GAINING INSIGHTS BY COMPARING PROCESSES

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Starting with apparently unrelated ideas and making connections between them by looking for similarities and differences is one way of gaining insights. In this paper some ideas that are compared are:

mathematical problem solving,
professional development,
research, and
assessment.

The cycles that can be used to summarise these processes are compared, some of the steps of the cycles that are neglected are discussed, and examples of insights that affect assessment are considered as examples of those that might be gained by comparing the processes.

INTRODUCTION

I subscribe to a constructivist view of learning and realize from this theory and from my own experience that topics are often compartmentalized in our minds rather than integrated. As a general aim I would want teachers and students to have a more integrated view of related topics and this paper is one attempt to try to integrate topics. From a mathematics education viewpoint I would want both teachers and learners to make sense of their world and enrich their view of it by seeing it from a mathematical perspective.

At present I am involved in a range of activities in mathematics education including research, professional development and assessment. In this situation I was reading a book by Eisner (1985) on evaluation and this triggered some connections between assessment and research. As I played with these ideas more links quickly emerged both between these two processes and problem solving and professional development. At about the same time I had read an article about the power of metaphor (Knight, in press) and was thinking that perhaps these four processes had a metaphorical relationship. Whether the four were related as metaphors or whether they were aspects of a general cycle was not critical and although I finally did conclude they were examples of the same general process, the insights that emerged were the important facts.

Another reason that emerged for comparing these processes is to attempt to break down barriers for teachers involved in research by making connections between their research role and aspects of their teaching. My hope here is to make the research work seem less intimidating to them.

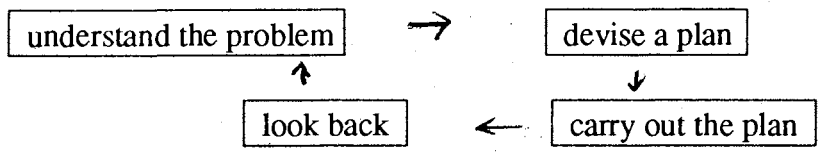
A further intention is to show traditional teachers that when they asked students to "problem-solve" they were asking them to be involved in the sort of task that they as teachers were very familiar with, rather than something that seemed very new. The obvious difference in context remains but I think that looking at similarities would reduce teacher anxieties.

FOUR COMMON PROCESS CYCLES

The four processes I compared were problem solving, professional development, research and assessment. At the start I looked at each separately and jotted down the steps, these are briefly outlined here.

1. Problem-Solving Cycle

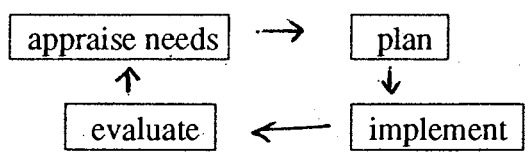
This summary of mathematical problem solving is linked to Polya's work (1957) but other problem solving cycles are similar.



- Understand the problem: What is the unknown? What are the data? What is the condition?
- Devise a plan: Have you seen it before? Do you know a related problem? Look at the unknown.
- Carry out the plan: Carry out the plan and check each step.
- Look back: Can you check the result? Can you check the argument? Can you derive the result differently? If no solution is obtained then start the cycle again and consider alternative procedures.

2. Professional Development Cycle

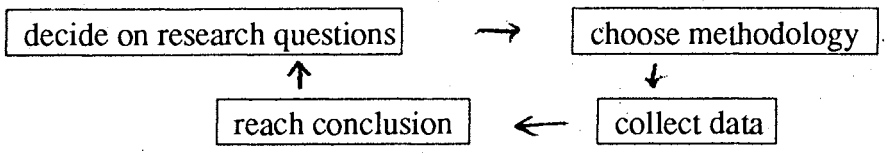
Professional development (inservice education, staff development, school development) is an ongoing part of school life and has often been regarded as having four parts that can be summarised by this cycle:



- Appraise needs: What are the professional development needs of the school, the department, and the individual staff members? What is the purpose for such development? Do the purposes fit within the school's policies and guidelines?
- Plan: How might these needs best be met?, What models are available? What opportunities exist? What needs to be organised?
- Implement: Implement the professional development activities.
- Evaluate: Were the activities successful in terms of the desired changes? What more needs to be done?

