THE PSYCHOLOGY OF PROBLEM SOLVING AS A VEHICLE FOR THE ANALYSIS OF PROFESSIONAL DEVELOPMENT OF INSERVICE TEACHERS.

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*The main features of a professional development program for inservice teachers (**ITAM**) are described and a subset of the data from two case studies is presented to highlight some of the strategies used by teachers while undertaking the program. The case studies demonstrate an isomorphism between the stages of growth experienced by the teachers in the program and the four problem-solving phases popularised by Polya. These phases provide a useful framework to analyse the success or failure of inservice experiences and provide some guidelines for those designing professional development programs. This research also highlights the usefulness of using our knowledge of student growth in acquiring mathematics concepts to assist in our understanding of teacher growth.*

Pre-service teacher preparation courses can only provide, at the very best, a platform upon which future professional growth can occur. Learning to be an effective teacher requires an ongoing commitment to knowing more about teaching, subject matter and how students learn. Knowing ways to assist teachers to face the challenges of growth is an important focus for research. However, it often appears to be a poor relation to many of the major research thrusts in mathematics education.

There has been a noticeable trend in recent years to use understanding of how children learn mathematics to provide insights into the area of teacher professional development (Pegg 1989; Begg 1992; Rice 1992a, 1992b; Mousley 1992a, 1992b). Pegg (1989) used this philosphy in analysing mathematics lessons. He stated (p.19) that

> teachers of mathematics..... grow in acquiring competence in planning and presenting mathematics lessons in a manner similar to the ways in which students (in the classroom) grow in acquiring mathematical skills. Consequently, much of what we currently know about how to help students grow in their knowledge of mathematics is relevant and of use in helping teachers grow in becoming better mathematics educators.

Rice (1992, p.250) placed professional development in a consructivist context by arguing that

> ...if constructivist principals are to underpin mathematical learning environments for children, they should also provide the basis for professional development programs.

Mousley (1992) invoked the work of Voight in adapting the perception of teaching as 'negotiation' in describing a teacher development course. Similar frameworks were used to underpin a professional development program for secondary teachers at the University of New England, Armidale. The purpose of the program was twofold. First, to help teachers identify and confront issues or problems that they felt needed to be addressed, and second, to record and analyse how the teachers involved in the program acquired new skills and understandings. To assist in monitoring the process of development within the program a framework was borrowed from the problem-solving literature.

Following a brief overview of the program, and a description of the problem-solving framework used, it is the second of these issues, namely, the monitoring of the behaviours and thinking processes used by the teachers, on which this paper reports.

BACKGROUND

The professional development program is referred to as **ITAM** (Improving Teaching Approaches to Mathematics)(Pegg and Redden, 1991). It was developed by (i) identifying and trying to minimise many of the disadvantages of current inservice packages offered to teachers in country regions; and, (ii) building into the program additional features and perspectives that have been identified as valuable in the research literature. The program was

designed primarily for teachers in country areas who suffer from problems of isolation. This occurs not only in the practical sense of large distances between centres but also in the professional sense. Conducting inservice programs is difficult in these areas: the costs are proportionately much greater than in larger centres; the organisation is more difficult; fewer teachers from the schools can be involved; the issues covered are usually decided by persons outside the school; and, there is seldom any backup or long-term follow-up, i.e., most courses are simply 'one-day wonders' (Owen *et. al., 1987*).

ITAM attempted to minimise these problems by providing all teachers in a mathematics staff at a school with access to support for a full year on a problem or issue that the staff themselves had identified and wished to address. That is, the program incorporated the idea that teachers had to have not only ownership of the issue to be investigated, but also, the solution and the type of support required.

The physical aspects of the program are shown in Figure 1. Two teachers were selected from each school to act as the driving force or coordinators of the program for their school. They were referred to as the key group. The key groups from all the schools involved in the program met on two occasions for a two-day workshop. The whole mathematics staff also attended two meetings, referred to as collegial meetings, but these were out of school time. It was at these meetings that the staff from adjacent schools met to hear what others were doing and to report on their own decisions and progress. The University personnel organised and attended all meetings but their major role was as catalysts for change. This involved encouraging participants to reflect on the nature of change and providing methods of inducing and managing change. The methods discussed included pupil-centred, department-centred and curriculum-centred approaches. These approaches place emphasis on ownership of the issues identified and the processes used by the teachers. However, there was a second major issue which underpinned the thinking behind the program's development. It concerned the problem-solving nature of the whole exercise.

