A Paradigm Shift? Investment in preschool and early years is vital for the future of science technology and engineering

Dr Sue Dale Tunnciliffe, Institute of Education, London University.

Why science education?

Why do we have science on the curriculum from the earliest of years? What is science teaching and learning all about? From the responses of governments and comments from various areas of business it appears that 'Western' or 'developed ' science and technology (ICT) and engineering or design and technology as it had been called England, are more and more important in this world, which is increasingly globalised. I was invited to attend a summit at the American Museum of Natural History in New York in 2008 where this very subject was of great concern to influential members of the USA. Earlier this year I met with the Science Minister of Malta who has been charged by their Prime Minister to develop interest and success in this curriculum area and body of knowledge not only in school children but also in the community at large, life long learners. A knowledge of Science and its applications, especially indeed biology, my own subject, is at the heart of many perceived and identified problems in the world which agencies are trying to redress.

Application of science to improve the world

The Millennium Development Goals of the Commonwealth, very similar to those of UNESCO are eight goals to be achieved by 2015 that respond to the world's main development challenges. The MDGs are drawn from the actions and targets contained in the **Millennium Declaration** that was adopted by 189 nations-and signed by 147 heads of state and governments during the UN Summit in September 2000. (http://www.undp.org/mdg/basics.shtml).

The eight MDGs break down into **21 quantifiable targets** that are measured by **60 indicators**.

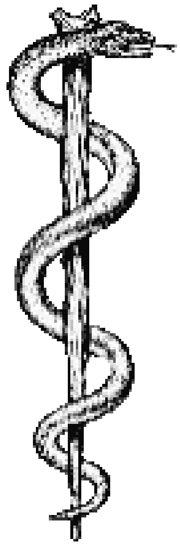
Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a Global Partnership for Development

Of particular relevance to we science teachers are

2.1 Net enrolment ratio in primary education
2.2 Proportion of pupils starting grade 1 who reach last grade of primary
2.3 Literacy rate of 15-24 year-olds, women and men

Whilst the goals do not mention science overtly they are all concerned with science and technology, these goals require an understanding of relevant science and technologies such as immunisation programme. Incidentally, Guinea worm may become the second disease, after small pox, to be eradicated. The application of some basic science and technology (engineering) contributed to the decline in cases of Guinea worm (*Dracunculiasis*). By knowing the life history including that the conveying organism is a copepod, a small water living crustacean, which is ingested and if ingested by humans infects that human with guinea worm. Knowing the science, the life history, and basic technology- filtering - people can use thin material to filter their drinking water, rather as people do in Bangladesh to filter out the Cholera vibrio, and prevent the larvae entering inside them and thus developing.

This disease frequently in termed as the Fiery Serpent.



The staff of Asclepius, used as the symbol of medicine, is thought to be derived from the function of winding the worm around and around as it is gradually rolled from the body of the host- technology indeed!

The rationale for teaching science changed in past two decades from teaching science to produce scientists for a country to a realisation that the majority of pupils learning science in schools will not become such and that the teaching traditionally; provided was of little relevance or intersect to the majority of school children. Albeit science was little taught in the state primary schools in England until the early 1980s other than having a n true table which indeed I think are an essential aspects of teaching and learning and much neglected as they develop observational and descriptive skills as well as helping pupils to learn about the natural world around them (Tomkins and Tunnicliffe, 2007). In their key report (Millar and Osborne 1998) remark 'the familiar justifications for science education have also worn thin when confronted by the daily realities of classroom life."

Science for all?

