

**PHILOSOPHYCAL EXPLANATION OF MATHEMATICAL  
EXPERIENCE: In Response to the Research on The Effect Of Epistemic Fidelity On  
Teaching Decimal Numeration With Physical Materials**

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**ABSTRACT.** Use of linear arithmetic blocks (LAB) was associated with more active engagement by students and deeper discussion than that of multi-base arithmetic blocks (MAB). Epistemic fidelity is critical to facilitate teaching with the models, but Stacey, K, et al (p.199-221, 2001) attributed the enhanced environment to the greater accessibility of the LAB material. This research and its results exhibits the writer to employ Greimas' Structural Analyses, Kant's theory of double-affection and other notions of philosophical explanation in order to uncover concepts behind the aspects of the process as well as the results of the research. The in-depth explanations of the nature of mathematical experiences, specifically about the effect of epistemic fidelity on teaching decimal numeration with physical materials, will expose not a single truth of its nature due to the fact that they will be put in the area of philosophy.

**KEY WORDS:** epistemic fidelity, physical material, double-affection theory,  
philosophical explanation

## **Introduction**

The results of the research on the effect of epistemic fidelity and accessibility on teaching with physical material (Stacey, K, et al, 2001) comes to some conclusion that: 1) the are numbers of favor differences of different model of physical material (LAB and MAB), 2) the most striking difference between the two models was their ability to model number density, with LAB found to be the superior model in this respect, 3) teaching with physical materials is an area of great difficulty for many students, 4) students did not attend to the volume relationships embedded in MAB and struggled to remember the names, rather than immediately appreciating the sense behind them, 5) MAB students experienced difficulty generalizing to numbers beyond the model due to their difficulties with volume and apparent dimensional shifts in their perceptions of the components, 6) LAB appeared to promote richer engagement in the classroom than MAB due to its greater accessibility (detail results of the research, refer to Educational Studies in Mathematics 47: 199-221, 2001).

It was acknowledged by the researchers that some manipulative materials can be distracting and open misinterpretation; teachers could overestimate the value of physical materials because they are already familiar with the concepts being presented (Ball in Kaye, et al, 2001). It also stated that, Meira (1998), the mechanical devices became 'visible' as things that required explanation, rather than 'invisible' resources for making the mathematics more accessible. Having considered those notions of the constraints in

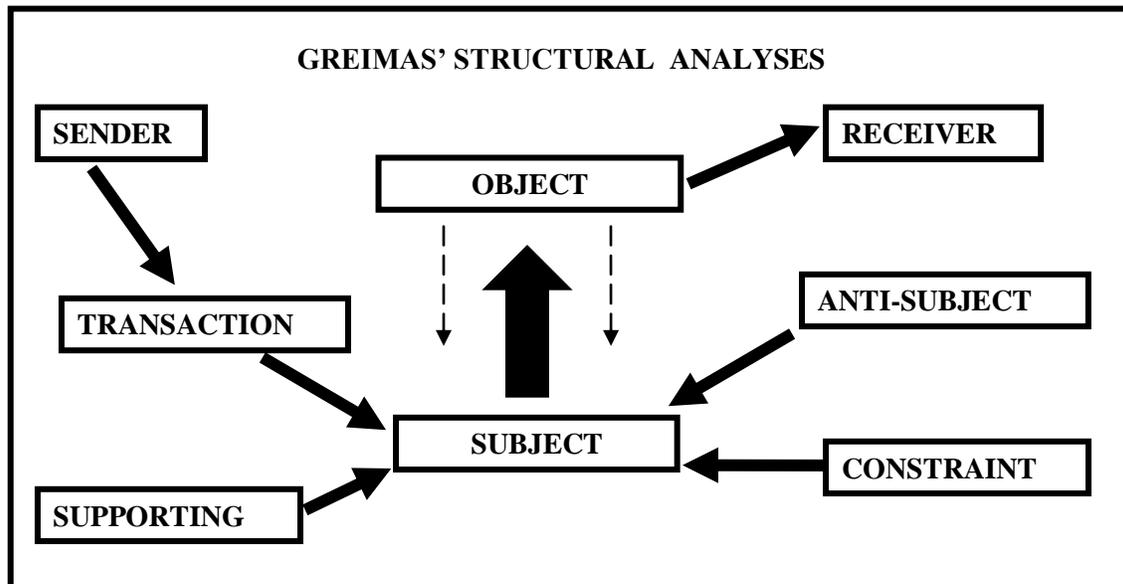
employing physical materials in teaching mathematics and having learnt the document of the process and the results of the research, the writer perceives that the research consists a lot of important critical concepts that need to be developed as the notions in the implementation of mathematics teaching as well as the notions of theoretical and or philosophical discussions. In term of theoretical concept, those important critical concepts consist of: 1) epistemic fidelity, 2) the posing problems devices, 3) the link between the features of the device and the target knowledge, 4) something objective, 5) students' engagement, and 6) accessibility. From the explanation, it can be inferred that the objective of this paper is to investigate general theory of the aspects of mathematics teaching learning processes with the context of the process and the results of the research conducted by Stacey, K, et al, (2001), on the effect of epistemic fidelity and accessibility on teaching with physical material.

