Science Education: A Look into the Future

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Abstract

This paper presents the author's thoughts about some of the problems faced by current science curricula. These relate, in the main, to a separation of school science from the practice of professional science and to a lack of investigations in school science. He suggests ways in which these could be remedied by taking a more inclusive, integrated approach to the teaching of the various science subjects, mathematics and the rest of the school curriculum

Science occupies a number of major roles in children's education beyond the simple concept teaching of the subject as one element of society's knowledge of the world in which we live. However, the most pressing reason for the expansion of science education in the past few decades is the desire of governments to develop those aspects of their economies that rely on knowledge and skills associated with science and technology. In addition to this the need to develop a scientifically literate population [1] that can make informed decisions about the future application of science to the needs of society is clearly an important goal of education.

In response to the economic need for more scientists, governments have begun to promote strongly STEM (Science, Technology, Engineering and Mathematics) within their education portfolios. It is the purpose of this paper to reflect on current weaknesses in science curricula and to examine ways which STEM and related developments may improve education in general and science education in particular. I shall concentrate on the current situation within the UK but the situation here is comparable, to a greater of lesser extent, to other advanced nations.

Science as a professional occupation differs greatly from what is found in school science classrooms. Science curricula are generally recognized as being content heavy and weak on thinking and investigative skills, whereas the professional scientist is a problem solver by trade. It is as if we hope that, having absorbed the factual content, learners will suddenly acquire creativity and problem solving abilities without these having been part of their curriculum. Alternatively, these may be seen as the responsibility of some other curricular area.

There are, of course, some attempts to include a wider content. In the UK, the curriculum up to 2014 included topics on scientific enquiry, but these represented a minor strand within the whole curriculum. This was most noticeable at primary level where one might expect factual content to be at a minimum. In addition many teachers found great difficulty with these topics as they were, by nature, more open-ended than those relating to knowledge. This situation results in curiosity being squeezed out of science learning and replaced with a need for retention of scientific facts. For many learners science is not seen as attractive. Lessons are highly teacher-led; there is little opportunity for learners to contribute to classes and even in practical classes the result of experiments is usually known beforehand.

Several factors contribute to the current problems in science education. Possibly the most significant relates to the makeup of the teaching profession. In post primary education few science teachers have had experience of their subject outside of the classroom. There are notable exceptions to this and some schemes exist where teachers can spend time in research, but teachers' general lack of experience as science practitioners limits their ability to convey the essentials of their discipline. This problem naturally progresses to bodies who design science curricula and set examinations as these are largely composed of experienced subject teachers. For obvious reasons most primary teachers have a limited science experience as is the case for the other subject specialities. Much good work has been done to provide primary teachers with science expertise through professional development, but this is often in the form of recipes for successful science activities and does not deal with the investigative nature of the subject.

A second problem for the development of successful science curricula is the nature of the testing and examination regime. It is relatively simple to test scientific knowledge in a formal setting, but testing scientific problem solving and creativity require an approach which is difficult to employ, particularly when the time limits for a test are short. Some attempts have been made to incorporate investigation into coursework, but these typically involve very prescriptive investigations that are repeated with each student cohort, and are very open to didactic instruction from the teacher. This is very understandable where equipment has to be supplied, and the activities are limited by the school timetable.

The final difficulty for the development of a dynamic investigative science curricula that would appeal to learners, that I will discuss here, is the lack of co-ordination between mathematics teaching and science. Specific mathematical processes such as the differential calculus and logarithms are clearly essential in at least the physical sciences, although one sees many students struggling to grasp these subjects without the necessary mathematical tool kit. However, the point I wish to make refers more to an appreciation of numerical approaches to investigation. I am constantly shocked to see highly qualified maths undergraduates fail to design effective investigations in biology. There is a considerable lack of understanding of the importance of topics such as replication of data points, of producing dose response curves and of looking for a mathematical relationship between cause and effect when students are given the task of designing investigations. The same is true for presentation and interpretation of results through the use of graphs. The mathematical learning they have appears to be difficult to apply outside the boundaries of their subject. This may simply be a manifestation of a problem that currently plagues many educational models where the desire to have high levels of attainment in subjects leads to overspecialisation at too early a stage.

When we look at science education it is cheering to note that changes aimed at making it more effective might also make the subject more attractive to learners. This has obvious implications for the STEM initiatives.