Many researchers have argued about the socio-historical legacy of traditional science and science education. In the past, science was reproduced as an objective, privileged way of knowing restricted to a selected intellectual elite and it excluded many students. It has traditionally been equated with Western science over many centuries and conceived in universal terms as transcending cultural boundaries. However, It fails to consider other cultures, which have their own views and theories of the world, and the science taught in school is remote from the everyday lives of the learners, especially girls and women. There has always been discussion about the under achievement in science subjects of both the ethnic minorities in a country and gender. Whilst girls doing better in virtually all school, young women choosing to take certain subjects post- 16 and in eventually having lower salaries even when they do jobs that require the same abilities. What can be concluded is that apparent underachievement in science and technology by particular groups is strongly connected to the ways that society views the members of these groups. In turn, such views can become internalized so that people see themselves as others see them" Frost, S., Reiss, M.J. and Frost, J. (2005). What is the remedy? It is hard to change the popular view in a society, the management of change is long and fraught but not impossible.

The View of Pupils.

Pupils have their own views and expectations about school science. "The image of science as an exciting practical activity, which many science teachers try to generate on open days, creates an unrealistic and ultimately unsustainable image of 'real' science" Abrahams, (2007). At the beginning of the decade a sample of secondary school pupils the majority aged between 16 and 19 years a, those attaining regional meetings for Science Year (2001 –2002) designed questionnaires for fellow pupils about science. A final questionnaire was complied and 1483 responses were received. Analysis produced a list of 10 recommendations from these pupils. Firstly, they wanted both ethical and controversial issues in their curriculum, and relevant practical work. Including dissection for those who wished to do this. Pupils felt there was a need for Science lessons to use relevant mathematics. They considered that teachers should be qualified to teach science and should have the appropriate science specialist. Respondents considered that the science curriculum should cover fewer topics so that those in place could be studied more deeply and that lessons should have more opportunity for discussion. Teachers should be effective and engage with their pupils and be able to use relevant appealing mind engaging visual materials Efforts should be made to render chemistry and physics more relevant to modern everyday life. They felt this already happened in biology. Primary science should be considered as important as English and maths in the primary curriculum. The results of the review argue that there was a need for the science curriculum to change. In fact, the curriculum was slimmed down with an increased emphasis on real world science after this with new curricula being written such as the Nuffield 21st Century Science project.

Data collected from the Rose Report (e.g. Sjøberg and Schreiner, 2008), show some general interesting trends. School pupils of similar age in a range of countries were asked the same questions Consider the story told by some of the data.

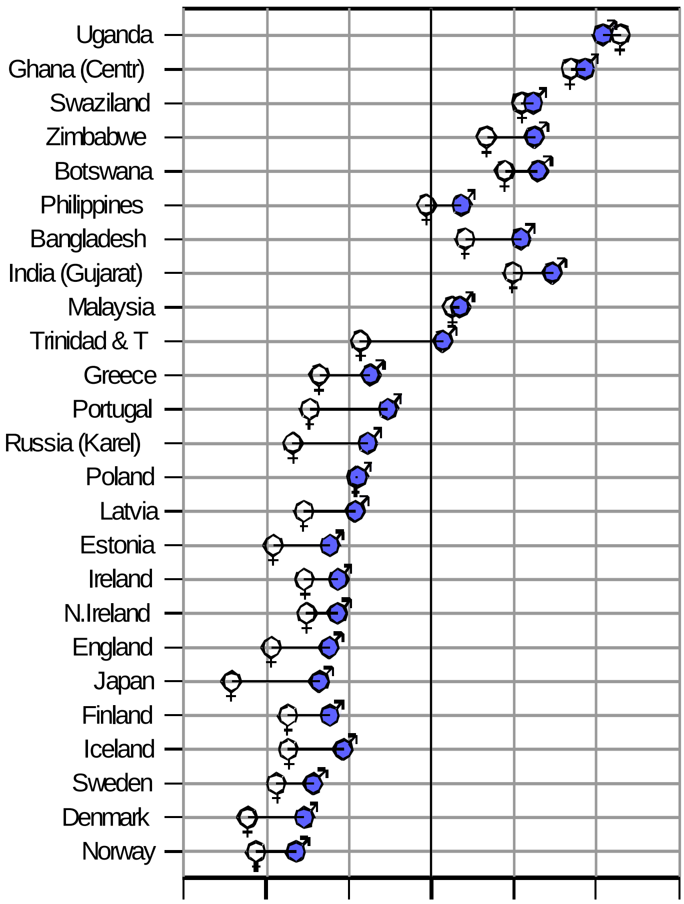


Fig 1 is in answer to the statement' Science and technology are important for society' (ROSE - Schreiner and Sjøberg)

