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TEACHER BELIEFS ABOUT LEARNING AND TEACHING IN PRIMARY SCIENCE AND TECHNOLOGY

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ABSTRACT

It is argued that the introduction of many new curricula with their associated teaching practices have failed because the beliefs, views and attitudes of teachers have been ignored. This paper reports the implications of the initial beliefs of primary school teachers involved in a professional development program about science and technology education. In particular, a mismatch between teachers views of learning and teaching is identified and analysed.

INTRODUCTION

The introduction of new curricula with their associated teaching practices, although well founded on learning theory, pedagogy and empirical research, has failed because the conceptions, beliefs, views and attitudes of teachers were often ignored (see Mitchener & Anderson, 1989; Richardson, 1989). Teachers have been at best regarded as a conduit for change; at worst as "a bothersome intervening variable" or "stone-age obstructionists" (Richardson, 1989, p. 379). Furthermore, changes in teaching practice have not been widely implemented because the way in which teachers teach matches their image of science teaching and their knowledge of and about science (Tobin, 1990; Gallagher, 1991).

Many have argued for the need to study such teacher conceptions. Briscoe (1991), for example, claims that an individual commitment to change is not enough. If changes are to occur in teaching practice, teachers must examine their beliefs, judgements, and thoughts regarding what they do and why they do it. Hewson and Hewson (1989, p. 191) state that if we wish to improve science teaching, a key question which needs to be answered is, "What thoughts most influence a teacher's teaching?" Richardson (1989, p. 389) argues that, "Coming to understand the 'meanings and concepts' of experienced teachers about their practice is...the responsibility of those who would enable teachers to change the way they teach..."

The challenge for science and technology education research in the 1990's, is to bring about a change in teaching so that theory and classroom practices are more closely aligned. To meet this challenge there is a need "to identify how teachers can construct knowledge about content and teaching so that their teaching performance improves" (Tobin & Fraser, 1987, p. 213).

The need for teachers to investigate, develop, internalise and consistently apply science and technology understandings, curriculum innovations and developments in pedagogy in a way that is satisfactory to them is not dissimilar to the need for children to investigate, develop, internalise and apply understandings of science in a way which is satisfactory to them. Interactive models of learning based on constructivist principles may provide a means by which these goals can be achieved (Osborne & Freyberg, 1985). Therefore, teachers should be encouraged to explore their conceptions, those of others and test them against experience and in trials.

The present study

The aims of this research were to investigate

* teacher perceptions of their confidence to teach science and technology and their perceptions of what is important in science and technology education,
* teacher conceptions of learning and teaching in science and technology education.

The participants were 40 teachers in the Primary Science Teacher Education Program (PRIMESTEP). The program was presented in two residential blocks, the first over five days and the second over three days with a 10 week break between blocks. Each of 10 school regions in NSW was asked to select participants for PRIMESTEP on the basis of their expertise, enthusiasm or interest in science and technology education. Therefore, they were a targeted group and are not a representative sample of NSW primary school teachers.

Three different methods of data collection were used: before and after surveys; participant/participant interviews; and records of teacher generated metaphors.

SURVEY

Participants were surveyed at the start of the first and at the end of the second PRIMESTEP residential blocks. A questionnaire was designed to obtain participants' personal and demographic details, their perceptions of science and technology and the new science and technology syllabus, their confidence in science and technology education and their conceptions of how children learn in science and technology. The second questionnaire was a subset of the first.

The quantitative data related to the participants' ratings of items according to their importance in science and technology education and their confidence in teaching science and technology were compared using ANOVA with repeated measures and Scheffé test. The changes in these items between the first and second surveys were compared using two tailed correlated t-tests.

The qualitative data obtained in response to the open ended question in the surveys, 'how do children learn in science and technology?', were analysed and categorised in order to identify general trends. Categories were grounded in the data and in some cases clarification of responses was sought from participants.

Results and Discussion

Confidence Participants were asked to rate their confidence to teach science and technology on a four point scale from 1 = not to 4 = extremely confident. Before PRIMESTEP the participants were fairly confident about teaching science and technology (mean = 2.5). After PRIMESTEP, the participants were significantly more confident (mean = 3.1, $t = 4.49$; $p < .0001$). The high rating of their confidence to teach primary science and technology may be atypical of other teachers given the select nature of this group but does attest to the effectiveness of PRIMESTEP in increasing teacher confidence.

