ELEMENTARY SCIENCE EDUCATION: TIME FOR A CHANGE?

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Abstract: The research literature indicates that science education in the elementary school falls short of what might be regarded as best practice. This paper examines the structure of elementary science education and discusses relationships between teacher knowledge, confidence and competence. Factors that constrain implementation and innovation are considered. Actual and potential relationships between elementary and secondary science education are discussed.
A case is made for replacing micro-oriented elementary science education with macro-oriented environmental education.

Best practice

It is often helpful when considering complex matters such as school curricula to start by asking what are the purposes of the various parts of a curriculum. In the case of science education several writers have attempted justifications. Blake (1977) for example appears to believe that it simply ought to be in the curriculum. Sherratt (1982) and Cleminson (1990) take a similar view . Waring & Schofield (1981) took the joy of learning view of science education - a view shared by Riley (1983). West (1986) argued for science education on the grounds that the learning of science text exemplifies the pursuit of rationality. It is also possible to argue that science text is a unique form of knowledge and, for this epistemological reason, ought to be part of the general education of every citizen.
The utilitarian argument for science education stresses the need for a science education curriculum that will help prepare children for the workforce. The argument is made that schools would be failing in their mission if they did not recognise the importance of getting a job. For the utilitarians, the processes and social context of science are important only to the extent that they might influence the major purpose. Finally, for some people the most important purpose will be to prepare children for the systematic study of science in the

secondary school.

It is quite possible to present counter arguments to each of these views. There is, for example, no special force in the imperative. Unless one moves the argument to the moral domain and invokes the moral imperative it can hardly be considered as a justification for including anything in the curriculum. The joy of learning perspective might be true before the child comes to school but it becomes manifestly false for many children as they move through the school system. The idea that the study of science contributes to rational thinking might be true in a specific sense but for the young child much of science is irrational - it is in conflict with one's sensory perceptions. It could also be argued that the epistemological purpose is not particularly strong either as more people appear to accept the view that science is a subjective, social construction. The division of knowledge and experience into disciplines has served us well but much of the child's non-school experience and learning is part of a `seamless web'. If we are teaching science for utilitarian purposes then we are ignoring the likely state of the labour market and we are ignoring he relative lack of evidence of any connection between school science and the state of the economy. Whilst one might not be particularly persuaded by any one of these arguments, collectively they are a rationale for elementary science education of some form.

Those who have studied elementary science education in Australia and in other countries have generally concluded that there is a significant gap between vision and reality. The reality that we speak about is a reality based on the interpretation of research data OR the perceptions (data-based or not) of people in positions of influence - such as politicians. There are individual teachers, and schools, that have excellent science education programs but when one looks more widely across the nation the data seem quite consistent and support the rather pessimistic conclusions that are usually reported. The research data suggest that the time allocated for elementary science education is usually quite low, that the time actually spent on science education can be even lower, that chalk and talk methods are common and that teachers feel that their science knowledge is inadequate. In a study of teachers perceptions of elementary science education Jeans and Farnsworth (1991) asked a sample of elementary teachers to respond to a list of randomly ordered descriptors. The sample chose 5.5 times more positive than negative descriptors. Typically elementary science was described as fun (the most common descriptor), investigative, relevant and thought-provoking. When asked to contribute other descriptors about one in four of the sample responded and added positive words like positive, exploring and simple. A few process words were given hypothesising, analysing and questioning. The two negative words that were contributed were expensive and space-consuming. One concludes therefore that the sample had a positive view of elementary science and saw it as fun, exciting, challenging, absorbing involving what if, hypothesising and finding out. None of the teachers mentioned descriptors related to technology or to gender issues. On average female teachers tended to choose more descriptors than male teachers: 8.3 words versus 7.4, and more positive descriptors than the men; 7.3 versus 6.4. There was no gender difference in the number of negative descriptors chosen. These figures should not be taken too literally but they do indicate that both male and female teachers have a fairly positive attitude to elementary science education. So although Westmore (1992) may be right when she says that few primary teachers have had positive experiences of science they nevertheless appeared to be convinced of the significance of science education.

