Science for all: what have we been teaching in the science curriculum and what should we teach?

Peter Fensham

Human beings have one thing in common—they are all unique. I remember the laughter and argument we had as to whether you could have this sentence in English (whether it meant anything), but—we do have one thing in common, lots of things in common, but we are still all unique.

The following paper was presented by Professor Fensham as part of a Queensland Section program devoted to Science Education.

Science: A newcomer in schooling

I want to say some things about the possibilities for science education with this century being the century of biological development and biological science. First though, I need to go back a little bit and remind us that Mathematics has always been part of schooling, no matter how little people had. Science, however, did not exist in schooling until much later. I remember being very surprised when I was doing my PhD in chemistry in England in the 1950s to find that some of my co-PhD students had not studied science at all in their English grammar schools. The University of Bristol had a special year, called the 'Intermediate Year' which was a bridging programme for people who wanted to do degrees in Science who had not studied it in their grammar schools. Australia was a little ahead as I had studied the sciences, but I was part of a very tiny minority of people who went on for 12 years of schooling. My name begins with "F" – and I was Number 304 in the Victorian Matriculation Examination—in all we were less than 1000—less than 8% of our age group. The only reason to study in Year 12 and hence, for doing science at that level, was because we wanted to go to University to undertake science-related courses. Fifty per cent of us did physics, chemistry, and two mathematics subjects. The number of people who do that now in Victoria (the Golden Four as it used to be called) is about 5% of the age-group, whereas we were 50% of the age-group of people in Year 12, but of course we were only 1/10th of the whole population.

A New Intent for Science Education

Science in schooling has been primarily dominated (and I will argue still is) with the aim of preparing people who want to have science-based careers, in other words become science-based experts. After the exciting and turbulent times of the 1970s and the awakening of the environmental catastrophe which was occurring often through the introduction of new science-based technologies, committees were set up in several countries to consider the state of science education. They all reported that science in schooling should be much more. Science for ***all*** students rather than for this small elite (of which I and many of you will have been part). In the later 1980s and early 1990s we started to try to put this intention into practice, with the buzz-word 'Scientific Literacy' coined. Buzzwords do not really help in practice, but they do draw attention to a need.

At that time, there was also the thought that if we could get school science right, we would also solve another problem which was then being documented, namely, the abysmal ignorance of the public about science. I remember the Minister for Education in New Zealand telling an audience that more New Zealanders knew that the earth went around the sun than Americans, but she did not tell us that it was only about 20% of New Zealanders. But does this knowledge matter? She did not address this question, assuming the answer, 'Yes', was self-obvious. On another occasion she would use the small level of this knowledge to argue in the budget debates for more money for education. It was thus a very useful statistic—we were better than Americans but we were so bad that we needed more money.

The underlying argument for both 'Science for All' and 'Public Awareness of Science' was that citizens now live in societies that are increasingly influenced by science and technology. There were two assumptions in these reports. The first is a pragmatic one: if it is useful, it must be right. We have to increase people's understanding of science because they will then have a better quality of life and be able to do things they otherwise could not do in the society which is dominated by science and technology. The second is the democratic assumption, that is, quality science education in school that will enable future citizens to participate meaningfully in the many decisions we now face as the possibilities of science and technology impinge on society in a big way. It was assumed that if we improve science education, then people will be more rational. Again politicians are very keen on this one and I expect it to be referred to when the new statement about science education in Queensland is launched by the Minister for Education and the Premier. I wonder if they will refer to the fact that science—a great human endeavour—is intriguing and fascinating and hence important to be shared. The reports of the 1980s in general quite overlooked this as the primary reason for school science education. Furthermore, it was missing in the new statement here until the very last stage of preparation. With its insertion Queensland will find itself a bit ahead of most of such reports.

