Ideas for enhancing primary and high school science education

Special Report:

Top Six Ideas in Science Education

(Selected from the recent international science education literature)

The 7E Learning Model

(From: Volume 2, 2003, pp.134-135)

The learning cycle continues to evolve. We have seen the three-phase exploration, invention, and discovery; the exploration, term introduction, and concept application cycle; and the 5E model comprising engage, explore, explain, elaborate, and evaluate. Based on our latest insights from research on how people learn, Eisenkraft (2003) has refined the extremely effective 5E model to propose a 7E learning cycle.

The modification involves two changes. First, to emphasise the importance of eliciting prior understanding, the engage element is expanded into an elicit and an engage phase. Second, an extend element is added to the elaborate and evaluate phases. The 7E model looks as follows:

- **Elicit:** Elicit students’ prior conceptions (e.g., by using a “What do you think?” question).
- **Engage:** Motivate students by arousing their interest.
- **Explore:** Have students make predictions, design experiments, collect and analyse data, draw conclusions, and develop hypotheses. Various degrees of teacher and student ownership and control are possible.
- **Explain:** Introduce concepts, terminology, laws, etc., and summarise the results of the exploration phase in these terms.
- **Elaborate:** Provide opportunities for students to practise the near transfer of learning. Simple applications of the new knowledge are made to new domains. This may include solving related numerical problems, or posing a different (but similar) question and exploring it.
- **Evaluate:** Use both formative (e.g., as occurs during the elicit phase) and summative evaluation, and items addressing aspects from across the entire learning experience.
(e.g., experimental design, interpreting data from a similar experiment, questions about the labs, and extend items [see following]).

**Extend:** Provide for the more distant transfer, to new contexts, of the new concepts and understanding (e.g., following a study of safety belts in cars, investigate the use of airbags and how they work).

**Reference**


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**The Activity Model for Scientific Inquiry**

*(From: Volume 3, 2004, pp. 29-30)*

The shortcomings of the typical “Scientific Method” commonly portrayed in textbooks have been long acknowledged. Harwood (2004) used interviews with over 50 research scientists, representing a broad range of fields, to propose an improved model for how science is done. His Activity Model for Scientific Inquiry comprises 10 main activities, as shown in the diagram. During the scientific process, scientists engage in as many of these activities, and in whatever order, as is needed. A particular activity may be used more than once.

![Activity Model for Scientific Inquiry Diagram](image)

**Activity Model for Scientific Inquiry**

*Questions* is at the centre of the figure, reflecting the central role of asking questions in any scientific inquiry. *Investigating the Known* might include the use of books, journals, and experts. *Articulating the Expectation* may involve making a prediction or hypothesizing. *Carrying out the Study* includes choosing a methodology, and can include other activities in the model. *Examining the Results* will need to address the validity of the results. *Reflecting on the Findings* requires asking what the results mean (i.e., what conclusions may be reached?). *Communicating With Others* will include collaboration during the inquiry, as well as formal oral or written reports.

The model might be used in a variety of ways. It could serve as a framework for open, guided, or structured inquiry lessons. For example, in the case of the former, the activities could be used to
determine if students are using appropriate thinking. Rather than having students engage in a complete inquiry project, there could be a focus on a particular activity (or combination of activities) alone. For example, addressing *Investigating the Known* could require students to search the World Wide Web and learn how to access and read journals and contact experts. Or, students might be provided with information from a case study and asked to *Examine the Results* and *Reflect on the Findings*.

Reference


### Inquiry Classroom Management Checklist

*(From: Volume 4, 2005, pp. 27-29)*

Most of the techniques used to manage a direct-instruction classroom are inadequate for an inquiry setting, which is typically characterized by more movement, more noise, and more opportunities for students to misbehave. Indeed, concern over management issues, such as a fear of losing control of the classroom, is a major obstacle to the more widespread implementation of inquiry-based practices.

To help teachers address this issue, Sampson (2004) devised the Science Management Observation Protocol (SMOP). This 25-item assessment instrument, based on research about effective classroom management, allows a classroom observer to rate each item on a 0-4 scale. The following Inquiry Classroom Management Checklist is a modified version of the SMOP, written instead to facilitate teacher self-assessment.

