

MALAYSIAN PRIMARY TEACHERS' CLASSROOM PRACTICE OF TEACHING AND LEARNING SCIENCE

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The present study discusses the findings from a research that was conducted involving fourteen teachers in a primary school. In the study, the teachers' classroom practices of teaching and learning science were observed and analysed. The data gathering procedures included 23 classroom observations and analysed by means of qualitative data analysis. The results did not allow a general correspondence to be established between teachers' understanding about teaching and learning science and the central values of science teaching. The implications of the research for in-service training are discussed.

INTRODUCTION

Teachers' perceptions of teaching and learning science will influence teachers' conceptions of the nature of primary science teaching and this will influence their decisions about the ways in which they organise their classrooms, their choice of strategies or activities, and their interactions with their pupils. Primary science teachers in Malaysia are encouraged to apply the 'guided inquiry' approach in teaching science. Inquiry, according to Harlen (1996), has a variety

of meanings such as learning which involves children learning actively æ hands-on as opposed to book learning or it means active learning taking account of children's previous experience and ideas. In this approach pupils are encouraged to raise questions and work independently to find answers. Therefore the essential skill pupils need for inquiry-based learning is that of asking questions. Bonnstetter's (1998) model of a guided inquiry is that teachers still have the authority to select topics and questions, and provide the material but pupils are required to design the investigation, analyse the results and reach supportable conclusions. However, in the Malaysian primary science context, inquiry is based on a guided approach as in Bonnstetter's model but not to the extent of pupils designing their own investigation. Teachers still hold the authority in selecting the design of the investigation, how results to be analysed and the conclusion that should be made.

The primary science curriculum in Malaysia sees children as experimenters, discoverers and problem-solvers. A teacher in this new programme is a guide, counsellor and facilitator with a diminished authoritarian role. The teachers' new roles include making suggestions and asking questions as the children carry out the activities. This requires teachers to pay more attention to the students' thinking skills and scientific skills, including science process skills and manipulative skills. Teachers are expected to provide children with relevant hands-on and minds-on activities.

Thus, a teacher's role in teaching science is to develop children's ability to carry out investigations as specified by the curriculum. Teachers need to identify learning outcomes clearly. Appropriate intervention strategies must be employed to help children achieve the desired outcomes. Teachers should also see themselves as a resource and feel free to impart certain knowledge and understanding to children, or to intervene and ask children to clarify their ideas, and explain procedures (Feasy, 1993). The curriculum

highlighted the need for teachers to emphasise activities and for children to be given more opportunity to investigate in the roles of experimenters, discoverers and problem-solvers.

This programme also requires teachers to develop an approach through which children construct their learning meaningfully. This makes it clear that the curriculum is not primarily about learning content, but it is a programme in which children are given learning tasks, materials and resources with which they interact with to construct their knowledge. This indicates that the approach to be taken by teachers is a constructivist one. To use such an approach (Scott, Dyson & Gater 1987; Harlen 1992; Shapiro 1994, Duit & Treagust 1995; Cross & Peet 1997) teachers must give priority to children's ideas. Thus, teachers become enablers for this process.

The constructivist approach (Driver & Bell 1986, Driver & Oldham 1986, Needham 1987; Cheung & Taylor 1991, Fensham, Gunstone & White 1994; Hawkins 1994, Hand & Treagust 1994; Appleton & Asoko 1996; McGuigan & Russel 1997, Murphy 1997; Appleton 1997, Watts 1998, Watts & Jofili 1998, Adam & Krockover 1999, Selley 1999, Leach & Scott 2000) offers an insight that is enormously valuable; it emphasises that the learner, during the learning process, necessarily reconstructs knowledge. Learning therefore occurs when there is a change in the learner's existing ideas, either by adding some new information or by reorganising what is already known (Driver & Oldham 1986, Driver & Bell 1986; Appleton 1997). It is not possible to teach a body of knowledge by direct transmission; the learner is always involved in reconstructing the meaning personally. The classroom activities suggested by the constructivists for eliciting, clarifying and reconstructing ideas become immensely valuable for the teacher who is monitoring and managing this reconstruction process (Millar, 1989).

It is the major aim of primary science education in the Malaysian context to give children the ability to think critically and creatively.

To do this, teachers need to provide children with the experiences that enable them to form ideas that are meaningful to them and consistent with their experience. Thus, in adopting such an approach, teachers particularly need knowledge and understanding of key ideas in science so that they can identify good starting points and know when children are closer to the scientific view or far away from it. Teachers must ensure that children encounter the experiences that will help them rethink their ideas. To develop Malaysian younger generations who will be the thinkers and decision makers in the future they need to be trained to do their own thinking. This could be achieved if majority of teachers teaching primary children value interaction with pupils closely in order to provide a range of meaningful experiences for pupils and help pupils to explicate and elaborate their own prior knowledge. The constructivist approach supports teachers in helping pupils understand science concepts meaningfully. As pupils have a personal experience of concepts taught from activities and interactions, they will develop a better understanding of the science involved.

METHODOLOGY

Qualitative data were collected through classroom observations. The teachers identified are those who have had experience teaching primary science since its implementation. Thus they were assumed to be knowledgeable and informative about the teaching of science. There were 14 respondents from the nine schools because at some there were two science teachers. The audio tape recorder was used extensively to record the classroom observation. The classroom observations were carried out as a written account of events as they occurred. The classroom observations were recorded as narrative descriptions and were analysed according to criteria including strategies used in the lessons, pupils' development in science-

science process skills, scientific attitudes and teachers content knowledge. Two observations of each of the fourteen teachers were planned.

