For a science curriculum that 'matters'

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● Laura Colucci-Gray

Abstract

Most of what we experience as salient in education is a matter of curriculum; however, decisions on content and delivery of science curricula are often conflicted between apparently irreconcilable purposes. This paper outlines the key features of a science curriculum as *heterotopia*, that is, as a space for enacting multiple and diverse sense-experiences. Moving beyond the neoliberal logic of expanding freedom of choice, it is a science curriculum that works in the humanistic sense of transforming the kinds of humans that we desire to be, overcoming the instrumental mission of science education, for a science curriculum that truly matters.

Introduction

Many will remember back in 2019 the young people's strikes for climate change that swept the city streets across Europe. That was the first wave of protests that – to this day – have involved many groups, raising important questions for education. First, there were concerns about pupils dis-attending their 'duties', disrupting lessons that had been planned for them, thus not getting on with the assigned work. However, the word 'strike' is powerful in the way that it reminds us of a breach of contract, one that links school labour with a future promise or compensation to be given in return. Move forward two years: proliferating research on the impact of COVID-19 measures on children's education highlights, without too much surprise, the profound inequalities of children's access to green spaces, cultural capital, digital infrastructures, and their exclusion from decisions that affect them directly, at all levels of society. So, on what terms should the educational contract be renewed? What is the purpose of school science education, and on what premises should school labour deliver on that future promise?

Changes operated by science and technology in-the-world

One of the most significant changes affecting Western societies over the past 50 years, at least, has been the quick chain of energy transitions, first from animal power to fossil fuels and then in quick succession, from solid fossil fuels (coal) to liquids (oil) and gases (natural gas). The changes have been driven by advances in technology, discoveries of new resources, geopolitical forces, social changes and other factors, which have resulted in a steady increase of energy consumption over time. People in high-income countries now consume 50 times more energy than ancestral communities of hunter-gatherers (Smil, 2019); they travel 100 times faster and eat twice to three times (Figure 1) the amount of meat-based products (OECD-FAO, 2017; Our World in Data), a diet fuelled – literally – by a fossil fuel-dependent agriculture (Hawkins, 2019).

While scientific research is preoccupied with the search for alternative sources to keep the economy growing, the transformations of energy from one source into another (e.g. from the chemical energy of coal into electricity, mechanical labour and heat), have significantly altered the Earth's patterns of distribution and accumulation of materials and energy at a global scale. The incidence, acuity and scale of current environmental crises have put into sharp focus the limits of a finite Earth, and of our knowledge, first highlighting that the future is not so certain and that such a future, as Hannah Arendt said more than 40 years ago, is clearly not the same for everyone. In philosophical terms, this poses big questions for human communities as a whole, reminding us that: (i) we are both and at the same time beneficiaries and unequal accomplices in socio-ecological transformations; and (ii) that the changes we face are not intellectual or abstract, but hugely experiential, involving everyday choices and actions. Depending on where we are located on the energy pyramid, we do 'see' the world

