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SCIENTISTS In and Out of School

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Do you know of anyone that fits the following description?

> *He owned a watch, but never used it except to time off the tests and experiments he happened to be doing. He never, actually, knew what time of day it was. When he got hungry, he scrounged up some food. When he couldn't keep awake, he found a place to curl up and hammered off some sleep...*
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> *He so consistently forgot to go to classes, so seldom turned up for scheduled lectures, that the university administration finally gave up. They no longer even bothered to pretend that he instructed. They let him keep his lab and let him hole up there with his cages of guinea pigs and rats and his apparatus. But they got their money's worth. He was forever coming up with something that spelled publicity – not only for himself but for the university. So far as he, himself, was concerned, the university could have had it all.*

This description is taken from a science fiction novel, *They Walked Like Men* by Clifford Simak. In this novel, the narrator declares that 'biologists and astronomers and physicists and all the rest of that ungodly tribe of science are just people like the rest of us'. Well, if that university biologist, is 'normal', then perhaps we need to re-examine our notions of 'normality'!

The particular portrayal of a scientist immediately raises a number of questions. Is this image typical in novels? Is it typical in other forms of popular culture – such as television and films? Is it accurate? Does it influence community attitudes to science and scientists? *Most importantly, how do such images influence learning science in school?*

Informal avenues for science education include museums, fairs and exhibits, literature and the media. Of these television appears to be potentially the most powerful because, if we are to believe surveys, children watch a lot of television.

I am particularly concerned with the natural sciences: that is, the physical and biological sciences which are taught in primary schools and secondary schools. The social sciences are important, but it is *natural science* that is the concern of school science.

Scientists out of school

How are scientists portrayed in popular culture?

George Basalla, in the U.S.A., distinguishes between what he called 'Popular Science', which is manifest in journals like *Scientific American* and *New Scientist* and 'Pop Science', the portrayal of science and scientists in the more popular media.

> *Scientists are rarely the heroes in the current world of popular culture. More likely, one encounters the pop scientist as a villain who uses his knowledge to destroy or thwart the hero who has the public sympathy. In comic strips, the villainous scientist is recognised by his title of Doctor or Professor, his peculiar features and his well-equipped laboratory, his intellectual brilliance and his nefarious schemes. Cartoonist Jules Feiffer described him as an elderly man with bad eyesight and posture who clutches a test-tube in his hairy hand or leafs through a thick book 'doing research on a secret formula to rule the world'.*

This unfavourable portrayal of scientists appears to be the rule in children's television as well. For example, scientists on Saturday morning children's television in U.S.A. are 'Moral cripples, driven by lust for power, or gifted with a spectacular insensitivity to the feelings of others'. Carl Sagan (it is his quote) believes that this image is extremely damaging because the message conveyed to the moppet audience is that science is dangerous. A quite consistently unfavourable image is being presented to people in the community, both to children and to adults.

What are some commonly-held views of science and scientists

Two workers in the U.S.A., Pion and Lipsey, reviewed the findings of a number of surveys over the past two decades. This is how they summarised the results of the various surveys:

> *The attitudes of the general public towards science and technology are overwhelmingly favourable, but at the same time science did suffer in the general disillusionment experienced by all major social institutions during the late 1960s and early 1970s. Furthermore, a tiny minority, voicing forthright negative opinions of science and technology, although still small, does seem to have grown during the last two years. Coupled with this is the evidence that persons of the typically supporting middle-class are also disproportionately more aware and concerned about such technological hazards as pollution and nuclear arms.*

Public attitudes, they say, towards science and scientists are unusually vague, distorted and superficial. Other observers have concluded that the community's attitudes towards science and technology are ambivalent: there seems to be a clear consensus that science is one of the most important factors in the improvement of our daily lives, but that this confidence in the value of science is counter-balanced by fear. Many in the community believe that scientific discoveries can be dangerous, even when military applications are excluded.