Table 1

Selected teachers' training and science backgrounds (the names used are pseudonyms)

Schools selected	Teacher Female (F) Male (M)	Primary Science Course attended and option during teacher training programme	Science background until secondary level
School A	Mansor - M	Orientation course - 5 days Malay Study Programme	General science (arts stream)
School A	Soraya - F	14 weeks in-service course English Study Programme	Pure science (science stream)
School B	Zarina- F	14 weeks in-service course Malay Study Programme	Pure science (science stream)
School B	Juliza - F	Orientation course - 5 days Malay Study Programme	General science (arts stream)
School C	Dzamani - M	14 weeks in-service course Malay Study Programme	General science (arts stream)
School C	Norizah - F	Orientation course - 5 days Malay Study Programme	Pure science (science stream)

School D	Shafie - M	Orientation course - 5 days Malay Study Programme	General science (arts stream)
School D	Nurul - F	14 weeks in-service course Malay Study Programme	Pure science (science stream)
School E	Muyidin - F	Orientation course - 8 days Science and Mathematics Programme	Pure science (science stream)
School F	Badriah - F	Orientation course - 5 days Mathematics Programme	Pure science (science stream)
School F	Ruhil - F	Orientation course - 5 days Malay Study Programme	Pure science (science stream)
School G	Aminah - F	Orientation course - 5 days Malay Study Programme	Pure science (science stream)
School H	Sharifah - F	Orientation course - 5 days Malay Study Programme	Pure science (science stream)
School I	Norbadriah - F	14 weeks in-service course Malay Study Programme	General science (arts stream)

OBSERVATION SCHEDULES

The observation schedule used in this study is adapted from Smith and Neale (1989) in their study of 'The Construction of Subject Matter Knowledge in Primary Science Teaching'. The purpose of their study was to analyse the subject matter knowledge and beliefs of ten primary teachers, focusing on their conceptual change in science. According to Smith and Neale (1989) the key features of conceptual change teaching in the lesson segments are as follows:

1. *Introduction:* teacher commence lesson with comments about lesson's content or activities, making links with other lessons
2. *Review:* teacher asks children to describe previous lessons' findings, conclusions and problems
3. *Lesson Development:* teacher presents new information or problem, elicits children's ideas and discussion, probes and clarifies understanding
4. *Investigations /activities:* children manipulate materials individually, in small groups, or take turns in whole group, to test out ideas
5. *Representation:* children present results of activities symbolically, in writing, measurement, graphs, tracing
6. *Discussion of Activities:* children present results, discuss explanations, comment on adequacy of explanations
7. *Summary or tie up:* teacher and/or children summarise the day's findings and link them to other lessons

Thus it can be seen that the development of the lesson is similar to a constructivist approach, with the lesson being focused on pupils' ideas and prior knowledge. The approach attaches importance to pupils' understanding of the concepts taught through activity-based teaching thereby allowing pupils to construct their learning. Hence it was felt that the observation schedule was appropriate and suitable for observing the teaching of primary science in Malaysia.

As the observation schedule developed by Smith and Neale (1989) focuses on teachers' content knowledge, teachers' roles, students' roles and activities and materials, it can easily be adapted to observe teachers' pedagogical content knowledge. However, the part of Smith and Neale's observation schedule which was adapted for the study is that which concerns teachers' content knowledge since the other criteria developed by Smith and Neale are not relevant to the Malaysian primary science teaching. Therefore, the classroom observation data for the other criteria were analysed from the narrative description of the classroom observation.

The criteria of teacher's content knowledge include:

1. Teacher asks for conceptual understanding rather than just factual or procedural understanding
2. Teacher's content presentation is accurate
3. Teachers define term and monitors use
4. Teacher uses examples, analogies and metaphors
5. Teacher's examples, analogies and metaphors are conceptually accurate
6. Teacher's examples, analogies and metaphors are developmentally appropriate to children's level
7. Teacher links conceptual content to children's informal experiences

FINDINGS AND DISCUSSION

Classroom Observations

Even though two observations of each of the fourteen teachers were planned, in practice only ten teachers agreed to be observed twice, and two teachers were only willing to be observed once. One teacher could only be observed once due to her being offered further study on a degree course before her second observation. One teacher could not be observed at all because she went for further studies before the first observation was done. The teachers themselves determined the time available for the classroom observations. They were given the freedom to choose whichever class and topic they wanted to teach and be comfortable when observed. Thus, the teachers determined the appointments. The only thing asked of them was that the period after the observation was a free period to enable an interview on the lesson observed. Generally, the time available for the lesson was about 60 minutes, a double period, as specified in their timetables. The main aids to observation were audio recording and field notes of the activities of teachers and pupils. The checklist prepared for the classroom observations was quickly abandoned since most primary science teaching observed did not exhibit the components from the checklist. Thus, during the observation field notes were kept, indicating the flow of the lessons and the events happening during the lessons. This seemed to be appropriate, since the lessons observed revealed their science pedagogical content knowledge.

ANALYSIS PROCEDURES

The nature of the questions to be addressed in this part of the research required a qualitative approach to analysis, since the main objective of the classroom observation was to see how teachers teach the primary science curriculum at classroom level. Thus the observations were analysed using these categories:

- Strategy used.
- Pupils' development regarding science: science process skills, scientific attitudes.
- Teacher's content knowledge.