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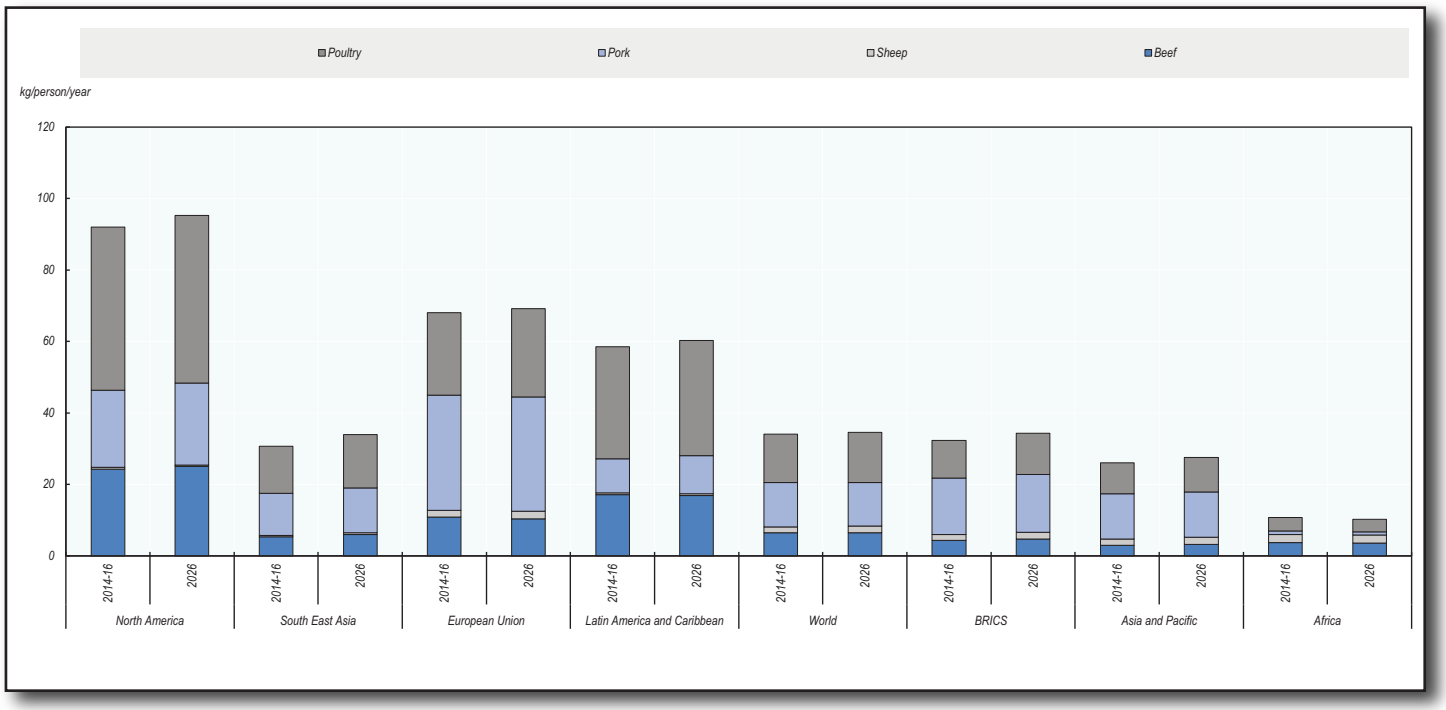
Figure 1. Meat consumption *per capita* and regions (Source: OECD-FAO, 2017).



differently; we identify different priorities and needs and, ultimately, we view and can relate with others – and with the Earth – in different ways.

The science curriculum across mixed purposes

Following the insights of Unger (1998), education is concerned with both a practical focus (to do with economic, technological or medical advancement) and a progressive one (concerned with personal and intellectual freedom). Both foci offer a route out of a crisis, by producing *capable agents,* who are able to act within the present order, but also to resist and see beyond it, opening up possibilities for change that are latent within the world as it currently is. Arguably, this combined route of practical and progressive intents is not unfamiliar to science educators. Referring to the four-purpose categorisation offered by Millar (2014), science education has sought to serve economic growth by means of increasingly more specialised and highly trained individuals; in service to this aim, science education has been largely framed instrumentally, as a means to either prepare students for high-level qualifications or for practical and vocational training. However, an important remit of science education has also been that of preparing students to think critically and make decisions in the face of complex issues affecting society and the environment. Millar (2014) referred to this as the democratic argument, concerned with all citizens gaining a better understanding of the science behind everyday events and making informed judgements on the basis of available evidence. While this is an important argument for science education, the question that remains is whether the science we talk about is the one that best serves the needs of diverse and heterogeneous communities. To this end, I would argue that the democratic purpose of science education is deeply entangled with a profoundly cultural endeavour. Understanding how science and technology 'work' in relation to the unequal distribution of physical and economic power – as described earlier – is a powerful way for

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understanding how scientific culture is made, but also how it could be re-made beyond material growth and a view of nature as objectified and inert. The latter calls for a science curriculum that deals openly with values, disclosing underpinning assumptions and narratives about humans' place in the world (Reiss, 2013; Colucci-Gray & Camino, 2016).

