PRIMARY SCHOOL TEACHERS' VIEWS ABOUT PROBLEM SOLVING IN TEACHING AND LEARNING SCIENCE

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Abstract: This study investigated how science teachers perceived problem solving in the context of teaching and learning science in primary schools. Teachers' views were probed through a survey method using both open-ended and 5-point Likert-scaled type of questions. Three hundred and forty eight trained teachers from 36 primary schools were involved in this study. It was found that the teachers' views about teaching and learning problem solving ranged from the beginning aspects of the teaching process, such as the identification of a problem/question for investigation, group work, developing basic and integrated process skills, to the concluding aspects of the teaching process. However, some teachers seemed to have misunderstood the nature of the problem-solving teaching approach. These findings have implications for primary school science instruction and for programs for professional development. Some of these implications will be addressed.

Introduction

Science teachers in Singapore primary schools are expected to use a variety of approaches to teach science in order to cater to the different learning styles of children. One teaching approach in science is the problem-solving teaching approach. It uses teaching strategies that foster problem-solving skills. It requires the pupils to ask relevant questions, explore, formulate hypotheses, plan investigations, predict outcomes, experiment, collect and evaluate data, draw conclusions, express their ideas, evaluate the ideas of others and seek alternative explanations (Tan, 1997). Teachers, in general, find it challenging to teaching primary science through the problem-solving teaching approach (Lawrenz, 1990; Harty, Kloosterman & Matkin, 1991; Chin, Goh, Chia, Lee & Soh, 1994). They face a number of constraints, including their own lack of content and pedagogical knowledge, their anxiety to maintain control over the pupils' learning activities, the pupils' abilities, as also factors within the school system. They tend to prefer the expository approach over the problem-solving approach (Tan, 1997).

Various research studies show that teachers' beliefs have powerful effects on their teaching the school curriculum (Tobin, Roth & Brush, 1995; Solomon, Scott & Duveen, 1996). The outcomes of the implementation of curriculum arises from their beliefs regarding the nature of science interact both with their goal of teaching science and the ways students learn it. Despite the belief that students' thinking skills need to be improved, science teachers generally place a greater emphasis on the acquisition of content knowledge than on the development of procedural skills (Germann, 1989). What do the science teachers think about problem solving, especially about teaching and learning problem solving in science? It is important to understand their views regarding problem solving in the context of teaching and learning science, if we want to find out ways of improving the teaching method by which to develop pupil's thinking skills through problem solving.

The purpose of this study is to investigate primary school teachers' views on problem solving in teaching and learning science. The research question for this study is, How do the teachers view the problem-solving approach in teaching and learning science?

Method

Sample

Thirty-six primary schools in Singapore took part in this study. A survey method was used. Initially, 500 copies of questionnaire were distributed to various primary schools selected at random, and 348 copies were returned (70% response rate) within two months.

The sample comprised 64 males (18%) and 284 females (82%). The average age of the sample was 38 years. The average number of years of teaching experience in primary schools was 20 years. The average number of years of teaching the new science curriculum was 5 years during 1991 to 1996. The new primary science curriculum was implemented in schools from 1991. As for the teachers' academic qualification, 12% had university degrees, 9% diplomas from polytechnic institutions, 40% Advanced Level and 38% Ordinary Level. About 75% of the teachers indicated that they had read one science or more during their earlier education. Of the four science subjects (Biology, Chemistry, Physics and Combined Science), Biology was the subject teachers had most commonly studied (48%).

Instrument

To explore the teachers' views about problem solving in teaching and learning science, two types of questions were set. One type of questions were the six-point Likert scale questions that allow teachers to focus their thought on a more specific aspect about teaching problem solving. Four such questions figured in the questionnaire. They concerned the teacher's views about hands-on activities, the importance and incorporation of problem solving into daily lessons, the teacher's confidence in using the problem-solving teaching approach. The teacher was asked to indicate his/her agreement to the statements on a six-point Likert scale, namely, 1 strongly disagree (SD), 2 disagree (D), 3 somewhat disagree (WD), 4 somewhat agree (WA), 5 agree (A), and 6 strongly agree (SA). Space or a remark column was also provided for their comments. The four questions were:

- Hands-on activities are worth the time and effort.
- It is important to integrate problem solving into daily lessons.
- I incorporate problem solving in my science lessons.
- I am confident of my ability to teach science using the problem-solving approach.