Strategies used in the lessons

Constructivist approach

In the 23 lessons observed only two teachers, Norbadariah and Soraya claimed that they were using the constructivist approach. Norbadariah used this approach in both lessons observed and Soraya used it in the one lesson that was observed before she left for further studies. The other teachers claimed that they were using the guided-inquiry-discovery approach as suggested by the curriculum guide. In the three lessons which were described as constructivist, the teachers claimed that they were using the five phases of the approach, i.e. orientation, elicitation of ideas, restructuring of ideas, application of ideas, and reflection (see, for example: Driver & Oldham 1986, Needham & Hill 1987, McGuigan & Russell 1997). In all three lessons observed, the orientation phase consisted of teachers either asking questions or using teaching aids for orientation on the topics to be taught. After the orientation phase, teachers did not elicit ideas and plan activities, but instead told pupils to do what had already been planned. Thus teachers' understanding of the constructivist approach is not clear: the notion

of meaningful learning through children constructing their own learning seems not to have been understood by teachers.

What teachers actually understand by orientation is merely an introduction to a lesson and, as observed, this phase only lasted five minutes. For example, Soraya's orientation phase sought to direct her pupils to the concept that living things need food. She asked two simple questions: 'What have you eaten during your recess time?' and 'Why do you eat?' These questions were asked to arouse pupils' interest and curiosity but the pupils saw it as merely the introduction to the lesson. This did not show that the teacher was aware that this point is a crucial component to stimulate interest and curiosity. She was not aware that this phase was the beginning of the process of recognising pupils' ideas about the materials presented. There was no other stimulus as her starting point. Thus, this teacher's view of the orientation phase is that it should pose questions to pupils to get the lesson started. Norbadariah's technique in her orientation (two observed lessons) was somewhat different to that of Soraya. In both of her lessons, the orientation phase consisted of bringing to the class some teaching aids to catch pupils' interest but not to arouse curiosity.

At the beginning, during the orientation, I use picture which do not seem to attract pupils attention ... maybe it's the magnet, it's an old magnet ... maybe it cannot work when there is a paper in between since its not strong anymore ... but it seem interesting, the children were trying to look behind the picture and some said that there was a cellophane tape and other things so it's quite interesting because I want to attract children's interest (Norbadariah).

As in Soraya's lesson, there was no actual contact with the materials or events by the pupils. This phase is important in encouraging children to explore their ideas within contexts which are relevant to their lives and experiences, and the key features of this phase is the provision of practical or familiar experiences (McGuigan &

Russell 1997) which was absent from these teachers' observed lessons.

The teachers' 'elicitation of ideas' phases were all prepared prior to the lessons. The observation showed that teachers' understanding of this phase was for pupils to show their prior knowledge of the concepts that the teachers wished to teach. For example, Norbadariah asked pupils to identify animals which give birth and those which lay eggs. In another of her lessons, the pupils made predictions about magnetic and non-magnetic materials. In both lessons, pupils were given a prepared worksheet to record their observations or discussion. By using the worksheet, the children understood that the lesson required the correct answers for the teacher.

During the elicitation of ideas, I found that there are pupils who know that some objects can be attracted by magnets, they might have played with it before ... but there are some who do not at all. Not even the magnet but those who know they even know that objects made from iron can be attracted by magnets. Therefore I have to discuss with the pupils first using the worksheet so that everybody will do the activit (Norbadariah).

Soraya gave a drawn concept map for pupils to complete to show their knowledge of the concept. It was not the pupils' ideas that were being considered here, but their prior knowledge. There was no opportunity for pupils to raise questions and no time was allocated for listening and talking to the pupils thus teacher could not identify pupils' ideas. Instead the teacher monitored pupils to complete the task given so that at the end of this activity they would be able to present the result or the discussion on the worksheet. This is not the type of elicitation envisaged by the constructivists. There was no elicitation of pupils' ideas which encouraged them to clarify their thinking. The activity given by the teacher was so structured that there was no opportunity for pupils to raise

questions. This would actually help children to clarify what they already thought and knew and what they wanted to find more about. Hence, the activities provided by these teachers did not encourage pupils to raise questions but instead invited them to answer questions given in the worksheet. As Hodson (1998) observes, in acknowledging and exploring pupils' ideas the aim should be to create opportunities for pupils to make their own ideas explicit, share them with others, subject them to critical scrutiny and test their robustness by observation and/or experiment. McGuigan & Russell (1997) suggest that aspects of this phase should include: teachers' use of a variety of ways of finding out and probing children's ideas, the valuing of children's expression of ideas, and the use of children's ideas as the basis of formative assessment to be used in subsequent teaching. These aspects were not observed.

In the 'restructuring of ideas' phase, teachers planned the lesson with an activity that made pupils realise the scientific concept they should have gained from the previous activity. Soraya introduced the terminology of herbivore, carnivore and omnivore, which she called 'the concepts.' After the introduction, pupils carried another activity to match the concept the teacher wanted them to acquire. It was with the same understanding that Norbadariah planned her 'restructuring of ideas' phase. In one of her lessons, this phase was observed to involve pupils making predictions on magnetic materials, then classifying magnetic and non-magnetic materials.

Then when we want to restructure their idea, this is where I let them test the objects that they predicted to be attracted or not to magnet. There were some right and wrong predictions but the most obvious one is the cuprum wire where most pupils predicted that it can be attracted by magnet. Then we discuss again the result but there are still pupils making mistakes and I asked them to correct their answers. Then only I explain that objects made from iron can be attracted by magnets and those that are not cannot be attracted

by magnets. This is where I introduce the term magnetic and non magnetic material. (Norbadariah).