Science-Society: An interface

Internationally, a debate was begun that I have represented in Figure 1. In it we have science as a great human endeavour within society but not understood by the majority of citizens who are located outside science. Inside the circle or inside this three dimensional faceted sphere (the three-dimensional things representation of science is more helpful because it shows many attractive colourful facets) is the world of science. What impinges on citizens is the interface between the world of science and society at large. I will come back to this model later.

If we could answer what the interface was, we would know what science for all ought to be. At present in education we seem to think that we have got the inside right. We think we know how to do what we have been doing since 1880, when science first appeared in American schools, that is preparing future scientists.

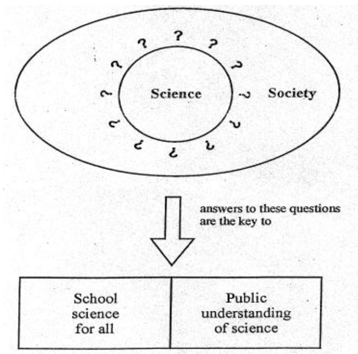


Figure 1: A representation of the issues facing school science

In the debate people argued from several different gounds. There were people who were particularly concerned about the *personal well-being* of citizens—that life will be better if people understand more simple, and not so simple, bits of science. Others were arguing that the world of work was changing, being very strongly influenced by technologies increasingly based on recent science discoveries. This is different from most of history, when technologies emerged long before their science was understood. So we need some sort of science to assist people in the modern world of work—*socio-economic well-being*.

Yet others were concerned about the democratic assumption ‘societies will function more smoothly and better if citizens know more science’—*democratic well-being*. Finally, there were those who said we still have to look after *the well-being of science*, otherwise the whole thing will grind to a halt. All these groups were arguing about what should be the content of school science.

There was good agreement about the purpose of scientific literacy for all students and about the four well-beings. The debate in country after country was between persons with science expertise—interested academic scientists and science educators. One other group was present—the curricular bureaucrats—and they in the end were the ones who said this debate has to stop because we have to write something down because the Minister wants to change science education tomorrow. Whether or not you have finally resolved the issue, we are going to write down where we are. These persons play a very powerful role.

A new but not new school science

The answers they wrote down included that science should be stretched across all the years of compulsory schooling. Queensland extended it down to the primary school in the early 1990s as did the other states of Australia, but only now it is saying that science will be compulsory in Year 10. Well, what are we going to do with all those years of science? England and Wales started off with a scheme that had 21 different strands of science learning so that no-one would mix them up with the original view that school science should be with only physics, chemistry and biology. However in that country when the curriculum writers said ‘enough is enough’—lo and behold they finished up with three strands of content stretched across eleven years of schooling plus one other called *working scientifically*. If you read behind the education-speak of the three content strands they are: physics, chemistry and biology. Nothing significant had changed. England and Wales were the first in 1991 to set out a new curriculum for science. A USA project in1993 ‘Benchmarks of Scientific Literary’ retained eight strands of content, four of which were physics, chemistry, earth science and biology. This was not a decisive curriculum project and as the states made their decisions they, in general, re-affirmed the importance of the four science disciplines. Australia in 1994 recommended the same four science disciplinary strands with the variation that working scientifically in some states was integrated and in others a separate strand.

Sweden, which had not had well-defined strands of content in primary schooling, now does have three clearly defined strands, basically physics, chemistry and biology, as has Korea in its new curriculum. Denmark is a strange exception with a new curriculum document for primary science and technology of just four pages that in effect say that in primary school science should now be present, and that teachers should carry out with their students scientific investigations in the environments that have meaning for the students. If they do that well, good science content will be learned, and that content will not be spelt out in common terms.

Each other country produced long lists of prescribed content. I remember the Canadian one for primary school was on a sheet, so long that I had to stand on a stool to stop it touching the ground. The common outcome of these debates was that almost all the traditional content was there, although now often stretched down to earlier years, together with additional content suggested by some others in the debate.