### Inquiry Classroom Management Checklist

*Features of the Classroom*

1. Do I have an effective way to get quiet in the classroom, within 10 seconds and without raising my voice or threatening punishment?
2. Do I consistently enforce a well-developed set of classroom rules, with interventions based on logical consequences?
3. Is there a set routine for students to get my attention?
4. Do students listen to me when I am talking, and do I avoid “talking over” them?
5. Is my lesson(s) student-centered and highly engaging, taking advantage of students’ curiosity?

*Student Collaboration*

6. Do I use a variety of cooperative learning techniques to ensure that all students are engaged?
7. Are student groups small (3 students per group is generally ideal), with each student having a significant role in the group?
8. Are students’ roles assigned effectively and fairly?
9. Do students respect the ideas and opinions of others?
10. Do I use structures to make each student personally accountable for content learned during a cooperative activity?

**Time and Student Engagement**

11. Do I inform my students of what they need to accomplish during a lesson, and give them a timeframe for doing so?
12. Are transitions between activities short (less than 60 seconds)?
13. Do I limit the number of instructions given before a transition or activity, and make them specific and clear?
14. Do I move continually around the room, listening to students, challenging them with questions, and keeping them focused?
15. Am I “with-it” (i.e., able to communicate an awareness of student behaviour), and able to do more than one thing at a time?
16. Is the majority of class time devoted to academic tasks?

**Materials**

17. Do I have an efficient method for stocktaking materials at the beginning, and end, of activities?
18. Is there a standard procedure for getting, and returning, materials?
19. Are my students accountable for keeping materials in good condition?
20. During lab work, do I move often between groups, but restrict student movement around the room?
21. Does inappropriate behaviour during lab work have a consequence, and is it documented?
22. Do I assign clean-up duties to specific students?

**Safety**

23. Have students been provided with a set of rules for laboratory work, and are they regularly reminded of them?
24. Do students know the location of safety equipment, and what to do in the event of an accident?
25. Do students wear safety glasses whenever heating, glassware, or chemicals are used?

While the above checklist identifies aspects that need to be addressed when planning to manage an inquiry classroom, it does not specify techniques for doing so. There may be multiple ways to effectively accomplish any particular checklist item, and such techniques could be gleaned by, for example, observing experienced teachers in action and by informal teacher-teacher collaboration. This journal will also make a contribution here. In the *Your Questions Answered* section of this issue, you will find a variety of suggestions for implementing the first item in the checklist (i.e., how to get all students in a class quiet and listening within 10 seconds). Other items in the checklist will be addressed progressively in subsequent issues.

**Reference**

A well-crafted rubric can be an indispensable tool for assessing a performance task. Rubrics have three basic elements: criteria (or parts of a task), standards (or levels) of achievement, and indicators, as exemplified in Figure 1 for a task requiring students to research a topic, draw a diagram or construct a model, and share their findings and understandings using an oral presentation.

In contrast to a rubric, a checklist contains only criteria and marks to be awarded for each, but is a useful starting point for developing a rubric. Bednarski (2003) offers the following advice for designing and using a rubric.