There has been a very large body of research undertaken into problem solving in schools. However, most of this has been directed at students. Further, a great deal of this work has revolved, in some form, about the ideas of Polya (1957) and, in particular, his four phases. Despite the generally favourable reception of these ideas, some writers have identified problems (see e.g., Schoenfeld, 1985). Nevertheless, it would appear that as long as the phases of Polya are seen as descriptive and not prescriptive, i.e., the phases are present in any problem-solving activity but a problem solver does not necessarily proceed in a step by step fashion through them, they represent an important vehicle to help describe and analyse behaviour.

The following discussion looks at the way two schools, which have taken part in the **ITAM** program, have proceeded. To assist with the analysis, the experiences of the staff will be considered within the framework offered by Polya's four phases, namely,

understanding the issue
developing a plan of attack
implementing the plan
reflecting back on the issue and the process.

School A

A department-centred approach was chosen initially to identify and *understand the issue* that was to be central to their **ITAM** project. Each member of the faculty was asked to submit five concerns to be placed on a common list. Using a modified Delphi technique, the items on this list were reduced to a central issue involving the "interest and motivation of students in the intermediate mathematics course", which became the focus of the project. [The intermediate course is a programme of study in Years 9 and 10 in NSW secondary schools. The target audience for this course is those students whose mathematics performance lies in the middle 50% of the cohort.]

The whole mathematics staff attended the first collegial meeting at which the key group presented a report on the problem identification process. However, when they were questioned by the rest of the participants at the meeting for clarification of the general issue, it became apparent that they had identified their problem only at the most global level. They were unable to be specific about the nature of the "interest and motivation of students in intermediate mathematics". They were unable, also, to identify any causes or elements of the problem. Because of this lack of clarity they were unable to plan any specific strategies for solving the problem. Rather their attempts at a solution plan were global and vague. That is, *developing a plan of attack* proved impossible. It became