What's Important in Science and Technology Education? Participants were asked to rate the importance of 12 items in primary science and technology education on a five point scale from 1 = low to 5 = high importance (see Rennie, Parker & Hutchinson,

1985). The 12 items consisted of two sets of items, those specifically related to science and technology (Set 1; see Table 1) and those related to all subjects (Set 2; see Table 2). The importance ratings of the 12 items in the first and second surveys were compared using a two tailed t-test and no significant differences in the ratings of any items was obtained. This suggests that the participants have constructed beliefs about what is important in science and technology education and these are resistant to change.

ANOVA with repeated measures was used to compare the ratings of the items within each set. Significant differences were found between the ratings of the science and technology items in set 1 (F between items = 16.15; df = 6, 234; $p < .0001$). The lowest mean ratings were obtained for Development of Knowledge and Manipulative Skills, followed by Preparation for Careers in Science and Technology. Follow-up tests revealed significant pair-wise differences as shown in Table 1 where any two means not joined by asterisks are significantly different ($p < .05$).

TABLE 1.
PAIRWISE COMPARISON OF IMPORTANCE RATINGS OF SCIENCE AND TECHNOLOGY RELATED ITEMS USING SCHEFFÉ TEST

	Prob. Solving	Interest in S&T	Relevance	Creativity	Career Prep.	Manip. Skills	Knowledge
Mean	4.8	4.7	4.6	4.5	4.0	3.8	3.6

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Significant differences were also found between the ratings of the items related to all key learning areas, set 2 (F between items = 7.723; df = 4, 152; $p < .0001$). Follow-up tests revealed significant pair-wise differences as shown in Table 2 where the rating of Written Skills was significantly different from other interactive skills i.e. Social and Verbal Skills ($p < .05$).

TABLE 2.
PAIRWISE COMPARISON OF IMPORTANCE RATINGS OF ITEMS RELATED TO ALL LEARNING AREAS USING SCHEFFÉ TEST

	Social Skills	Verbal Skills	Self Discipline	Integrating Subjects	Written Skills
Mean	4.5	4.2	4.1	4.1	3.7

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Of the 12 items, the development of scientific and technological knowledge was rated lowest in importance. This was surprising since, in the PRIMESTEP course evaluation when participants were asked to respond to the open ended question, 'What was the most important thing that you got out of the course?', the most common response was knowledge and understanding. After the 10 week break the participants were asked to explain why knowledge and understandings were important for them but relatively unimportant for their pupils. This question was followed by a long pause (a very unusual occurrence on this course). When they responded they said that they did not believe they had rated it lowest in importance, that the teacher needed to know to be confident about what was being taught, that the teacher needed to apply the knowledge and anticipate the pupils learning outcomes. Further research is needed to determine how much primary school teachers think they need to know and whether their perception of the need to know inhibits their teaching of certain content in primary science and technology. Evidence is provided later that one of the reasons teachers fail to teach science and technology is because they perceive they lack the necessary scientific and technological knowledge. It is tempting to suggest that by rating the development of science and technology knowledge by pupils as relatively unimportant their own lack of knowledge becomes unimportant and their self esteem as teachers is thereby protected.

INTERVIEWS

During PRIMESTEP the participants were asked to maintain a journal in which they recorded their responses to a variety of reflection tasks. In one task, each participant was asked to interview another to determine views of how teachers should teach science and technology and then of how children learn in science and technology. The interviewer then summarised the views of the interviewee in the journal. When the summaries were finished the participants commented on whether the views on learning and teaching described were consistent and whether teachers taught in the way that it was said they should. This task was completed at the start of the course but after the survey.

In order to identify and justify the existence of the general trends and key ideas two researchers independently analysed the data. The results were compared. Evidence was sought to verify these interpretations.

Results and Discussion

Views of Learning The participants seemed to experience little difficulty in clearly explaining how they believed children learn. Children were said to learn in a variety of ways. The following summary of views of how children learn is ranked approximately in order from most to least commonly expressed in interviews.