- The number of standards/levels may vary with the task, but two or three standards generally work best.
- Always order the standards with the highest level first (on the left).
- Avoid ambiguous wording (e.g., few, most, limited, creatively) in the indicators, the “rules of the game.”
- Do not use two or more indicators that measure the same thing, as this could penalise students more than once for the same shortcoming.
- Keep rubrics manageable by avoiding excessive length and complication.
- Assign points to each indicator to reflect its weight/importance.
- An overall grade (A to C, say) may be assigned on the basis of the total obtained from adding the points scored on each indicator mastered. For example, an A might correspond with a score of 47-50 out of a possible 50. Determine the grade score range so that students can still receive an A, even if they fall short on either one of the more highly-weighted indicators or one or two of the less weighty indicators.
- Do not assign points for unacceptable performance. Accomplish this by not including indicators that describe such in the rubric. Rather, where there is no acceptable performance, assign either “No points” or leave the grid position blank. In particular, the lowest (last) level for a particular criterion is not for unacceptable achievement and also does not necessarily represent a C grade.
- A “work habits” criterion may be used to assess effort, meeting deadlines, contribution to group work, etc..
- To encourage creativity, include a “WOW” criterion. This awards points to a student who does something noteworthy that is not required by the rest of the rubric, or something above a highest standard. This does not penalise students who meet all the expectations of a project, as the WOW points are bonus points that are added to the total score (but which are not included in the total possible score).
- Provide a self-evaluation column. Asking students to reflect upon, and evaluate, their work prior to submitting it will encourage increased student-teacher communication and motivate students towards submitting quality products.
- Spell out expectations by issuing rubrics to students at the beginning of tasks.
- Where a project involves consecutive dependent tasks (e.g., research, followed by a presentation), use the rubric to evaluate each task before proceeding to the next. This provides students with the opportunity to address deficiencies that might otherwise result in them being penalised again for the same shortcoming.
- Really good rubrics develop over time, as the result of revision that includes student feedback.
<table>
<thead>
<tr>
<th>Criterion</th>
<th>Standard</th>
<th>Self-evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent</td>
<td>Fair</td>
</tr>
<tr>
<td><strong>Research paper</strong></td>
<td>6 Discusses and justifies . . .</td>
<td>3 Discusses . .</td>
</tr>
<tr>
<td></td>
<td>2 No spelling or grammatical errors</td>
<td>1 One or two</td>
</tr>
<tr>
<td></td>
<td>9 Discusses the . .</td>
<td>6 Discusses the .</td>
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<td></td>
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<td>. with one</td>
</tr>
<tr>
<td></td>
<td></td>
<td>omission or error</td>
</tr>
<tr>
<td><strong>Diagram or model</strong></td>
<td>2 Uses correct colours</td>
<td>(No points)</td>
</tr>
<tr>
<td><strong>Oral Presentation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WOW</strong></td>
<td>3 Included something extra that demands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>attention!</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 1*: Sample structural overview for a performance task rubric. Each number gives the points scored for demonstration of that indicator.

*Reference*


**Teaching Controversial Issues: An Improved Approach**

A controversial issue is one that a significant number of people argue reasonably about without reaching a conclusion. Controversy can arise as a result of insufficient evidence being presently available to decide an issue, where the outcomes depend on future events that cannot be predicted with certainty, and where judgement depends on how different people value the known information. In the case of the latter, the differences are usually based on underlying beliefs or understandings, such as religious beliefs in relation to abortion, cultural differences regarding links between “race” and intelligence, and moral issues connected with genetic engineering.

In addition, while many controversial issues do have a scientific component, they may also have social, political, or economic concerns. For example, the development of genetically modified crops can be viewed as scientists helping to feed the world, as companies trying to make money, or as “mad scientists” inventing “monsters.” Oulton, Dillon, and Grace (2004) therefore conclude that asking students to resolve a conflict based on scientific reasoning alone seems insufficient.
**Problems With Present Approaches**

An approach that might be presently used with 14-19 year-old students, say, is to display a newspaper article, ask students what they know about the issue, display this information and fill in any major gaps, discuss the pros and cons of a particular solution in small groups, invite a whole class debate, and ask students to vote for or against the solution. Homework might require students to write a short argument for or against the solution, and be assessed on the basis of the accuracy of the scientific content.

However, such a traditional approach does not adequately address the nature of controversial issues. This, in conjunction with misunderstanding of the nature of science, the role of scientists, and the potential and limitations of science, may be contributing to the public’s lack of confidence in science and scientists as effective problem-solvers.

Also, debates requiring students to vote on an issue can require them to draw a conclusion prematurely, or based simply on some appealing characteristic of a presenter. Besides, isn’t it unfair to ask students to make such a decision about an issue that adults cannot agree on?

At the same time, teachers might be striving to focus on rationality, reasoning, and the facts, to present a balanced view, and to remain neutral themselves, but all of these positions have shortcomings. As has been previously discussed, focussing on scientific reasoning alone is insufficient and unrealistic. While the notion of a balanced view might at first seem reasonable, it is a contested one because the balance is likely to differ with the worldview of the teacher. Teachers need to make subjective judgements about what information to provide, and in what format, and different formats may affect students differently. Perfect balance is probably impossible. Finally, teachers find it difficult to sustain neutrality, as this can impact negatively on rapport with a class and their personal credibility. In light of the foregoing rejection of balance, neutrality is hard to justify. And, can we really expect students to be open about their thoughts and feelings if the teacher never does the same?

