Reforming science education: the need for co-ordinated science

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ONE OF THE major challenges of the National Minimum Curriculum is the proposed reform in science education. The National Minimum Curriculum proposes that:

"Co-ordinated Science can replace the existing specialisation in this area of the curriculum. Co-ordinated Science includes themes from the different branches of science, technology, nature studies and applied science. In establishing Co-ordinated Science as a basic subject from Form 1 until Form 5, the curriculum ensures a more widespread knowledge of science" (NMC, p. 81).

This proposed reform has raised a number of questions and a huge debate among science teachers. One of the main questions which needs to be answered is: "What is this Co-ordinated Science which is being proposed and what are its aims?" This is a serious question and one which cannot be taken lightly since an understanding of what Co-ordinated Science is all about is the first step towards the proposed reform.

What we need to do first of all, therefore, is to try and understand the philosophy behind the proposed reform. Once the philosophy has been accepted we can then work towards the common goal of developing a science education programme which will be beneficial to all of our students. However, we need to believe in this proposed reform and the reform can only start with the teacher. As pointed out by Bybee (1993) "any effective transformation of science teaching rests with the teacher" (p. xii).

So we need to start the story at the very beginning and try and define what we understand by "co-ordinated science". A variety of terms ranging from integrated to combined to balanced science have all been used and perhaps the distinction between the different terms is elusive. The major science syllabuses which are used in the UK are:

Combined Science: these bring together a selection of the content from the separate sciences to fit into a single or double (in terms of time) Ordinary level course.

Integrated Science: this takes the combining step further by arranging the content into themes that draw on more than one traditional area – structures, for example, or the human senses.

Modular science: these courses include practical, everyday selections of topics aimed at lower ability students. The intention is to work through self-contained modules with separate tests at the end of each one.

Co-ordinated science: these courses keep the subject areas identifiable but try to make explicit links between them.

(Adapted from Turner and DiMarco, 1998).

These definitions show clearly that there are many ways of organising science content and the way in which "Co-ordinated Science" is described in the literature is not necessarily the "Co-ordinated Science" intended by the NMC. As defined by Working Group 7 of the National Steering Committee on the Implementation of the National Minimum Curriculum (May, 2000), "co-ordinated science aims to ensure science literacy for all through an interdisciplinary thematic approach" (p. 1). The Working Group further proposes that the name "Co-ordinated Science" be changed to "Science" (p. 6) as this will give a clear indication of the kind of science education which should form part of our National Minimum Curriculum.

Our main aim as science teachers will therefore be to teach "science" in order to ensure "scientific literacy". But how do we define "science" and "scientific literacy"? Bybee describes how historically the goals and subject of school science courses were identified with knowing the "structure of disciplines" and engaging students in the use of the "scientific method".

To achieve these goals students have been required to memorise the technical language, symbols and theoretical underpinnings of each discipline. Science was in fact taught as the separate physics, chemistry and biology (Keeves and Aikenhead, 1995) and no attempt was made to create links between the three disciplines. However, as Bybee (1993) continues to argue, since the turn of the century the old boundaries that separated the study of biology, chemistry, physics, geology and astronomy have faded away and many new research fields, such as biochemistry, biophysics, astrophysics, biotechnology, and genetic engineering, have been developed.

Research in modern science tends to be more holistic and integrative across fields and is more socially driven than theory driven. Keeves and Aikenhead (1995) also identify five scientific and societal changes which have led to changes in the teaching of science in schools. These changes are:

1. *Universal secondary education:* This has led to a focus on a more general education for all, rather than a highly academic education for the select few.
2. *Life-long education:* This is the need for constant retraining even in one's adult life.
3. *Learning to learn:* Since scientific knowledge is constantly changing, individuals need to acquire skills of effective independent learning and inquiry.
4. *Emergence of science-related social issues:* Students need to be aware of social problems such as the population explosion, health-related issues, climate change, etc. They need to be able to debate meaningfully the resolution of issues raised.
5. *The impact of technological change:* In today's world science cannot be discussed without discussing technology (pp. 28-31).

Within the framework of these changes science education needed to respond in a number of clear ways. One of the first things which has been done is to clearly identify the main aims and goals of science education. Bybee (1995) suggests that science education should ensure that citizens:

- Know, value and use science and technology in their personal lives.
- Have some understanding of how science and technology relates to social issues.
- Understand and appreciate science and technology as a human endeavour.
- Participate in a democratic process, through the context of science and technology (p. 68).

This is the basis for developing what has been defined as "scientific literacy" or the ability of individuals to understand the basic principles of science to be able to make informed decisions in their own personal lives and in their lives as citizens of a democratic society. More recently (1999) scientific literacy has been defined by the Organisation for Economic Co-operation and Development (OECD) as:

"By scientific literacy we mean being able to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (quoted in Harlen, 1999).

While no one can argue against the importance of scientific literacy, the debate has been whether "scientifically literate" students can in fact become the scientists of tomorrow. The argument, is of course, that getting a general grounding in science will not give students the depth or the detail which will allow them to continue their studies at a further level.