The other question was an open-ended question that allows teachers to freely reflect at a personal level on what they think of problem solving in primary science curriculum. This question was, What do you understand by "problem solving in teaching and learning science"? Space was provided for the teachers to respond.

Results

The teachers' responses to the two types of questions were analysed quantitatively and qualitatively respectively. The quantitative data included the teachers' responses to the four six-point Likert scaled questions. Its analysis involved the calculation of the responses to the six scales in terms of percentage, means and standard deviations (Table 1). The qualitative data included the teachers' responses to the open-ended question. The teachers' written responses were analysed to determine the teachers' views about the process of teaching problem solving.

Using quantitative data

From Table 1, about 80% of the teachers either agreed or strongly agreed that hands-on experiences were worth the time and effort. About 72% of the teachers agreed or strongly agreed that problem solving was important to be part of their daily lessons. Only 44% of the teachers agreed or strongly agreed that they incorporated problem solving in their science lessons. The contrast between the teachers' beliefs and their actions can be seen in their responses to Q2 and Q3.

Table 1: Response distribution (%) to the four six-point Likert scaled questions

QUESTION	SD (1)	D (2)	WD (3)	WA (4)	A (5)	SA (6)	Mean	Std Dev
Hands-on activities are worth the time and effort.	1.1	0.3	1.7	17.0	43.4	36.2	5.1	0.9
It is important to integrate problem solving into daily lessons.	0.9	0.3	3.2	23.3	46.8	25.0	4.9	1.0
I incorporate problem solving in my science lessons.	0.3	1.4	10.3	42.2	40.2	4.0	4.3	1.0
I am confident in my ability to teach science using a problem- solving approach.	0.9	3.7	10.1	44.0	34.8	6.0	4.3	1.0

As for the teachers' confidence level in teaching problem solving, about 41% of the teachers either agreed or strongly agreed that they were confident of their ability to teach science using the problem-solving approach. On the other hand, more than half (59%) of the teachers were not very confident about the teaching approach. Some of the teachers indicated in the remark column that they were not sure of the approach, or that they lacked the science background knowledge:

- "I don't understand the approach."
- "Not too sure what the approach entails."
- "My science foundation is not strong."

Some teachers said that they would welcome training in the problem-solving teaching approach. The following teachers' comments support this finding:

- "I will be glad to attend problem-solving course based on science if available."
- "The teacher must be trained to teach problem solving."

Using qualitative data

There were 277 teachers (79.6%) who responded to the open-ended question that required the teachers to write down what they understood about problem solving in teaching and learning science. Based on the teachers' responses to the open-ended question, the teachers as a group indicated that teaching problem solving in science involved the following teaching processes:

- Identifying a problem/question for investigation,
- Developing science process skills,
- Working together in groups, and
- Applying science concepts to solving problems.

Identifying a problem/question for investigation

Some teachers felt that a problem/question for investigation could come from either the teacher or the pupils. Some teachers suggested that the problem/question for investigation should come from the teacher. Some examples of the teachers' comments on this finding are as follows:

- "The problem for investigation should originate from the teacher."
- "A teaching approach using problem solving is to present a problem situation and pupils have to research for solutions."
- "Pupils are presented with a clearly defined problem/question."

On the other hand, some teachers considered that their pupils could also formulate the problems themselves. However, some teachers encountered difficulties, such as pupils lacking basic process skills, and designing ill-structured problems for investigations. The following teachers' comments reflect some of the difficulties:

- "Some pupils need to be taught some basic skills in problem solving. Certain questions they have to ask while planning a procedure, getting the necessary materials, and naming a control where necessary."
- "The pupils' abilities affect the structure of the lesson involving problem solving. If the pupils' previous experiences are poor, the teacher needs to teach the higher-order skills from the scratch."