Role-plays and simulations are often suggested for stimulating debate and developing an appreciation of the perspectives of others. However, there is little evidence to support the effectiveness of role-play in changing affective outcomes, preparation for such activities is time-consuming, and teacher training is needed. Besides, it may be difficult, even impossible, for a student to play a role that requires a different worldview from their own. Role-plays such as a public enquiry may still be useful, but more for developing an understanding of such an event than of the issue involved.

Classroom discussion also has its drawbacks. Successful discussion requires a deal of teacher preparation time, students--possibly even teachers--need training in discussion techniques, and the poor models of debate presented by society (e.g., the outrageous antics on television shows) impede effective classroom debates.

**The Purpose of Schooling**

Before considering an improved approach, we do need to acknowledge the varying educational contexts in which controversial issues will be treated, and that different schools may adopt different positions on different issues. The nature and purpose of schooling includes the following, not necessarily mutually exclusive, possibilities:
1. To encourage students to develop personal views and opinions.
2. To instil societal norms.
3. To reflect critically on the nature of controversial issues (i.e., a socially critical approach that explores the power and authority behind issues).

All schools might accept the first position when considering, say, genetically modified crops, but this is unlikely to be encouraged in, for example, Catholic schools in relation to the morality of abortion or, in the case of racism, in societies where an antiracial approach has been mandated. The third position would not be welcomed in some societies, as it would challenge the political status quo.

**Suggestions for a Way Forward**

Oulton, Dillon, and Grace (2004) suggest that the following be included in a revised approach to the teaching of controversial issues:

1. Make the nature of controversial issues explicit. For example:
   - Different groups can arrive at different views (i.e., there can be multiple perspectives) based on different information, or different interpretation of the same information as a result of a different worldview or value system.
   - Reason, logic, or experiment may not always resolve an issue.
   - A controversial issue may be resolved when further information becomes available.
2. Promote a more realistic view of the nature of science, including its strengths, limitations, and tentative nature.
3. Develop skills of critical inquiry in students (e.g., asking probing questions, not being put off by stock answers, and distinguishing between strong and weak evidence, sound and unsound reasoning, and facts and emotions).
4. Be open about balance in presenting controversial issues not being perfectly achievable, and develop students’ ability to be critically aware of bias. Perhaps it is indoctrination that is to be avoided, emphasising balanced learning rather than trying to strive for balanced teaching.
5. Have the teacher make his position, and the way he arrived at it, explicit at the beginning so students are aware of potential bias in aspects of the learning experience. This will actually help to protect teachers from being accused of bias in their teaching. At all times, though, both teacher and students retain the right to remain silent on matters they do not wish to share.

**An Alternative Model**

An improved approach to teaching a controversial issue might be to display a newspaper article (or use some other stimulus activity), question students to gather their ideas about the issue, display these ideas and fill in any obvious gaps, provide the class with various position statements as to solutions (e.g., in the case of Foot and Mouth disease on English farms in 2001, the UK Government, National Farmers’ Union, an organic farming organization, an animal welfare group, and the Dutch Government), have the teacher explain why she chose these groups to represent a range of opinions, and working in groups, invite students to use the position statements and other resources (e.g., the Internet) to answer the following for their allocated organisation:

1. Who comprises this group?
2. What are the aims of the organisation?
3. Who does the group represent?
4. How is the group funded?
5. Does the group’s publicity materials indicate any key values or position?
6. What evidence is the group using in the debate?
7. From where do they get their evidence?
8. Are the limits of their evidence described?
9. Does the group identify contrary arguments?
10. What are they aiming to get us to believe?
11. How strong does their argument appear to be?
12. What consequences follow from their argument?