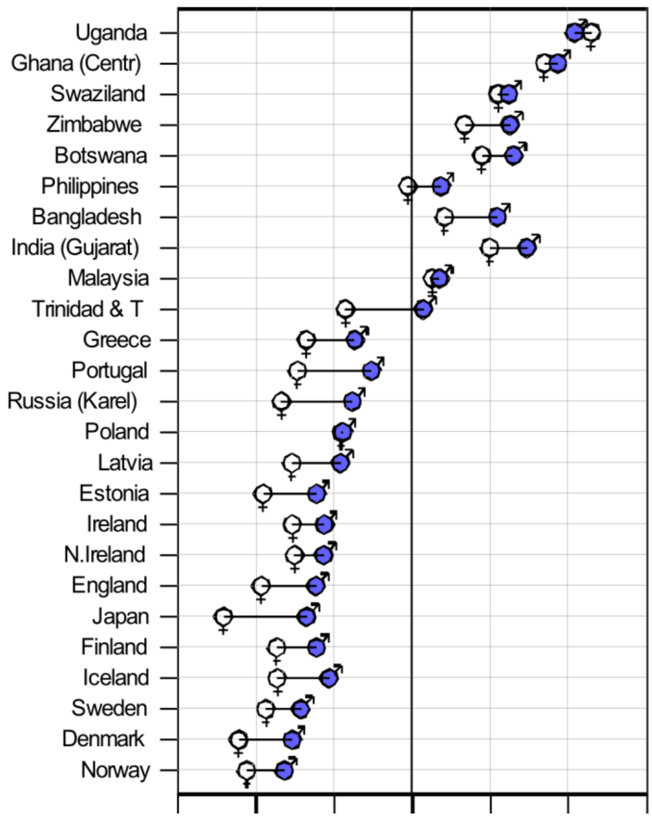


Fig 2 'I like school science better than most other subjects' (ROSE - Schreiner and Sjøberg)

Pupils were asked whether they aspired to a career in science and the same pattern of a positive response from both boys and girls in developing countries as the above tow graphs was found, pupils were aspiring to such in developing countries whereas those of developed countries did not.

Is there more to a career than the subject?

Do pupils in the developed world aspire to more than the subject for their career? More than a soulless subject it seems. Researchers, e.g. Jenkins and Nelson, 2005, Jenkins, 2006, found that secondary aged pupils in England did not regard science as a subject of career choice.

The Tytler report (Tytler at al.2008) (focused on Australian school pupils) determined that young people from their life aspirations by the age of 14 years and they think about their response to STEM subjects (Science, Technology, Engineering and Maths) in human terms and succeeding in engaging self-efficacy and lacked relevance for these young people, the future citizens. Furthermore, the report found that access to STEM studies after school were restricted by the subject choice available which was still based on the traditional three sciences, Physics, Chemistry and Biology, and such subjects did not embrace the relevance and prevalence of STEM in modern society with reflecting terms such as nana technology, genetic modification, rehabilitation engineering. Nor does school focus on what STEM means to them in their self realization of how traditionally evolved school STEM subjects reflect the role of STEM in developed subjects and teaching does not appear to make the point that STEM is all a human Endeavour for people by people. A pertinent reflection upon this issue is that many teachers) and indeed their political masters) are unfamiliar with such modern developments too.