* By Interacting with Materials and Environment, by 'Doing', 'Hands on', by the Scientific/Technological Processes eg, 'by designing and making', 'by Investigating', 'by trying, testing ideas', 'by applying ideas'.#
* By Interacting with Others, Cooperating/Sharing/ Discussing e.g. 'by working with others', 'by sharing', 'by working in groups'.
* When Motivated/Interested, Enjoyment e.g., 'fun', 'arousing Interest', 'by being motivated', 'by being stimulated'. (Motivation was usually viewed as extrinsically generated, coming from the teacher or science and technology activities.)

* By Thinking/Reflecting, Changing/Constructing their Own Ideas # e.g. by 'forming new ideas when they have seen what they have done', 'modifying ideas', 'creating a view of their world'.
* From Experiences # e.g. 'from their life experiences', 'from everyday experiences'.
* From Teaching, Guided Discovery eg, 'by being guided by the teacher' or By Being Directed eg, 'by being informed', by 'valuing the children's ideas'.
(# These views were very rare in the survey but more common in the interviews.)

The views of learning espoused in both surveys and interviews were consistent. In the interviews these were typically complex in that each participant identified a greater range of components of learning than in the survey but all of these were invariably identified by some of the participants in the survey. Their ability to express these ideas clearly suggests that they have meaningfully constructed beliefs about learning. However, it may simply represent an ability to repeat and link clichés together to form sensible statements rather than an articulation of their own beliefs. The consistency of the data on learning obtained from a range of sources, reported later, implies the latter.

Views of Teaching Those who were able to clearly define the teacher's role tended to describe it in a mechanistic way. The descriptions outlined what the teacher does before and after learning but very rarely explained what the teacher does when children are actually learning. That is, before learning begins, the teacher plans, motivates, sets up the activity, organises groups. After learning the teacher assesses and evaluates. During learning few clear indications are given; some vague references to 'questioning' and acting as a 'guide'. Many defined their role in the negative by stating what they do not do. The following summary of views of how teachers should teach is ranked approximately in order from most to least commonly expressed in interviews.

* By Organising of the Tasks, Environment and Resources eg, 'structuring stimulating situations', 'sequencing activities', 'planning', 'adequate prior preparation',
* By Assessing/Evaluating eg, 'diagnose the pupils knowledge and skills', ' the teacher would engage in purposeful evaluation'
* By Motivating eg, 'provide an enthusiastic and comfortable atmosphere', 'interest and excite the student's natural enthusiasm', 'provide exciting, interesting activities for students... match them with the interests of the students.'
* By Setting up and Managing Groups eg, 'teachers should involve students in group work', 'students placed in groups to cater for diversity of student knowledge and skills'.
* By Interrogating eg, 'by asking questions', 'keep children on task: prompt and probe.'
* By Not Doing Things eg, 'no chalk and talk', 'not too much demonstration', 'not waste kid's time by drawing pretty pictures of experiments', 'not... demonstration style'.
* By Modelling Learning eg, 'by modelling learning', by 'learning with them (the pupils)'

The summaries of the participants' views of teaching often outlined these teaching and learning processes but rarely made connections between them. Very few teachers stated

what their role was in the learning process. When asked about teaching, many teachers stated how they thought children learn. For example, 'Children learn by investigating their own ideas and experimenting', 'They learn by solving problems'. In this way, when they attempted to outline the teachers role while children were actually learning, they tended to refer to what the children were doing or how they would be organised. There were some notable exceptions to this pattern when teachers did attempt to describe a role for the teacher during learning. For example,

> ...the teacher providing ideas and materials, they(sic) present a problem and discuss possibilities. ... Teacher's role is to assist and guide, to help children to think through own solutions. Teacher should observe, question, discuss and guide and provide the opportunities for learning.

It seems that the participants have a clear view of how children learn and their role as an organiser of the learning environment but rarely did they explain how they would promote thinking, reflection and the modification of ideas, cooperative learning, investigating and designing and making. Yet, these were all identified as being ways in which children learn. It is as if the teacher had no role at all when the children are learning.

The participants did not see any inconsistency between their views of learning and teaching. This is not surprising since when many described teaching they did so by describing learning. For example, they often referred to 'child centred learning' and 'cooperative learning' when discussing teaching. They defined their role by defining the children's role.