Yet, how the different purposes shape the science curriculum is itself a matter of culture and ideology, affecting the balance between content and process in curriculum design, and the pedagogical opportunities for students and teachers to co-produce and co-create new knowledge. For example, within the curriculum tradition (Tahirsylaj, 2017), a rationalist ideology will privilege the transmission of disciplinary knowledge, and input-output regulations, tasking teachers with setting objectives and measuring specific outcomes for economic accountability. This is the example of curricula in England or Sweden. Alternatively, humanistic and socially-reformist approaches as found in New Zealand, Wales, Northern Ireland and, to some extent, Scotland, aim to focus on cultural experiences, personal development and learning outcomes, highlighting teacher autonomy in cross-curricular work, with output regulation superseding input regulation. Typically, there always remains a tension in these curricula between openness and the need to provide uniformity, particularly if the outcomes are being measured through an assessment process that is disconnected from the process of teaching itself.

The result is an over-emphasis on training as opposed to educating, either by focusing on procedures or by tightly controlling experiences in order to deliver particular outcomes. As Grundy, back in 1987, commented: *'Processes become a set of skills, e.g. how to light a Bunsen burner. The actions have become the ends; the processes have become the product. Whether or not students are able to apply the skills to make sense of the world around them is somehow overlooked'* (Grundy, 1987, p.77).

Such emphasis on procedures can be so acute that it often overrides difference altogether, with some pupils being fundamentally excluded from a science education that does not speak their language; that does not conform to their home experiences; that is disconnected from their lived experiences and that does not address their concerns (Calabrese-Barton, Schenkel & Tan, 2021). This curriculum model drives a wedge between teachers and pupils; as shown in a study by Lidar *et al* (2017) on the impact of curriculum changes on teachers' behaviour in Sweden, the authors noted that, while all teachers justified their actions with wanting to do 'what is best' for students, how 'best' was shown in practice greatly differed, from delivering scientific knowledge and preparing students to do well in tests, to supporting their development as individuals.

Hence, a curriculum is a powerful discursive tool for framing how students and teachers perceive the aims of education, which are indeed multiple and different to different people.

Habits of perception

As helpfully summarised by Osberg and Biesta (2021), the trouble with school education today is that of intellectual purpose. A lot of attention is paid to education as the formal process of setting curriculum and assessment but, when undertaking and reviewing teacher education and training, such attention is in fact unable to *'do justice to the complexity of human togetherness under conditions of globalization, multiculturalism and differential states of technologisation or "development"'* (Osberg & Biesta, 2021, p.58). Notably, the authors point to the fundamental disconnect between an idea of education that is mainly 'psychological' and described through the language of learning, mental development and capacity, and an idea of education that is instead

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fundamentally concerned with questions of culture, values, ideals and knowledge.

This is particularly relevant to science education, for the ways in which science and technology have changed our abilities to perceive and act in the world are fundamental to a renovated understanding of what it means 'to think and to act scientifically'. This has important implications for teaching. As John Dewey argued, patterns of knowing have to do with *habits* of perception and *milieu* (Dewey, 1929)*, that is* how we *'are sensitised to'* and *'make communion with others'*, rather than with knowledge *per se*.

However, the question of training habits of perception is not simply concerned with acquiring the specialised ways of handling equipment, being able to tell an air bubble from an organelle when seeing a cell under a microscope, or making science fun and attractive to increase its appeal. Rather, it is through questioning the ways *in which particular sense-experiences* are elicited or filtered out, legitimised or denied. It requires perceptual attention, to become aware of how our science and technological artefacts can bound and/or extend human perceptions and actions, and what consequences this can have for communities of beings who may be far away from us.