The vision is, almost by definition, an ideal to be sought after but perhaps never achieved. It is often a view derived by academic staff from their reading of the literature. The literature presents the most recent intellectual arguments and these are arguments about what might be the case rather than what is the case. The significance of the gap between the two is a matter of judgment and depends on who is examining the gap. In this sense there will always be a gap between vision and reality in science education. It seems clear however that the size of the gap should and can be reduced. To do so by enhancing the quality of school science education will require the commitment of considerable resources. In times of economic difficulty this is something that government's are unwilling to do unless they can see the possibility of a rapid return on the expenditure.

Structure of elementary science education

The notion of structure in elementary science education is less clear than in the case of secondary science education. Nevertheless the fundamental questions are similar.

- i How should we best conceptualise science education?
- ii How systematic should it be?
- iii What will be the balance between theory, demonstration and practice-discovery?
- iv Will the curriculum design be spiral, block, some combination of the two or something quite different?
- v What science domains will be represented and what criteria will we use for the selection of content?
- vi Should there be a systematic science education program over the six or seven years of the primary school
- vii Should the primary program be articulated with secondary science education?

Conceptualising science education

There is no one right model of science education but it is important to have some model that has a rational defense and that meets the needs of teachers and students. It is this basic model that guides curriculum design, content selection and the pedagogy to be used. We can think of science education as consisting of three major components, science text, science context and science education pedagogy. Each of these has a set of associated issues about which one has to make considered decisions.

Text

What text should be included in elementary science education? There is no simple or definitive answer. We can approach the question from an academic perspective and, having regard for the purposes, decide on the most appropriate body of text knowledge. We could come at the question from another direction and start by asking what teachers actually know. If we take this latter course it is reasonably clear that there is no systematic body of knowledge that is shared by most elementary teachers. This is not of course to say or imply that elementary teachers have no science knowledge. It is more that the case that each teacher's science knowledge is idiosyncractic rather than systematic. There are several reasons for this. They include differences in the high school science background of teacher education students, differences in science education in teacher education programs, differences in school policies and practices and the non-systematic nature of professional development in science education. If each primary teacher had a significant body of science knowledge I don't think that the idiosyncracy dimension would be very important. The evidence is that few teachers do have such a body of personal knowledge. This lack of knowledge makes the matter of the elementary science education curriculum particularly important.

It is well established that teacher education students have tended to take biological science in the upper years of secondary school- that is if they take any science at all. There seems to be few studies of what actually happens in teacher education programs but one's personal experience suggests some generalisations. The proportion of the first three years of course time allocated to science education is probably in the order of 5-8% and would very rarely exceed 10%. In a generalist teacher education program that attempts to cover some text, context and pedagogy in seven or eight curriculum areas one cannot expect the time allocation for any one area to be much more than 5-8%. Within this 5-8% there seem to be considerable differences in the balance between the three components. Some institutions argue that the amount of text knowledge that can be included is so minimal that it has to be the student's and employee's responsibility and that the best use of course time is to concentrate on the context and pedagogy. Other institutions have been less influenced by contextual matters and have concentrated on text and pedagogy. Even within the text component there seem to be considerable differences between courses. In some cases the text content mainly reflects curriculum content. If there is any practical work required it will be some combination of curriculum content and discipline knowledge.

Finally, one might note that the Australian Science Teachers Association (ASTA, 1985) and Silis (1988) have argued that the emphasis in an elementary science education program should be on skills and attitudes rather than on factual knowledge.

