Evaluating A Training Procedure for Problem Solving

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Taplin (1992) addresssed the notion of effective perseverance by exploring managerial strategies used by children in their attempts to solve mathematics problems. The focus was on those students who were termed "perseverers" because they reached a stage in their problem solution where they recognised that they had not reached a satisfactory answer and decided to take some action - start again, modify their strategies or change to different strategies rather than give up immediately. A model was developed which described the sequence of strategies used most consistently by successful students. This paper will describe the next stage of the project, investigating the application of this theoretical model to a teaching experiment. Evaluation of the instructional sequence is based primarily on observation, with comparisons being made between pre-treatment and post-treatment performances. The paper will focus particularly on evaluating teachers' perceptions of the model.

Introduction

Although a great deal has been written and debated about mathematics problem solving, it is still clear that there are difficulties associated with teaching people how to succeed at it. It has been argued that one way of addressing these difficulties is to learn more about managerial strategies used by successful problem solvers (Schoenfeld, 1985; Lester, 1985, McLeod, 1988). One of the managerial strategies related to problem solving is concerned with perseverance, in particular with spending time on task effectively, rather than giving up too soon because of not knowing what to do next, or "overpersevering" when it might be more efficient to use another strategy such as help seeking. There has been little attention paid to the question of how time is most effectively managed once a student has exhibited willingness to persevere with a task. Mason, Burton and Stacey (1987) caution that perseverance can be a hindrance if the problem solver persistently pursues the first idea which comes to mind. They emphasize the importance of reflective, flexible thinking, particularly in planning strategies to be used and in seeking insight or fresh ideas.

Taplin (1992) addressed this notion of effective perseverance by exploring managerial strategies used by children in their attempts to solve mathematics problems. The aim of her study was to investigate strategies used by persevering problem solvers. In particular it was concerned with identifying successful strategies used by perseverers, as opposed to ineffective strategies which may have been symptoms of "overpersevering" (Nelson-Le Gall and Scott-Jones, 1983). The study was based on the six-level paradigm developed by Uprichard and Engelhardt (1986). At the first stage of the investigation, reported in Taplin (in press), a comparison was made between the students who persevered with a problem and who were ultimately successful in their solutions and those who were unsuccessful or eventually gave up. A model was developed (Figure 1) which described the sequence of strategies used most consistently by successful students.

Figure 1: Model of problem solving strategy sequence commonly used by successful perseverers

(i) select first strategy
(ii) (if necessary) repeat the strategy 1-3 times
(iii) try a different approach
(iv) repeat from (i) if necessary

At the next level of the investigation a small scale training program, reported in Taplin (1992), suggested that an instructional sequence to train children in the use of the model did help them to work more effectively on task until a solution could be reached. At the final level of the Uprichard and Engelhardt paradigm, the effectiveness of the instructional sequence is tested in a group experimental design, in a regular classroom setting. It is the initial part of this step which is the focus of the study reported here. Consistent with Uprichard's and Engelhardt's recommendation, evaluation of the instructional sequence is based primarily on observation, with comparisons being made between pre-treatment and post-treatment performances. The evaluation model to be used in this study is an investigative one such as that described by Smith and Hauer (1990). In this type of evaluation "the methods or procedures to be used at each step in the investigative evaluation are determined on the basis of information resulting from the prior steps. The evaluation proceeds one step at a time, without the steps being planned ahead of time as in a conventional, preordinate study.... the next step cannot be started until the questions of the prior steps are answered" (p.490). Before introducing the model to a classroom situation it is important to establish whether the practitioners who will eventually use it find it to be useful and practical and whether they have any particular ideas about how it should be implemented (Ben-Peretz, 1980). For these reasons, evaluation of the model by the teacher is the first logical step in the process of designing a trial in a classroom setting. Consequently, this study was directed towards a critical evaluation of Taplin's model by teachers. The study focused on an exploration of the following questions:

(i) is it feasible to train people to use the problem solving model?
(ii) does training in the use of the model encourage problem solvers to be more independent in their ability to select new strategies?
(iii) do problem solvers and their teachers believe that the problem solving model is a useful tool to enhance problem solving performance?
(iv) how would teachers recommend using the model in their classrooms?