Lyons and Quinn (2010) elicited factors affecting the choice of sciences in the Australian School system. There are many more options for pupils to choose from and indeed ghee are many more subjects on offer, such as Psychology, Environmental sciences in school circular and post school forensic sconce degrees, nursing and para medical professions all are science focused but not named with the traditional labels of physics, chemistry and biology. Within engineering there are fields of study such as music technology, acoustic engineering, nano engineering which are related far more it appears in the eyes of young prospective scientist and engineers than the traditional labels. School children have difficulties seeing themselves as future scientists and consider too the value of science versus the effort they need to make to achieve that status and there is, possibly, the lack of relevance and personal worth of wanting to study science and engineering. The Australian study however found there was not a decline of interest in science in primary schools. My personal observations are that, when pupils progress to secondary sector the sparkle of science and design technology disappears from what pupils have reported to me when they start at secondary school, relevant content and delivery- pedagogy- and a sparkle from the teacher is vital.

Thus, the message is School Science education can only succeed when pupils believe that the Science they are being taught is of personal worth to them. Here, 'personal worth' should not be construed too narrowly. For many pupils, science is of value only in so far as it is of instrumental use, for example for further education. Other pupils, though, search for meanings and may feel that Science can help them to understand their place in the world. Such diversity among pupils means that a Science curriculum and a way of teaching Science cannot assume that there is only one reason for learning about Science. However, unless Science teaching really engages with the concerns of real pupils, they will , and do in my experience, learn little from it.

Perhaps it is salient to recall the term ‘renaissance man’, where people, such as Leonardo Da Vinci, saw no subject boundaries of what have in the West now with the two domains of arts and science. Indeed the artificial boundaries set up our societies was initially echoed in a famous lecture in 1959, 50 years ago, CP Snow warned that science and arts were becoming 'two cultures' - but the problem now, I think, is far, far worse.

Science for Citizens

One of the arguments frequently heard as one of the important reasons for teaching science is that science education should be provided be for all in order to produce scientifically literate citizens who thus would possess understanding of the concepts of science, their history and rationale which would help the citizen understand issues confronting them in their society, such as immunisation programmes, being able to evaluate evidence in reports and take an informed decisions kn such issues as cloning, sustainable science, climate change and thus possessing a vocabulary of science

But does the school science produce scientifically literate citizens?. What does such a term mean? My experience from England seems to means that citizens have a familiarity with some scientific works and a vague understanding. Have they however, they really understood the science involved in for example that an immunisation programme must be carried out in a large percentage of the population to be effective or that and antibiotic courses completed

Most 'graduates' from school science education whom I have encountered in various countries do have an awareness of words of science and thus have acquired a scientific vocabulary up to a point, and this is capitalised on by advertisers. I arrived in a rice eating country, no longer classified as a developing nation, to see a hoarding advertising rice by the side of the highway This advertisement claimed their rice was 'DNA tested'. Beauticians sell products to women using science words like such as 'collagen', 'derma genesis' for a cleanser, 'Re-Nourish Toner is enriched with oligo', defined as few or little with a of a larger group of nitrogenous compounds! 'Nucleic defenses- anti age protection reinforce reinforced Protection Anti aging sun care NUCLEIC DEFENSE': A product at vast expense! . Put together they form a trade mark- but what is the science? People learn a vocabulary and are impressed it seem too me with hearing the word in products.

.People train as teachers with their own science knowledge and may have learnt more at university. Howe4ver, not all teachers if science at all levels are science graduates and teaching outside one's specialised science presents issues for both teacher and learners. There is it seems also a 'Great divide' The majority of Science graduates entering teaching train to teach science in secondary schools. When I graduated I did not have to train to be able to teach the so called academic children in selective schools and, indeed, eventually entered primary education on the basis of a postgraduate certificate from the Institute of Education London University for teaching biology and general science in grammar schools, the schools for the academically elite in England in those days.