Developing science process skills

A number of teachers felt that the problem-solving teaching approach involved a range of science process skills which are prescribed in the *Primary Science Syllabus* (1990). It is recommended that pupils in the lower primary levels acquire the more fundamental skills such as observing, classifying, measuring and using equipment, and communicating (*Primary Science Syllabus*, 1994, pages 4 - 5). In the upper primary levels, the integrated process skills are emphasised with the incorporation of basic process skills. The integrated process skills are interpreting/inferring information, controlling variables, formulating problems/questions and hypotheses, and planning investigation. The following are examples of the science process skills some teachers emphasised:

Observation	"Pupils carry out an activity, and come up with reasons to explain their observations."
Classifying	"Classifying skill" was mentioned by several teachers
Collecting data and measuring	"Pupils need to be able to …experiment, collect … data."
Communicating	"Pupils present findings in definite, measurable terms, make a final scientific statement or present a solution."
Interpreting data/inference	"The pupils interpret the data and look for patterns and relationships before making inferences and conclusions." "Pupils draw conclusions and explain what caused the experiment to fail." "The pupils analyse the findings in the experiment before reaching the conclusions."
Identifying and controlling variables	Several teachers mentioned this skill
Formulating problems/ questions and hypotheses	"Pupils find an acceptable solution to the problem, perhaps, after testing several hypotheses." "Pupils should be involved in discussing the possible solutions to a given problem." "Pupils need to ask relevant questions."
Planning investigation	"Pupils plan an experiment to find the solution. The process of planning an investigation is the essence of problem solving in teaching and learning science."

In the development of problem-solving skills, pupils may learn heuristics and other methods to approach a situation, such as researching on the problem, finding background information, and using library resources. The following teachers' comments reflect the views:

- "Problem solving involves the use of higher-order questions and hence more critical thinking."
- "Pupils discuss means to overcoming the problem. In the process, they discover heuristics and other methods of approaching a situation systematically. As they work through the problems independently as scientists, they learn and acquire more skills and experience to solve other problems."
- "Problem solving is a skill that requires the pupils to use proper terms, logical steps, correct concept and initiative to solve a given situation scientifically. It is an application of all they have learnt or seen happening in their everyday life to tackle that problem."
- "Research work or project work may be considered a type of problem solving and pupils should play an active role in gaining knowledge in science."
- "In addition to the skills required in science processes, problem solving calls upon literary skills, for example in locating sources of information, collecting data from resources."
- As mentioned above, planning investigation is one of the integrated science process skills. Some teachers' comments shown below reflect their understanding of this process skill:
- "Pupils are able to plan their investigation and interpret information from tables and to draw their own conclusions using their science process skills."
- "Problem solving in teaching and learning science comes after an experiment is carried out. Pupils discuss and decide on what data to collect, what variables to control and the materials to use. They interpret the data, look for patterns and relationships before making inferences and conclusions."
- "Problem solving requires active, physical and mental participation of pupils. Pupils need to ask relevant questions, explore, experiment, collect and evaluate data, predict outcomes and draw conclusions, express their ideas and evaluate the ideas of others."

On the other hand, some teachers indicated that designing an experiment by pupils themselves could be quite a challenging task. They also commented that some of the activities in the workbooks were structured to guide younger pupils in experiencing some higher-order process skills. A teacher's comments support this view:

- "Designing an experiment, on its own, is a difficult task for young pupils. Therefore the curriculum is set in such a way that the experiment's aim, hypothesis and method are presented, and the pupil is required to furnish his/her results, observations and conclusion. The pupil is expected to derive the concept."

Evaluating outcomes of an investigation is part of the scientific procedure. An important part of the problem-solving process is the verifying of the method and the results. Pupils should analyse the results of their investigations before reaching the conclusions. In the problem-solving approach, the teachers commented that pupils should be encouraged to make critical comments on the outcomes of the investigation of question/problem. The following are some of the teachers' comments about the follow-up activities after the completion of investigation:

- "When answers are not definite or unknown, encourage the pupils to make critical comments."
- "Problem solving is a complex and non-linear activity. The solution for every problem involves many skills. It is providing pupils with opportunities for them to do realistic work. It must be followed by a post-lab discussion on the thinking processes that are used."

The following are some of the teachers' comments on the importance of research skills as a form of verification:

- "An experiment is re-conducted to check for any flaws in their method of investigation."
- "Pupils retest the experiment to confirm results."
- "For results that do not coincide with what are expected, the pupils make a list of possible errors."

Some teachers considered the explanation of the outcomes of the investigation is important in teaching problem solving. They encouraged their pupils to predict outcomes, evaluate the steps taken in the investigation, interpret the data, and look for patterns and relationships in the data.