In practice this has tended to reinforce the old curriculum content because that was what secondary science teachers understood and primary teachers recognised as what they had not understood in their own schooling. A large international project in the early 1990s called the Third International Mathematics and Science Study (TIMSS) which was a cross-national assessment planned initially to have eight content strands mirroring the debate in the USA. In the end, because students can only endure so much testing time, it finished up testing physics, chemistry, earth science, and biology with a few environmental items—a strong reinforcement of the traditional science content.

When the debate was stopped—not finished—we ended up with long lists of content to be learned by every student which was more than the content that the specialist few students had been learning before. Now we are beginning to see that something was wrong with this solution. I have thought hard about how this mistake was made, and I now believe that we asked the wrong group of people to have the debate. We asked only science experts to tell us about the interface between science and society.

Science-tinted glasses

If you think about this, and if you could get inside this sphere or circle of science, you would find that it is so very densely packed that you can only see the interface through a host of other bits of science. Science experts look at the world through scientific glasses and so they can justify all of these bits. Ohm’s Law is important because it is the basis of the use of electricity in the home even though most citizens can use their electrical appliances without knowing Ohm’s Law.

Richard Feynman (a great Nobel Laureate in physics who was very successful at making science understandable through diagrams) once said ‘people who have been trained in science see the world differently’ and I think that is where the problem is. We have asked people who have science-tinted glasses, so everything could be justified—everything that was already there and lots of new things that were not there—an impossible blend.

Warnings unheeded

Even before the bureaucrats called a halt to the debate a few people had raised doubts about the enterprise. Two Americans wrote a paper in which they said scientific literacy is clearly not essential in the same way that language literacy and number literacy are. These people pointed out that every society in the western world has extremely successful people who not only know no science, but actually boast that they do not know any science. They do not boast that they are illiterate—and they do not boast that they are innumerate. So scientific literacy may well be important, but we are not yet clear as to why it is important. I think we chose the words ‘scientific literacy’ because we wanted to put science into the primary school and give it some of the status that language and number studies have at those levels. What we achieved was that science is probably now taught in every primary school in Australia, but when is it taught—an hour in one afternoon, whereas language literacy is taught every morning, as is number literacy. I do not think that ‘science literacy’ has turned out to be a helpful slogan.

In a very interesting paper Bingle and Gaskell in Canada studied people looking at the controversies on the TV between two groups of scientists—official Government-funded scientists and Greenpeace scientists—arguing about forest practices in British Columbia. They found that people do not make their decision between these two groups by assessing the science being argued but by the way they trust the two groups as presented on television. Bingle and Gaskell go on to point out that if we ever get school science in the compulsory years to the highest pitch we can imagine, the students would not be able to distinguish between the worth of the scientific arguments these two groups of experts were using. Most of these socio-scientific issues are scientifically so complex, that each group of scientists has to be selective about the aspects they will investigate and make this decision on the values they hold or are required to hold. So the science can be correct in both cases, but it is sectional. So this very new word, trust, has come in about scientific information in the public arena. For example, has my colleague at Monash, Professor Alan Townsend, set back the public’s trust in stem-cell research by making selective use of evidence before the Parliamentary enquiry and by the way in which he presented this as authoritative? He is seen as an arrogant person, and that affects people’s trust.

So science education faces another question, *How do people learn to trust scientific information?*

Failure in practice

By the year 2000, in most Western countries and in many Asian countries, new science curricula were in place, allegedly an answer to ‘science for all’, but increasingly now being found wanting. For example, in England a study was reported of some of the few primary teachers who had taught science well and enthusiastically before the National Curriculum. Now that science is compulsory and there are tests during the primary years, this group of teachers teach science in a transmissive way rather than their earlier very interactive mode. They have so much content to get through to ensure that their school will do well in these national accountability tests and not suffer the penalties which now exist in England for schools that do not measure up on the so-called National Accountability standards. For this and other reasons it was good to find that in England in 1998 an important report came out, supported by the Royal Society and the Nuffield Foundation so it had a lot of status. It was called 'Beyond 2000' although it appeared at the end of 1998, and this report basically says the National Curriculum got it wrong—so wrong indeed that it cannot be patched and sometime after 2000 the issue of science education in schools will need to be rethought. It was good that this clear admission of failure came from England since the National curriculum there had influenced so many other countries in the world, and particularly Australia and New Zealand.

