Classroom Research

JAN VAN DEN BRINK

1. Introduction

During the PME (Psychology of Mathematics Education) conference in 1988 in Hungary a discussion group called "Classroom Research" was formed to consider the problems connected with the use of intensive research methods and techniques. Various Dutch organisations in education also showed great interest in these research methods. This was evident from the fact that at the end of May, 1988, the Dutch Association for the Development of Arithmetic and Mathematics Education (NVORWO) and the Dutch Association of Mathematics Teachers (NVvW) organised a conference on the theme "Methodology of Research". The main purpose of the conference was to study what opportunities, problems and solutions arise through the use of intensive methods and techniques and how the latter affect objectivity, the reduction of data, and the validity of conclusions.

The main feature of these methods is that they remain close to the individual pupil; they concentrate more on the motivation of a pupil, and particularly on the answers he or she gives, than on general features such as frequencies and correlations.

There have been a number of important developments in the methodology of intensive research methods. We mention some of them here

- Classroom teaching is regarded as a source of inspiration for these research methods.
- Suggestions have been made about how methods can be improved and how they can be investigated more thoroughly. Emphasis is therefore on
  a) keeping detailed records so that weak spots are revealed and
  b) careful reflection about research situations after the events have been recorded
  Typical quantitative data concerning, for instance, the social environment and the intelligence of the children may serve as a guiding principle
- Because the use of intensive research methods produces a surplus of data, quantifying and reduction techniques form an essential part of the methodology. Various solutions to these problems have been proposed.
- Last but not least, a theoretical underpinning of these methods is contained in Smaling's interpretation of objectivity, which does justice to the object. This interpretation has consequences for research planning and research methods. We shall discuss these developments in this paper, but not in exactly the same order. Our comments and arguments are based both on the work of the members of the PME discussion group and on the proceedings of the Dutch conference mentioned above.

2. Objectivity

Smaling's interpretation [1987] of objectivity as a methodological norm in educational research, using the so-called Münchhausen metaphor, is an appropriate theoretical background for practical work using intensive methods. From the stories by the Baron Von Münchhausen Smaling extracts two features which illustrate what he understands by objectivity. First of all he points to a "contrafactually regulatory principle": Von Münchhausen saves himself from a bog in an impossible manner by pulling himself up by his wig. In other words, objectivity is in fact never achieved: it is simply a goal to aim at. However, in order to attain as much objectivity as possible you have to act *as if* it has already been to a certain extent achieved (the objectivity is contrafactually regulatory).

Secondly, Smaling points to the "network" character of the adventures of Von Münchhausen: they could have happened anywhere in the world. The network character of objectivity arises from a combination of various aspects of striving for objectivity; the following aspects may be mentioned: the researcher, the object of study, the relations between researcher and object of study, the aim of the study and its scope.

By means of this methodological pluralism (leaping from aspect to aspect as if from ice-floe to ice-floe) one has a better chance of doing justice to the object. This objectivity — doing justice to the object of study by examining it from different aspects — fits the circumstances from which intensive methods are born. Objectivity generally implies that the character of the judge should have no influence on the judgment. In principle it should be possible for the work (the assessment) to be taken over by a machine. This "machine principle", however, is only an algorithmic approach to the concept of objectivity and thereby the concept suddenly shrivels to a technical norm, an organised, mechanical test. Viewed from this angle the concept of objectivity is nothing more than a general methodological norm.

In the last few years, however, new views have developed within the social sciences. The "forum" concept has emerged: the tendency to make concessions, to do justice to the object, to look at it from many angles. The role of the tested subject is under discussion. Can the test-subject, for instance, also have a researcher role?

The notion of jumping from ice-floe to ice-floe reflects these aspects of research: various kinds of data, various researchers, users, theories and methods. Allowing the authority of the test-subject to vary is also an idea that fits the above-mentioned interpretation of objectivity; in this way one does justice to the object of study.