Then, each group might present its findings using, for example, a short oral, handout, and/or poster, with the teacher leading a class discussion of the strengths and weaknesses of both the presentation and the arguments from each group. Homework might comprise designing a television news critical question for a representative of each organisation, explaining (for assessment purposes) why they were asking the question. The question would be marked on the basis of the degree to which it reflects a student’s ability to analyse weakness in arguments and to pose questions that could effectively elicit answers.

(Editor: To take the next step and make a decision on an issue, the background developed using the foregoing process might be used as input to a Decision Making Matrix [see Volume 2, p.86].)

Reference


**Going Beyond STS: Towards a Curriculum for Sociopolitical Action**

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**Abstract**

This article asserts that STS-oriented curricula, while of value in presenting a more authentic view of scientific practice and its cultural context, are too timid in their approach towards the political interests and social values that underpin scientific and technological developments. A case is made for politicizing students through an issues-based, technology-oriented curriculum aimed at social critique, values clarification, and preparation for sociopolitical action.

**Introduction**

Regrettably, science is often regarded as a body of knowledge that can be transmitted by teachers, memorized by students, and reproduced on demand in examinations. Regrettably, too, science is often portrayed as the de-personalized and disinterested pursuit of objective truth, independent of the society in which it is practised and untouched by ordinary human emotions, values, and conventions. Although the science-technology-society movement (STS education) has done much to shift the emphasis of science education in some educational jurisdictions towards a more authentic representation of scientific knowledge and scientific practice (Kumar & Chubin, 2000;
Solomon & Aikenhead, 1994; Yager, 1996), the reforms do not go nearly far enough. Although some curricula draw on elements of the history, philosophy, and sociology of science to show students how scientific inquiry is influenced by the sociocultural context in which it is located, this insight is not used to politicize students. Too often, teachers avoid confronting the political interests and social values underlying the scientific and technological practices they teach about, and seek to avoid making judgements about them or influencing students' views. Two points are worth making. First, curriculum cannot be value-free. Values are promoted as much by what is omitted as by what is included. Second, the so-called “value-free” approach diverts attention away from what I consider to be the major purpose of science education: preparation for responsible citizenship.

It almost goes without saying that science education should lay the foundation for further study and for a potential career as a scientist, engineer, or technician, but it should also be concerned with enabling young citizens to look critically at the society we have, and the values that sustain it, and to ask what can and should be changed in order to achieve a more socially just democracy and to ensure more environmentally sustainable lifestyles. This view of science education is overtly and unashamedly political. It takes the Advisory Group on Education for Citizenship and the Teaching of Democracy in Schools (Qualifications and Curriculum Authority [QCA], 1998) at its word—not just education about citizenship, but education for citizenship: “Citizenship education is education for citizenship, behaving and acting as a citizen, therefore it is not just knowledge of citizenship and civic society; it also implies developing values, skills and understanding” (p. 13, emphasis added).

**Politicizing the Curriculum**

My view is that politicization of science education is best approached via an issues-based and technology-oriented curriculum. In the modern world, technology pervades everything we do; its social and environmental impact is clear; its disconcerting social implications and disturbing moral-ethical dilemmas are made apparent in the media almost every day. Consequently, it is much easier to see how technology is determined by the sociocultural context in which it is located than to see how science is driven by such factors, and it is much easier to see the environmental and societal impact of technology than science. This is not an argument against teaching science; rather, it is an argument for using technology as a means of contextualizing science in a way that makes it more accessible to students.

In Hodson (2003), I outline my proposal for a curriculum focused on seven areas of concern: human health; food and agriculture; land, water, and mineral resources; energy resources and consumption; industry (including manufacturing industry, the leisure and service industries, biotechnology, and so on); information transfer and transportation; freedom and control in science and technology (ethics and social responsibility). Within such a curriculum, a judicious mix of local, regional, national, and global concerns can be addressed in terms of four levels of sophistication.