Science context

There is a significant body of opinion in the literature of science education that it is misleading to think of science as a systematic and objective exploration and mastery of the material world. The views usually come from sociological argument or from philosophical argument. The sociological argument has been quite influential and has several strands. One of these is that the stereotypical image of a scientist as a white anglo-saxon male does not recognise the contribution made by women, it supports a power structure that disadvantages women, it perpetuates an elitist view of science knowledge and it help scientists to evade public scrutiny and public accountability. These arguments focus on:

i improving opportunities for women in science as researchers and as science administrators

ii recognition of the achievements of women in science

iii a call for the deconstruction of science so that it can be reconstructed in the public domain with an informed and properly represented public, sharing ownership and able to take part in debates on matters of science, technology and society.

iv pressure on science educators to alter science education so that it takes account of these matters.

The gender dimension of science education in the post-primary sector has been the subject of considerable debate (Johnston, 1984; Hildebrand, 1989; Martinez, 1992) with a number of writers suggesting that there should be separate science education classes and maybe even separate science content - based on the notion that the relevance of some topics in science education is gender-dependent (Smail et al., 1982; Taber, 1991). For those who are persuaded that this is necessary the issue arises of when boys and girls ought to separated for science education. As with most educational research very few generalisations actually hold good. Lock (1992) has shown that for some practical skills such as planning, observing and reporting there are no significant gender differences. Teachers in the Jeans and Farnsworth study were asked to comment on the idea of separate education classes for boys and girls. Although a number of teachers recognised arguments for separation in post-primary science, around 88% of the sample were strongly opposed to the idea for primary schools. Opposition was expressed in strong terms; rubbish, sexist, abhorrent and garbage were among the terms used. Ten percent however made a variety of supportive comments some of which would no doubt be shared by the 90% who were opposed. For example, a number of teachers made the point that all-girl groups could sometimes be quite appropriate provided that there was whole class discussion and follow-up. There was only one teacher who gave unreserved support and argued that it helped develop confidence in girls in what is commonly seen as a male domain. Others who supported the notion saw the benefits of having smaller classes to work with.

Although the sample had a clear view about the relevance of the gender dimension it is less likely that there was any general view about the importance of other contextual factors in elementary science education. In most cases it appears that the sociological arguments outlined above have had little effect on what happens in the classroom.

Science education pedagogy

The basic question appears to be whether there is, or should be, subject-specific pedagogy in the elementary school. How adequate is the seamless web perspective for elementary schooling? The ASTA (1985) expressed a preference for the generalist elementary teacher when it argued that an effective teacher of language, mathematics and social studies should also be a good science teacher. One might want to argue for some degree of subject specialisation in the elementary school but there doesn't seem to any argument for subject-specific methodologies.

Given that the learning processes of elementary school-age children are facilitated by manipulation of concrete objects, science education ought to have a substantial practical component. In fact, science education of some kind is an ideal subject for the elementary school because it can be as practical as the teacher wants to make it. The introductory investigation of plants, animals, natural and man-made materials etc. using the senses and simple manipulative techniques can be information-rich and does not need sophisticated equipment. It does, however, require the teacher to have a personal body of knowledge that is sufficient to give them the competence and confidence needed to guide the child's learning efficiently and effectively. The proposition that most elementary science education should be practical and not too concerned with theories and models does not mean that it is necessarily non-cognitive. It is reasonably clear that almost all children in the elementary school are in Piagetian terms, sensori-motor or concrete operators. That is, they deal with the world of objects, ideas and feelings by considering specific real-life events. This view of the learner is reflected in constructivist theory.

The pedagogy of science education is dominated by two distinct perspectives, one based on construction and the other based on reproduction. The constructivist perspective assumes that learning is the construction of personal, idiosyncratic images or representations of reality. It is a form of genetic epistemology (Piaget, 1972). Learning is not a simple reproductive process in which knowledge is received from external sources and stored in long term memory. It is a process in which information is accepted, interpreted, integrated and then stored. The learner actively tries to make sense of experience and to accommodate it to existing cognitive structures in much the same way that Bruner, Olver and Greenfield (1966) and Piaget (1972) proposed. In some cases this constructed understanding is well-formed in the sense that it mirrors accepted social constructions. In other cases the created image is poorly formed and does not coincide with paradigmatic knowledge. The constructivist teacher emphasises the continuity of learning; new learning is based on prior learning. The underlying pedagogic model is one in which learning tasks are shared and one of the teacher's main tasks is to see that there is an appropriate division of responsibility for learning. The learner is then accompanied through processes of conceptual clarification, cognitive dissonance, reassessment and reconstruction (Driver, 1986; Driver & Oldham, 1986; Hand, Lovejoy & Balaam, 1991). The process is learner-centered and the teacher emphasises facilitation rather than representing herself as a repository of knowledge (Hill & Wheeler, 1991; McElwee (1991).