'Beyond 2000' makes a number of recommendations about what should happen, but the primary statement that they make about what they did wrong was that they have changed the position of science in the curriculum of schooling. They made science compulsory at every level of schooling, but they did not change the content to be learnt. The content is still essentially the content to prepare future scientists, so there has been in practice a minimal response to the debate about 'Science for All' as requiring something different.

New ideas

What has happened since 1998? I had a chance in those years to do some work with colleagues in Hong Kong. They wanted to do a study about scientific literacy since this was now a bandwagon area in international science education, and they wanted to involve the mainland of China to which they were now incorporated politically. So the project, called 'The Three Cities Project' was devised, and it involved Guangzhou, Hong Kong and Beijing—all big cities but with different characteristics. Hong Kong is the one part of China which is interested in democratic decision-making, debating things like genetically modified food and the placing of a new Disneyland in Hong Kong, an incredibly polluted area. Guangzhou is the great manufacturing heart of China, where most things 'Made in China' come from. Beijing is the national capital where the leading universities are, the leading research institutes, and the leading libraries.

So in this project about scientific literacy we decided to focus on the special features these three cities have as different big cities, and the common ones they share as big cities. For citizens living in big cities coping with life every day is pretty much the same as it would be, if we included Brisbane. So, in this way you will see in *Figure 2* that we associated these three cities with the four *well-beings* that were part of the science literacy debate. Beijing and *scientific disciplinary well-being,* Hong Kong and *personal well-being* and *democratic well-being*, Guangzhou and *socio-economic well-being*.

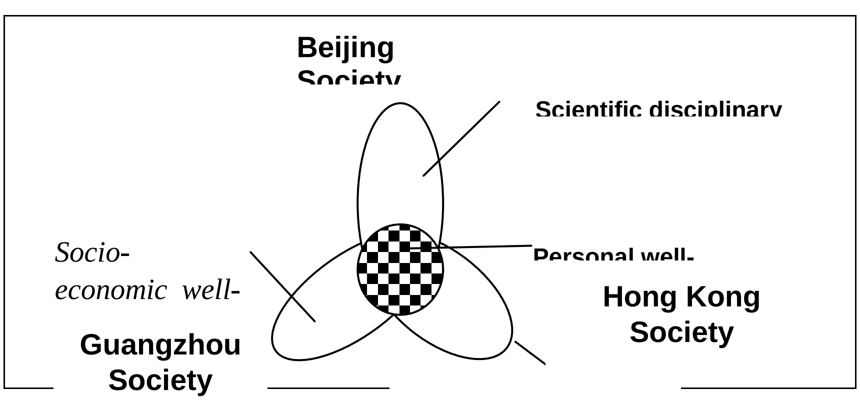


Figure 2: Three Cities Project: Exploring the society of three cities in China to identify how Science and Technology impinge on their citizens

We decided what to do was to go to social experts—people who are intimately involved with the lives of citizens and to ask them to tell us about the problems citizens face in their experience—the common presenting problems. We got long lists of problems, which were then filtered to remove the ones which seemed to be entirely economic or social or political. In this way we got a shorter list that seemed to have some science component. We argued that if people knew that 'science', it may alleviate the problem for them.

We were interviewing these persons about the public at large, but in the end that is what school science for all, or scientific literacy, was meant to be about. If we got some interesting answers we could make some recommendations for new content for school science. Table 1 sets out one example from the *personal well-being* area.