- **Level 1**: Appreciating the societal impact of scientific and technological change, and recognizing that science and technology are, to some extent, culturally determined.
- **Level 2**: Recognizing that decisions about scientific and technological development are taken in pursuit of particular interests, and that benefits accruing to some may be at the expense of others. Recognizing that scientific and technological developments are inextricably linked with the distribution of wealth and power.
- **Level 3**: Developing one’s own views and establishing one’s own underlying value positions.
- **Level 4**: Preparing for, and taking, action.
Level 1 is about the complex interactions among science, technology, society, and environment. Technology is not shaped by scientific knowledge alone; rather, it is the product of particular sociopolitical, cultural, and economic circumstances. In turn, technologies such as the printing press and the computer, or the steam engine and the internal combustion engine, shape the lives of people and impact on both the natural and built environments in quite dramatic ways. Level One awareness includes recognition that the benefits of scientific and technological innovations are often accompanied by problems: hazards to human health, challenging and sometimes disconcerting social changes, environmental degradation, and major moral-ethical dilemmas.

Although there are STS-oriented curricula that identify problematic features of scientific and technological development, many regard decision-making in science and technology as a relatively simple matter of reaching consensus or effecting a compromise. In contrast, the intention at Level Two is to assist students in recognizing that decisions are usually taken in pursuit of particular interests, justified by particular values, and sometimes implemented by those with sufficient economic or political power to override the needs and interests of others. In consequence, the advantages and disadvantages of scientific and technological developments often impact differentially on society. In other words, science and technology may serve the rich and the powerful in ways that are prejudicial to the interests and well-being of the poor and powerless, sometimes giving rise to further inequalities and injustices. In many ways, the material benefits of the industrialized world are achieved at the expense of those living in the Developing World. The intention of Level 2 is twofold. First, students recognize that critical consideration of scientific and technological development is inextricably linked with questions about the distribution of wealth and power. Second, they begin to see that problems of environmental degradation are rooted in societal practices and in the values and interests that sustain and legitimize them.

Level Three is concerned primarily with supporting students in formulating their own opinions on important issues. Its focus is values clarification, developing strong feelings about issues, and actively thinking about what it means to act wisely, justly, and honourably in particular social, political, and environmental contexts. Like global education (Selby, 1995), with which it has much in common, it begins with the fostering of self-esteem and personal well-being, and extends to respect for the rights of others, mutual trust, the pursuit of justice, cooperative decision-making, and creative resolution of conflict between individuals, within and between communities, and throughout the world. It is driven by commitment to the principle that alternative voices can and should be heard in order that decisions in science and technology reflect wisdom and justice, rather than powerful sectional interests (Maxwell, 1992).

The fourth level of sophistication is where the radical character of this curriculum is principally located: helping students to prepare for, and to take, responsible action. Socially and environmentally responsible behaviour will not necessarily follow from knowledge of key concepts or even from the possession of the “right attitudes.” Almost every one of us has personal experience illustrating that it is much easier to proclaim that one cares about an issue than to do something about it. What translates knowledge into action is ownership and empowerment. Those who act are those who have a deep personal understanding of the issues (especially their human and environmental implications) and feel a personal investment in addressing and solving the problems. Those who act are those who feel personally empowered to effect change, who feel that they can make a difference and, crucially, know how to do so. Thus, a prerequisite for action is a clear understanding of how decisions are made within local, regional, and national government, and within industry, commerce, and the military. Without knowledge of where, and with whom, power of decision-making is located, and awareness of the mechanisms by which decisions are reached, intervention is not possible. In
other words, the kind of scientific and technological literacy that this curriculum proposal is designed to achieve is inextricably linked with education for political literacy. The likelihood that students will deploy their knowledge of political structures and mechanisms in significant sociopolitical action in adult life will be much greater if they are given opportunities to take action as part of the curriculum experience. Examples of such action include conducting surveys of dump sites, public footpaths, and environmentally sensitive areas, generating data for community groups such as birdwatchers and ramblers, making public statements and writing letters, organizing petitions and consumer boycotts of environmentally unsafe products, publishing newsletters, lobbying local government officials, working on environmental clean-up projects, creating nature trails, assuming responsibility for environmental enhancement of the school grounds, monitoring the school’s consumption of energy and material resources in order to formulate more appropriate practices, and so on. It is not enough for students to learn that science and technology are influenced by social, political, and economic forces. They need to learn how to participate, and they need to experience participation. It is not enough for students to be armchair critics! As Kyle (1996) put it: “Education must be transformed from the passive, technical, and apolitical orientation that is reflective of most students' school-based experiences to an active, critical, and politicized life-long endeavour that transcends the boundaries of classrooms and schools” (p. 1).