METAPHORS OF TEACHING AND LEARNING

After the participant/participant interviews, a short lecture was given in which a variety of teacher metaphors were considered. Participants were then asked to construct their own personal teacher metaphor of how they thought they should teach. When this was done they derived a metaphor for their pupils. They were then asked whether they were satisfied with their metaphor? Finally they were asked whether the metaphors described were consistent with the views of teaching and learning summarised in the interviews.

The procedures used to analyse the interviews were also used in the analysis of metaphors. The views about learning and teaching expressed in the surveys, interviews and metaphors were compared. Similarities and differences among these were identified.

Results and Discussion

Although the teachers typically described teaching and learning as 'child centred', the vast majority of personal teacher metaphors were teacher centred eg. 'captain of a ship', 'architect', 'pianist', 'musician', 'entertainer', 'conductor', 'torch'. The teacher metaphors portrayed the teacher as an 'organiser' and 'controller' who brought together individuals for a purpose organised by the teacher. The children were characterised as 'members of a team', 'keys on a piano', 'members of the crew', 'builders following a plan' and 'sponges absorbing the light'! For example,

> I (the architect) provide the plans (basis) from which the children build their "buildings": some branching out from the basic design...They are building on what I have planned for them.

Such metaphors indicate, at a personal level, that many teachers still see themselves teaching in a teacher centred environment in contrast to their articulated views about 'child-centred' learning.

A minority of participants recognised the inconsistency between the metaphors of teaching they described and their summaries of how to teach and how children learn in science and technology. In one instance the teacher saw herself as the 'conductor' and the children as 'members of an orchestra'. When she realised the inconsistency she changed the metaphor to that of a 'musician'. The children thus became the musical 'instruments' upon which she played and she, like others who reflected on this inconsistency, experienced cognitive dissonance.

> After reflecting, I think my role/metaphor, to be more of the musician - because its the musician who plays the instruments. This would then mean the children become the instruments. ... If I'm the musician, the students are the instruments. Who then is the conductor?

The inconsistency of the teacher metaphors and the fluidity of the thinking expressed in some of the metaphors contrasts with the consistent pattern of views expressed about learning across two surveys, an interview and a metaphor. Even where teacher centred metaphors were described the metaphor given for the learner still managed to imply that the learner had some control and operated with considerable independence. The builders did their own building of understandings, the crew on the ship had to take 'responsibility for their own actions', the musicians and instruments were 'creative', members of the football or basketball team 'cooperated' while on the field/court 'away from the coach' and the audience 'interacted'. This implies that teachers have constructed a fixed and definite view about learning.

In contrast, the conceptions of teaching appear to be undergoing change, or perhaps the participants have two distinct views of teaching. One says what they should do, as expressed in the interview, and this involves 'child centred' approaches but appears to be inadequate because it does not describe what they are doing when the children are learning. The other view which arises in the metaphors, also clearly states what they feel they should do but this is teacher centred. These metaphors place the teacher firmly in control and at the centre of attention. There appears to be a clear perception of how they want children to learn but these child centred approaches demand a change in teaching practice. It is the nature of these teaching practices that they are not sure about and therefore they retreat or 'revert' to practices about which they feel more confident but which are more didactic and hence in conflict with their perceptions of learning.

In child centred learning, the participants clearly state that the teacher's role is to keep out, and not to intervene. This conflicts with their personal view of the role of the teacher described in the metaphors. This conflict was at times identified by the participants. For example,

> I need to become a coach who can leave the game to the players once it is in progress and wait till half time to be able to have more input. I must admit, at this stage, I would probably be a coach who runs on to the court during the game when you see a problem arising.

Why don't teachers teach in the way they say they should? When asked whether they teach the way they said they should, the majority (95%) of the teachers said they did at least some of the time. When asked whether other teachers teach in this way, the majority (73%) clearly stated that other teachers do not. The reasons suggested for not teaching in the way they said they should were classified as either external or internal constraints (see Table 3).

