EDUCATION FOR DEMOCRATIC CITIZENSHIP: THEORY AND TEACHING PRACTICE

Session 1a: CDC in Science Education

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The following text will explore how we can (and why we should) consider and incorporate, the European Council's Competences for Democratic Culture into Science lessons.

I will be considering this through four main themes: the sociological; the historical; the communal and the practical.

When teaching science we need to be aware of how content is being integrated into student world views. Scientific information can come across as a collection of truths, somehow independent of the cultural and social environment in which they were established. It is helpful to point out that this is not the case. The ideas, models and key figures we highlight in the classroom have been selected to encourage advancement in our subjects. But the progress made is not value neutral. Care needs to be taken to ensure that we are framing scientific learning so as to assist in the development of positive attitudes towards things like human rights, cultural awareness, tolerance and acceptance of others.

Many specifications state that they want learners to appreciate how scientific methods and theories have developed over time. Unfortunately, this is highly complex and requires teachers to have a solid grasp of a web of factors. It's important that students know what has shaped our understanding, and it is important that school teachers feel confident in providing it. What needs to be avoided is the presentation of scientific advancement as dependent upon just a few key figures that battled it out until a victor emerged. I have seen children laughing at the fools from the past that thought differently to the way we do now: why wouldn't they? But if they see this model as the means to progress, how can they fully appreciate how viewpoints are established, supported, challenged and eventually changed. If we use a more sociologically aware approach in the class room our students and the world they take over could reap the rewards.

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It is worth noting that the scientific gladiators we highlight often seem to have a lot in common: men like Newton, Darwin, Dalton, Mendeleev, Mendel, Leakey. Marie Curie provides a slight variation on the theme but, maybe this is not terribly important given the fact that we should be focusing on the ideas not their proponents. But if that is the case why include these people in the specifications at all? As they are there, what do they represent? We need to clarify that for our students.

Let's take the case of Isaac Newton. He was born in the 17th century at the start of the first English Civil War into a wealthy, although pretty broken family. He never married (it's been suggested he was gay), he was aware of the death of thousands in the plague but he survived. He practiced alchemy, and had a deeply held set of Christian beliefs but his faith, along with much else, was unorthodox. Newton recognized that his achievements built on the work of others both before and contemporaneous with him – despite the fact that he had many priority disputes and was quite possibly coping with autism. The turmoil of the civil war gave a little more religious freedom to university academics. The restoration came with royal patronage of the sciences and the country became richer and more cohesive – becoming the Kingdom of Great Britain during Newton's lifetime. This was all very handy for Newton, who was in some senses in the right place at the right time. He was an academic, bright, comfortably off, isolated, and zealous man. He survived war and plague to live more than twice the average age for his time. He had access to the work of many other great thinkers and just enough magical thinking to accept something like non contact action at a distance. He could also be considered relatively free in both social and religious terms… and we haven't even touched on what was going on in the rest of Europe! The lone genius is a popular narrative, but isn't it more interesting to ask students what conditions made his success more likely?

A similar analysis could be undertaken with any of the scientists identified in the science specifications. It enables students to develop an appreciation of the importance of the political and social environment to any endeavour. It helps explain how real scientists approach their work on a personal level and presents them within a civic framework. It also makes the scientific profession accessible and encourages conversations that ultimately enrich the learning of each student.

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The flow of the science curriculum focuses on key shifts in thinking that lead ineluctably towards our current position. There are, however, advantages to teachers presenting students with a more fine grained narrative. Take the atom for example. It's useful to ask why the modern concept of the atom didn't gain traction until Dalton in the early 19th century. Dalton wasn't the first to come up with the idea. It had been in circulation for over 2000 years. Many supporters of atomic theory existed before Dalton's model emerged.

Could we say that the idea took hold because the time was right? If it wasn't for Dalton, would it have been for someone else? (There were priority disputes.) By the time Dalton came on the scene, atoms had been used to construct early kinetic models of gases. And the laws of conservation of mass, definite proportions, and multiple proportions had already been established. He was part of a community. He was stimulated by access to other people's material, and his own work was circulated critiqued and extended. After Dalton, progress continued on a number of fronts around the world, but many scientists did not accept the reality of the atom right up to the early 20th century… despite the timeline in school books.

It might be useful for students to reflect upon how the position in history of those like Dalton supported the acceptance of their work and ideas. Consideration could be given to the strength of scientific communities, communication systems and technological advancements. Students could be asked to consider each of these features in both earlier and more modern societies. How do they influence progress? Have scientists always embraced the spirit of community? Has communication always been free, effective and productive?

So far we have considered presenting science to students as a process influenced by wider society and as a product of historical context. Both of these observations support the development of civic scientific responsibility. It is not suggested that whole lessons be devoted to these concepts, but it would be beneficial to learners if such aspects were included in programs of study. Contextualizing and collectivizing scientific progress directly encourages the values of democratic citizenship.

To further explore the community aspect of science we might ask if its representatives reflect the population at large. Do we have a view of who scientists are? Looking through the specifications, we might be pretty convinced that scientists are all very similar. It is important for teachers to draw the discussion towards the diversity among those given a high profile, the breadth of additional contributions made and the importance of scientific teamwork.

With the exception of Marie Curie, who made herself impossible to ignore, those named in the UK specifications are white men. This is not in itself a problem, although in terms of encouraging participatory attitudes among learners, teachers need to ensure that scientific society is reflected in a more balanced fashion. This might be strengthened by exploring personal non-scientific positions. Religion, for example, influenced the lives of many scientific figures: Dalton was a Quaker, Mendel was an Augustinian Friar. Another might be sexuality: this is more difficult to establish but it's not impossible to surmise in some instances.

