixed point, 10 meters or steps away from a wall, while the rest of her or his team were trying to embody the track of the sought line, in which each point was supposed to have the same distance from the fixed point and from the wall. The room where the task took place had very wide walls, enough for the four teams of three or four students to explore the task. What will be sampled here from that study is how the methodology allowed the phenomenological detection of the crucial influence of the embodied intuitive stock of Mary. The *embodied* grounding of Mary's

mathematical achievements was revealed methodologically by the reduction to (focusing on) her intentional cognitive treatment of the mathematical task, and by bracketing (neutralising) what did not affect Mary's experience.

By tracking how Mary *intentionally* handled her drawing of the wall and the Cartesian plane, I noticed how she transformed her drawing into a different view of the classroom, where she was confusedly trying to embody the solution of the task. Mary's view was an intuition,² drawing back to the Scholastics' perception of a 'new vision', which allowed her a breakthrough that followed her up to the end of her treatment of the task. It was in an **actively embodied** rather than in a metaphorical sense that Mary used her perception of a "bird's-eye view". It was this initial embodied intuition that was operating, as a sensory-motor environment to all her understandings, up to the end (see following paragraphs). This phenomenon was lit by *full bracketing of non-significant issues to her constitutive moments*, of the objects that helped her unlock the task. By mentioning non-significant components, I mean all the actions that did not interfere with the student's (constitutive) building process, such as the teacher's non-guidance protocol. Therefore, bracketing is not arbitrary, and it could be responsible for further analyses, as soon as the reduction's furthest application is done (Zagorianakos, in press). Mary's example is not fully analysed here: it has been drawn to showcase the applicability of the methodology, realised by the methods and the techniques, which are introduced in the following section.

Methods and Techniques of the methodology—The student's progress with the task

The methods included participant observation, gathering of documents that included the learners' reflections on their learning processes, and interviews (email or in person). The methods concerned semi-structured live interviews, where the technique was to trigger the flowing of the students' reflections on the actions that brought objects to the surface. Another interview technique was to drive the discussion without force towards the intentional acts that led the learners to their constitutive moments of objects. How did they feel about them? What was special, for them, about these objects? The methods were used so that the intentions that led to the mathematical objects would be revealed; and the techniques were aiming at keeping the researcher in low profile, while bringing the student's narrative vividly to the foreground. Due to such methods and techniques I took advantage of the teacher's self-bracketing in order to study how the students' mathematical experiences were structured.

Let's see how the student's development with the task happened:

After the investigation in the classroom, when the student was in utter confusion about what the sought line was supposed to look like, Mary went home. There she drew on grid paper the wall as a straight line, and a Cartesian plane with the y-axis perpendicular to the 'wall', and the two axes intersecting ten grids away from the line (wall). The student's first intuition appeared, as she

² From late Latin *intuitio*(n-), from Latin *intuit-*, *intueri* 'contemplate', from *in-* 'upon' + *tueri* 'to look'. [Concise Oxford English Dictionary (Eleventh Edition)]. Intuitive in the sense of a special, immediate regard on what is given, as intended.

grasped her drawing on the grid paper as a *bird's-eye-view* over her very recent, embodied but unsuccessful classroom activity.

Not metaphorically, but in a very actual sense the student realised due to her *bird's-eye-view* perception of her diagram how wrong her perception of the task had been in the classroom: she actually observed that the sought line could not be a straight line parallel to the wall (as she had initially supposed), at half way distance from the fixed point and the wall, while being constantly equidistant from the wall and the fixed point. It is evident that her bird's-eye-view perception had equipped her with a movable vision over the classroom, through the diagram, and a trace of this was that her perceptions were time-related: the straight line was equidistant from the wall and the fixed point at some point, but not in the following of the process of a "movable point", in which the student started perceiving the curve. So then she started with three points and she started looking for more points belonging to the sought line, by using a ruler parallel to the line (wall) and between that line and the x-axis, thinking of the sought line as being continuous and therefore aiming at finding the points where her ruler intersected with the sought curve. While being in this *operational mode* Mary employed the Pythagorean Theorem (PT) as an *objectification instrument*, to track points belonging to the sought curve and thus unlock its shape. The student's intentional roots were traced; they revealed that the student's recollection of the Pythagorean theorem was in the service of her *intention* to find more points belonging to the curve, while *operatively* using her bird's-eye-view perception of her diagram. This insight adds an *operatively intentional layer*, a clearly embodied layer right at the appearance of the PT as a points' determining instrument.

After finding five points symmetrically located around the y-axis (two of them by using the PT) she had the intuition that the line must have a "bell-shape", from where she thought of the x-square functions. The student's idea of x-square functions was the second intuitive step, described by Husserl as an abstract *intuitive step*, based on the empirical ("bell-shape") intuition.

Her exploration culminated in a critical abstract intuition which, through the "synthesis of coincidence" (Husserl, 1973, p. 74) brought to the surface the general rule, the general formula for all curves, with any given distance from a 'wall'. And even then, the *embodied* sense of her understanding of the algebraic solution remained vivid in her recollection: She perceived the curve as an empirically driven "moveable point", since "you could stand on anywhere on the line $y = \frac{a}{2} - \frac{x^2}{2a}$ and you would be equidistant from the wall and a fixed point" (interview extract).