<u>Procedure</u>

The sample consisted of 54 practising primary school teachers, 10 male and 44 female, from local schools. These teachers were participants in an in-service mathematics education course. The classes they taught ranged from Grade 2 to Grade 6. The group represented a wide range of experience with teaching mathematics and was considered to be representative of the primary teachers in the local community. The teachers were trained in the use of the problem solving model (Figure 1) using the procedure described in Figure 2.

Figure 2: Recommended procedure for introducing problem solving model

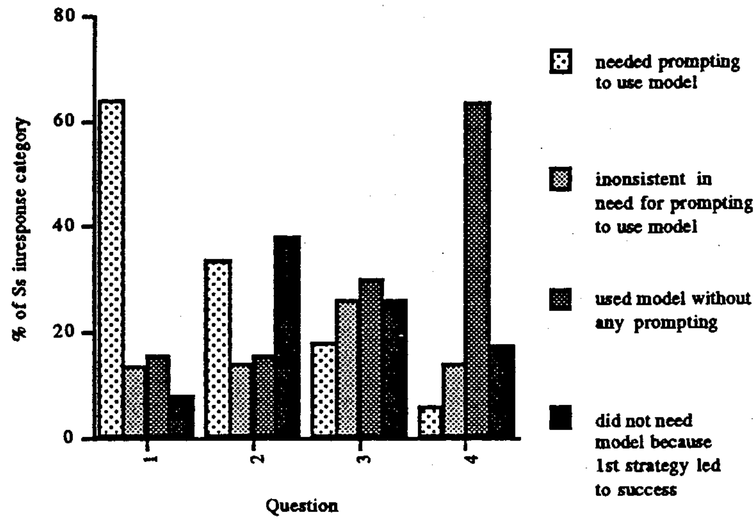
(i) Give the student a preliminary problem to solve wihout guidance. Observe whether the student instinctively used the model.
(ii) If the model was not instinctively used, introduce it and demonstrate using the example provided.
(iii) Ask the student to repeat the first problem while you guide him/her to use the model, i.e. prompt the student to change to a different approach after a maximum of three repetitions of the previous strategy.
(iv) Give two more problems, monitoring the strategy pattern and reminding students, when necessary, to follow the model.
(v) Give a fourth problem and ask the student to try to follow the model, changing approach when appropriate, without any prompting from you.

The teachers were given four non-routine number problems and a list of potentially successful strategies to which they could refer for help if they needed it. They were then asked to select a student, or a group of students, and trial the model, using the same procedure. They worked with the student/s until a successful solution was achieved, and recorded details of the extent and nature of their intervention. The results reported in the following sections will address three issues: the feasibility of training problem solvers to use the model, the extent to which teachers found it useful and useable, and their recommendations for implementing the model in the classroom.

Feasibility of Training to Use the Problem Solving Model

The 54 teachers interviewed a total of 105 problem solvers (46 male and 59 female), ranging from children in the lower primary school to adults. Emphasis was placed on observing how effectively the students were able to exhibit use of the problem solving model rather than just on the answer (Silver, 1985). There were three distinct stages in the procedural acquisition process described by Taplin (1992). In the first the students needed to be told when and why it was a good idea to change to a different strategy at a particular time. In the second they were able to recognise the need for change on some occasions, but were inconsistent and still needed prompting at times. The third stage was one of independence, where the student was able to follow the procedure and make appropriate changes of strategy without any prompting. A summary of the students' progression through these stages in shown in Figure 3. For the purpose of this analysis, responses made by groups or pairs were considered as a single response, making a total of 95 responses. One of these was excluded because the student refused to try to use the model, preferring to keep to her own method.