The Ancient Greeks often get mentioned by teachers (although they are not always in the specifications), but it would be constructive to highlight contributions made during the Islamic Golden Age for example. It would seem a striking omission not to mention Alhazen when discussing ray optics. It would also be remiss not to mention women like Mary Anning, Cecilia Payne-Gaposchkin and Rosalind Frankin who contributed so much to their disciplines.

It would also be useful for learners to hear mention of the achievements of scientists with atypical neurological or physical conditions like Aspergers (Einstein), ALS (Hawking), Deafness (Jump Cannon), missing limbs (Leakey).

Stressing that science is an endeavour that goes on within society, and not in isolation from it, is motivation for students to take their learning beyond the classroom. Modern collective endeavours, in the age of big science, are easy to find. Although the Manhattan Project in the 1940s is highly noteworthy, we now have the Large Hadron Collider which employs thousands of people from dozens of countries. Other big projects include the International Space Station, the Human Genome Project, the Millennium Seed Bank Partnership, the SESAME synchrotron and many, many more around the world.

Students do not have to just observe scientific collaborations, the advent of highly organized citizen science projects means that anyone in the world can participate in research work from deep space to bird conservation.

These activities extend data collection from the confines of the laboratory to the whole world and give users access to a vast amount of information - previously accessible only to professionals.

Up to this point the aspects of science content I have drawn attention to could have been delivered in any discipline. Students could have been asked to research topic areas, answer questions, engage in debates and discussions or give presentations. The feature that absolutely distinguishes science lessons from many other learning experiences is practical work. Experimentation is essential to science. It gives students the opportunity to both secure their theoretical understanding and hone their critical inquiry and communication skills.

The common experimental aim of the group requires communication, co-operation, negotiation, role allocation and dispute resolution, all of which are essential qualities in members of a democratic society that need to be nurtured by the science teacher. It is in this activity that we see students trying on the leadership role. Can they recognize the talent of others and enthuse their team?

The most productive practical experiences will only provide an objective and access to resources. Health and safety will be monitored, but otherwise students will be encouraged to manage their own progress. The decisions involved in the selection of the correct tools and establishing a legitimate procedure are a valuable learning experience –as is taking responsibility for a lack of success and undertaking a critical reevaluation of the approach.

Once data is collected it needs to be assessed and criticized. Students will need to establish whether concluding that a causal relationship exists is justified. Could other factors be at play? How sure can they be of their findings? Can they persuade others that their interpretation is correct?

It is in practical work that we are most likely to see the synthesis of skills and ideas in full force. Students will use every area of their understanding to solve the problems they face. They will then endeavour to combine their theoretical expectations with their observations. Not only is the learning of science content secured, but there is significant opportunity to demonstrate the competences required for participation in democratic culture.

An additional benefit to practical activities is the understanding students develop for the validity of data collected by others. Never has it been more important for scientific literacy to be promoted amongst the population. An appreciation of number and the ability to convert data into knowledge is essential to making informed decisions in the polling booth. There is no way we can participate effectively in a democratic society, if we don't understand the technical language, graphs and tables being used to shape our decisions.

There have been numerous instances of political figures cynically exploiting ignorance to achieve their ends. The ability for rhetoric to inflame, deceive and misdirect has always been with us, but never before has it been so easy for divisive messages to spread around the world sowing confusion and discord.

There are many uniquely modern phenomena that we must ensure our young people understand. Take climate change, for example. Climate change has a number of subtle and not so subtle impacts. The graphs presented show a steady, although saw toothed, rise. Appreciating the trends and dismissing periodic variations requires a scientific eye. It requires technical knowledge to internalize the meaning of axes labels saying things like "C02 ppm" –let alone comprehending the physical significance of the reading. Scientifically literate students also take note of scales, time frames, ranges, sample frequencies and correlations.

Grasping the impact environmental change has on the complex and subtle interplay of ecosystems requires some training. The same goes for understanding the pros and cons of potential damage limitations strategies.

Educators shouldn't lose sight of the the fact that students live in a world where giving a scientific gloss to a fringe idea lends it credibility. Science educators should assist students in moving away from looking for authorities and towards informed critical thought.

Evolution does not have a direction. Vaccines do not cause autism. 5G Radio masts do not cause Covid-19

Delivery of the science curriculum provides learners with the awareness, motivation and ability to fully participate in the democratic process on all its levels. It lays the ground work for informed local government consultations and ensures petitions have a rational foundation. Local communities benefit from informed volunteers caring for their environment, influencing building regulations and town planning directives. Setting up effective civic associations, organizing well reasoned collective action and informed contributions during referendums all require scientifically savvy citizens.

Science lessons should give students an understanding of how policies have been shaped to produce things like Earth wires in plugs and seat belts in cars, and explain how those students might shape policy themselves in the future.

Debate is a corner stone of democracy. A solid understanding of the facts informs positions on difficult problems such as the true impact of drugs and alcohol on the individual and the nation.

Classroom exchanges could consider how population growth is affecting our planet or how equipped our infrastructure is to ensure good water management and food production. How concerned should we be about AI, cloning, vaccines, micro plastics, pesticides and nuclear power?

In the foregoing, I have explored how science lessons could (and should) incorporate the European Council's Competences for Democratic Culture. We examined how students could be encouraged to view science in a sociological context, looking at factors that shape scientific endeavour. We looked at how a richer historical knowledge could stimulate critical thinking. I indicated the need to highlight the potential for community engagement. And we saw the uniquely scientific opportunities provided by experimental work.

In order for modern democracies to thrive, science educators need to produce numerate, capable, proactive and vigilant critical thinkers. To achieve this we need to view our lessons through a slightly broader lens. We need to see beyond an edifice of scientific facts

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and recognise that we are offering something more; something that nurtures citizenship and encourages active participation in the operation of society.

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