Of course, when we talk about community perceptions of, and attitudes to, science we have to put this in some kind of context. The absolute levels of confidence in institutions such as science, medicine and the military – measured by public opinion polls – vary quite widely over time. The relative rankings of institutions, on the other hand, are fairly stable over the same period. Analyses of surveys show that, in fact, confidence in science, relative to confidence in other institutions, has risen in the last decade.

In addition a number of studies of attitudes towards the scientists who do the science have been conducted. Pion and Lipsey made this comment: 'While the public perception of science as an institution or activity appears vague and somewhat contradictory, the public image of scientists might better be described as stereotyped and distorted.'

In 1981 a report of a survey of fifty-five students at an Australian university appeared. These students came from the different parts of the campus, both Arts and Science and their images of scientists were generally the stereotyped images that other surveys have reported. Here are some descriptions of *scientists* and *science students* written by various students in this survey:

'Open-minded, but choosing to be shallow'.

Male Arts student

'Know heaps about science but not much about other things. Not aware because it isn't part of their course'.

Female student

'Ocker, loud-mouthed engineer-type students'.

Male student

'Proper Australian males who swear, drink and screw a lot'.

Male Arts student

'Proudly call themselves "capitalists"'.

Female Arts student

'Basically conservative in their ways of dress, political beliefs, and attitudes towards women and ethnic groups'.

Male Science student

Bridgstock & McDonald who conducted this survey, concluded:

The earlier studies could hardly have identified the scientists with male chauvinism as the concept barely existed before the last decade. It appears, therefore, to be a relatively recently addition. The attribution of Ocker characteristics, on the other hand, appears to be a function of the Australian scene. It is not hinted at in any other study, further, other English speaking countries do not appear to have a single unitary concept as the Ocker.

Thank goodness for that! Thus far, the results seem to conform that in the Australian University the core image of the scientist exists but in a somewhat milder form than usual. The core has, however, picked up some additional attributes which can hardly be regarded as favourable. These include the male chauvinist tag for scientists and, at least in Australia, their association with the Ocker image.

How do *real* scientists behave?

One of the problems is that there is surprisingly little evidence on which we can build a more realistic picture. Scientists do not write about themselves – they write about their work. They write in an impersonal style; the papers they produce give a very strong impression of rationality – an impression that the knowledge was produced in a reasoned, deliberate fashion, devoid of human qualities; theories seem to leap from dispassionate observation. Despite their writing, scientists are human; scientists know it, but unfortunately many members of the community don't appear to believe it.

Scientists have inadequately explained the human dimension of science, and science has become almost a religion with Nobel laureates as 'high priests'. It is very unfortunate that very little has been written by scientists to convey to the general public the nature of research, or the attitudes towards it of the scientists who do it. More writing of this kind is beginning to appear, although not necessarily by scientists. To believe that scientists simply look at data in a cool, rational fashion, and that theories leap up at them almost unbidden is a dangerous misrepresentation of the progress of 'real' science.

Cawthorn and Rowell writing on this issue describe it in this way:

No longer is the scientist viewed as engaging in research which is open, impractical and critical, seeking to prove, as Bacon would have done, or refute as Popper would have done, hypotheses. However, the scientist carries out research which is very closely circumscribed in its conceptual, methodological, experimental and other ways. That is, scientists bring to their observation theories, and the theories determine the kinds of observations they make and the very data which they collect.

Many school science text books give a misleading impression here. In one textbook we can find the statement: 'Science progresses by the accumulation of facts that arrive from observation.' Another, 'the process of the scientific method begins with the collection of data. Data for scientific and technical purposes are obtained in the first place in one of two ways. By observation and by experiment. The next step in the scientific method is the systematisation of data. The next step is to suggest the hypotheses to fit the facts. It must fit the facts or the facts are useless. If it does fit the facts it can be tested.'

No practising scientist would recognise this as a description of the way he or she works. In pop culture we have scientists presented in a stereotype. Usually it is of a man, cool and purely rational. The serious consequences of this is that the practice of science is seen as a cool and rational process, a matter of observing dispassionately, and allowing the 'facts' to speak for themselves. Perhaps the recent increase in the popularity of a variety of pseudo-sciences such as astrology is (at least in part) a reaction to the sterile picture of science people have seen.