The constructivist view of learning is now thought to be so self-evident or so intuitively right that it dominates learning theory particularly in mathematics and science education (Leder & Gunstone, 1990). It is problematic as to whether it can be assumed that all human learning is best described by constructivism. It may be the case that constructivism describes some learning styles better than others. The most frequent observation that we make about humans is that they differ on almost every attribute.

Whilst constructivism seems to be widely accepted it does not mean that all other paradigms of science education are no longer valid. The reproductive paradigm might be criticised for over-emphasising the role of the teacher but it is difficult to see how constructivism by itself can lead to the discovery of standard nomenclature, theories and quantitative relationships.

It is of course true that much of elementary science education is not concerned with quantitative relationships. When we talk about elementary science education we should not overlook the unreality of the fundamental theories upon which science rests. The atomic structure of matter for example is intellectually satisfying for some but it defies the evidence of one's senses. The notion that a table is largely space is in direct conflict with our sensory impressions. Such concepts are not amenable to discovery learning (Smith, 1983).

Systematic science education

It appears that elementary science education is less systematic than say language and mathematics education. What is taught and how it is taught seems to be more influenced by personal decisions than by group consensus. Even when teachers use a structured curriculum package or text it seems that they are likely to select topics, themes etc. on the basis of their knowledge and not on any systematic basis. The issue therefore is whether systematicity is sufficiently important to try to do something about it. On balance, my view is that it is this important and hence I am inclined to the view that we need a structured program of science education of some kind that meets the criteria set out in the section under the heading of curriculum design.

Theory, demonstration and practice-discovery

From all of the evidence available we can conclude that intelligence is developmental. It becomes progressively more powerful with increasing experience. The neonate's initial explorations of the world is sensory-perceptual. The basic stuff of intelligence is direct experience of the world of objects and relationships. As far as is known there is no contrary observation. Elementary schooling should, therefore, be as directly related to sensory experience as is possible. In the earliest years of schooling most teachers teach in accord with this general principle. With increasing experience most children move beyond reliance on direct sensory experience. However, teachers have found that it is useful to introduce new areas of learning by starting with concrete experience. In this regard science learning in the elementary school is no different from any other learning.

The distinction between observation and practical experience is not sharp and it can easily be argued that practical work includes observation. It is however useful to distinguish between practical work that explores objects and practical work that explores relationships. Practical work that explores objects often has a taxonomic purpose. A typical example would be sorting leaves on the basis of their physical characteristics. Practical work that explores relationships typically identifies and manipulates variables. A common example is the study of the conditions for rusting. Both observation and practical experience are suitable and perhaps necessary in an elementary science education program. The predominance of practical investigation does not necessarily mean that there is no room for demonstration. There may be times when cost, clarity or safety indicate the need for a demonstration. The phase-change behaviour of water will involve heating water to produce steam. For safety reasons the teacher of young children may well judge that this is best done under her direct control. Techniques such as animal feeding and seed planting will probably be demonstrated first and then followed up with student activities. The general notion of hands on learning in the elementary school is well accepted and applies equally to science education. The issue is hands on what? If we answer from a process perspective we will focus on process skills such as observation, comparison and classification. If we take account of the social-cultural context we will include processes of reporting, communication and accountability. These aspects will also be important to those who argue that science education should be derived from paradigmatic science. From this perspective the science education curriculum ought to illustrate the predictability, regularity and parsimony of science. Considerations such as these help one to realise that science education is not a unitary activity. It is a complex, multifaceted enterprise requiring high levels of pedagogic competence it is to be effective.