Table 1: Personal well-being: The Contextual Science—knowledge, awareness, policy/legislation and values/commitment—for falling from high (a high of Industrial Accidents) in Everyday Coping.

Scientific and technological knowledge	Scientific awareness	Scientific policy and legislation	Scientific values and commitment
• Acceleration of rigid and flexible bodies due to gravity • The effect of impact forces on skeletal structures • Choice of materials and design of safety devices and their proper location on human bodies	• The importance of following safety legislation and wearing a safety belt at all times • The importance of following the proper way of using a safety belt	• Policy and legislation about use of safety devices and their proper location on human bodies • Regulations and guidelines for proper use of safety devices	• Value issues in care needed to train workers in the proper use of safety devices • Value issues in workers' willingness to use them properly as legislated

Most of the learning in a school curriculum can be allocated to three classic curricular categories—knowledge, skills and attitudes. Teachers will be familiar with knowledge, skills and attitudes. We found that *personal well-being* in science did not fit so neatly into these categories. Certainly, there was a thing called *scientific and technological knowledge*, but science and technology were hardly distinguished—you could not really distinguish these two as was done here in Australia and in most of western countries in the reforms of the 1990s, creating technology as a separate subject from science.

We needed a category we called *scientific awareness*—awareness that science might have something to say, but I do not need to know it until I happen to need it. I need to know how to access that information if I need it. The sense that science is not a residue of passive knowledge, but a quarry that can be mined when I need it, is a very different sense from what school science has been. People were very concerned about the many regulations by which life in today's society is controlled and which have a science base they do not understand. This is an aspect of the politics of implementing science in society. *Why do we have a speed limit? Noise level limits? Why do people have to wear seat belts? Why are people supposed to wear ear-muffs when they work in noisy environments*? I was watching a person the other day doing just that, wearing ear-muffs but on his head, not over his ears). We have regulations that you must wear them. He met the regulation, but failed to pass on practice. In Hong Kong we found a common cause of public accidents in the high-rise buildings are due to falls, both among the general public and among the people who build high-rise. For the latter, there is a regulation which says that if you are working in high-rise situations you must wear a safety harness at all times. A cause of the accidents in falling is the damage that arises because the person had the safety harness on, but in a wrong manner that caused its own damage. The regulation was about wearing a harness, not how to wear it!

This whole question of scientific policy and legislation has been totally absent from the 'science for all' reports and from the scientific literacy debate. Then we found questions like: *How committed are you to the science information*? *How do you value this information compared with other more social knowledge*? We know from the media that that there are such debates about the worth of science information against other social information. Why has the Australian government chosen to not sign the Kyoto Agreement other than it is valuing economic short term knowledge higher than the longer term consequences of the science knowledge of global warming?

Similar sorts of things appeared when we looked at *democratic well-being*. We needed different headings again—social participation, scientific awareness, values and commitment. For *socio-economic well-being*, it was interesting that the people we interviewed in the factories in Guangzhou said 'Oh well, there is some specific technical knowledge in our factory, but we can teach the people that fairly quickly. But we do want people who know that the technology they are using this year will probably be different to the technology they will use next year; and that markets generate new technologies and new technologies generate markets—the interactive link between the economy and science through technology'. They also wanted people who could see from different perspectives how to generate creative ideas for solving the problems of manufacturing in the industrial world.

Science education, even after 1990, if you look at any assessment of science that is used in schools, is full of correct answers. There is only one answer per problem. We do not ask questions in science like *Write three possible answers to this question*.