In the other lesson, Norbadariah checked pupils' presentation of the activity in the elicitation phase and then gave further input and some explanation of the concept. It can thus be seen that these teachers' understanding of the restructuring phase is to prepare an activity to correct pupils' wrong answers (not concepts) from the previous activity. There were no elements of pupils testing their ideas; both the elicitation of ideas and the restructuring of ideas were pre-planned by the teacher. Pupils were not given any opportunity to plan or design a test to enhance their understanding of the concept. They were also deprived of the opportunity to use their investigative skills to clarify and support their personal thinking. If pupils are allowed to test their ideas, they will be better able to understand the concepts, and it will be significant for them to link their ideas with scientific concepts. In practice, the concepts were not built upon or constructed by pupils but were still based on a teacher-directed activity, which forced concepts onto pupils with activity merely a means of getting pupils involved in the lessons. This phase should include components such as: 'learning opportunities make some contact with children's ideas,' 'children are encouraged to support their ideas with evidence,' 'children decide what constitutes evidence' and 'teachers promote children's learning by helping them gather and reflect upon relevant evidence and the implications for their previously expressed ideas' (McGuigan & Russell 1997). These were absent from the teachers' observed lessons.

In these lessons, the 'application' phase was used to produce an outcome from the lesson. For example, Norbadariah made pupils produce a scrapbook on animals' ways of breeding. In another lesson, she wanted pupils to find out more things that are magnetic and non-magnetic in the science room.

In the application of idea, I asked them to look for objects that are magnetic material and non magnetic material around the classroom. They understand that when they put the magnet, it stuck therefore it is a magnetic material and they know that iron is just the name but actually the object is the iron grill. It can be seen that they know that only iron is attracted by magnet (Norbadariah).

For Soraya, the idea of 'application of ideas' was for pupils to make a classification of animals eating habits. This activity did not give pupils the opportunity to solve any problems in order to see if they could apply and transfer acquired knowledge and skills. According to Scott, Dyson & Gater (p. 14, 1987):

In the application phase, pupils are given the opportunity to use their developing ideas in a variety of situations, both familiar and novel. Thus new concepts may be consolidated and reinforced by extending the context within which they are seen to be useful. Application 'task' might include further experimental work, creative writing, discussion work and so on.

The final phase was 'reflection.' Reflection or review for the teachers meant the conclusion of the lesson. For Norbadariah both of her conclusions involved asking pupils questions about the lessons and inviting them to complete a concept map she had prepared.

For the reflection, I use concept map to let pupils see clearly which are magnetic materials and which are non-magnetic materials (Norbadariah).

As for Soraya, her reflection was to give a verbal problem to be solved by pupils concerning the concepts learnt. Both lessons were concluded by the teachers themselves and not by the pupils. Hodson (1998) points out that reflecting on their own learning helps students to appreciate that conceptual change is involved in learning. In reviewing change in ideas Scott, Dyson and Gater (1987) invite pupils to reflect on how their ideas have changed by drawing

comparisons between their thinking now and at the start of the unit. These elements of reflection were not present in the lessons observed.

It seems that these teachers do not have an in-depth understanding of the constructivist approach. What could be seen was a teaching strategy which was very much teacher-centred. Most activities were directed and instructional and there was no evidence to show that pupils might construct their learning using their own ideas. All activities were tightly controlled and planned. Even the making of a concept map did not allow pupils to demonstrate their creativity.

What was seen was the teacher explaining verbally the ideas or concepts that pupils should gain from the activities. This was done as early as the introduction phase. Pupils were told what they were supposed to learn from the activity. During the activity or the group discussions or the whole class discussions, pupils were controlled by the teacher æ including the information under discussion and the direction of the discussion by the class or group. This was done through the worksheet that had been prepared earlier. Another aspect of this controlled activity was that the teacher initiated the answering of questions but did not comment or suggest ideas. It took the form of exchanges within a sequence regulated by the teacher. The teacher chose children's answers selectively in order to arrive at the answer that was wanted.

Thus, central to all the lessons was the teacher's exposition. The teacher tightly controlled the talk and activity children were engaged in to serve the purpose of putting across certain ideas or concepts to be learned. The activities tended to follow input by the teacher, instead of developing from children's ideas. They were therefore seen as a means of illustrating the scientific concepts and act as a confirmation. As Drummond (cited in Frost, p.10, 1997) observes:

It is children's learning that must be the subject of teachers' most energetic care and attention—not their lesson plans, or their schemes of work, or their rich and stimulating provision—but the learning that results from everything they do (and do not do) in schools and classrooms.

Teachers need to change their perception from a teacher-centred to a pupil-centred approach in order to teach according to constructivist techniques. However, Louden and Wallace (p.652, 1994) show that it is not easy to change teachers' pedagogical beliefs and ideas they have used for a long time:

Clearly, "Malcolm" found it hard to participate in a programme which questioned his closely held values of teaching ... In the end, the struggle resulted in an attempt to integrate the programme's philosophy into his image of teaching while retaining his investment and pride in his skill as a teacher.

Therefore, the respondents' science pedagogical content knowledge could be described as inadequate as shown by this classroom observation evidence. Teachers need to be helped in implementing a constructivist approach. The process of becoming constructivist must involve teachers in reconstructing their own knowledge of science and of science teaching (Louden & Wallace 1994).

Guided inquiry-discovery approach

Another approach to science teaching suggested by the primary science programme is the guided inquiry. In all the other teachers' patterns of teaching, it was observed that all activities pupils were engaged in were structured. Most lessons observed used the following patterns or procedures:

- The teacher explains the topic of the lesson as a brief introduction.

- The teacher briefs pupils on the procedures they should follow to gather their data or for observation.
- Pupils gather data or observe in the way prescribed.
- Pupils organise data in tabular form or any form required by the teacher.
- Pupils answer a series of questions about the data or observations (most of the questions involves science process skills).
- Pupils present a conclusion of the activity (but mostly dictated by the teacher).