Scientists in school

What effect is all this having on school students?

It is difficult to establish causal links between the images presented in pop culture and the perceptions that children have of science and scientists. That is, it is difficult to establish (unequivocally) that the poor image of scientists presented on television and films, leads to negative attitudes about science among children. In the case of television, links between out-of-school television and educational outcomes – such as achievement – have been difficult to establish. Nevertheless, it is reasonable to suggest that negative images in pop culture don't help.

What do your pupils think of science and scientists? Some time ago, we got some primary school children to draw a scientist, and to describe what science was and what scientists did. We analysed the drawings using a set of indicators which Wade Chambers, at Deakin University, developed from a study conducted over 20 years ago by Mead and Metraux. The stereotyped scientist was indicated by:

1. Lab coat (usually, but not necessarily white)
2. Eye glasses
3. Facial growth of hair (beard, moustaches etc.)
4. Symbols of research (scientific instruments and laboratory equipment)
5. Symbols of knowledge (principally books, filing cabinets)
6. Technology – the products of science
7. Relevant captions such as formulae or the Eureka syndrome.

Chambers had looked at a large sample – nearly 5,000 students in Australia, Canada and the United States. The results we obtained here in Western Australia were very similar to his. As you move up through the grades, as you get older, you recognise or use more and more of the indicators.

In the samples we used in Western Australia, in fact, one was a group of black children in a rural location, and the second group was from a metropolitan school attended mainly by white children. The white urban children's drawing averaged more indicators at each grade level than the rural black children. Have the white townies seen more television, comics, and magazines, or do they allow these to influence them more?

We asked some of the children to talk to us about their views. Here are two children's thoughts. One student, we found, had a fairly realistic image of scientists. He saw them as ordinary people with other interests and activities apart from science. He met quite a few scientists – most people would not and and he knew a little about what they did but he still limited his discussion to the 'mixing of chemicals' stereotype. He saw mad scientists as mainly fictional but conceded that it was possible for scientists to be mad. He enjoyed science at school.

The second student had a strong 'mad scientist' image – he saw scientists as people who are evil, mix dangerous chemicals and work for themselves. (That is, they don't get paid.) Although this student had met scientists, it was only in labs and he didn't know them as people. He thought that normal scientists invent things or make things for chemists. He read about mad scientists in books and mentioned Dr Frankenstein several times. He liked to imitate shows from television and play the mad scientist with his own chemistry set. He quite enjoyed science in school.

The overall picture is not good. Scientists have to be more vigorous in fighting negative stereotypes. They should do this when communicating science to the public, and, more importantly, by the way they teach science to future teachers of science.

Changing students' views of science and scientists

We science teachers have an important role to play in combatting the stereotypes. What kind of action can we take?

We can make sure we emphasise the people who have built up science in the past, and those who continue to do so. Every science topic can be used to highlight the contribution of past and present scientists. This emphasis can help overcome the view that science is possible only if you are a bloodless sort of person with a passionless cool, rational, 'objective', completely impartial mind. I'm not suggesting a 'history of science' topic (although this can be useful) – rather, we should suffuse every topic with this human dimension. On occasion, some time could be spend on some particularly interesting episode in the history of the science of the topic being taught.

One such example is the story of the establishment of a model for the structure of deoxyribose nucleic acid, DNA. A televised movie, *A Life Story*, was a dramatisation of that particular adventure. The story was a biassed one, because it was told from the point of view of one of the main actors, James Watson. Nevertheless, the film did convey the excitement, the passion, and the romance in this particular event in the history of science. The model proposed by Watson and his co-worker Francis Crick was enchanting, it was captivating, it was beautiful. It was also very powerful, because it immediately suggested how hereditary information can be passed from parent to offspring.