Beijing and scientific well-being

There is a real concern internationally that people are not going into the what our Chief Scientist Robin Batterham described as ‘the enabling sciences’—physics, chemistry, and mathematics—because they lead on to the more fashionable cross disciplinary frontiers of science. Physics and Chemistry departments in Australian universities have already been closed or converted into multi-disciplinary new departments. Monash University and the University of Queensland have led the way in this radical restructuring of the sciences in Australia. So we decided to explore in Beijing based on the model shown in Figure 3 which indicates that all students at school in the compulsory years will be studying science but only a very few will go on to become future scientists. *How does this selection occur and what are its consequences?*

We argued they will become future scientists because they are encouraged to keep going in science because they can clear the hurdles that schooling sets up for success in science, and those that they continue to face in undergraduate and postgraduate studies in science faculties. Whatever are the emphases of these hurdles, so these characteristics will be strong in these future scientists. We took a risk and went to interview the heads of eleven leading research institutes in Beijing, saying ‘We understand that you have the pick of the cream of the persons who have done well in science in China through schooling, undergraduate, and postgraduate—you do not have a problem about people being full of whatever that is.’ Of course we knew what it was—it was cognitive scientific knowledge, detailed knowledge of the sciences and not even always about the nature of science itself. Facts about science are the essential ingredient of most of these hurdles, particularly in school and in the undergraduate years.

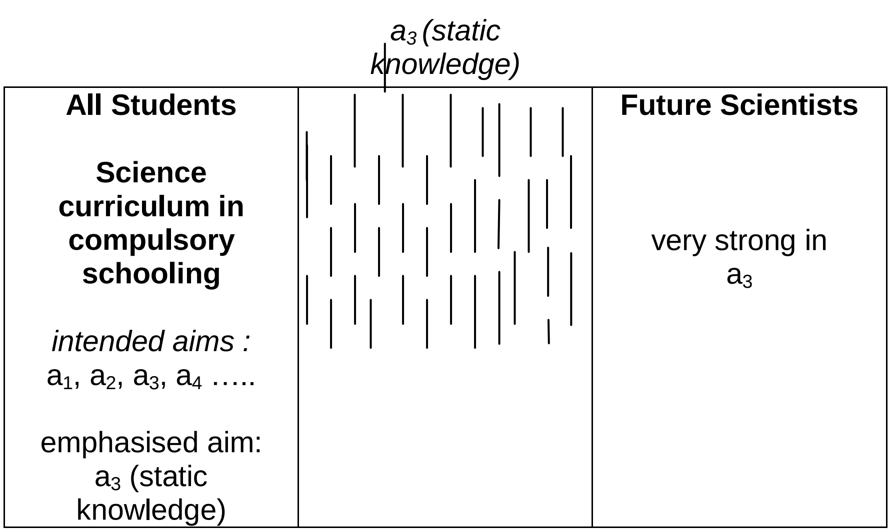


Figure 3: Priorities for successful science learning and for selection to continue with Science

We wanted to know if these persons we interviewed would identify features other than knowledge as important in scientists. Table 2 indicates the features that at least five of these 11 chief scientists identified.

Table 2: Scientific qualities in addition to knowledge that are important to the well-being of Science

Creativity Desire to Inquire Ability to Communicate Team Spirit	Personal Interest Perseverance Social Concern

Three Cities Study in China – Nancy Law/Peter Fensham

We would like to see them rather more creative, to have a personal interest in science rather than just being good at it. We would like them to have some perseverance with the long road that research really involves which has never been put on them in being successful through undergraduate and in school. A desire to enquire is important and it is different from personal interest.

We would like them to be able to communicate to other scientists and particularly to the people who fund our research because they only seem to be able to talk to each other, only having this very specialised language that they are not good at translating. We would like them to have more 'social concern' about the consequences of science. They also need to be able to work in 'scientific teams'—and success in science in education has been such an individual matter. A PhD is still an individual product, although no science now is conducted individually.

So that was one more set of rather interesting possibilities that might be built into school science because it would be both good for future scientists (that is for *scientific well-being*) and it would certainly be good to be producing ordinary citizens who would have a more long term interest in science. We did a big study in Victoria some years ago when there was no science virtually in primary school and we found that students entered secondary school with great expectations about science—by the beginning of the second semester those expectations had been quenched for most students. Science turned out to be note-taking—black and white pages on a book to be remembered, like all the other subjects they had ever studied.