One of the most important developments to current science curricula would be to enhance interaction between the various subject disciplines. School science in the UK is primarily concerned with physics, chemistry and biology. Obviously, these emerge as separate subjects in the final school years but when the so called ‘science’ curricula for earlier classes are looked at it is clear that the courses are divided along the lines of the individual subjects. Even in the primary classroom headings such as, Life Processes and Living Things; Materials and their Properties and Physical Processes [2] relate unambiguously to specific subjects. Surely with this age group, and probably up to about the age of 14, children should be looking at all the relevant scientific aspects of themes taken from the world they see around them. This is a natural way to work, and more significantly, many biological processes are entirely dependant on the physics and materials that they involve. I believe we are simply seeing senior school science being reinterpreted in different words for the learning of younger children when a completely fresh approach is required.

Integration of topics within science education and mathematics should be encouraged within post primary education. For instance, many biology teachers will lack the appropriate knowledge of physics and chemistry to deal with topics such as photosynthesis at a high level. This applies equally to areas of chemistry and physics. Mathematics, which is often referred to as the ‘language of science’ also needs to be integrated more closely with the sciences. Governments constantly urge that numeracy is to be taught across the curriculum, but few innovative strategies are in place to help teachers implement this. Such novel approaches will require innovation by curricular bodies, who may argue that such overlap between subjects may cause difficulties with assessment procedures. Schools also need to look at new ways of teaching across the sciences. This will be difficult in schools with strong departmental division of responsibilities but it is essential for schools to be proactive in developing effective teaching strategies between science departments.

The question of integration of subjects has also important implications for STEM. At present there are many organisations actively supporting careers in these subjects and attempting to attract children to take degrees in relevant areas. However, if there are no parallel developments that integrate the curricula of the subjects and if they remain content heavy in nature, then STEM is unlikely to be successful and to be seen by hard-pressed schools as simply yet another innovation.

It is important to look not just at integration between science based subjects but also at the importance of integrating science itself within the whole curriculum. Obviously, by the time learners are applying for university entrance, they will be studying individual subjects but for much of their earlier school career they would benefit from a closer integration of the curriculum. This would then taper down in later years. Interesting approaches to primary science have been developed in Ireland. In the Republic of Ireland science, history and geography are grouped loosely within a single curricular area, Social, Environmental and Scientific Education [3]. In Northern Ireland a somewhat more structured process sees the subjects grouped under 'The World around Us'[4]. Both these initiatives allow teachers some flexibility in how they approach the topics and it will be most interesting to await the evaluation of these curricular reforms.

An appealing example of integration of science with other subjects is displayed by a development in Wales, 'My Square Mile' [5] where children were encouraged to study their local area using a variety of techniques from across the curriculum. We have utilised a similar approach where art is integrated with science. Here both subjects have equal status and the integration occurs through analysis of the commonalities that exist between the practices of both disciplines. This moves the learners' involvement from that of a passive recipient to that of active player, thus mirroring the roles of real scientists and artists though at an age specific level. This approach, 'The Leonardo Effect' [6] has proved popular with teachers, children and parents and allows factual content to be learnt alongside the development of skills. We are currently applying this to early post primary education. Here the results are still positive but the departmental structure of many schools requires a greater degree of internal reorganisation than was seen in primary.

The choice of art as a partner for science is important in this work. It is obviously a highly practical subject so fits well with the science activities children are used to. Moreover, children relish the opportunity to apply both their analytical and imaginative strengths to the same topic, and see design as a valued partner to science in achieving their final goal. There is a clear corollary from this to the STEM initiative. Interestingly in several countries the acronym STEM has been amended to include art converting STEM to STEAM. This brings the essential element of design into a strategy aimed at enhancing industry.

In summary, I would strongly urge those who care about the future path of science education to think less about increasing the amount of science that is taught in school but to look to how science can be integrated into the whole learning experience. This will be beneficial not only for the study of the sciences but will also enrich the learning experience and make school a motivating place for many who do not find it so at present.

References

[1] Osborne, J. (2007) 'Science education for the 21st century', Eurasia Journal of Mathematics, Science& TechnologyEducation3, 173-184

[2] Department of Education (2014) UK Primary National Curriculum until 2014. http://www.education.gov.uk

[3] National Council for Curriculum and Assessment (1999) Primary Curriculum. http://curriculumonline.ie

[4] CCEA (2006)The Northern Ireland Curriculum, Key Stage 1 and 2, The World Around Us. http://www.nicurriculum.org.uk

[5] Adams E. (2005) My Square Mile, Teachers' Notes. https://www.hwb.wales.gov.uk
[6] Hickey, I. & Robson, D. (2012) 'The Leonardo Effect: Motivating Children to Achieve through Interdisciplinary Learning' Routledge, Abingdon