The whole DNA story, of course, is not all excitement – there was much slow, painstaking experimental work to be done before a model for DNA could be proposed. This experimental work was done by many scientists, and each piece of work constituted an important part of the jigsaw. Two important pieces of the jigsaw were Erwin Chagraff's finding that the ratio of pyrimidine and purine bases in his DNA samples was 1:1, and, the X-ray photographs of DNA which were taken by Maurice Wilkins (who later shared the 1962 Nobel prize with Watson and Crick) and Rosalind Franklin (who died tragically at a young age, and whose work wasn't properly acknowledged by Watson). Watson and Crick were able to put together the different pieces of the jigsaw into a simple, but beautiful model – the familiar double helix model of DNA. The DNA story was an exciting adventure, and science is full of them – our students will be intrigued to hear about these exciting episodes.

Another approach we can adopt to combat stereotypes is to make sure students have the opportunity to conduct some non-routine experimental investigations. Routine experiments teach important practical skills but in addition to these experiments, we can get students to investigate some intriguing problems using some of the methods scientists might use. Such open-ended experimental investigations can be useful in giving students a realistic glimpse into the world of scientific research.

The two approaches suggested here are a start – you can probably suggest others... I'd be very interested to hear about approaches that you've tried in your classrooms.

Why should all students do some science?

One reason is practical: to give everyone an understanding of scientific ideas which can help them lead healthier, safer lives. There is an enormous ignorance, for example, of human nutrition and electricity in the home; sometimes, this ignorance leads to tragic consequences. (According to one writer, interest in human nutrition is 'a kilometre wide and a centimetre deep'; a lack of basic understanding of, for example, the concept of a balanced diet, has led to well publicised tragedies involving children who were given 'diets' of water only. Everyone should understand some basic ideas which will help them to interact safely and healthily with the world (human and artificial) around them: trees and plastics, swamps and chemicals in the home, endangered species and electricity... the list goes on.

A second reason for requiring all students to study some science is to help them understand some of the problems that face us, such as pollution, the 'hole' in the ozone layer, pesticides in meat... the list here is endless too. These problems require wise decisions, and we need to know how and when science can help. When science cannot help, because the ultimate decisions must be made by our political leaders we need a public which understands the problem scientifically and votes or protests rationally. We cannot contribute to securing intelligent decisions if we are ignorant about science.

The third reason for studying science is that it's an important part of human culture... as is religion, art and sport. To know nothing about science is to be cut off from an important part of a great adventure. Unfortunately, for most of us, adventure is not a word we associate with science. Our students usually use words like 'boring', 'hard', or 'uninteresting'. We need to work in such a way that they use words like 'exciting', 'adventurous' and 'fascinating'! Adventures in science abound. These adventures are not a thing of the past. There are enormously exciting adventures taking place right now in areas like superconductivity, quantum physics, organic chemistry, astronomy, biotechnology...

There is a fourth reason for studying science: to make sure we have a pool of able, talented, enthusiastic people to carry discovery on. I was appalled recently to read a suggestion that 'we don't need scientists – we need good business people – we can always buy in science'. This sort of thinking leads to economic problems. Yes, we can buy the science – but at enormous cost! We need our best and brightest young people to continue to maintain our own basic scientific research. This is an area in which Australia and New Zealand have excelled, despite their geographic isolation and small populations.

Basic research is not only important – it is crucial. Unfortunately, those who are ignorant about science don't realise this, and continue to over-emphasise 'applied', 'mission-oriented' or 'targeted' research. Some of the most important breakthroughs in 'high' technology have been based on basic research for which no immediate application seemed apparent at the time. Indeed, Lord Rutherford, a New Zealander, one of the most eminent experimental physicists of his time, reportedly said that he saw no possible practical uses for his work on splitting the atom!

It is important for us to encourage young people to take part in the scientific adventure. In the long term, this will happen if the community places more value on the work of scientists than it currently does. Perhaps we can divert a little of our adulation of those who excel in sports and business to those who excel in science! We can all encourage our bright, creative young people to pursue careers in science and science-based occupations. Just as important, we can all make sure that all our students, regardless of their career intentions, understand what science is and what scientists do.

Notes

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