International Studies

Another new direction that is interesting has come out of one of the large international comparative studies I mentioned earlier. The Third International Mathematics and Science Study (TIMSS) has not provided much in the way of innovative ideas as I hinted before, because it is basically a test of memory of rather old fashioned scientific knowledge. However, in 1998 the OECD decided to do something in this area and created a project called the Programme of International Student Achievement (PISA) which is studying science, mathematics and reading. It is very different from TIMSS. It is an attempt to measure how well 15 year-olds can make use of whatever their sources of science knowledge have been in situations which commonly occur in the lives of citizens. It was sold to the countries by saying that this project will inform you about how well your education system is preparing people for life as citizens in reading, mathematics and science. All the countries said 'Yes, that is something we would like to know more about'.

Barry McGaw who is now head of education in the OECD, characterised TIMSS as about what students know or remember of school science, whereas the PISA study is what students can do with the science they know, wherever they learnt it. The Science Expert Committee of PISA decided, because the science testing time in 2000 was very limited (reading was the major area in that testing), to test only one aspect of the way science impinges on citizens, namely, in media reports about science. How well could 15 year-olds critically appraise science reports that appear in the public media? The things we set out to test are:

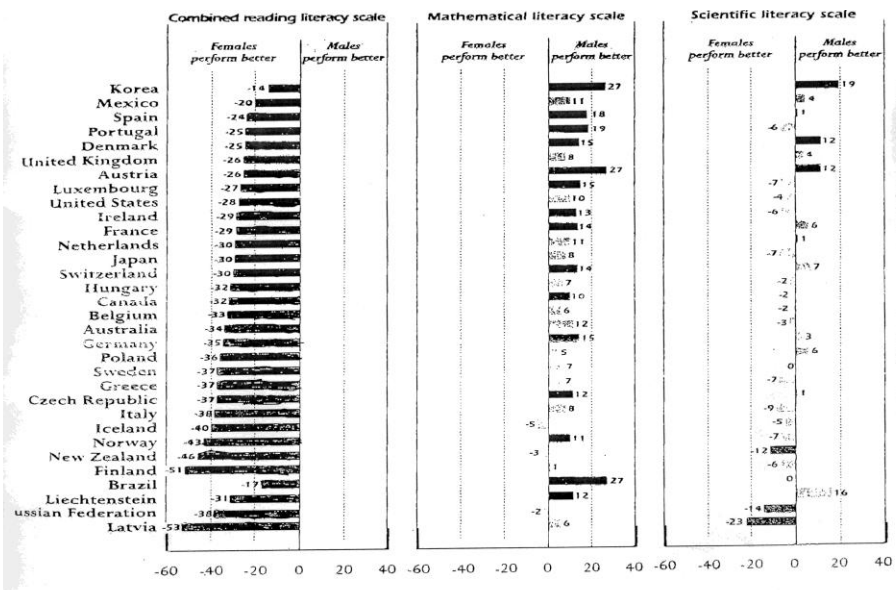
- what is the question being asked in this media report; is there more than one question; what is the science question being asked?
- is a science claim made in the report?
- does the report provide any evidence for what it claims, if not what sort of evidence could have been given?
- how would you communicate the worth of this media report to other people that have not read it?
- demonstrate an understanding of the science concepts involved in the media report by applying them to the media report.

An example of the short reports of science was an article headed **Dieting makes you forget.** It goes on to ask 'Having trouble with your memory? Finding it hard to concentrate?' Then it suggests 'perhaps you should give up that diet etc'. For such a media report in PISA Science we would ask three or four questions along the lines of the five aims of the PISA that have just been listed.