3. Research Cycle

Research can take many forms. The stages of traditional positivist research can be represented on a similar cycle although deciding on the research questions often involves a considerable exploratory stage, these stages are given as:



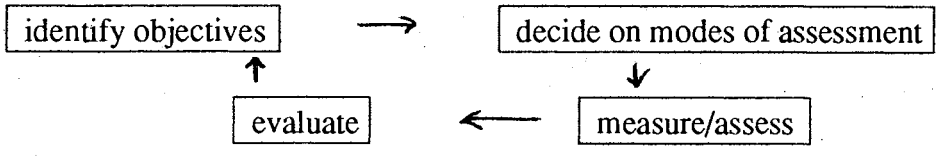
- Decide on research questions: What are the research questions or the research area to be explored? What are the limitations and context of the proposed programme? What does the literature say?
- Choose methodology: What research methodology would be appropriate? What is the time scale for the project?
- Collect data: Gather the information.
- Reach conclusion: Summarise the results, draw conclusions from them, how can the findings be disseminated, what further research needs to be done in this area?

Often the research starts in different ways. For example, experiences might lead to conclusions which then might lead to a decision to begin some more formal research. Action research is one particular form of research where there is more stress on the cyclic nature of the process but the stages are similar for most research programmes. In the case of critical inquiry the cycle — reflect, plan, act, observe — is virtually the same (Kemmis and McTaggart, 1988). Interestingly action research is viewed by some (Cohen & Manion, 1989) as a form of policy implementation and teacher development as much as it is research.

Another example related to research is the research-development process where the research cycle is followed by a similar development cycle.

4. Assessment Cycle

The process of assessment, in a similar way can be summarised with the following cycle:



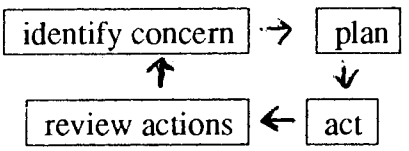
- Identify objectives: What is to be assessed? What is the purpose of the assessment? Is it for diagnostic, formative or summative purposes? How will the information be used?
- Decide on modes of assessment: What assessment modes and tasks might be used to get the information? Design appropriate activities.

- Measure/assess: Administer the assessment activities.

- Evaluate: Make evaluative judgements from the assessment data. Make decisions on the action to be taken with respect to the unit of work, the programme as a whole, the learner, or the reporting procedure.

A GENERAL CYCLE

The four cycles described above have many similarities and some differences, they can be summarised with one cycle:



Being cyclic, any of the stages might be the starting point although traditionally in mathematics we start with a problem.

- Identify concern : Both the content and context of the concern are considered with one important aspects of context being reason or purpose.

- Plan: A range of models and strategies need to be considered in terms of whether they are likely to be useful in the particular situation.

- Act: The action stage is often the comparatively easy stage if good planning has preceded it.

- Review actions: This stage is concerned with evaluation, possibly reporting, and making decisions about the next steps.

A general cycle like this fits a number of different situations. For example, if one is trying to negotiate a curriculum (EQUALS, 1989) then one works through four steps – decide on aims, agree on tasks, produce, assess – in a similar cyclic process. Other tasks it can be used for are teaching at the macro level (looking at a year's work), teaching at the micro level (looking at an individual lesson), resource development, and curriculum development.

The cycle could be regarded as the basis of a life-skills programme if we intend to encourage learners to approach challenges systematically.