The view that the phenomenological methodological components offered to the study

So, the *phenomenological reduction* and *bracketing (epochè)*, as distinguished from methodic doubt, and being a suspension compatible with certainty, led me to the *phenomenological attitude*. This attitude is equivalent to focusing exclusively on the intentions and their correlated objects in the natural attitude, without "*excluding* of a living conviction, which remains alive" (Husserl, 1983, p. 60). Bracketing enhances focusing and focusing is indicating what needs to be bracketed or seriously studied, phenomenologically or otherwise.

The study of the student's intentional apparatus became my Ariadne's thread in unlocking Mary's lived experience. I finally managed to understand how she imaginatively (with imaginative

intention) flew on the wings of her *bird's-eye view* intuition, over the diagram that she drew at home, on grid paper—i.e., using the mathematical diagram as a re-presentation of the classroom where the embodied treatment of the task took place—and finally, how she developed her *bird's-eye view* intuition in order to accomplish all her subsequent intuitions.

The cultural artefacts (grid paper, Cartesian plane etc.) were imperative for Mary's accomplishments, but it was through (and due to) the researcher's phenomenological reduction and bracketing that the focusing on the intentional apparatus of the learner's lived experience finally disclosed the following aspects: (a) *how* the first, empirical bird's-eye view intuition (not 'just' as a metaphor but as an actual, embodied perception) was essential in unlocking the task (Zagorianakos & Shvarts, 2015, pp. 152–154); and (b) *how* her embodied and mental intentionalities were intertwining as she moved further, in activating a general formula for all parabolas (ibid.). The shifting from the natural to the phenomenological attitude (the reduction and the epochè) is a critically innovative *methodological* move, which can unlock the lived experience of the learner by transforming it into a *phenomenon*, in its original (Husserlian) sense, for the researcher. So the methodology is concerned with the study of *focusing* on the learner's object constitution—objects that become mathematical objects as they fulfill the demands of a mathematical task or a question brought in a mathematical context. The focusing is on the objects as they appear *for the learner* and therefore, *as they are intended by the learner*. This focusing allows for the tracing of the *intentional paths* that bring the learner into *contact* with a particular *object*, due to the learner's *pairing* of the object with a certain strategy, while solving a problem:

Through 'something reminds me of something' a *pairing* of two given things in consciousness first arises. Through reflection we see that association is not a blind mechanism, because I can recreate and understand through which connecting point(s) a pairing originally arose in consciousness. (Held, 2003, p. 43)

As an example of the analytical potential that the methodology has made accessible, Mary's intuition on the shape of the curve—as being an x-squared curve, after her empirical intuition of the shape of the 5 points as a bell shape—is phenomenologically perceived as an association generated by a pairing. The empirical image of the bell was paired with the x-squared curves' graph, due to the student's intention to explore a possibility for embodying mathematically the empirical image. This intentional trail from operative (embodied) to active mathematical knowledge production (culminating in Mary's formulas) is a viewpoint on Mary's mathematical lived experience that was developed due to the methodology of intentional focusing (reduction), and teacher bracketing (epochè), in this phenomenological experiment. Practicing this methodology may make the researcher realise the radical view the methodology may offer in the study of cognitive events, particularly when enriched by a phenomenological theoretical viewpoint.

The methods encompass *regressive* and *repetitive reflections* on the data, without taking anything for granted, as far as the appearances of the objects *for the learners* are concerned. The key is to focus exclusively on the acts, and on the intentions that are expressed through them, as they are directed towards objects, as they surface and as they are intended by the learners. Then the focus moves on to objects that triggered the acts and on the acts that brought the latter objects to

conscious exploration, within the learner's lived experience. In this sense, this methodology, by using the phenomenological attitude has the effect of a phenomenological mill unit. This is what the *unit of phenomenological knowledge production* element of the methodology diagram (Figure 1) depicts, as the vertical arrow is moving: The vertical arrow in the diagram is making one full route from the top to the bottom of the rectangle, synchronously to the inner round circle arrow completing one round. Then the whole process is repeated in a more informed manner, phenomenologically, thus producing sounder and more evident 'images' (adumbrations), and according findings of the phenomenon under examination. A top-bottom vertical arrow on the left side of the methodology diagram (Figure 1), which is moving through the *unit of phenomenological knowledge production* rectangle, is concerned with the researcher's own shifting of attitude, from the natural to the phenomenological one. The cognitive phenomenon, as it is unfolding for the researcher, is an orchestration of expressions in the conscious reflective and in the subconscious pre-reflective areas of knowledge production. The methodology shows the switching from a natural attitude to the phenomenological attitude. This is done by specifically thematising the intentional layers that are concealed (taken for granted) in the 'natural' reading of the phenomenon (which is the study field), and can take place by applying the epochè, the neutralising of natural intentions that must occur when we contemplate the intentions that we are studying. The researcher's own change of attitude and the transformative effects on her/his previous ('natural') viewpoint are thus enabled to be at the centre of analytical attention.

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