When the aims of the project for science were made public, we were first of all told that all we would demonstrate is that no 15 year-old anywhere in the world could do such a test. When we asked 'Why not since this is the end of science learning for many of them?' these critics said things like 'They are not mature enough', or 'They have not been taught to do this type of thing in science and students of 15 can not do anything in science they have not been taught'. It was true that no OECD country was teaching students in 1999 to critically appraise media reports in science. They may have done critical appraisal of texts in language, but these would not have been concerned with science. The other major criticism was that the test would be far too wordy for any science student because they have to read 100 or so words of the article of which a question is asked.

It was indeed a novel form of science test. When the results appeared two things were immediately apparent. First, the overall performance was higher than the prophets of doom had suggested. The second of these results is shown in Table 3.

Table 3: Gender Differences in Student Performance on PISA 2000 Tests: *Differences in PISA scale scores*



ote: Statistically significant differences are marked in black and red.
urce: OECD PISA database, 2001. Table 5.1a.

The left-hand column is the reading result in 2000. In every OECD country girls outperformed boys on a very extensive testing of reading—every country showed a statistically significant difference. In Mathematics, boys outperform girls in most countries. In Science, no gender differences in 26 countries, in three countries boys performed better, and in three countries girls were better. In this test of science, more dependent on reading than any science test has ever been, and taken by the same students as the test in reading, there was no gender difference.

This is a really intriguing result, which needs an explanation and the only one I can come up with is that journalists know how to write interestingly about science. They might not necessarily write correctly, but they know how to write in an interesting way. The journalists' articles are always little stories, and we knew these would work early in the project when one of our team found an article in a European paper about a student called Jessica who was 20 and she lived on a chocolate diet (57 chocolate bars a week and one standard meal) and she was perfectly healthy. A nutritionist made predictions about a dire future. In a trial we found our students would have read 1,000 words about Jessica—they were absolutely fascinated—'What happened to Jessica after all this?' There was no problem to get them to read. I believe that in PISA Science we stumbled on to something we have failed to use in science education for 50 years—to see and teach science as a set of stories. Storytelling may be a great way to teach science, as it is to teach many other things. The development of science is a set of stories—each has characters who argue with each other and each has a plot to be solved. All sorts of intrigue take place, and we have not been sharing these stories with our students, just the rather arid outcomes.

One final point

Douglas Roberts in Canada was far ahead of his time, when in 1982 he analysed a number of science curricula for the educational purposes that were intended to be served. He chose to use the word ‘curriculum emphasis’ because he said you could not achieve 10 different purposes at once (see Table 4).

Table 4:Curriculum emphases or purposes for school science

1.	Everyday Coping	Science knowledge and practices that can be applied outside school in the short time future.
2.	Nature and Structure of Science	Experience and understanding of the nature of science as a great human activity
3.	Correct explanations	Providing as well as possible current scientific explanations for natural phenomena
4.	Science, Technology Decisions	Engaging in decision-making about scientific and technological issues in society
5.	Scientific Skill Development	Acquiring a good degree of a number of intellectual and practical skills used in science
6.	Self as Explainer	Encouraging learners to engage in their own “theory building” about natural phenomena
7.	Solid Foundations	The scientific knowledge needed for the science to be learnt in the next levels of schooling
8.	Science as Application	Science as useful knowledge and practices in society
9.	Science for Nurturing	The science in taking care of humans and the environment
10.	Science in Making	Making things—learning the science involved in the materials and the making processes

One purpose will win out, and that purpose will be the one that has been in school science traditionally—to teach science this year because you will need this knowledge next year if you are still studying science—the purpose of *Solid Foundation*. It may be true that all of these purposes have a place at some point in schooling. So one more lesson we have to learn is that science in schools can have different emphases at different levels. I will finish with the big question: *What emphasis should Year 10 Science in Queensland have* ***?*** We have a great opportunity to introduce *Science for Citizenship*, as has happened in Holland and now in England. In the final years of compulsory schooling, these two countries now have a mandatory subject which is essentially *Science for Citizenship*. If you want to study Physics, Chemistry or Biology, you have to do them as optional extra subjects.

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