Teacher Training

There are now in England a number of paths through which an aspiring teacher can pass in order to gain qualified teacher status to teach in the state schools. The traditional route for science defrauds is that of a one-year course after their first (or second) degree know as a Postgraduate Certificate in Education. At the Institute of Eductaion in London such PGCE programmes are modular and have 120 credits. (some of these are at Masters degree level and the remainder at Honours degree level. Thus, after successfully completing a PGCE graduates may proceed towards an Institute of Education Masters degree (it awards it own degrees) by successfully studying a further three modules within five years of finishing their PCGE. If a student does not take another course they are awarded a PGCE. Both the primary and secondary PGCE students are also a recommended to be granted qualified teacher status if they meet all; the standards set down by the Department of Children, Schools and Families (DCSF).

There are other ways of training to be a teacher. The Graduate Teacher Programme (GTP) is for graduates who need to continue earning whilst they train. Such students are employed in a school and paid as an unqualified teacher, receiving training as they work and thus can acquire QTS, Qualified Teacher Status. There is also at the Institute of Education an Overseas Trainee Teacher Programme (OTTP) for teachers qualified in counties not members of the European Economic Area (EEA) This too is an employment based programme. The qualifications held by applicants must be recognised by the National Recognition Information Centre for the United Kingdom.

All rounders with a good general knowledge train to teach primary children. Such an approach harkens back to the days in England of monitors in schools who taught younger children and pupil teachers. 'Learn on the job ' as it were is a system that is back in England although the trainees are expected to have some science knowledge.

The earliest and most important teachers- mothers- untrained and unpaid

Mothers, or other carers, are the first teacher of a child. Science and the other STEM subjects are a part of a mother's day with children. There is relatively little research on very young children and how they experience science and technology (engineering) phenomena, which are features of their early play or everyday tasks and actions.

Is there a critical period for development of such concepts? Children are intuitive scientists (Gopnik, 2009). I consider that there is although no research confirms this (yet!).

The starting point for the learning of science and engineering is at this early age and occurs in the immediate environment of the child with the people with whom s/he spend their time. These places are where they live and the immediate environment outside. In these locations children witness everyday activities such as cooking, cleaning, washing, various activities with materials such as textiles, wood, clay, as well as identifying and being involved with basic life processes such as moving, breaching, eating excreting and the human activities associated with the life processes and beyond. Children are immersed in their environment, built, human constructed or natural such as their village or neighbouring biological phenomena which all contain various amounts of technology and biodiversity from a simple cooking vessel being used on an open fire to mobile phones; from natural vegetation to manicured garden. Moreover, the natural environment is of comprised of physical, geological and biological and features of this. such as rocks, plans, watercourses may be observed. Additionally the culture and particular uses of science and technology by the community with whom the children live are evident and noticed.

The starting point for science is observation. (Johnston, 2009). We aim to encourage their carer to share the observations and talk about such and increase their own self-esteem and literacy.

“Children, we now know, need to talk, and to experience a rich diet of
spoken language in order to think and learn. Reading, writing and number
may be acknowledged as curriculum ‘basics’ but talk is the true foundation
for teaches. (Alexander, page 9)

Furthermore, there is an intimate link between language and thought and thus the cognitive development of a child is affected to a considerable extent by the nature, context and forms of language, which s/he hears and uses (Halliday, 1993).

As children acquire early language they begin to label phenomena. This naming is an inherent human need (Bruner, Goodnow and Austin 1956; Markman. 1989). Additionally, young children ask questions incessantly when given an opportunity (Tough, 1977), a behaviour, which often disappears in the formal educating environment where classis triadic dialogue takes over. However, there is a move towards developing dialogic talking in classrooms (Alexander, 2008). The philosophy of the teacher, school or informal presumably, has been identified (Fleer, 2009) as a significant contributing factor to a child learning sconce and this viewpoint is greater influencing factor on the scientific learning of children than either the confidence or knowledge of the teacher. Moreover, Fleer also found that children need a mediator in their play to make sense of what they observe, otherwise alternative conceptions are formed from their narratives and interpretations.