Working together in groups

Some teachers indicated that their teaching of problem solving involved pupils working together in groups to carry out investigation. They commented that a classroom environment needed to be conducive for the pupils to work in groups. The teachers thought that the co-operative learning in science hands-on activities encouraged a higher level of participation among pupils in learning, and interaction within a group could also motivate pupils to evaluate different methods of solving a problem. The following are some of the teachers' comments on the advantages of group work for problem-solving tasks:

- "As pupils work in a co-operative group in a hands-on session, it encourages them to be more inquiry-minded, arouses their curiosity and achieves maximum participation."
- "Through informal interaction and brainstorming, pupils learn by listening to their friends' ideas."

Applying science concepts to solving problems

A few teachers indicated that pupils should understand the concepts taught and know how to apply the concepts to answer or solve the problem/question. They commented that teachers should follow up problem-solving activities by showing and explaining the underlying knowledge relevant to problem solving. The following teachers' comments reflect the importance of basic science concepts for solving problems:

- "Using the basic concepts taught, questions are posed that requires pupils' positive thinking in suggesting ways and means to answer the questions."
- "Problem solving equips pupils with the ability to analyse a given problem or situation and be able to suggest logical ways of solving it by applying concepts learnt in a logical sequence."

Some teachers also indicated that the problem-solving teaching approach not only allowed pupils to apply learnt knowledge to solve problems but also improved the pupils' understanding of a particular concept or phenomenon. The problem-solving experience makes the learning more meaningful and consequently, more lasting. This is reflected in the following teachers' comments:

- "The understanding of a science concept through problem solving tends to be more lasting than a concept which is merely stated to the pupils."
- "At the end of what they have done, pupils draw some conclusions regarding their problem. They may have gleaned some scientific concepts/ knowledge and they have a better, clearer and deeper understanding."

Summary

Some important results on teachers' views about teaching problem solving were found in this study. Many teachers believed that hands-on experiences were worth the time and effort and that problem solving was important enough to be part of their daily lessons. But there seemed to be fewer opportunities for the incorporation of problem solving in science lessons, according to the teachers. About 59% of the teachers were not very confident of their ability to teach science using a problem-solving teaching approach. Based on their comments, some seemed to have misunderstood the nature of the problem-solving teaching approach. The main reasons were that they were not sure of the problem-solving approach and lacked science background knowledge. The teachers as a group, in general, perceived that problem-solving teaching approach involved the following processes:

- Identifying a problem/question for investigation,
- Developing science process skills (basic and integrated process skills),
- Working together in groups, and
- Applying science concepts to solving problems.

The study showed that it was teachers who usually provided the problem/question for pupils' investigation. However, in the primary school science syllabus, pupils are expected to formulate the problems/questions, plan experiments, and to carry them out (*Primary Science Syllabus*, 1994). Though majority of the teachers appreciated that science teaching involved the development of science process skills, not many actually encouraged pupils to actively formulate hypotheses or plan investigations.

Group work is a feature of the problem-solving process. Through it, pupils carried out hands-on activities that included problem-solving tasks. Concerning the application of science concepts, the teachers appreciated the importance of science concepts underlying the problem-solving tasks.

Implications

This study examined the teachers' understanding of the problem-solving teaching approach in the teaching and learning of science. The problem-solving teaching approach was not totally new to the trained teachers. Many science teachers in primary schools seemed to display a reasonable amount of understanding of the problem-solving teaching approach. The teachers gave their views on their understanding of the process of teaching primary science using a problem-solving teaching approach. Their comments ranged from the initial aspects of the teaching process, such as the identification of a problem/question for investigation, group work, developing basic and integrated process skills, to its concluding aspects (e.g. verifying results, evaluating outcomes, and applying the concepts to solve problems).

However, the study showed that the problem-solving teaching approach was not frequently used in the primary school science curriculum and more than half of the teachers did not feel very confident about teaching science through problem solving. In addition, there were a small percentage of teachers who seemed to have misunderstood the nature of the problem-solving teaching approach.

One way to support science teachers to effectively teach problem solving is to provide them with relevant training courses addressing the problem-solving teaching strategies for specific science topics. Another, even more important, is to provide time for planning and for interaction with other teachers. At these sharing sessions, teachers can reflect on their practice with their peers on what they do in class, share the extent of success, and discuss ways to improve the teaching. Information

technology or internet can also be used as a resource and a tool for searching and communicating innovative teaching ideas both on science instruction and science investigation.

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