One of the respondents mentioned the strategy she used in the guided inquiry-discovery approach must start with giving pupils some explanation first. This implies that this approach is also misunderstood by teachers and it is actually a traditional approach in science teaching. This is reflected in her comment:

Firstly I have to introduce the topic to my pupils to gauge their interest then I introduce to them the term "temperature". I explain the ways to read thermometer correctly and then why do we need a thermometer to measure temperature. After that, I explained the safety precaution and then carry out the experiment and discuss with the children their finding then the conclusion (Badriah).

Another said,

In the induction set, I want them to understand why the bulb lights up, therefore I explained the reasons the bulb lights up was due to the flow of electric current. Then only I asked them to make an inference when they have understood that when there is a flow of electric current the bulbs will light up (Nurul).

In terms of procedures for pupils to carry out, they were already structured by these teachers. One of the teachers responded:

Before the children carry out the experiment, I explained the hypothesis, how to identify the variables, then I gave them the format of a table for recoding. Then I explained that they are going to investigate that there is a flow of electric current ... material that let electricity to flow through and material that do not let electricity to flow through. The observation table was given to them to be filled in with their prediction first then only they do the experiment (Nurul).

Another explained,

I introduced the topics and relate them to the previous questions answers session with today's investigation that is to prove that light moves in a straight line. Then I gave instruction, distribute the materials. Children did the activity guided by the activity card but before that I read the instruction together with the them but I forgot to draw the diagram in the activity card so I drew it on the blackboard and explained it (Aminah).

This implies teachers perceive that a guided inquiry-discovery approach means that the pupils' activity must be structured and thus pupils will follow the procedures step by step as planned in the activity card.

In making a conclusion, teachers did not guide the children to the ways in forming a conclusion of the activity done but instead it is given to children to be written in their activity book. This is reflected in one of the teachers' response:

Lastly the children did the conclusion, here in the conclusion I explained that the conclusion is actually the hypothesis, this is where I emphasised which is conductor and which is insulator (Nurul).

Another teacher commented,

Finally I made the conclusion, I feel the children cannot make the conclusion, it is quite difficult ... I have to give it to them ... they can only do the observation but to conclude on their own ... it will take time ... that is why I gave the conclusion (Dzamani).

This common pattern shown by teachers did not reflect a true guided inquiry/discovery method. There was no element of pupils' discovery because teachers had already explained the concepts in their introduction. The activities given were intended to involve pupils according to the curriculum's pupils-centred approach. Furthermore, the activities were intended to confirm the scientific concepts that pupils had to learn. To the teachers 'guided' means that they have to tell the pupils everything. They do not realise that this is not really a guided lesson, but is instructional teaching. In all the observed lessons, the teachers gave instructions for every step of the lessons' development. Most of the practical work observed consisted of following the 'recipes-methods' to verify theory or to illustrate concepts, and much of the practical was routine. Teachers understood that pupils should be encouraged to discover science for themselves with teachers' 'guidance'. The focus was on scientific method with an underlying assumption that pupils had no prior knowledge, so that all observations were perceived as neutral. The most significant problem was that, because the activities were relatively tightly controlled and the 'right answer' was often apparent, there was little scope for 'discovery' in the true sense of the word.

The classroom observations confirmed that teachers' values in teaching science stressed activity-based learning through a guided approach. However, as the observation shows, the guided inquiry approach used by teachers is misleading. According to Bonnstetter (p.3, 1998):

Guided inquiry still has the teacher selecting the topic, the question, and providing the material, but students are required to design the investigation, analyse the results, and reach supportable conclusion.

However, Bonnstetter adds:

A recent teacher workshop suggested that both student and teacher be listed under the procedures/design section. They pointed out that many times we must fluctuate between teacher and student directed at these interface components.

The observation showed that there were no negotiations between teacher and pupils to decide upon procedure/design sections as teachers have already prepared the procedure to be carried out. This implies that these science teachers use the traditional hands-on science experience. The teacher directs the decision-making from topic to conclusion. This traditional methodology is rather predictable: everyone works on the same task, follows the same plan, and works towards the same correct answer. Therefore, teachers claim that they use a guided inquiry approach does not correspond to the programme developers' intention. This is shown in one of the respondent's lessons on electricity and is reflected in his comments:

I have to demonstrate first. I will show them how to connect the wires because if they do it, guided by charts in the workbook, they will not be able to do it. This way the pupil will make less mistakes and it will save time, and then they can proceed with the activity and follow the instructions (Mansor).

An important component in scientific inquiry is that questioning occurs throughout the inquiry learning process (Chaille & Britain cited in Schmidt, 1999, Edwards 1997, Chiappetta 1997). Pupils must be able to ask questions about content according to their prior knowledge. Teachers could help pupils to experience inquiry

learning through the use of the 'KWLQ' procedure as suggested by Schmidt (1999). The procedure is as follows:

K : What I Know

W : What Do I Want To Find Out,

L : What I Learned,

Q : More Questions.

The implication is that these Malaysian primary science teachers' understanding of the guided inquiry approach is incorrect because it is based on the belief that pupils are unable to carry out any activities without their instruction. Furthermore, teachers' understanding of the guided inquiry approach needs to be developed in terms of its meaning and application of the approach, e.g. by applying the 'KWLQ' procedure.

PUPILS' DEVELOPMENT IN SCIENCE

To analyse teachers' understanding of the development of pupils in science, two aspects—science process skills and the scientific attitudes—were observed.

Science process skills

In teaching science process skills, the teachers exhibited similar patterns. The skills were incorporated during the activity but not taught in ways that helped pupils to acquire and develop the skills. As an example, Juliza's lesson was on plants respiration. The teacher gave pupils a general question, 'how do plants respire?' Then a boy answered, 'through the leaves.' When the teacher asked for any other answers and received no response, she immediately said that this was their hypothesis: 'Plants respire through the leaves'. Thus, pupils were not taught that when they are doing an experiment, they should develop a hypothesis first so that in the experiment they will need to use other science process skills to develop the

content or concepts. The lesson, in fact, was an instructed lesson and the science process skills were taught through the worksheet. This is reflected from one of the respondents comment.