Communities and governments should encourage the parents, and other carers, mostly women, and many deemed illiterate because they do not read or write or have very limited skills in these two strands of the four aspects of literacy, the others being listing and speaking. These women can listen and they can speak. They furthermore know and are familiar with the science and engineering phenomena in their lives. By helping them talk about these and identify the phenomena, actions and artefacts, and then to tell the children we maintain that we can develop science and engineering literacy in both adults and children. Pre formal education is the most important stage of a child’s learning path. We, as educators and policy makers, should do we all we can to endure that this path is smooth and recognise that there are many different aspects of science learning, each built upon another.

The Paradigm Shift

Policy makers must recognise that, without this early years science foundation, the structure that ensues is shaky indeed- as the voices of pupils are beginning to reveal. Effort and money poured into the secondary school appear futile if similar effort, recognition and money are not put into the child’s earliest years of education before school and then in primary school. Is this the next critical paradigm shift in science education?

.

References

Abrahams, I. (2007) An unrealistic image of science. *School Science Review*, March 2007, 88(324)

Alexander, R. (2008) Towards *Dialogic Teaching: rethinking classroom talk.* Cambridge. Dialogs. York.

Bruner, J. S., Goodnow, J. J. and Austin, G. A. (1956) *A Study of thinking.* New York, John Wiley, Science Editions, Inc.

Fleer, M. (2009) Supporting Scientific Conceptual Consciousness of learning in a 'Roundabout Way" in Play Based contexts. *International journal of Science Education,* 31(8): 1069-1090

Frost,S, Reiss, M.J. and Frost, J. (2005) Gender and minority ethnic attainment *School Science Review,* March 2005,86(316)105-112

Gopnik, A.(2009) *The Philosophical Baby: What Children's Minds Tell Us About Truth, Love, and the Meaning of Life* . Farrar, Straus and Giroux, New York, USA

Halliday, M.A.K. (1993) Towards a Language-based theory of Education. *Linguistics in Education* 5

Jenkins, E. W. & Nelson, N. W. (2005) Important but not for me: students' attitudes towards secondary science in England, *Research in Science & Technological Education,* 23(1), 41–57

Jenkins J.W.(2006) Student opinion in England about Science and Technology. *Research in Science & Technological Education* Vol. 24, No. 1, May 2006, pp. 59–68

Johnson, J.S. 2009) What does the skill of observation look like in young children? *International Journal of Science Education.* 4 (11) :2511-2526

Lyons, T. & Quinn F. (2010). Choosing Science: *Understanding the declines in senior high school science enrolments.* Research Report to the Australian Science Teachers Association. UNE

Markman, E. (1989) *Categorization and naming in children: Problems of induction.* The MIT Press, Cambridge Mass.

Millar, R. and Osborne, J. (eds.) (1998) *Beyond 2000. Science education for the future.* London: School of Education, King's College London.

Murray, I. And Reiss, M./J. (200)5 The student review of the Science Curriculum.)School Science Review,September 87(318)84-=93.

Nuffield Foundation (2005) *21st Science Project*. http:/www.21st centuryscience.org.

Snow, C.P. (1958) The *Two Cultures*. Cambridge University Press Cambridge.

Sjøberg,S. and Schreiner,C. (2008) Young *people- science and technology attitudes and values interest and possible recruitment deducted results from research..* Brussels , Oct 2. 200 8 accessed 25 March 2010

Tomkins, S.P. and Tunnicliffe,S.D.(2007)Nature tables: stimulating children interest in natural objects *Journal of Biological Education*. Volume 41 Number 4, Autumn :15-155

Tough, J. (1977) *The Development of Meaning*. London, George Allen and Unwin

Tytler, R., Osborne, J., Williams, G., Tytler, K., and Cripps Clarke, J. (2008) *Opening up Pathways: Engagement in Science, Technology, Mathematic and Engineering, (STEM) across the Primary-Secondary School transition. Canberra. Department of Education, Employment and Workplace Relations*. Accessed at http://www.dest.gov.au/NR/rdonlyres/1BC12ECD-81ED-43DEOF698F8A6F44E2/23337/FinalJune140708pdfversion.pdf