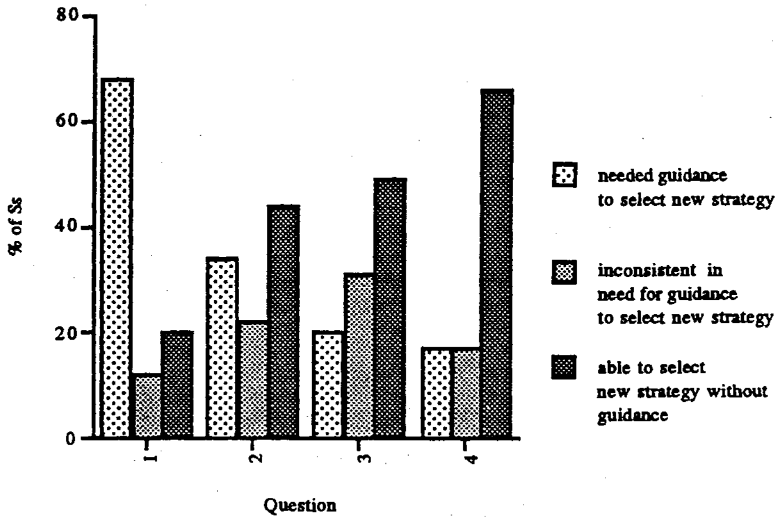
Figure 3: Summary of Ss' acquisition
of problem solving model (by question)



Observation of the patterns in Figure 3 suggests that the percentage of problem solvers needing to be prompted to use the model decreased steadily across the four questions. There is a corresponding increase in the percentage of problem solvers who were able to apply the model independently, without any prompting. On Question 3 there was a slight increase in the percentage who were inconsistent in their need for prompting. This supports the notion that they were in a phase of transition towards more independent use of the model. While it is clearly necessary to consider the effect of training in the use of the model on a longer-term basis than just four problems, observation of the patterns in the development of the students' use of the model suggest that it is feasible to "train" people to use it, at least in the short-term. It is necessary, however, to note that on the second and third questions the model was not necessary for quite large numbers of students because their first strategies led to success.

As well as considering the patterns of problem solvers' acquitisition of the model, it was important to consider the extent to which they were able to select different strategies. Figure 4 indicates, for each question, the extent of problem solvers' independence in selecting new strategies. Figure 4 suggests that there was a decrease across the four questions in the percentages of problem solvers needing help to think of a new strategy. There is a corresponding increase in the percentages of problem solvers able to select a new strategy independently.

Figure 4: Summary of Ss' ability to select new strategies independently



Teachers' Evaluation of the Problem Solving Model

The teachers were interviewed in a retrospective, semi-structured clinical interview (Ericsson and Simon, 1980). This section will focus on the following prompts which were given to the teachers:

(i) do you believe that the problem solving model is a useful tool to use in your mathematics program?

(ii) how would you use the model in your classroom?

Interviews were tape recorded and transcripts were analysed using the Constant Comparative Method (Glaser and Strauss, 1967). The focus was on the criteria which the teachers believed contributed to making the model useful and "usable" in their classrooms. The teachers' comments and recommendations will be summarised here. A full discussion is available from the author.

Sixty-five per cent of the teachers responded that they thought the model would be a useful tool to enhance the problem solving performance of the students in their classses. It was interesting to note that 20 per cent of the teachers reported that the students with whom they trialled the model were already intuitively using it and hence did not need to be "taught" it. However, all of these teachers indicated that they thought it was potentially useful in situations where the students were having difficulties. Only 4 per cent of the teachers believed that the model was not particularly useful. These and the 11 per cent who were unsure did not offer any criticism of the model itself. They doubted whether it had a place in their particular programs because they did not perceive that it addressed the types of difficulties, if any, their students experienced with problem solving. Three teachers believed that limiting attempts to three may lead to "many potentially valuable approaches [being] abandoned before they can bear fruit" (Schoenfeld, 1985, p.98). Sometimes four or five attempts brought success with their students.

The teachers who believed in the usefulness of the model attributed its potential success to the fact that it promotes five important factors:

(i) flexibility of thinking,
(ii) positive attitude and confidence to take risks and change directions,
(iii) practicality and simplicity of administration,
(iv) motivation to persist with a task and to try new tasks,
(v) creativity in searching for a variety of approaches.