Through the questions given in the worksheet. During the earlier explanation about the temperature rises if our body is hot ... maybe at that time they do not see the relationship ... therefore through the questions I developed ... the questions in the worksheet (Nurul).

On one occasion, pupils said they did not know the term 'inference'. The teacher explained the meaning and then gave the answer to the question on inference. This is further evidence that the development of the science process skills was geared entirely to the requirements of the examination, and not the learning needs of the pupils.

However, it should be noted that teachers were able to blend the science process skills with the science concepts by using basic skills such as observing, classifying and predicting. The problems teachers had related to other process skills such as hypothesising, controlling variables, and making inferences. The observations confirmed that some respondents faced difficulty in trying to explain to pupils how to develop a hypothesis. Furthermore, some of the respondents observed were not able to explain which science process skills they wanted the pupils to acquire. Others just mentioned the relevant process skills somewhat unconvincingly. This difficulty is reflected in one of the teacher's comment:

It is difficult to teach the science process skills, I know that it is important but it is difficult with the knowledge that I have how am I teach these skills ... so now I have to get guidance from books (Badriah).

Another teacher responded:

When I have to do experiment with the children, I have to look for reference books to find out what is needed for the experiment, the aim of the experiment, what is to be achieve ... all of it need to be find out. I have to make references ... the problem is to find the references (Mansor).

Observations showed that teachers divorced scientific skills from the content and the context. A majority of teachers were observed setting exercise questions after, rather than during, the practical activity. Thus, the science process skills were not an integral and continuous part of the process, rather an arranged appendage. One main reason for this was the expectation of pupils doing well in the final examination in Year 6. The examination includes science process skill questions as one part of the paper. This encourages teachers to exhibit a 'teach for the exam' syndrome.

This analysis of science process skills acquisition by pupils confirms that the skills were not gained through the context of science; rather they were taught in a vacuum. The teachers' understanding of a process-led curriculum remained superficial, and factors such as the exam influenced the way teachers approached skills acquisition.

The observation confirmed the importance teachers gave to developing scientific skills in an inquiring manner as stated in one of the objective of the Malaysian primary science curriculum that 'the child should be able to know some simple basic science process skills' and the various methods used to develop pupils' scientific skills. However, the development of the skills is not as suggested by Harlen (2000). This indicates that these primary science teachers lack important science pedagogical knowledge.

Scientific attitudes

In the Malaysian context of the primary science curriculum, scientific attitudes are not given priority. For all teachers observed, these were developed co-incidentally during the activity and teachers did not emphasise or ever mention them to pupils.

One respondent states that she had more important things to think about and she forgot to integrate the scientific attitudes. She added that pupils would gain these through their activities in the lessons. One comment made by one of the respondents regarding scientific attitudes:

My problem is that sometime I forgot about the scientific attitudes ... maybe sometime I instilled the scientific attitudes but I forgot to mention it ... maybe the students apply the values but they do not know which scientific attitudes ... indirectly ... the students are not aware (Norizah).

There is no doubt that these attitudes are developed through scientific activities, but by not realising this element, teachers do not take advantage of the situation to develop pupils' scientific attitudes from an early stage.

The interpretation here is that these teachers' thinking about, and understanding, of the importance of scientific attitudes needs to change. Pupils' attitudes affect the willingness of individuals to take part in certain activities, and the way they respond to persons, objects or situations (Harlen 1996). Children should be taught scientific attitudes so that they will be drawn more towards science as a subject and will also have a better understanding of science and further their interest in the subject. This attitude would help pupils to think and work scientifically and teachers should take it more seriously, not just as an element to be acquired. Teachers are responsible for developing these attitudes through encouragement and examples.

Teachers' content knowledge

In analysing teachers' content knowledge, an overall view of the lesson was taken. The teachers' content knowledge component was not great due to it being seen as a process rather than a content-led curriculum. However, it was observed that most of the content given to pupils was correct, covering such diverse topics as animals' eating habits, conductors and insulators, energy and forces.

A focus on teachers content knowledge

Aminah was observed twice and the knowledge that she wanted to transfer to her pupils were animals' eating habits and the characteristic of lights. In the first observation, her content knowledge was observed when she defines the terms of herbivore, carnivore and omnivore and when she tried to link the conceptual content to children's informal experiences of the mouth-parts of animals with their eating habits. In the second observation, her content knowledge was only seen when she explained the use of the concept on reflections of light in everyday life. Her examples of rear mirror in cars and periscope showed that it was conceptually correct.

Badriah was also observed twice and the knowledge that she wants her pupils to gain is the effect of heat energy. Here her content knowledge was observed when she defined the term heat and she monitors the use in pupils' answer and another of her content knowledge was observed when she gave examples of the heat energy (by using the transparencies). Both of her content knowledge was correct.

Juliza was also observed twice. Her content knowledge was observed when she concluded the lesson for her pupils by explaining the movements of animals and also explaining the physical characteristics of animals with certain movement. In her second lesson, her content knowledge was observed when she

discussed the result of the children activity through worksheet (most of the answers were given by teacher). However, both of her content knowledge was correct.

Mansor was observed once. His content knowledge was observed when he discussed the results of the activity and during conclusion of the lesson. He mostly defined the term of conductor and insulator and monitors it uses in the activity.

Muyidin was also observed once. His content knowledge was observed when he concluded the lesson for his pupils. From pupils activity he explained the basic need of animals discussed in the lesson.