SOME INSIGHTS AFFECTING ASSESSMENT

By comparing any two of the processes and looking for similarities and differences one might expect to see things in different ways and gain new understandings. I have selected some examples of insights that might be gained when one looks at each process alongside assessment. I chose this one as I was currently working in this area but I am sure that similar insights would be gained by comparing the processes in other combinations.

In problem solving we know that numerous strategies at different levels of sophistication can be used to solve a problem. Calvin Long (1991) presented a good example of this: A farmer knows he has chickens and pigs in the farmyard. He knows that there are 100 animals and 224 legs. How many chickens and how many pigs does he have? This problem can be solved by guess and check, by looking for a pattern, by drawing a diagram (imagine 224 legs pictured as 112 pairs, and then link pairs until one gets only 100 animals), by using a simple equation, by using simultaneous equations, or by more logical and creative methods (such as asking all the animals to stand on 2 legs and raise their other two, 100 animals implies 200 legs on the ground, 24 in the air, therefore 12 pigs). With assessment many teachers often use a limited repertoire of traditional methods rather than considering a whole range of interesting and creative possibilities.

Professional development does not assume that all people have the same needs and starts with an appraisal of needs to decide whether the focus should be beginning teachers, heads of department, school improvement, or the implementation of a new curriculum or whatever. Usually the decision is made that a number of alternatives need to be offered to cater for the range of needs. I see little evidence of the acceptance that students have different assessment needs. We remember Cockcroft's seven-year ability range (DES, 1982) when it suits us, we know (Department of Education, 1988) that essay questions probably favour girls, multichoice seems to favour boys, some groups (such as Polynesians) prefer cooperative activities rather than individualistic tasks, and some students are not good readers or writers, yet the choice of assessment activities rarely takes this range of needs into consideration.

Research methods can be qualitative or quantitative and within each of these paradigms a range of methods exist but in particular in the reporting phase with quantitative results we usually use numbers (statistics) while with qualitative results we are more likely to use the results to tell a story. Even with quantitative work we usually write a report to interpret the statistical data into the context of the original problem and we see our numbers as a tool for the work rather than as the product. In assessment in mathematics we seem to get bogged down with marks - as if 47% meant anything more accurate than somewhere between 40% and 55% or a C, when in fact a sentence or two of constructive remarks might be a more suitable way of providing feedback.

NEGLECTED AREAS

Other insights this comparison gives us concerns the identification of areas of neglect.

With the problem-solving cycle we know that traditionally the emphasis has been given to the "act" step - implementation of a given strategy to a particular problem (drill & practice) while other steps have been neglected. Curriculum developers stressed the need to build up the "planning" stage in terms of having a range of strategies and systematically considering which are appropriate, as well as broadening the range of concerns by presenting challenges that relate to the real world rather than merely textbook type exercises. The review stage becomes more important when the question is broadened and when multiple solutions begin to emerge.

With professional development (Begg, 1992) often little time is given to identifying the concern (needs appraisal? the content and the context of the development? who is it for? the expected outcomes?) Similarly planning often makes assumptions about a model for

development instead of realizing that different ones are useful for different reasons and that by considering the factors that make professional development more effective, models may be modified to better suit a situation. Instead, a concern is voiced and a one-day course is provided in spite of our knowing that it is unlikely to cause any change in teacher behaviour and very little evaluation occurs, and when it does little use is made of the information that is collected.

Some years ago most academic research, in particular for higher degrees, was done in the quantitative paradigm and it has taken a considerable time for the consideration of the models to be expanded to include the qualitative methods where the review stage is told as a story rather than as the summary of statistics. One neglected aspect of the review stage with educational research is the reporting/dissemination to the important teacher and development groups rather than limiting this to research reports and journals that are likely only to be read by other researchers. Another area of neglect is when decisions are made about methodology and techniques of EDA (exploratory data analysis) are not considered when statistics are being used. EDA methods seem to fit both with exploratory research and with research that combines aspects of qualitative and quantitative approaches.