Students' Reactions to the Model

The teachers were asked to discuss the potential usefulness of the model with the students. Not all teachers did this, so comments were only collected from 58 of the students. Fifty-six of these thought that the model improved their problem solving performance because it stopped them from using one unproductive strategy repeatedly. They reiterated the importance of supplying a list of possible strategies for those having difficulty in thinking of new ideas.

Teachers' Recommendations for Using the Model in the Classroom

The second question asked of the teachers who found the model useful was, "How would you use the model in your classroom?" They made recommendations about introducing the model, consolidating its use, and group sizes and composition.

Introducing the Model

It was agreed that the problem solving model could easily be adapted and used with any age-group. The approach should be introduced early in a child's school years before pre-determined ideas and negative attitudes set in, and then developed throughout their schooling. It was suggested that children need to see the validity and posibilities the model offers and would be more likely to do this if they were to use their own strategies - and make their own mistakes - initially before being introduced to the concept of the model.

Consolidating the Model's Use

It was commonly advocated that it would be very important for the teacher to model the procedure in front of children so that they can see it being used widely, not only in specific problem solving exercises, but also in everyday situations. It was also suggested that it would be necessary to display the model in the classroom along with a list of general strategies. Clearly, when introducing the model, the teacher needs to be familiar with the problem and the strategies/hints which are likely to be appropriate to use. Another comment was that the teacher needs to be sensitive about when and how to interrupt or give advice. Although some students had the desire to persevere, they considered they had failed to achieve if the teacher had to interrupt and suggest a new approach.

However, it was noted that by the third and fourth problem they were more willing to accept the advice that was being given.

Group Sizes and Composition

Using the model in small groups was the most popular recommendation, made by 63 per cent of the teachers. The main reason given for this choice was that children might struggle with finding new and different strategies on their own but that small groups would allow for a reasonable amount of brainstorming and sharing of ideas. Also, those who do not participate at first are having the idea modelled for them. The teacher needs to be able to intervene at just the right time and that this continuous presence could be most easily facilitated in a small group situation where the teacher can conference with these students when the rest of the class is working on something else, and give individual prompting and guidance as needed. Sixty-seven per cent of teachers in the sample worked with students in a group situation rather than on a one-to-one basis. Half of these reported that students worked co-operatively together in pairs or groups, with one student taking the leadership role. On the other hand, the other half commented that at some stage throughout the problem solving process the children wanted to work alone or with just one other person and in some cases were competing with each other to find the solution first. Often they would switch back and forth between independence and group co-operation. These teachers recommend that the implementation of the model should allow for children to adjust the grouping arrangements as their needs change. Twenty-one per cent of the teachers recommended using the model in a whole class situation, but clarified that this would be beneficial only for the initial introduction when whole class-brainstorming could be useful.

Summart and Recommendations from this Study

The use of teachers to implement and evaluate Taplin's problem solving model has suggested the following.

(i) It has added further support to Taplin's (1992) claim that it is feasible to train problem solvers to use the model independently in a comparatively short time and that its use encourages problem solvers to become more able to select alternative strategies.

(ii) It has suggested that the problem solving model is regarded by students and teachers as a potentially useful tool which they are prepared to use in their classrooms.

(iii) It has led to some recommendations about how the model can most effectively be implemented in the classroom, including that:

- it should be introduced to young children and its use reinforced throughout their schooling,
- it is most feasible to introduce the model in small group situations,

- the teacher's input and modelling of the procedure should play a critical role in the early stages,
- students should be allowed flexibility to work co-operatively or independently within the groups as their needs change.

The next step in the evaluation process is to introduce the model to the classroom setting to explore questions such as:

(i) Do students use it automatically and easily in a variety of problem solving situations and retain its use over a period of time?

(ii) Can it be implemented successfully with students who are initially non-perseverers?

(iii) How can small-group interaction in using the model enhance effective perseverance in problem solving?

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