3. Development and evaluation

Development and evaluation must be weighed and compared within this framework People often try, mistakenly, to regard the development of teaching-ideas and teaching-materials as a procedure that occurs without rationalisation or reflection This way undervalues development research According to this interpretation, evaluation is the proof of the pudding But people forget that you have to learn how to eat the pudding Developers need more information than simply the remark that the curriculum being researched is workable. Which criteria must be met? Which criteria will suffice? Which are already satisfied?

During the development of the prototype of a curriculum there should be a number of evaluation moments

- When a designer is designing a curriculum he must know very quickly what material he is producing But other matters (which are often ignored) like aptitude, motivation, surroundings, method of teaching, also exert an influence They should also be taken into consideration The situation is comparable to the network character of the Münchhausen metaphor
- The prototype curriculum must be tested to see if the desired results can in fact be achieved This provides a second moment for evaluation
- Finally there is a product Thus there is a third moment for evaluation

A sharp division of roles between developer and evaluator is not required until the very last This last evaluation is the one made with external users in mind Made too early such an evaluation can frustrate the ongoing work of the developer

On the other hand early participation can induce the evaluator to do evaluation research, i.e research into new ideas about evaluating It is therefore important to distinguish between evaluation research and evaluation Evaluation research is research into the possible forms of evaluation; evaluation, on the other hand, is assessment with the help of scientific and systematic methods and using assessment criteria — it is more a technical procedure

4. Observation and reflection

Observing is not only watching carefully, it is also reflecting on what has been observed: "seeing something in your mind's eye", "reconsidering something at home", "watching with understanding" are phrases that reinforce this notion It has long been contended that observing also involves reflecting: "Voir, savoir et revoir" (Comte) There are various arguments to support this view

"Causal reasoning" can serve as a theoretical reconstruction of classroom teaching as it is perceived [Hoeben, 1989] The curriculum developer will support his teaching designs with a further elaboration of causal reasoning

A second argument is that the developer has a theory in his head which he does not explain but which has a great influence on the research work. He has to be made conscious of this theory, possibly through a reconstruction of it, or via introspection

A third argument is that many parts of a developing research project are not mentioned or explained by the developer As a result reconstruction is needed to improve the research Often developers and researchers do not know exactly why they do something or even what they are doing Evidently they must sometimes be told by external evaluators

Outsiders, however, constitute a special problem a expressed by the difference between "logic in use" an "reconstructed logic" The first is created in practice Th second is restricted to rationalising. What are the possibl differences between the concepts of knowledge of the out sider and the researcher, between practical experience an a too simplistic picture of the situation? As an outsider on is separated from practice and one runs the risk of becomin a real outsider

A fourth reason stems from the view that reflection mus form part of the research since it is one of the intensiv research techniques and research methods However, a dis tinction must be made between reflection by the investigato himself and reflections that others make on his observations There is a problem of reliability and dependability here Reflection by the researcher seems to be less reliable tha reflection by others (at least if the reflections of the researche are intended for others) By giving their views, others hel to look at the data from various sides and from different view points and thus justice is done to the object

A fifth point supporting reflection is the difference betwee "empirical observation" and "measuring" The evaluato must operate not only as a mentor of the "measuring guild" for, as in the natural sciences, a great deal of knowledge i obtained purely from observations and experiences This cer tainly holds for children learning mathematical concepts

A sixth point is based on the idea that one can arrive a different kinds of truth via different senses [Von Glasersfel & Cobb, 1983]

All these factors indicate how important it is to *reflect* o the observations of a research situation

5. Weighing and harmonising research designs and methods

The weighing procedure inherent in the Münchhause metaphor in fact involves the normative aspect of suitabl methods: what is feasible, what is not? What criteria are bein applied and do they fit the research methods used? There ar in addition many reasons for carrying out an investigatior each of which requires so many different techniques

The researcher/designer wants to make something Thi means "improving" a product But he may also want t "sell" the product, or to proceed with theory forming Va ious methods are appropriate in these different starting sit ations If the aim is product improvement then criteria fro outside are less important than if the aim is to sell a produc to teachers and others In the latter case the opinion of othe plays a decisive role

The formulation of theory also requires special method Principles of research may then be involved, e g if one op for "mutual" research situations in which the test-subje is considered as observing the test-leader — a situation n encountered in scientific research

These mutual research situations are characteristic of educ tional research and are objective in the sense of Smaling, b they have consequences for the way in which the researc is conducted Where there is mutual observation (see se

tion 7), for instance, the functions and the authority of test-subject and researcher change continuously. This fits with the Münchhausen metaphor, but the researcher must keep the situation under control and find out to what extent he wishes to let the role of the test-subject change. He should report on this. (The role of the researcher in research processes can be determined in various ways; for instance, you can check how often he speaks compared to the test-subject or you can consider the assessments of various researchers.)