In my experience with assessment, stage three (implementation) has been the main focus. Little consideration is given to the purpose for the assessment and whether the results are going to be used in a useful way. Most mathematics teachers use a limited number of assessment activities, and little is done in reporting conclusions in a constructive way to students. Perhaps if teachers look at the whole cycle a more balanced assessment might result.

WHO IS INVOLVED

In professional development the following questions are sometimes asked:

Who is deciding what professional development is needed?
Who is going to provide the professional development?
Who is expected to change?
Who will provide on-going support?

In research similar questions are asked:

Who is doing the research?
Who is involved in the researched?
Who is it for?
Who owns the data?

The answers to these "who" questions are partly answered when the need is stressed for teacher involvement in and ownership of all aspects of professional development (Begg, 1992) and similarly when collaboration is discussed in relation to research, particularly action research (Cohen & Manion, 1989). Certainly in both teacher development and research the questions are usually considered.

What about in problem solving? We often talk about the real world (real to whom?) where much problem solving is a group activity. Many problem-solving activities from groups such as EQUALS stress this need for cooperation. Sometimes we give the learners some say regarding the problems they choose, the people they work with, and the methods they

use, but as teachers we usually put limits for learner autonomy. It seems that the "who" questions are not given enough consideration.

From a constructivist viewpoint considerable work needs to be done regarding assessment and the roles of assessment may well be different with the different teaching strategies that might evolve. However we would expect assessment to still have a part in our programmes. Educationalists like Carl Rogers (1969) would suggest with experiential learning that the most important assessment is the informal self assessment that the learner does and with some teaching models based on constructivist theory I think we need to consider this idea. However I am not aware of much learner involvement regarding assessment. I would hope that learners are involved in both asking and answering these questions: whether assessment should occur? whether it should be formal or informal? whether it should be teacher, self, or group assessment? whether the results should be reported? and whether the results reflect the quality of the learning or the teaching? In the same way we have very little learner input when we evaluate our programmes? Perhaps we need to answer the "who" questions in assessment with more collaborative approaches too.

ALTERNATIVE MODELS

An alternative model for assessment was offered by Bill Barton at a workshop I recently attended (Barton, 1992) when the discussion on assessment was trying to break the emphasis on summative assessment and focus more on diagnostic and formative. This model seems to fit better with a constructivist view, it puts assessment (objectives, modes, assessment, evaluation) in a closer relationship to planning (curriculum, school scheme and resources), teaching and learning and these can be represented by the strands of a rope.

Applying this model to problem solving we have the strands of problem, strategies, and content links and the more able student often jumps steps because when these related aspects are viewed holistically, a way through the situation often seems obvious.

In professional development too the components of the cyclic process can be merged by the teacher who is constantly considering new ideas, integrating them into a personal framework and trialling them in class. This is more obvious with changes in content rather than changes in teaching style and is probably to do with the greater confidence of teachers in relation to the content of their teaching.

In research, in particular with the exploratory and qualitative research paradigm, a similar merging and interaction exists between the area of study, the methods and the data (and the resulting action in the case of action research or emancipatory research).

Using this rope model the insight for me is the "connectedness" which is something that with a reductionist view from our behavioural upbringing we seem to have lost .

CONCLUSIONS

The similarities between these activities are not surprising as all of them have aspects of a "problem to be solved", consequently the problem-solving cyclic model based (not necessarily mathematical problem solving) for all these processes seems appropriate for the novice and the connected model (the rope) for the expert.

I know that I have regarded these activities as being different and have obtained a richer view by looking at them together both in terms of the components with the cyclic model and holistically with the rope model. Perhaps students need help in making these connections and we need to stress the similarities rather than the differences. The benefits gained by reflection on them should be challenging but not threatening as each person will be integrating their own existing ideas with some less familiar ones.

I am not implying that a general theory exists for these activities as many differences exist between them and a study of the contrasts will similarly provide insights to our students. Perhaps the message is summed up in the familiar assessment task: "Compare and contrast ..."

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