## **Methodology**

The level of philosophical discussion have their characteristics such as the need to cross-check as well as to compare with several point of views independently, to construct general theory of subject related. Mackenzie, J.S, (1917), stated that philosophy has to take account of the general results of the investigations of all sciences to endeavour or to construct a general theory. To achieve the purpose the writer employ some philosophical approaches such as interpretation, internal coherences, idealisation, comparison, analogy and description. Based on those approaches, accordingly, the writer adapts Greimas' Hermenitics Structural Analyses to show the inter-relationship among the components of decimal numeration teaching with physical materials as it was carried out as part of the research of Kaye Stacey et al. To achieve the objective i.e the general theory of the related subject, the writer strive to implement the theory of 'double-affection' to the scheme of Greimas' Hermenitics Structural Analyses with the context of the process and the results of the research, conducted by Stacey, K, et al, (2001), on the effect of epistemic fidelity and accessibility on teaching with physical material.

## **Greimas' Hermenitics Structural Analyses**

In that scheme, the student was put into the centre of the mathematical teaching learning activities; the teacher has a role as the 'the sender' as well as the 'supporter' in such a way that their students learn physical material as an object of learning; the 'transaction' between the teacher and their students happened if there is a motivation of the students to learn the objects i.e. physical material; the 'constraints' need to be considered and to be anticipated as well as to be found its solutions in such away that the students are able to interact with their physical material; the 'anti-subject' arises if there is extremely constraints such as bullying, un-expected accident etc. in such a way that the students are not able to interact with their physical material mathematical objects; the 'receivers' are the people or the agents that takes the benefit of the students' interaction with their objects, therefore, the student him/herself can be perceived as 'receiver'. The following is that the scheme:



Source: Haryatmoko, 2004

## The Myth of Double Affection

The theory of double affection is a classical attempt to rescue Kant's account of perceptual awareness from what is alleged to be a glaring inconsistency (Gram, S.M, in Werkmeister, W.H, 1975). According to Kant, 'to be affected by anything' is to experience the effect of an object upon the faculty of representation (ibid, p.29). Kant provides two kinds of objects which affect the subject: there are 'thing in themselves' which affect the self; and there are 'appearances in themselves' which act on our sensibility and are independent of whatever characteristics attach to our sensory receptors (Werkmeister, W.H, 1975). Facing this Kant's notion, Gram, S.M, in Werkmeister, W.H, (1975) delivered the following argument:

" Suppose we say that what affects our sensibility is 'a thing in itself'. This account of what affects us, however, prevents us from distinguishing between a case in which somebody perceives an object and the quite different case in which an object exert a merely causal influence on the body of the perceiver. This can be seen by consulting an elementary fact of perception. The fact is that to perceive anything is to perceive it under 'a certain description'. If this were not the case, then we could not distinguish between the perceiving of one object rather than another. But if we must always perceive something under a description, to say that we are affected by 'a thing in itself' when we perceive anything would imply that we perceive that objects satisfy certain descriptions. And this would contradict the claim that we cannot be perceptually acquainted with 'a thing in itself'.

The above propositions were delivered to argue Kant's description that affection as the experience of the 'effect' of an object on our sensory apparatus; whilst, the dilemma facing Kant's theory has nothing to do with the quite separate issue of whether

what is related to sensibility is the effect of an object rather than the object itself; and, the issue concerns the nature of the object which is immediately present to perceptual awareness rather than the casual relation in which it might stand to some further object. The notion of affection does not, however, become fully clear unless we can specify the kind of object which can stand in such a relation to our sensibility (ibid, p.29). He then erected the next dilemma as shown the following:

“If ‘a thing in itself’ can act upon our sensory organs even though we cannot perceive it to satisfy any description at all, we would not be able to distinguish between ‘the situation ‘ in which an object casually affects our bodies in certain ways and we do not perceive the effects of that action from the quite different situation in which the object exerts such as influence and we do perceive it. If the first affection is to hold between ‘a thing in itself’ and ‘an act of perceptual awareness, we would have to be able to perceive ‘thing in themselves’ under descriptions appropriate to them or obliterate the distinction between causation and perceptual awareness”.

