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Opening Visions for Science Education Futures

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In the current knowledge-economy era, governed by evidence-driven decisions, benchmarking and targets, together with the possibility of large-scale monitoring through the availability of Big Data, important and critical questions arise about the nature and production of scientific knowledge. Who is involved in setting the criteria for its validation, in what contexts and for what purposes? Scientific debate progresses through the accumulation of evidence and logical argumentation, but at the same time through justifications, which carry biases, assumptions and views of the world which are often left undisclosed. Such is the argument put forward by Isabelle Stengers in a book only recently published in English. As a philosopher, she argues, her task is not only that of dealing with and describing the 'probable', that is, what may be reasonably accounted for in the domain of scientific research and praxis, but also 'to activate the possible' (Stengers, 2017), that is, to think situations by taking account of the vast and broad sphere of the 'unknowns'.

As Stengers demonstrates, the linear approach to knowledge production, from the validation of direct links between variables to the commissioning of research directed towards products and outcomes, is founded upon two central assumptions. Firstly, a linear concept of time, whereby the image of the ticking clock, the urgency and speed of knowledge production is linked to the idea that all people on the Planet have a common history or a common future. However, that is certainly not the case in an increasingly unequal and inequitable society. Secondly, the presumed objectivity of a scientific statement automatically provides a certain immunity, for 'objectivity' may be a proxy for 'acceptability', 'safety' or even 'desirability' of particular research and enterprise activities.

From a knowledge-economy perspective, the world can be approached from afar as a place for interventions introduced as if purporting to provide generalized benefit. These are the basis of the university-industry partnerships: the offer of secure grounds which will be validated and defended in the name of science. In contrast, the lives of people on the ground are

far more complex, shaped by structures and history, and enacted through a myriad of subjective and contextualized experiences. In this space there is no single future but many, possible futures which may be desired, feared or even dreamt of. This awareness runs counter to the expectation of 'knowledge speaking truth to power'; rather, it calls for wider conceptions of inquiry, to include posing and wrestling with questions which may well not be directly related to a specific focus, or which may not be wholly answerable, either now or later. So we ask: what is the role of education, and science education in particular, vis à vis ideas of time and the future?

This special issue of *Visions for Sustainability* brings together a number of international contributors who all attended the 12th European Science Education Research Association Conference held at Dublin City University in August 2017. The title of the conference, "Research, practice and collaboration in science education" aimed at stimulating educational researchers to look beyond traditional contexts for science education research and practice, from formal to non-formal and informal agencies, designed and circumstantial learning opportunities, and to expand horizons for science education. Here we offer a selection of papers which explicitly deal with visions for the future. Our desire is to engage in debate about questions concerning the futures of the many populations, human and non-human, inhabiting the Earth, and our ability as human beings to think creatively about the future so as to encourage more sustainable points of view, approaches and trajectories.

Accelerating transformations...

Humanity's current perceived global reality is largely described and measured through the eyes of science. Science is a highly variegated field that has in recent decades acquired an increasing ability to measure a vast number of phenomena and processes, in particular thanks to powerful computing machines. There are now essentially incontrovertible data on the human trespassing of the biophysical boundaries of the Planet, the growth and

spread of critical environmental conditions (reduction of soil available for farming; pollution of ocean water and freshwater systems; impoverished air quality in urban settings) and the hazardous transformations many ecosystems are undergoing. In 2007 the number of people living in cities went past that of those who live in rural areas, and the percentage of urban dwellers is continuing to rise. Data for 2018 (World Bank Group, 2018) put the figure at 54% and the forecast is that this will reach 70% by 2050 (UNESCO, 2016). As a result, an ever-greater number of children will be born and grow up in cities, thereby risking having little or no contact with Nature. Within a very short time-span, we have seen the expansion of information technology networks, an ever more tightly-knit web of communication which is now covering the entire Planet. Such digital networks both connect and alter the physical and mental activities of a vast part of humanity.