This understanding changes traditional approaches to cognition from being largely 'in the head' to an ecological approach, whereby the mind is not separate from the body, and such body exists in continuity and through an ongoing exchange of materials, energy and information with the environment. In this sense, we cannot understand the human subject – that being teachers, students, parents – without taking into account the broader context, or more-than-human dimension – the physical home, the school, the technological artefacts, the artefacts of the streets or the plants in the garden, with which we co-exist as human beings (Dowling, Lloyd & Suchet-Pearson, 2017).

From this position, we move beyond rationalist approaches, and into a space for radical democratic action. A curriculum as *heterotopia* means that knowledge – and scientific knowledge first – is inviting practices that stimulate, as opposed to shut down or preclude and limit, the 'sensing' and 'knowing' of the world, at different scales, by means of analogies and stories that bridge the 'here and now' with the 'out there'. Take, for example, the common *Elodea* algae that yield their internal structures so generously to microscopic observation in everyday classrooms. This may be deserving of a different quality of attention, for they can tell us something about the technician who resourced them (or didn't); the aquarium or the pond in which they originated and lived; or the excitement of the students who are seeing beauty and structure within an organism that is different from themselves.

What is suggested here is the opportunity to allow for the scientific experience to question the habitual, bring a sense of foreignness to the everyday calling, and cultivate 'dispassion': that is, a sense of freedom from the projections and expectations bordering us in our personal and professional roles in everyday life. How could this enable a transition to a new contract for education? A contract that matters for now and into the future?

A science education that matters

I would like here to draw on the Scottish Curriculum for Excellence (CfE). Arguing for interdisciplinary learning across the curriculum and placing emphasis on experiences and skills, it appears to strive for a model of education beyond the delivery of knowledge for qualification. Yet, the shift from understanding curriculum as a form of delivery to being part of a process of knowing, taking place in a community and in a place, is a subtle and skilful process. Let's take the example of the technology section of CfE at first level (primary education): *'By exploring and using*

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technologies in the wider world I can consider the ways in which they help' [TCH-1.01a], and in the same column we find: *'[...] I have raised questions on the issues and I can share my thoughts'* [TCH-1.01a]. A contradiction is perceptible between accepting the utilitarian power of technology for solving problems to questioning its impacts and consequences (which can only be appraised after the event), and this permeates the strand all the way through to the upper levels. This reminds me of the story of the inhabitants of Macondo in *One Hundred Years of Solitude,* whom the author Gabriel Garcia Marquez described as being in a permanent alternation between excitement and disappointment, doubt and revelation, and which eventually caused what Marquez described as *'a leaf storm in the whirlwind'*...

While science and technology will refer back to diverse experiences of their uses in different communities, at different times, a democratic understanding brings the subjects together in dialogue on the fundamental ways that science and technologies have shaped the material and social organisation of the world. An important shift in this regard is moving scales in the curriculum, from the specific to the general and back, from the micro to the macro and back, each time bringing in a different disciplinary perspective (Colucci-Gray *et al,* 2013). In the story of the people of Macondo, the leaf storm began after Mr. Herbert returned to the community with the scientific know-how and a banana company, which forever changed the course of life in the community.

Transporting this example to today, the industrial production of food and how it affects different communities around the globe is a concern for science education, not simply in the appraisal of the nutritional qualities of bananas, or in the skilful use of carbon-based fertilisers to produce food, but in the sense that such power is unequally distributed; it disproportionately affects the powerless – groups who are economically and socially disadvantaged, and children, cast in a subsidiary position to the larger customer base. As I have described in an experience of school gardening elsewhere (Gray *et al,* 2019), a new and important task for science education is to bring together knowledge and action, offering the chance for students to redesign their worlds for convivial and communal instrumentations by first serving different ways of interpreting the problem, and then appraising together the offer of a solution. This view is primarily political, as it brings difference to the fore and cultivates the ability to co-exist with the multiplicity of other people's lived experiences, taking seriously the power of the more-than-humans to affect the ways in which we can make communion with others.