What we can learn is that there should be any other relation between ‘thing in themselves’ and affection. Kant asserted that ‘space’ and ‘time’ are forms of our sensibility; what affects our sensibility is an object that has ‘spatial’ or ‘temporal’ characteristics i.e. a phenomenal object. If the object which affects the forms of our sensibility cannot itself have ‘spatio-temporal’ characteristics, then what affects us must, on Kant’s theory, be a thing in itself . Empirical affection does not require that the objects in our sensory field lack spatio-temporal characteristics; while, transcendental affection countenances the existence of objects which affect ego in themselves. However, the distinction between these two kinds of perception is still a myth (ibid 32-33).

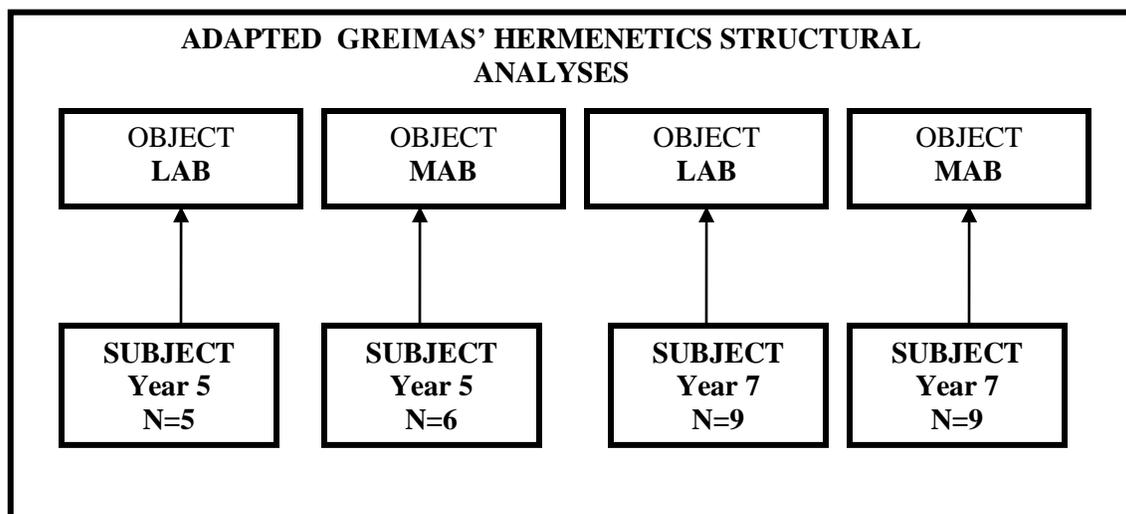
## **Discussion**

In their theoretical review of the stated research, Stacey, K, et al, (2001) indicated that epistemic fidelity of the material is one of the factors influences the transparency of instructional material. They also indicated that epistemic fidelity of the material depends on the materials themselves in which the mathematical domain being represented does not depend on their use by students. Explicitly, they defined that the epistemic fidelity of an instructional material is a measure of the quality of analogical mapping between the features of the material and the target knowledge domain. Further, they stated that epistemic fidelity of a model depends on the relationship of features intrinsic in the model to target mathematical structure, and is independent of user characteristics. On the other hand, Gram, S.M. (1975) provides a clear and comprehensive statement, of the case that likely as what Stacey, K., et al infer as epistemic fidelity, that he called ‘double affection’. He claimed that what affects our sensibility is ‘a phenomenal object’; it allowing anything which has spatial or temporal characteristics to count as such an object. Further he stated that, according to Kant, sensibility is the capacity (that the researcher claimed as ‘quality’) for receiving representations through the mode in which we are affected by objects.