The curriculum proposals outlined here are unashamedly intended to produce activists: people who will fight for what is right, good, and just; people who will work to re-fashion society along more socially-just lines; people who will work vigorously in the best interests of the biosphere. It is here that the curriculum deviates sharply from STS courses currently in use.

**Changing Values and Changing Lifestyle**

The gist of my argument is that science and technology education has the responsibility of showing students the complex but intimate relationships among the technological products we consume, the processes that produce them, the values that underpin them, and the biosphere that sustains us. Within an issues-based curriculum oriented towards sociopolitical action, it is not acceptable to regard environmental problems as an inevitable consequence of technological development or to imply that science itself can solve the problems by simple technical means. Projecting such messages depoliticizes the issues, thereby removing them from the “realm of possibility” within which ordinary people see themselves as capable of intervention. As a consequence, dealing with environmental problems is left to experts and officials, and ordinary citizens are disempowered. Education for sociopolitical action entails recognizing that the environment is not just a “given,” but a social construct. It is a social construct in the sense that we act upon and change the natural environment, and so construct and reconstruct it through our social actions. It is a social construct in the sense that we perceive it in a way that reflects the prevailing sociocultural framework. In consequence, environmental problems are not problems “out there” in our surroundings, but problems “in here” (in our heads), in the way we choose to make sense of the world. They are pre-eminently social problems--problems of people, their lifestyles, and their relations with the natural world.

By adopting this position, we can challenge the notion that environmental problems are inevitable. If environment is a social construct, environmental problems are social problems, caused by societal practices and structures, and justified by society’s current values. It follows that solving environmental problems is a matter of addressing and changing the social conditions that give rise to them and the values that sustain them. It follows that science education for sociopolitical action is inescapably an exercise in values clarification and values change. Hence Level 3 in the scheme outlined above. Environmental problems will not just “go away,” nor will they be solved by a
quick “technical fix” while we blithely maintain our profligate lifestyle. We have to change the way we live; the planet can no longer sustain our present way of life.

It is a well-worn cliché to say that we live in a global village, and that what we do in our own backyard can impact quite significantly on people living elsewhere in the world. It is also the case that our actions now impact on the lives of future citizens. The ethics of previous generations have dealt almost exclusively with relations among people alive at the same time. In startling contrast, the impact of contemporary technology makes an urgent issue of relations with those as yet unborn. In recognizing this new reality, we would do well to heed the wisdom of the First Nations people of North America: “Treat the Earth well. It was not given to you by your parents; it was loaned to you by your children. We do not inherit the Earth from our ancestors, we borrow it from our children” (oral tradition). It is not too much of an exaggeration to say that the degree to which young citizens incorporate sustainable practices into their professional and personal lives will determine the quality of life for future generations. It is my contention that the science curriculum has a crucial role to play in teaching students how to exercise the enormous power of technology responsibly, carefully, and compassionately, and in the interests of all living creatures.

The most fundamental element in this values shift is the rejection of anthropocentrism (and the objectification and exploitation of nature that follow from it) in favour of biocentrism: having respect for the intrinsic value of all living things, cultivating a sense of compassion and caring towards both human and non-human species, having a concern for maintaining the existence of biological and cultural diversity, challenging and rejecting all forms of discrimination, and making choices that are designed to maintain an ecologically sound and humane lifestyle. Laszlo (2001) describes the inculcation of this clutch of values as developing a “planetary ethic”--an ethic which “respects the conditions under which all people in the world community can live in dignity and freedom, without destroying each other’s chances of livelihood, culture, society and environment” (p. 78). He goes to some length to reassure readers that abiding by a planetary ethic does not necessarily entail major sacrifices or self-denying behaviour. Striving for excellence, beauty, personal growth, enjoyment, even comfort and luxury, is still possible, provided that we keep in mind the consequences of our actions on the life and activity of others by asking:

- Is the way I live compatible with the rights of others?
- Does it take basic resources from them?
- Does it impact adversely on the environment?

References