Another example to clarify "mutual research situations" in which the test-subject's authority is obvious is to invite children to play as arithmetic book authors. In their books we have to look for adequate criteria the "authors" brought in so that our results can not only be based on our preconceived categories.

One of the reasons why the weighing and harmonising of methods of educational research has become *possible* is that the educational field is an inexhaustible source of new original methods and techniques. Various examples can be given of the way in which teaching can inspire new research methods. We shall return to this point later (see section 7). However, a more fundamental question in this connection is whether research methods can in fact be devised independently of teaching.

As was shown above, the weighing and harmonisation of methods is a consequence of the standpoint of the use of different research methods because they emphasise different aspects of the striving for objectivity. Another question that arises in this connection is whether an interpretation of one method fits in with an interpretation derived from another method.

6. Reduction of data

In conversation with children new points are continually arising. The problem is how to reduce all these data. Should one choose one item only and ignore the rest? Some practical solutions are given below:

- Interpret the data *at home* — allowing some time for reflection.
- *Ask the teacher* for a commentary on the conclusions and observations made by the researcher. In this way you do justice to the object. It gives indications how the reduction can be tackled. The difference between recording something and interpreting it is primarily a journalistic problem in which the ideas of all the participants must be taken into account.
- *Go through* the data repeatedly in order to create a collection of criteria by which to record the frequency of phenomena [Van den Brink, 1987].
- Attempt to *link* observed behaviours [Siemon, 1988].

7. Intensive research methods and techniques

The Münchhausen metaphor is attractive in reference to educational research. But how do you get a number of different but interesting "ice-floes" as mentioned earlier? A practical solution is to regard the educational field as a source from which the researcher can draw techniques. This solution makes the researcher a slightly less distant figure. There is a wealth of research plans, methods and techniques which are inspired by classroom practice. We give an overview of these together with a short explanation and some comments.

Research designs and methods

Contexts of various kinds can be regarded as research situations. Donaldson [1979] demonstrated that when children were playing with toys they got higher scores on Piaget phenomena than when they were in an official test context; they were in a better position to interpret the situation.

Playing at exchanging roles is another good idea: pupils ask the test-leader to perform certain tasks — instead of vice versa. Similar play-situations can be created with the help of equipment. For instance, a role-exchanging question-and-answer game between child and computer about "neighbour-sums" can fire the children's imagination.

Balacheff [1985] deliberately created *conflict situations* involving geometrical problems in order to find how a class of children learned mathematics; he called these conflicts "socio-conflicts", following Brousseau. Bell [1983] organised what he called conflict-discussions after every arithmetic lesson in senior classes.

In research into the way in which young children do arithmetic we have used mathematical properties such as one-to-one-correspondence, invariance of quantities and magnitudes, etc. to create conflict situations in arithmetic. Situations of this kind can serve as an excellent basis for research.

Teaching can stimulate us to create *meaningful* research situations which are "genuine" for children. For example, pupils of one class can write arithmetic books for the use of pupils joining that class in the following school-year, or pupils can write a letter to an ill pupil about the lesson(s) he has missed and try to help him catch up [Ellerton, 1987 and Ellerton, 1988]. There are research situations that fit into the world of children and which stimulate them into being creative.

The research techniques must be in a research context which is also meaningful for children. The researcher must see to that. You do not achieve such a context merely by asking someone to speak aloud or by devising a task for the test-leader. You have to find appropriate contexts. Socio-cultural factors are of primary importance [Bauersfeld, 1983; Crawford, 1988].