Curriculum design

If we are to have a systematic science education program how should it be organised within one year and over the years, of the elementary school? Should it be thematic, integrated or segregated? There are some criteria that can be used to suggest answers to these questions:

i the intellectual demand on the student should become more complex over time

ii the student's knowledge and skill should actually increase

iii there should be some means of assessing i and ii

iv the student should gradually come to recognise science as a distinctive form of knowledge

v the content should be as inclusive as possible

The significance of the first criterion is that it implies that careful planning is needed to ensure that there is an increase in intellectual demand. It can be satisfied in several ways, for example, a spiral design in which basic skills and concepts are revisited and new complexities introduced, or, by using pedagogic techniques that become progressively more symbolic, or, by introducing new and more challenging topics. It is quite possible that these parameters can be met with almost any curriculum design but some planning is necessary to ensure that the student's experiences do become more demanding and are not simply more at the same level of difficulty. Whether one opts for a content emphasis or a process emphasis the second criterion also requires deliberate planning if the experiences are not to become too repetitious.

Evaluation of the intellectual demand of a science education curriculum and of its gradient of difficulty must be matters of judgment and not measurement. One might, for this reason, choose to ignore this criterion but these indices are essential elements if one wants to assess the value of a curriculum or if one wants to compare one with another. The process of

evaluation is made more complex if science education is part of an integrated curriculum.
Even in this case however some attempt needs to be made to assess the value of the content.

Unless one accepts that there are some distinctive characteristics of science there seems to be little point in including in a school's curriculum except perhaps as a series of attention-grabbing events that have little relationship to each other or to systematic reasoning processes. The fourth criterion therefore suggests that the science education curriculum should be organised so that the student develops some basic idea of why some activities count as science and some do not. The fifth criterion implies that the content should be equally accessible to all children.

Science domains
Whilst there is a general feeling among elementary teachers that science education is important there is less agreement about what form it should take. The debate can be summarised as a process-content matter. There are some elementary teachers, certainly in the minority, who would prefer that elementary science text should be drawn from the science disciplines (chemistry, physics, geology, astronomy, biology). This is derived from a notion that elementary science education ought to be some kind of introduction to secondary school science. Teacher views on the purpose of elementary science education are not well documented but it may well be that many teachers do think that elementary science education ought to be some form of preparation for secondary science education. It is clear however that the majority of teachers do not support the emphasis on content that illustrates or is simply drawn from the various scientific disciplines. There seem to be two general opinions. One view is that topics drawn from biology are the most suitable for the elementary school. There are several reasons for this view. They are likely to have had some contact with biological topics in their high school science education and they believe that biological topics are relevant and inherently interesting to children. The other view is

that the matter of selection of text content is less important than the selection of processes.
That is, processes such as observation, classification, hypothesising and reporting ought to be the substantive content and should replace science text. This popular view has had the support of some leading science educators (Harlen & Ennever, 1972) but nevertheless the teaching of processes as substantive content does not seem to have improved perceptions of the quality of science education.

Teacher knowledge, competence and confidence
Several studies have indicated that many elementary teachers have less confidence than they would like to have when they are dealing with science education. One might reasonably assume that a teacher's effectiveness in the classroom is a function of her confidence and her pedagogic competence and her text and context knowledge. Confidence may well be a general personality trait for some people but for many people it is probably best thought of as a general positive disposition that has strong contextual determinants. In either case a confident teacher does not mean ipso facto that the teacher will necessarily have a sound knowledge base. The notion of pedagogic competence implies an adequate level of pedagogic skill but it quite conceivable that a competent teacher might not have the confidence for effective teaching particularly if she does not have the relevant intellectual competence - founded on content knowledge. In order to test this speculation Jeans & Farnsworth (1991) asked a broad sample of elementary teachers to rate their personal confidence and competence in each of eight curriculum areas. The mean rating for science education competence was 6.5 and this was higher only than for music education. For comparison, language education was 8.3 and music education was 4.8. The corresponding confidence ratings for science education and music education were 7.0 and 5.0 respectively.
Using the means of the individual data the correlation coefficient was 0.813. This supports the hypothesis that confidence and competence are closely related and that changes in one may well result in changes in the other. If we can increase teacher

