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Improving Pupil Performance in Mathematical Problem Solving: An Example of Classroom-Based Research

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ABSTRACT

Classroom-based research is seen as a natural growth of the conscientious teachers' normal teaching activities: a conscious effort to find alternative ways of teaching and a systematic and objective approach to their verification. It is proposed that the concept of sampling is fundamental to the issue between traditional and action research. It is argued that a re-orientation to sampling-over-time-at-one-spot rather than sampling-over-space-at-one-point-of-time may lend localized educational research with greater relevance to the teachers' concerns for what happens in their classrooms. An example of how a primary school teacher used classroom-based research to improve pupil performance in Mathematics is illustrated. Key words: Singapore, Action Research, Mathematics Education, Classroom-based Research.

Action or Research?

Research means different things to different people, but action research is the same thing given different names. It has been labelled as applied educational research, classroom inquiry, teacher-based action research, classroom-based action research, teacher-research, and school-based action research, etc. . Notwithstanding the subtle nuances, especially important to brand-conscious people, these labels all refer to the same attempt in involving teachers more actively in improving classroom practices and pupil performance and behaviours, through systematic planning, conscientious trying, and objective recording – with and without statistics.

The interest in teacher research based on problems they encounter in their classrooms grows naturally out of their desire for a better understanding of what they do and for a more effective way of doing what they have been doing. This interest is further strengthened by the disillusionment with traditional research which is supposedly non-action. This is clearly illustrated by the following quote from Hustle, Cassidy & Cuff (1986, p. 7) "There is no doubt that everyone with a direct interest in classroom teaching is disenchanted with traditional educational research."

While pointing out that there is a broad agreement on the irrelevance of traditional educational research and the need for a more direct, pointed research, these authors also stress the lack of certainty on what has been dubbed 'action research'. They go further to raise some pertinent issues which include:

- Is it more a question of 'action' rather than 'research'? Can 'action' and 'research' be combined?
- How can teachers be involved?
- What methods are available? Are they valid?
- Has traditional research nothing to offer?
- Can any use be made of extant published materials?

It is doubtful if such issues will ever be resolved to everybody's satisfaction and their discussion is obviously beyond the scope of this paper, which is an attempt to show by a real example how a teacher tried to improve pupils' performance in solving problem sums in her Mathematics lessons. Comparison will then be made between teaching and research and possible actions will then be suggested.

The disillusionment with traditional research has a history of more than ten years and action research is therefore not something new, though it is still very much fashionable to talk about it. The disillusionment has led to the search for alternatives to the physical science and agriculture models favoured mainly by psychology-oriented educational researchers. Several alternatives have been proposed and tried with much fervency; these include the all too familiar illuminative research, naturalistic inquiry, ethnographic research, anthropological research, case study research, and qualitative research (Schibeci & Grundy, 1987).

While much of the discussion on the alternatives has focused on the 'richness' (and therefore the presumed usefulness) of qualitative information vis-a-vis the 'hardness' (and therefore the assumed limitations) of quantitative data, such discussion seems to have missed a fundamental point, that of sampling. Of necessity and by tradition, educational research attempts at the so-called representative sample, in the survey research sense. Geographical locations are uppermost in the mind of the traditional researcher when he samples; in other words, sampling of space at one point of time is the main concern. While this has its value in policy-oriented evaluation research, the usefulness of the research outcomes when one tries to particularize (say, in a school) is always disappointing; this seems to be the root of the disillusionment with traditional research.

A school exists in one geographical location and it exists over a period of time, normally without much perceivable changes in its characteristics in terms of its pupils, staff, and social and physical environment. In short, the educational ecology of a particular school is relatively stable. And, schools are different. This is one reason, perhaps the main one, that sampling-over-space research does not help any particular school; to be fair, it is not intended to be so in the first place as it was conceived for a different purpose.

Since a school enjoys a considerable degree of ecological stability in its educational environment, it may make better sense for research to be based on sampling-over-time-at-a-spot, if it is to be of relevance to the particular school. This means the same study can be repeated with several cohorts of pupils presumably with similar characteristics over a few years, thus accumulating findings for, if necessary, building a school-based theory for a particular curricular endeavour, teaching procedure, or guidance programme. The need to shift the focus from 'universal' to 'local' theories has been urged by Cronbach (1975) and recently further explicated by Schibeci & Grundy (1987).