Norbadriah was observed twice. Her content knowledge in her lesson on the topic of animal's breeding was observed when she explained on ways animals' breed by giving examples. During this phase it could be seen teacher tried to links conceptual content to children's informal experiences. Her content knowledge was observed when she explained the magnetic materials are made of iron in the second lesson.

Norizah was observed twice. In her first lesson, teacher's content knowledge was observed twice. First, when she explained briefly the ways to preserve food. Here she tried to link conceptual content to children's informal experience of food becoming bad. Her second content knowledge is observed when she gave the definition of the term 'pickling'. Teacher's content knowledge was not observed in the second lesson since this lesson was only carrying out the activity of the lesson. The theory part has been explained in a previous lesson (told by teacher during the lesson to researcher)

Nurul was also observed twice. In her first lesson on the food web, some aspects of her content knowledge were observed. Firstly, she gave a definition of food chain. Then she asked for conceptual understanding when she asked them what would happen if there

were no grasses. Another evidence of her content knowledge was when she showed them a transparency on habitat in a pool and asked pupils to develop food chain and food web from the picture. This showed her content presentation was correct. In her second lesson, teacher focused on science process skills, thus much of her science pedagogical skills emerged but not much of content knowledge. However, the content knowledge was only observed when she discussed the result of pupils' activity of the insulator and conductor.

Soraya was observed once. A number of content knowledge was observed during the lesson. Firstly, in introduction she links present lesson conceptually to previous lesson when she mentioned that food is the basic need of living things and that animals have different eating habits. Another of her content knowledge was observed when she defined the term of herbivore, carnivore and omnivore. Then she links conceptual content to children's informal experience of human eating habit. Lastly when she gave a problem on the animal eating habit, here she asked for conceptual understanding rather than just for factual or procedural knowledge.

Shafie was observed twice. In his first lesson, his content knowledge was observed when he linked present lesson conceptually to previous lesson of the plants basic need of water. In this lesson one wrong content knowledge that teacher made was when he mentioned that boiled water do not permit oxygen to get into it not that oxygen has been removed by boiling. In his second lesson quite a number of his content knowledge was observed. First, when he links conceptual content knowledge to children informal experience. This was done in the introduction phase by asking pupils why people need to eat and drink and link this with plants' basic needs. Another content knowledge was when the teacher gave examples of rats eating bread showed that the example is conceptually correct. However, when teacher starts explaining the

photosynthesis of plants, this showed that teacher content presentation is not developmentally appropriate yet to children's level in this lesson.

Sharifah was also observed twice. In her first lesson, her content knowledge was observed when she tried to link conceptual content to children's informal experiences. This was done when she asked pupils to role-play as doctor and patient getting a treatment and doctor was using a clinical thermometer. Evidence of her content knowledge was observed when she explained about thermometer and the method of reading a thermometer. This was done, by using a prepared transparency of a picture and information on thermometer. This showed that her content presentation is accurate. In her second lesson, the content knowledge was not observed because she spent much time on correcting pupils' activities and dictating correct answers on the task sheet.

Zarina was also observed twice. In her first lesson the only content knowledge observed was when she links present lesson conceptually to previous lesson. The previous lesson was on food chain and the present lesson was on food web. The reason for no content knowledge could be observed was due to the whole lesson was spent for pupils drawing the plants/animals in the food web (teacher did not emphasised that the children need to write the names of plants/animals only). In her second lesson, she also link present lesson conceptually to previous lesson when she asked for examples of apparatus that use heating elements and the lesson on effect of heat. Another of her content knowledge was observed when teacher made conclusion of the lesson; here she links conceptual content to children informal experiences. This was done by explaining that effect of heat in the electric appliances that is important in life and gave the example of a rice cooker.

Dzamani was also observed twice. In the first lesson, his content knowledge was seen when he linked present lesson conceptually to the previous lesson. Here, it was done, by asking pupils questions on sources of electric current. He then linked conceptual content to children's informal experience when he asked pupils the example for uses of batteries. He then asked what energy changes take place when using torchlight. Another evidence of his content knowledge was seen when he linked conceptual content to children's informal experiences of electrical appliances at home with the changes of energy that occurred in the electrical appliances. In his second lesson, his content knowledge was observed when he linked present lesson conceptually to previous lesson. Here the teacher tried to link pupils' knowledge on electric circuit so that they will be able to test the conductor and insulator materials through the electric circuit. He also asked for conceptual understanding rather than just for factual or procedural knowledge. This is when he asked: why are wires wrapped by materials made from rubber? Further evidence that shows his content knowledge was, when he defined the term of insulator and the term conductor and monitors the use of the terms throughout his lesson.

In conclusion teachers' content knowledge was observed when:

- Teachers presented content accurately (during explanation) (seven respondents).
- They linked conceptual content to children's informal experiences (seven respondents).
- They defined terms and monitored their use (six respondents).
- They linked the present lesson conceptually to a previous lesson (four respondents).
- They asked for conceptual understanding, rather than just for factual or procedural knowledge (three respondents).
- They used examples (two respondents).

Only a few respondents (three in three lessons) asked for conceptual understanding. Most of the questions teachers asked sought more factual or procedural knowledge.

This implies that teachers found it easier to ask for factual knowledge since the questions for conceptual understanding requires teachers to use higher order thinking skills. To be able to do this teachers need the knowledge to transform and translate this content knowledge during teaching.