competence we might increase their confidence and this might result in better primary science education. The high rank of mathematics education suggests that the teachers in this sample see themselves as more confident (8.4) and more competent (8.1) than has been suggested by the many critics of primary schooling. On the scale used for this item 10 indicated fully competent and fully confident respectively and so the data for science education are encouraging. Teachers are positive about their ability to be effective science educators. It is however a matter of concern that they are more positive about every other curriculum area except music education. Increasing experience was accompanied by perceptions of increasing competence in mathematics education (p=0.054) but not in science education (p=0.249). Experience and confidence were positively associated for mathematics education (p=0.001) but not for science education (p=0.697). For science education, male teachers rated their confidence significantly higher (p=0.013) than female teachers. The data show that the concept of a generalist primary teacher equally competent and confident in all curriculum areas has rather weak support. When the teachers were asked to select possible causes of low confidence the largest single contributor was lack of knowledge. The other major contributor had to do with difficulties of obtaining and organising materials. These data indicate that the task of increasing the personal-knowledge base of primary teachers is urgent. It is also expensive. One might try to do this with well-written printed materials but anecdotal evidence suggests that this is not a very effective means of informing and influencing primary teachers.

Articulation

If we were to follow the old maxim of leaving well enough alone or if we are guided by the view that if it isn't broken don't fix it we would be tempted to accept that we have a system of schooling that works more or less well for many students. It is reasonably clear however that the discontinuity the child experiences between the last year of primary school and the first year of secondary school is quite unsettling and one should ask

whether this needs to be the case. Part of the discontinuity is no doubt due to the very different curriculum structures of the two sectors. It is not particularly obvious why there should be this break in continuity and in the case of science education there seems no point at all. Preliminary data from a current study of how secondary science teachers perceive elementary science education suggests that articulation is of more concern to elementary teachers than to secondary science teachers. Secondary science teachers do give some support to articulation and there are a number of interesting practical experiments under way to bring the two sectors closer together. They also give several reasons why they are not especially active in curriculum matters at the elementary level. These include lack of time, lack of interest, a view that the curriculum of elementary science education is not a major issue, and a belief that there is simply no need to articulate the two levels because secondary school science education makes no assumptions about prior science education. The point needs to be made however that there are two quite different cultures involved and so the issues are individual, attitudinal and perceptual as much as they are organisational, professional and intellectual.
In many cases links between elementary and secondary school tend to be structural, organisational and administrative rather than at the curriculum level.
It is matter of judgment as to whether one accepts the divide or whether one thinks that it is sufficiently important to try to do something about it.

Environmental education
When elementary teachers themselves feel that what they are doing falls short of what they think ought to be done, when secondary science teachers do not place great importance on elementary science education, when attempts at curriculum reform do not seem to have been very successful, and when there are such pressing environmental issues to be managed one must consider whether or not the time has come to make some changes to what we are doing in elementary science education. There are several possibilities. We could:

i remove science education from the elementary curriculum
ii increase the teacher's science text and context knowledge
iii develop a state or national science education curriculum
iv replace part or all of science education with environmental education