On the other hand, it is essential to describe the methods accurately. For instance, when children write arithmetic books the children's personal involvement is a basic factor. That should be mentioned. Perhaps such a technique is only suitable for certain pupils? All the pros and cons should be mentioned.

Methods of observing and recording

Teacher's perspective

If the teacher gives a lesson, e.g. about calculators, and holds a video camera under his arm, then he creates a research situation which makes it possible to study pupils from the viewpoint of the teacher [Van den Brink, 1986]. Such a situation improves the quality of the recording: important but lost moments during the lesson can still be registered if the teacher pretends he did not hear the pupil's answer and then re-records the scene when the pupil repeats her answer.

The method of *mutual observation* [Van den Brink, 1981] is a significant extension of the clinical interview. The method has a dual function: the test-leader becomes an open book for the test-subject, he gives his own interpretations of the behaviour of the test-subject and the test-subject can react to these interpretations. The idea is that mutual observation is a way of making a more detailed study of metacognition *via* the exchanging of roles.

Van Eerde and Van den Berg (1988) let pupils engage in "self-observation" by showing them their own solutions again and letting them think about them. The authors call this *bespiegelen*, by which they mean "looking at oneself in a mirror".

Freudenthal demonstrated that more can be deduced from discussions *between test-subjects* than from discussion between the test-leader and the test-subject.

Activity participating observations and *thinking aloud* are generally recognised and accepted methods of intensive research.

Anthropologists use *field notes*. These are rather like memos.

Within the framework of the reading of verbal tasks in arithmetic *eye movements* have been recorded [Verschaffel, 1988]. The technique is to be regarded as a supplement to verbal reporting. A pupil never tells the entire solution; eye movements therefore give extra information. On the other hand, the use of this method brings many of its shortcomings to light: eye movements are exceptionally difficult to interpret; the technique imposes physical constraints on the children and can only be used in conjunction with short tasks.

Interviews and observations spaced out *over long periods of time* are an excellent way of showing children's development and for the researcher they are an important source of knowledge about children's notions [Streefland, 1988].

Another method is *systematic dialogue* [Nelissen, 1987]. Here is an example of an investigation in which children are confronted with an open mathematical problem:

> Gerard and Jasper have both worked for half an hour in their gardens. In that time Gerard has cut half of his lawn but in the same time Jasper has cut only a quarter of his. Who has done more work?
>
> Most children are inclined to say "Gerard" spontaneously. The test-leader then says: "What you say is possible of course, it's not wrong, but think again — there's another possibility".

The child may well solve the problem immediately. The test-leader then asks the child why he solved the problem that way, etc.

Interesting remarks can be made about *interviewing children*. Children can do sums correctly or incorrectly. But what does this tell us? Asking the pupil seems to be a suitable way of finding out the method of solving the problem. But continual questioning gives rise to irritation. The pupil cannot see the sense of all this questioning. And how far can you do justice to the pupil's answer if you already know a great deal about the subject-matter? Perhaps you're surprised that there is another way of reasoning. Then you must show your surprise during the interview.

There are always children who tackle problems in an unorthodox manner. *Protocols* showing how children work provide clues for diagnoses and remedies. However, little attention is generally given to the analytical side of the protocol. What was the researcher's objective? Did he want to examine several protocols of one pupil or did he want to study protocols in relation to various criteria, or study them in a different order? Or was he interested in protocols relating to comparable learning processes? What were the circumstances in which the protocols were made? Can one make different analyses of the same protocols?

The protocol is a way of considerably reducing a situation. What, for instance, is the meaning of the word "conversation" as used in the protocol? Is it really a lively conversation involving a wide variety of intonations, turns of phrase, etc ? Is the form reflected accurately in the protocol? And of course, it's not possible to deal with children's misunderstandings once they have been recorded in the protocols. These examples of pros and cons of intensive research designs, methods and techniques which are inspired by classroom teaching, certainly do not give a complete picture of current thinking on such matters. Questions of "purpose" or "benefit", for example, have not been mentioned yet. Nor were the possibilities of restraining the researcher from getting into a self-confirming cycle of activity in which he or she only pleases him or herself. What I have reported in this paper is only a beginning.

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