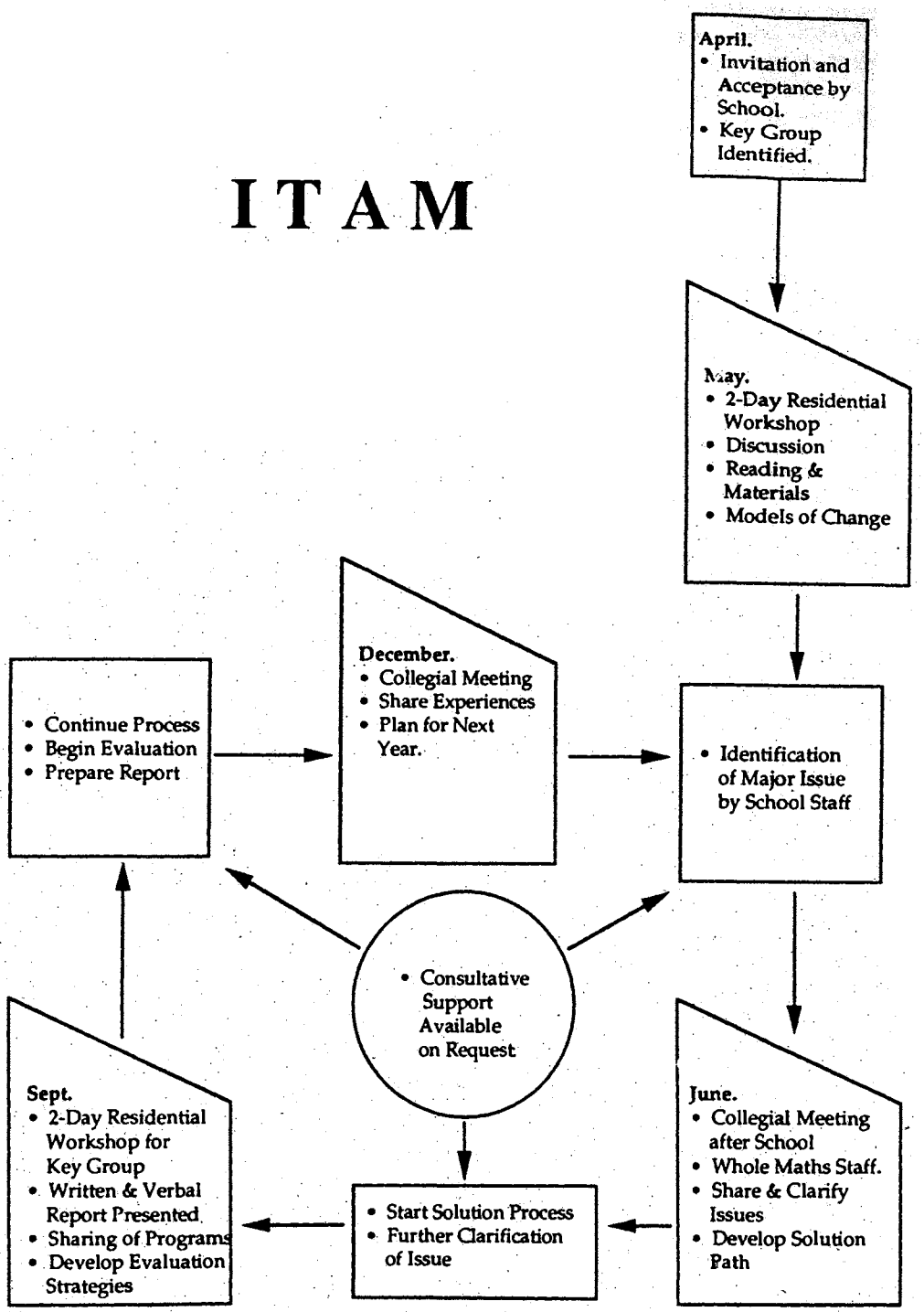
ITAM
April.
• Invitation and Acceptance by School.
• Key Group Identified.
May.
• 2-Day Residential Workshop
• Discussion
• Reading & Materials
• Models of Change
• Identification of Major Issue by School Staff
June.
• Collegial Meeting after School
• Whole Maths Staff.
• Share & Clarify Issues
• Develop Solution Path
• Start Solution Process
• Further Clarification of Issue
Sept.
• 2-Day Residential Workshop for Key Group
• Written & Verbal Report Presented
• Sharing of Programs
• Develop Evaluation Strategies
• Continue Process
• Begin Evaluation
• Prepare Report
December.
• Collegial Meeting
• Share Experiences
• Plan for Next Year.
• Consultative Support Available on Request

Figure 1

evident that insufficient time and energy had been spent on phase one, *understanding the issue.* The staff were reflecting the behaviour of many students when confronted with non-routine problems. They were tending to rush towards Polya's third phase, *implementing the plan,* without adequate preparatory work.

To address this problem it was decided to return to phase 1 to find out what the issue really involved. A three-pronged attack was decided upon which consisted of surveying and interviewing past and present students and conducting a staff survey. These surveys identified four specific issues of importance to students and ten specific possible changes that the staff believed would improve the "interest and motivation" of students in the targeted mathematics course. The ten changes were broadly based and focused on using community resources, changing teaching organisation, content changes, class restructuring, excursions and the incorporation of technology. The time spent collecting data to better *understand the issue* had a number of benefits which were appreciated by the staff. A much clearer focus was identified and a greater staff commitment to the project was noticed.

Before the project was completed School A was confronted with a major structural change that was imposed on it from an external source. The mathematics staff reacted to this change in an interesting way. First, they felt such commitment to their original project that they continued *implementing the plan* despite the external forces. Second, they were able to apply the skills gained during the **ITAM** program to react to the new situation positively and in a constructive way.