To remove science education from the elementary curriculum would be a council of despair.
If we accept that its presence is justified we need to turn our attention to how best to make it work. It may well be that elementary science education would actually be improved if we were to think of environmental education as an integrating concept. We can argue about the nature of environmental education but in this paper I simply mean the study of macro issues such as pollution, global warming, the ozone layer, the use of energy rather than the study of micro phenomena such as the rusting of nails, the germination of seeds and so on. These issues involve complex relationships but local manifestations such as erosion, deforestation and environmental pollution are readily observable. It may be that teachers will feel even less confident and will be even more hesitant about their knowledge. On the other hand it may well be that they will see more relevance in these local and global issues. These broad issues lend themselves to themes in which general understandings are more important than detailed knowledge. In fact the management of a sustainable environment requires some degree of respect and perhaps even reverence. These attitudinal components seem ideal content for the elementary school. It may even be that environmental education will be more girl-friendly than our current forms of science education. There are many practical activities, based on environmental themes, that are non-competitive, suitable for groups and that have some community benefit. By definition, environmental issues integrate text and context. It might even be that articles in newspapers, magazines and teachers' journals will be more readily used than the information that appears in textbooks.

Innovation

If we decide to make changes in elementary science education there are a number of contextual issues that are often overlooked but which seem vital to the success of any kind of change or innovation. Many innovations seem to be in the nature of policy dictates that assume teachers are simply agents in the processes of government. This matter is addressed in Jeans (1990) but a brief account is given here because of the importance of attending to the way in which innovation is attempted.

The relationship between teachers and employers has gradually become more complex and teachers have sought a greater degree of autonomy in the exercise of their knowledge and skills. Although much of teaching is a craft teachers now see the employment relationship as one in which a salary is paid for the delivery of a professional service rather than one in which a wage is paid for carrying out a set of directives from a central office. The growing professionalism of teaching (Maeroff, 1988) is occurring at a time when governments want to have more influence, not less, on what is taught and how it is taught (Gellert, 1985). However, the tendency toward central control is a two-edged sword. There is much to be said in favour of a common teaching program across the nation. Clearly much energy can be saved if schools do not feel compelled to reinvent the wheel over and over again. On the other hand a unified system makes it easier for national government to use the schools as agencies of policy implementation. If one agrees with government policies then one may find it tolerable to be treated as a direct arm of government. If, on the other hand, one has moral or ethical objections to such policies there is a professional dilemma which must be resolved in some way (Longstaff, 1989).

However one conceptualises the relationship between teachers and the State (Giroux, 1990) and whether or not one believes that teachers should be instruments of government policy implementation (Tilford, 1985), it is quite clear that the State government expects schools to play a major part in the implementation of their economic and social justice policies. If teachers are to do this several conditions need to be met:

i Teachers need to know what the policies are and how they can be operationalised. This is not always easy to achieve because of the costs and technical difficulties of making information available to a large number of teachers. Much information dissemination is in the form of publications of one kind or another and for teachers, this seems to be one of the less effective means of communication.

ii Teachers need to be neutral, if not sympathetic, towards the policies and the proposed method of implementation. A teaching force cannot be assumed to be a homogeneous group of people who will be like-minded on all issues. Inevitably there will be considerable variations in the degree of personal support for any policy at all.

iii The number of policy initiatives must be such that they can be implemented by evolutionary rather than revolutionary adjustment. From a societal perspective schools need to be a conserving force maintaining and extending one's cultural heritage, and a reforming force pointing towards a fairer and more just social order (See Shapiro, 1988). A recent study (Jeans, 1990) indicates that teachers are very aware of the tensions but, nevertheless, see themselves as agents of modest social change. Policy initiatives that are too numerous, or point in conflicting directions, or have values that are not supported by the teaching force, will engender resistance and loss of morale. The task of reformation then becomes that much more difficult.

Consideration of the possible role of environmental education is not new. Robottom (1983), for example, considered relationships between environmental education and science education. When a proposal to make a change from science education to environmental education is considered against the three criteria given above it is seen that on these grounds it is achievable. It is not, however, an all or nothing matter. Teachers who feel comfortable with science education and who feel that they have a worthwhile curriculum ought to continue with it but there are many teachers who are not in this position. For these teachers environmental education might be a more suitable concept. One cannot prove in any way that such a change will be a change for the better but on the evidence available there are grounds for suggesting that we look for alternatives to the typical kinds of science education in our primary schools.

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