TABLE 3
REASONS SCIENCE AND TECHNOLOGY IS NOT TAUGHT AS IT SHOULD

Internal	External
. Fear of a lack of control, noise . A lack of pedagogical knowledge . Fear of lack of knowledge in science and technology . Fear of change and the temptation of the known . It is perceived as too hard.	. A lack of time . Pressure from supervisors . The need to follow school policies . Resources . Children lack necessary skills . Community expectations . Formal testing.

The reasons imply that the teachers may have the following perceptions of science and technology education:

* Science and technology requires too much time to be taught appropriately and there are quicker ways than by using child centred approaches:

  I try to teach the way it was said you should but sometimes I interfere with the "creative processes" of children because of time restraints - need to be somewhere else, eg. assembly...

* Child centred approaches which are appropriate for learning and teaching in science and technology result in classes which are noisy and make the teachers feel as though they have lost control. Some participants perceive executive members of staff as supervisors who are conservative and prefer traditional approaches:

  ...because they feel they are not in control of the situation - children are noisy etc. Quite often neighbouring teachers/executive etc raise their eyebrows at the chaos... They prefer the organised quiet work approach.

* Science and technology should be taught in a particular way with a set content resulting in the development of scientifically and technologically acceptable knowledge:

  ... because of stereotype images of what 'good' science teaching is about. What students must know and that incorrect knowledge should not be allowed.

* There is a tension between what teachers feel they should be doing in order to teach science and technology well, what they feel comfortable doing and the expectations of others as to what they should be doing. There is a general feeling that both the internal and external constraints reduce the amount of control teachers have over what they can do in their own classrooms. For example,

  I do teach this way ... to some extent. There are external constraints placed on teachers which influence teaching style, eg, the school practices and policies,

like having to follow set text books and having to prepare children for regular formal examinations.

I try to teach this way but find it very tempting to revert to too much teacher input. I find it very difficult to work out appropriate activities. Some teachers.... find it difficult to move away from the traditional step by step - do it my way approach. Some teachers are not convinced that science and technology is really valuable. Many simply lack the confidence to start: that includes knowledge of physical science content but also the inquiry process.

CONCLUSION

The teachers involved in this research appear to have clear views about learning which are resistant to change and broadly consistent with modern views of learning. Their views emphasise the need for the learner to be motivated and allowed by the teacher to develop their own understandings. The views expressed about how to teach describe teaching in science and technology as occurring by a sequence of steps which occur before and after learning. Even these teachers who have been specifically targeted because of their commitment to science and technology education do not appear to have a clear view of how they should interact with children in order to promote learning. The two distinct views described of how teachers should teach, one which is 'child centred' the other teacher centred, suggest that their views of teaching are undergoing change or may represent differences between what they actually do and what they believe they should do. The teacher centred view of teaching was inconsistent with the views of learning which were described. Those teachers who commented on this contradiction were concerned by the mismatch between their beliefs and practices.

Alternatively, it may be that these teachers have no commitment to their stated views of learning and believe teacher centred models are the most effective strategies to bring about learning but such a conclusion is not supported by the journal entries. On the contrary, a picture of teachers committed to science and technology and a change in teaching emerges but, because they are unsure about exactly how they should teach they revert to familiar less desirable teacher centred strategies. For example,

...the preparation time is finite... consequently I take the 'easy way out' and opt for the directed approach. ... Maybe I'm a "closet chalk-n-talker" paying lip service to modern techniques and ideas? No perhaps that's too harsh. I am aware of change. I'm not comfortable...

Finally, apart from difficulties experienced in matching teaching strategies to beliefs about how children learn, teachers generally believe there are factors in schools which inhibit the implementation of good teaching practices. These include, supervision by executive staff, programs and assessment; the very things which should have, as their primary function, the enhancement of learning and teaching. These external influences require further investigation. In particular, to what extent is it merely a perception that these determine what individual teachers do in their classrooms and that they have little control over them?

The findings suggest that teachers do need opportunities to reflect on their beliefs of teaching and learning as these influence how they teach but they also have a need to develop strategies to promote learning; a need about which they themselves may not be clearly aware and one which is unlikely to be met solely through reflection. Attempts to bring about change need to also focus on the school as well as the individual teachers since each teacher seems to believe that a range of school based factors, over which they believe they have little control, may inhibit the introduction and implementation of teaching practices which they believe are appropriate.

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