From those two points of view we may learn that although there similarities of the claim of the relation between subject and object of learning, although the writer could not

identify what did they mean by ‘a measure of the quality of analogical mapping between the features of the material and the target knowledge domain’, except that of its category consists of excellent, good, satisfactory and unsatisfactory. If the researchers meant that epistemic fidelity is the capacity for receiving representations through the mode in which we are affected by objects, the next problem is that we need to clarify them. Kant implied that affection is to be partially defined in terms of a relation in which an object stands to certain spatio-temporal forms; and this kind of relationship is specified in terms of a connection between an object and these forms, not in term of an object exhibiting these forms and sensibility. It is important here to conclude that, according to Kant, if the object which affects the forms of our sensibility cannot itself have spatio-temporal characteristics, then what affects us must be ‘a thing in itself’(in which the researchers indicated it as ‘material in themselves’). It seemed that the researchers did not specify the affect of the different characteristics of the object in term of ‘appearances in themselves’ and ‘things in themselves’.

Next, they also indicated that the ‘accessibility’ of the materials is a collection or psychological factors that arise in the use of the materials by students but which are not specific to particular students (ibid. p. 2001); further it was stated that accessibility of a model of physical material depends on characteristics of likely users interacting with features of the model; accessibility, stands above the detailed analyses of particular tasks in particular classrooms that Meira (1998) in Stacy (2001) has traced in his quest for ‘transparency’. Accordingly, there are at least two issues (both social and psychological) that may impact of LAB and MAB. In LAB the issues consists of: 1) students’ confusing the organizer rods with the value of the component and 2) students’ confusing about the left-right positioning of the place value columns. It is clear that what the researcher infer by ‘accessibility’ is something related to the subject that what inferred by Kant as ‘sensibility’. Further Explanation of the Scheme of the Research



Differences accessibility were actually found that students in MAB group experienced confusion with remembering the new names components. There was no such confusion in the LAB group. How numbers are represented? In MAB group, the students did not understand that the components relative value is based on their volume. In term of ability to generalise beyond the model, the students were confused by the apparent dimensional shift and appeared to be looking for a forth dimension. Were the different learning outcomes related to differences in epistemic fidelity or accessibility? The LAB model was more effective on decimal numeration; the LAB model was found to more transparent model for numeration; the LAB model was more effective model of number density; the LAB model should also be better model for rounding decimal number.

In term of the differences between the group, the LAB model was more favourable and the LAB model appeared to promote richer engagement in the classroom due to greater accessibility. The Year 5 students appeared reluctant to use the MAB; it was a constant struggle to get them to use it. There was more discussion and exchange the ideas in the LAB group and there more significantly episodes of talk referring to the LAB model than the MAB model. There was evidence that LAB students spontaneously exploring new ideas, which did not occur with students using MAB. When LAB was not available, students made connections with other physical representations, such as ruler lengths and MAB; One student pointed out “LAB is another type of MAB”; “These are the exact same thing”. The LAB group scored higher than the MAB group on every measure of attitude(Likert items). In term of the attitude, the LAB group is typified by one student’s comment: ”Learning what the numbers mean –how big they were–just from length, was the best”.

## **Conclusion**

The research has given the researchers an insight into the different roles of epistemic fidelity and accessibility of physical instructional material. The researchers hypothesise that epistemic fidelity is necessary for securely grounded teaching of concept with a model, whereas accessibility promotes rich classroom engagement. Epistemic fidelity and accessibility have different roles in establishment transparency. From all of those findings, the writer strives to develop the method to uncover what are there behind the concepts.

Over all, we regard to the students’ status of mathematical knowledge resulted by manipulating with physical materials, in the schema of Greimas’ Hermenetics Structural Analyses. If the distinction between the two kinds of perception is still a myth, then we can still argue it on the status of mathematical knowledge. As it was acknowledged by the researchers that some manipulative materials can be distracting and open misinterpretation; it can be explain with the theory of double-affection due to the fact that the teachers are already familiar with the concepts being presented. The writer perceives that Kant’s notion of appearance in them selves and thing in themselves are useful to explain the issues of visibility and /or invisibility of the mechanical device.

The writer emphasizes that the different context, i.e. in term of time and space as it was notified by Kant, may influence students perception of the objects. Therefore,

teachers need to employ those kind of factors as supporting one in teaching learning of mathematics. The link between the features of the device and the target knowledge was very intensively to be discussed by Kant in his *Critical of Pure Reason*. General theory of the aspects of mathematics teaching learning processes is to pursue in term of the relation of student as a subject and physical material as an object in the schema of Greimas' Hermenetics Structural Analyses. The effort to pursue those relationships will determine the extent of the quality of philosophical point of view.

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