School B

The key group of School B reacted in a much more 'open' way to the invitation to identify a problem to be addressed within the context of **ITAM**. They adopted a pupil-centred approach initially, in an attempt to ascertain childrens' perceptions of mathematics at their school. The methodology adopted was for every mathematics student to keep a diary of his/her mathematics lessons for a period of one week. Analysis of these diaries led to the formulation of four hypotheses about students' perceptions of mathematics and mathematics lessons. While these were not particularly original ideas, the fact that they were generated within the school gave them added importance in the eyes of the teachers and, hence, a greater commitment to instituting a program of change to address the issues identified.

Then, students were surveyed in an attempt to confirm or reject these hypotheses and to investigate if these views were consistently held within the student body. Additional surveys of parents and teachers were conducted to gain further data. Of interest is the great amount of effort that the mathematics staff put into *understanding the issue* prior to embarking on a solution strategy. It is clear that the value of this thoroughness is evidenced in a number of aspects. They include a strong commitment to the project by the whole staff and clear support shown by the school executive. Further, a clear understanding of the problem facilitates the *development of a plan of attack* for solving the identified issue.

The *plan of attack* involved the formulation of three aims which were addressed by adopting a changed approach to both lesson structure and assessment. The lesson structures were changed to incorporate problem solving as a mechanism for introducing and developing concepts. That is, teaching *through* problem solving rather than the more traditional teaching *about* or *for* problem solving was encouraged. The espoused philosophy of the staff was to "encourage students, through planned activities, to discover mathematical concepts for themselves and hence be encouraging the development of our students' feeling of ownership of their mathematics and coming to think of themselves as mathematicians rather than regurgitating machines." The adoption of problem solving as a philosophy underpinning the teaching process had implications for the school's traditional assessment procedures which had appeared to encourage rote learning.

As a consequence, assessment techniques that encouraged class participation and consideration of methods and procedures of problem solving by the students were introduced. The surveys had confirmed the importance that students and parents placed on formal assessment procedures that were recorded and reported to parents. Hence the staff ensured that attempts were made to quantify as many of the new criteria for assessment as possible.

The *implementing the plan* phase was an ongoing process requiring continual monitoring and modification. Polya's *reflecting back* phase became an ongoing evaluation process that identified new problems requiring new solutions. While School B's project had begun with a student-centred approach, the *reflecting back* phase had pointed to a set of structural problems within the school's administration and resource allocation policies. However, because of the long process that had preceded the identification of these new problems, there was substantial evidence for their existence and also a commitment for their resolution. The earlier part of the **ITAM** project had indeed become the *understand the issue* and *develop a plan of attack* phases for these latter issues.

IMPLICATIONS AND CONCLUSION

These two case studies provide an opportunity to consider some general issues in relation to the professional development of teachers.

- Time spent carefully identifying the issue, which may include collecting data, is critical in developing a greater understanding of the issue to be addressed. School A lacked a clear goal in their initial attempt at *developing a plan of attack* while School B's more thorough and considered analysis provided a clear view of how to proceed.
- It takes considerable time to move through the phases. Both schools spent seven months in the first two phases of *understanding the issue* and *developing a plan of attack.*
- Movement through the phases does not need to be linear as in the case of School B. School A's lack of initial success in developing a plan of attack indicated the need to return to the first phase.
- Within the context of **ITAM,** Polya's phases are not discrete but appear to provide the opportunity for ongoing development. This can happen in two ways. The *reflecting back* process provided the new issue for School B while School A was able to use the skills developed in the process to react to an issue generated from outside. Thus, while not having ownership of the issue initially, they had developed ownership of a process for handling such issues.

Polya's problem-solving phases provided a useful framework for analysing problems associated with teacher inservice and professional development. As with research observations with school children, the phases were descriptive rather than prescriptive. A too rigid adherence to step by step hierarchical phases in a short time frame will lead to a superficial treatment of an issue and not develop in teachers the skills necessary to support ongoing teacher growth.

This research has provided further evidence that using theoretical perspectives from children's learning is both valuable and appropriate for planning and reviewing teacher development programs.

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