Nevertheless, to concentrate on 'localized' research within a school or even a classroom to the negligence of the traditional sampling-over-space-at-one-point-of-time research is to throw away the baby with the bath water. This perhaps could be avoided by having many schools doing the same study on a particular problem of common interest by using the same data collection methods and research design. The findings will be of direct relevance and usefulness to each participating school. The findings of different schools could then be integrated through meta-analysis (Glass, McGaw & Smith, 1981) which allows the investigation of contributing background factors, thus enabling theory building, if so desired.

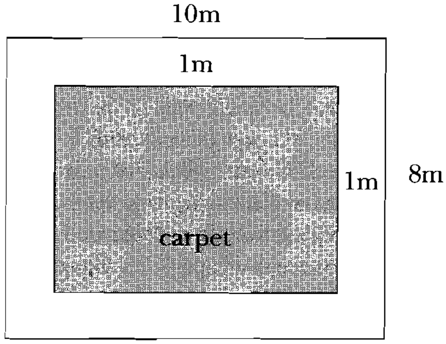
So much on the disillusion; now, a vision of possible actions.

Actions Taken

What can I do to improve my pupils' problem-solving performance in Mathematics? This is a question that keeps ringing in the minds of many conscientious Maths teachers and so it did in the mind of Miss Chiang, too. Miss Chiang who participated in a course on classroom-based research methodology decided to try out her ideas and see whether they would work. She first gave an intact class of forty Primary 5 pupils this problem sum to work on:

> A room is 10m long and 8m wide. A carpet is placed on the floor of the room, leaving a space of 1m wide all around it. Find the area of the part of the floor that is not covered by the carpet.

Of the forty pupils who tried this problem sum, only nineteen (47.5%) got it right – obviously not an impressive outcome. Miss Chiang then asked herself: If I were to present the same problem with a diagram, would it help? So a week later, she asked the same class to try the same problem, but this time with the diagram as shown below. To Miss Chiang's delight, this time, thirty-two (80.0%) of the class got it right. In other words, by using the diagram, she was able to raise the pupils' performance by 32.5% (i.e., 80.0% – 47.5%).



After some discussion, it was realized that two questions of interpretation may arise. First, the increase of 32.5% might have happened by chance and does not represent a real improvement. This was checked quite easily by drawing a table showing the numbers of pupils passing and failing on the two occasions. Then, the z-value for checking the difference between two proportions from the same group was calculated as 3.606, which indicated that the increase was rather unlikely the result of chance. This, of course, was very encouraging.

		With diagram		
		Fail	Pass	Total
Without diagram	Pass	0	19	19 (47.5%)
	Fail	8	13	21
	Total	8	32 (80.0%)	40

The other question of interpretation has to do with the design of the study. Since the pupils tried the problem twice, though with one week in between, would it not be possible that the increase was due to practice effect, testing effect, or some other condition that favoured the second testing? How can this interpretation problem (typical of the single group pre-and-post-test design) be avoided in the future?

Having been encouraged by the first study, Miss Chiang tried her hand at another attempt to improve her pupils' performance in Maths problem-solving in another way. This time she asked, Would there be a difference if I ask a few questions to guide the pupils in thinking through the problem? She used the problem below to check on this idea:

> The average mark of 10 pupils taking an examination was 70. What would be the average mark if one pupil who got 88 marks was absent?

Now that she has become more research-wise, she avoided the second interpretation problem by using two comparable groups. The *Guided* group of twenty pupils, before trying, were asked questions on what was given and what was being looked for. The *Unguided* group of twenty-one pupils were simply asked to do the sum. The results were again rather encouraging:

	Unguided	Guided	Total
Pass	9	16	25
Fail	12	4	16
Total	21	20	41

Thus, 80.0% of the *Guided* group was able to solve the problem as compared with only 42.9% of the *Unguided* group, with a difference of 37.1% suggesting that preliminary guidance through discussion did help. To check whether this difference occurred by chance, the chi-square test was used and the value of 5.939 indicated that this difference could be taken with much confidence.

These show how a thinking teacher can make her teaching more rewarding to herself, her pupils and, of course, the school. Is what Miss Chiang did very different from 'normal' teaching? How close was it to what one would call 'research'?

Classroom-Based Research

By convention, educational research has been largely if not exclusively done by outsiders — commissioned research bodies, education authorities, university and college lecturers, and postgraduate students. This has led to the unsatisfactory situation of irrelevance of educational research as seen by those most intimately close to education — teachers in the classroom. This unhappy state is emphatically (or pathetically?) described by Cassidy (1985, p.133): ". . . much professional pedagogic research is undeniably of little direct use to the teachers . . . findings which are either so specific as to seem banal, or at a level of generality which seems hopelessly remote from the teacher's everyday experience."