A cultural renewal in education will thus involve questioning the fundamental structures of the educational experience: who has access to science education and who doesn't? Whose experiences – teachers, pupils, communities – are seen and whose are not? In what way are the filters of technology and language shaping decision-making and understanding of purpose in science education? And how could such conditions change?

With these questions in mind, we move beyond a science education concerned with curriculum knowledge (whereby the question is *'how much do I cover?')* to embrace a science education concerned with the *very condition of being a citizen* who can exert power and be conscious of its implications.

This brings the teacher together with the students away from the era of measurement, focused on setting promises for success, into the future, to the current time where the concern is about making the future together:

- Who are we as a community?
- What will become of us?
- And who decides?

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References

Calabrese Barton, A.M., Schenkel, K. & Tan, E. (2021) 'The Ingenuity of Everyday Practice: A Framework for Justice-Centered Identity Work in Engineering in the Middle Grades', *Journal of Pre-College Engineering Education Research* (J-PEER), **11**,(1), Article 6

Colucci-Gray, L. & Camino, E. (2016) 'Looking Back and Moving Sideways: Following the Gandhian Approach as the Underlying Thread for a Sustainable Science and Education', *Visions for Sustainability,* **6**, 23–44

Dewey, J. (1929/1988) *The Quest for Certainty*. In: *John Dewey: The Later Works, Vol. 4,* Boydston, J.A. (Ed.). Carbondale: University of Southern Illinois Press

Dowling, R., Lloyd, K. & Suchet-Pearson, S. (2017) 'Qualitative methods II: "More-than-human" methodologies and/in praxis', *Progress in Human Geography,* **41**, (6), 823–831

Gray, D., Colucci-Gray, L., Donald, R., Kiriacou, A. & Wodah, D. (2019) 'From oil to soil. Learning for sustainability and transitions within the school garden: A project of cultural and social re-learning', *Scottish Educational Review*, **51**, (1), 57–70

Grundy, S. (1987) *Curriculum: product or praxis?* Lewes: Falmer Press

Hawkins, I.W. (2019) 'The diet, health and environment trilemma'. In: *Environmental Nutrition: Connecting Health and Nutrition with Environmentally Sustainable Diets,* Sabate, J. (Ed.), pps. 3–25. London: Springer

Lidar, M., Lundqvist, E., Ryder, J. & Ostman, L. (2017) 'The Transformation of Teaching Habits in Relation to the Introduction of Grading and National Testing in Science Education in Sweden', *Research in Science Education*, **50**, (1), 51–173

Millar, R. (2014) 'Designing a Science curriculum fit for purpose', *School Science Review*, **95**, (352), 15–20

OECD-FAO (2017) OECD-FAO 'Agricultural Outlook 2017-2026. "Per capita meat consumption by country and region"'. In: *Commodity Chapters.* Paris: OECD Publishing. https://doi.org/10.1787/agr_outlook-2017-graph98-en

Osberg, D. & Biesta, G. (2021) 'Beyond curriculum: Groundwork for a non-instrumental theory of education', *Educational Philosophy and Theory*, **53**, (1), 57–70

Priestley, M., Alvunger, D., Philippou, S. & Soini, T. (2021) *Curriculum making in Europe: policy and practice within and across diverse contexts*. Bingley: Emerald

Reiss, M. (2013) *An aims-based curriculum. The significance of human flourishing for schools (1st Edition)*. London: Institute of Education Press

Smil, V. (2019) *Growth: From Microorganisms to Megacities.* New York: MIT Press

Tahirsylaj, A. (2017) 'Curriculum field in the making: Influences that led to social efficiency as dominant curriculum ideology in progressive era in the U.S.', *European Journal of Curriculum Studies*, **4**, (1), 618–628

Unger, R. (1998) *Democracy Realised. The progressive alternative*. London: Verso

Dr. Laura Colucci-Gray, Moray House School of Education and Sport, University of Edinburgh.
E-mail: **Laura.Colucci-Gray@ed.ac.uk**