Another factor that showed the limited application of teachers' content knowledge was that only two respondents were using examples. By using many examples, analogies and metaphors in their teaching could help pupils to better understand the concept taught. This implies that teachers lack the knowledge of how to reorganize and sequence content, represent it and provide appropriate examples, metaphors and also applications which are critical features. Most of teachers' content knowledge observed was accurate. They explained content knowledge verbally or with the aid of transparencies. All respondents did this during the discussion of results or the conclusions to the lessons. Furthermore, the teachers linked conceptual content to children's informal experiences when they asked questions on the application of a concept in pupils' everyday lives. In many lessons teachers placed an emphasis on the definition of terms that showed teacher's still have the idea that it is important to transfer content knowledge and understanding of scientific concepts and facts in order for the pupils to understand the subject matter. It can be stated that teachers' content knowledge reflects how they think and what they understand to be important, and is given mostly by transmission through definition or explanation during the discussion and conclusion of a lesson.

The findings showed that teachers' knowledge of content, the way they translated that content into appropriate usage in lessons, their knowledge of children's development in science through

science process skills, scientific attitudes and of effective teaching strategies, all proved to be important components for teachers to consider in their teaching of the Malaysian primary science programme.

CONCLUSION

There are several factors that contribute to teachers' lack of science pedagogical knowledge. First, the teaching approach used in science classes shows a discrepancy between curriculum aspirations for classroom practice and the observed patterns of classroom interaction, and this affects the implementation of the curriculum as intended by the developers. Secondly, the investigation of teachers' development in pupils' science learning shows that teachers' desired outcomes for pupils are very much influenced by the academic achievement, thus depriving pupils of other important outcomes of science learning. Thirdly, the roles teachers adopt in their classroom teaching also show a discrepancy from the intended roles. Teachers' science pedagogical knowledge, at present, is not sufficient to help them teaching the primary science curriculum effectively. As the study shows, teachers do not have a clear understanding and knowledge of the pedagogy, which needs to be understood by teachers experiencing it themselves, as suggested by Watts (1998), Appleton & Asoko (1996) and Stofflett (1994). Although there is a change world wide in the approach to school science learning based on constructivism, the Malaysian primary science teachers however, still need further progressive training in the constructivist approach as a new reform in the science pedagogy. When teachers do not have a clear understanding of an approach, most of them do not use it in class, or, if they do, it is with uncertainty and is modified according to their understanding and experience.

In the Malaysian context, using the science process skills (as stated in Module 2 by Curriculum Development Centre, 1994) enhances the thinking skills. Thus, teachers attach great importance

to thinking and science process skills. Teachers also maintain that science content is important. This implies that teachers generally understand the balance between process and content in children's science learning. This seems to support Swatton's (cited in Warwick & Linfield, 2000) argument that teachers generally adopt a 'holistic' view, with a strong organic relationship between process and content in children's learning. This means that both content and process skills require teachers' careful attention and knowledge to integrate them during teaching so that development in both aspects is gained by children. It is evident that these teachers appreciate the interaction of processes and concepts in children's learning science. However, due to a lack in science pedagogical knowledge, they face problems in developing this two-way interdependence to determine the achievement in pupils understanding of the world around them and the scientific method to support that understanding. As the concept of science learning through pupils' active participation in activities gains strength, the need for materials and apparatus becomes acute. Without the opportunity for students to do their own investigating, their experiences are restricted (Driver 1983).

Teachers' understanding of the importance of activity-based learning with practical activities or investigation in science learning has resulted in them planning most lessons with this in mind, despite the lack of apparatus and large classes. This obviously does not help pupils' construction of meaning and understand science when only a few pupils are able to handle apparatus and be engaged in practical work. The teachers have not demonstrated an in-depth understanding of the curriculum, caused mainly by the lack of science pedagogical knowledge. Teachers need more clarification of what the curriculum guide actually means. For example the actual meaning of the 'guided inquiry approach', the 'constructivist approach' or even the meaning of the role of facilitator in the context of science teaching and learning need to be explained in more depth. This will help teachers to plan and use the correct strategy for

effective science teaching. The curriculum developers need to understand that teachers require a simple and straightforward language directed towards practical classroom problems. The study shows that teachers' classroom practices are not quite compatible with the central values of science teaching. This is disturbing indeed for it questions the appropriateness of the intended primary science curriculum in a Malaysian context.

RECOMMENDATION

The results from this study suggest some challenges for the designers of the in-service programmes. The usual method of disseminating an innovation has proved ineffective; therefore a different method must be introduced for a more effective implementation of an innovation. Ariza and Gomez (1992) found that there was a distinct change in teachers' pre-conceptions when the in-service teacher education strategy adopted a conceptual change teaching programme. This was also useful in exploring teachers' concepts about science, how to teach science and how pupils learn science. Similarly, Haney, Czerniak and Lumpe (1996) also suggest that conceptual change models of staff development may help to accommodate teachers' attitudes towards implementing the strands, which are critical components in the educational change process. This study has shown that teachers' classroom practice is influenced by their preconceptions and understanding of teaching and learning of science and its objectives. These preconceptions and understandings coalesce into teachers' perceptions. Any proposed innovation has, consequently, to be congruent with these perceptions if it is to be acceptable to teachers. The present study shows that teachers' perspectives and understandings are incompatible with the central values of science teaching. Teachers' problems should be acknowledged and viewpoints taken seriously. Therefore, teacher development and change has to start from exploring and evaluating

teachers' current practices and beliefs, and has to take account of their concerns about their own professionalism and feelings of self-worth. Reform or innovation in the science primary classroom must be based on knowledge of teachers' actual practice and an understanding of, and support for, the environments in which primary teachers work. Teachers need to work collaboratively so that they can bring their shared experiences and problems and discuss these with experts, thereby developing their understanding of science education. The confidence derived from this approach would help teachers in their respective classrooms and they would be able to generate new personal views towards science teaching in general.

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