The situation described above also leads to a divisive compartmentalization between the *we* (the insiders, teachers who are frequently bothered by the researchers) and *they* (the outsiders, researchers who frequently bother the teachers.) Thus, teachers as research-users find very little that they can use and the researchers produce a lot that the teachers cannot use.

However, the artificiality of the insider-outsider division can be clearly seen if *teaching* and *researching* are compared and contrasted.

Teachers may not realize that whenever they teach in the classroom they are in a very real sense *experimenting*, though without documenting. This is so because, first, they cannot be perfectly sure that teaching will bring about the desired learning outcome; in other words, the desired outcome is *probable* rather than *determined* – a question of more or less and not all or none. Secondly, perhaps due to their heavy schedule, teachers may not have the habit of reflecting on what they have done in the day. Thirdly, teacher education programmes typically are more concerned with developing a set of teaching skills than with developing a set of skills to develop teaching ability; the latter concern definitely calls for the development of the habit and skills in reflecting one's own actions and some form of proper documentation (again, with and without statistics). The recent movement of classroom-based teacher action research is obviously a conscious effort to redress this problem of sufficiency.

The tenet here is that teachers can easily become classroom-based teacher-researchers with one step beyond what they have been doing all this while. The action taken by Miss Chiang to improve pupil performance in Maths problem-solving is a good example of what every teacher can do with a little extra effort to reflect and document. Admittedly, in the beginning, some form of familiarization with practical research skills and occasional discussion with an 'outsider' may be necessary, but these seem to be all that would be needed.

A similar idea of 'insider research' has been made explicit by Ebbutt (1985) in his classification of a range of activities then occurring in schools in England. He contrasted the usual Teaching Mode (A) and the traditional Teacher-Research Mode (E), with three other shades in between. What turns teachers into teacher-researchers is the practice of systematic data collection and analysis to verify or falsify hypotheses and writing reports that are open to critiques. This may look formidable to the uninitiated, but all it says in plain English is, for checking on a teaching idea, properly record the pupils' behaviours and test marks, scrutinize the outcomes objectively, and seek the views of fellow-teachers with similar or identical interests.

More Actions, Please

It is a truism that the best way to learn is to teach. And, therefore, the best way to learn about the effects of different ways of teaching is to teach in ways that are different. This, of course, means action research (or classroom-based research, etc.). This spirit of continuously searching for the more effective ways to teach is aptly described by Britton (1987, p. 16), "As researchers, then, and as teachers and human beings, we are in the business of learning by experiment."

What then can we as teacher-researchers do, say for example, in problem-solving in Mathematics lessons? We need to work on the possible and the practical. What are these, then?

There are several sets of variables related to problem-solving in Mathematics. First, some of these call for long-term theoretical or basic research which are beyond the province of classroom teaching, for instance, research into thinking skills and information processing. Then, there is the curriculum aspects of selecting, sequencing, and presenting problems for solving; this is best left to curriculum developers as it takes time to design a syllabus and to compile a textbook, and teachers always have to take the given of the curriculum. Of course, pupils' home background and life experience and even pupil gender may have a bearing on their problem-solving in Mathematics lessons; knowing research findings in this regard may help teachers avoid aggravating pupils' difficulties in problem-solving, but that is about all it does. What is there, then, left for teacher-researchers to do?

Beyond thinking, curriculum, and pupils, there is a host of what can be broadly termed 'situational variables' on which teacher-researchers can try as a means of improving pupil performance in problem-solving in Mathematics. Some possible starting points are shown below and thinking teachers are able to add to the list:

- Teach 'mathematical language';
- Active participation of pupils (Pratton & Hales, 1986);
- Personalize the problems (Wright & Wright, 1986);
- Review related concepts and operations;
- Use of diagrams;
- Guiding questions;
- Re-phrase and simplify the language of the problems;
- Cooperative problem-solving (Sherman & Thomas, 1986).

These are apparently 'peripheral' and may not be all specific to problem-solving in Mathematics. They are, however, situational 'ingredients' of learning which may have an effect on pupils' performance. They help to prepare the pupils for the problem-solving tasks ahead and thus better equip the pupils both cognitively and emotionally.

In sum, this paper suggests that teachers interested in improving their pupils' performance through small-scale research need only to take one step beyond what they normally do. A Think-Try-Check (TTC) approach to classroom-based research may not solve all problems all the time, but it definitely will help the teacher-researchers in grappling with some of the problems some of the time, and this is what the probabilistic (as compared with the deterministic) view of teaching is about. And we call this classroom-based research, etc.

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