However, one of the main aims of education is to prepare individuals to lead personally fulfilling and socially responsible lives. As Black (1993) argues, given the large and growing relevance of science in the private, social and political spheres, the optimum planning of a science experience is of utmost importance.

For the majority of students, science is part of a general education and here science enables students to develop the skills necessary for them to be able to think for themselves, solve problems, and participate in the decision-making of the society to which they belong. For other students, science is the stepping stone to a profession in the field of science. The same science curriculum therefore needs to provide the first stages for a training in a science career for the minority as well as a broad overview of the basics of science for a majority of the students.

These two purposes may often appear to be in tension and lead to different arguments about curricular decisions, namely that students who intend to continue to study science need depth in specific science subjects leading to a differentiated curriculum while others argue that students who do not intend to continue to study science need only a broad view of the subject and this leads to a co-ordinated or broad and balanced science.

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The position we take is that all students whether they intend to pursue a career in science or not need to have a basic understanding of science and feel confident with the science they are studying. They need to achieve scientific literacy through understanding the relevance of the science which they are studying and finding stimulus and enjoyment in what they are learning.

The pursuit of scientific literacy therefore aims to equip both future citizens with a basic understanding of science as well as future scientists with a basic understanding of the relationship between science, the individual and the community. According to Black (1993) any science programme should therefore aim to:

- give students a basis for understanding and for coping with their lives;
- enable students to understand the applications and effects of science in society;
- learn about the concepts and methods which are combined in scientific enquiry;
- gain insight into what science as a human activity is like through historical examples; and
- contribute to the general personal and intellectual development of the students.

These aims can, according to Black, all contribute towards the development of a common broad science curriculum which provides students with a basis for making choices together with positive motivation to consider seriously a further commitment to science.

These aims cannot be achieved by teaching the individual sciences in isolation since each science subject has its own philosophy and ways of going about things. As Black (1993) argues, it is unacceptable to teach the sciences separately without any close co-ordination and until age 16 all of the science should be encountered by all.

All this leads to an understanding of science which is process rather than content-based, it crosses the boundaries between the separate ideologies and creates a co-ordinated science which is rich, authentic and context-based, allowing students to acquire:

- an understanding of some aspects of science content. That is an understanding of some of the facts, laws, concepts and theories which make up the accepted scientific knowledge about the natural world;
- an understanding of the scientific approach to enquiry. This involves an understanding of how and why scientific methods are used and the ability to interpret outcomes; and
- an understanding of science as a social enterprise. This includes the understanding of the relationship between science and society in the daily lives of individuals and the influence of society on the choices made by scientists.

This will result in students developing a number of attitudes, skills and knowledge as well as having acquired certain personal and social habits.

As stated by Keeves and Aikenhead (1995), "planning to improve the teaching of science is a recurring challenge for all science educators" (p. 43). What they recommend however is that:

1. All students study some science formally during all grades of schooling.
2. During the years of compulsory schooling all students should study content from the four fields of science – biology, chemistry, earth science and physics.
3. Greater emphasis should be placed on learning the skills of investigation and inquiry in the study of science with the laboratory and experimentation playing an important but not exclusive role.
4. The relevance of science should be emphasised through greater consideration of the application of scientific principles to everyday life, technology, the production of food and the conservation of the environment.
5. At all grade levels, relationships between science, technology and society should be emphasised.
6. The learning of science should be seen as a lifelong process, and not limited to the years of schooling, because scientific discovery not only is ongoing, but it is advancing at an increasing rate (p. 43).

All of this can be achieved by introducing "Science" as part of our curriculum. The main aims of teaching the separate sciences will still be reached but through a different packaging. At present students learn a lot of separate content which they mostly study by heart to regurgitate for the examination. However, at times they do not grasp the basic science concepts which they need to develop.

They then move on to higher courses in science without having a clear idea of the connections between concepts and subjects. Our argument is that with a good solid grounding in science where students learn the processes of science, the basic concepts, the relevance to society and an everyday context, students will be more prepared to make linkages between ideas and to use these ideas to further their own learning in science.

In Malta we are still at the early stages to make any such claims but the important thing is to give science a chance. What we know now is that students are learning science in an abstract way mainly for the examination. The NMC is giving us the opportunity to change this. Together we can develop a science curriculum which is more fun and interesting as well as intellectually rewarding for all students. Let us give it a chance.

References

Black, P. (1993). "The purposes of science education" in E. Whitelegg, J. Thomas, & S. Tresman (Eds.). *Challenges and Opportunities for Science Education.* London: Paul Chapman.

Bybee, R.W. (1993). *Reforming science education.* New York: Teachers' College Press.

Harlen, W. (1999). *Purposes and procedures for assessing science process skills. Assessment in Education,* (6), 1: 129-144.

Keeves, J., & Aikenhead, G. (1995). "Science curricula in a changing world" in B.J. Fraser and H.J. Walberg (Eds.). *Improving science education.* Chicago: The National Society for the Study of Education.

Turner, T., & DiMarco, W. (1998). *Learning to teach science in the secondary school.* London: Routledge.