Environmental transformations, urbanization and digitalization are all phenomena related to what are commonly considered to be scientific 'progress' and technological 'innovation'. Both progress and innovation are signifiers which express ideas that occupy a central place in the collective imaginary. These words have arguably shaped and driven research and development projects, spurred on economic investments and propelled the use of energy and resources over the past two centuries, with irreversible transformations of the world as outcomes we have only recently begun to understand. Yet this imaginary is still evident and dominant today, whereby ideas of wellbeing and development continue to be largely associated with a need for economic growth. Techno-science, the building of knowledge aimed at generating immediate gains measurable in material terms, is seen as the engine of growth. This view of science has also long permeated the world of education. Children and young people are encouraged to opt for scientific study in the belief that the competences acquired will help them build successful careers and contribute to improving the state of the world and promoting the wellbeing of all.

... and reflections on the educational implications

Trusting techno-science as the vehicle for 'improving' the world we live in depends on the belief that scientific knowledge is in itself neutral and objective, and that it is up to people to make good or bad use of it. Such a belief ignores the way in which the production of scientific knowledge depends on many factors that are related to a range of questions. Which problems are being considered worthy of investigation and resolution? Who is able to or interested in financing the research? Which political powers decide whether to promote one strand of research over another? Who is in charge of monitoring the validity of the experiments conducted and the results that are being communicated? Who is responsible for ensuring that a regulatory framework exists to assess risks and uncertainties associated with the introduction of new technologies on the market?

The realization that research for military purposes receives larger funding than research serving civil or educational purposes, that research expenditures are higher for the larger multinational companies, that the negative impacts of presumed 'innovations' only come to light after often irreparable disasters, provides potent indicators of the influence of power relationships over the construction and application of knowledge. Hence, talking about science in an educational context requires new perspectives and new goals, in order to develop young people's desire both to access and to do scientific research, together with the reflective and reflexive abilities required for posing questions concerning the what, the why and the how of scientific knowledge, and addressing the need to define the roles and responsibilities of civil society in order to decide if and how to participate actively or to delegate this role to the 'experts'.

Overcoming growing alienation ...

Given the relationship of interdependence between every human and non-human entity and the environment in which it exists, the radical change of scenarios we have observed both in the natural systems and human

relationships, in particular since the middle of the twentieth century, poses crucial questions about the transformations occurring in children and young people. The apparent ease with which they learn new ways of acting, communicating, thinking and feeling emotions, simply by being immersed in the digital infosphere, raises questions for us about the consequences of losing other ways of being and doing the same things, typical of those who - until a few decades ago - were immersed in the biosphere.

This lack of contact with Nature, its inhabitants and rhythms, its variety and unpredictability, constitutes a sharp and highly significant discontinuity for a species like ours which has gradually developed, over a very long period of time, adaptation strategies which are extraordinarily diversified in order to respond to a variety of natural environments. The digital sphere, while enabling the transfer of an enormous amount of data and information, is still largely a structurally-uniform system when compared to the creativity and diversity expressed by the biosphere. Moreover, while natural processes are spontaneously evolutionary and auto-poietic, the digital sphere is controlled (and thus amenable to manipulation) by a handful of centers of power and it is dependent upon enormous flows of energy, in the absence of which it immediately switches off. Hence, it is extremely vulnerable to perturbations when compared to the resilience and adaptability of natural systems. Such dependence and vulnerability are inevitably passed on to those members of the infosphere who are unable to develop adequate independence and autonomy.

A science education which looks to the future must necessarily start from our present condition and work towards a culture which encompasses new digital resources while maintaining awareness that the roots of humanity, and thus its evolution and survival, are steeped in the web of life (Capra, 1997):

Digital literacy (scientific thinking, problem solving, computing abilities, coding) and programming of computers represent new languages with which we need to familiarize ourselves so that we do not become passive

subjects of the digital sphere. However, this process needs to go hand in hand with a 'digital wisdom', that is, a responsible and conscious take on one's digital identity, an adequate monitoring of personal data, a right balance between one's life online and offline, so to avoid dependency on the web (Patrignani, 2017).

Helping young people to exploit in a responsible way the opportunities offered by the infosphere and manage their relationships within the digital domain is a necessary part of the whole educational process. Today it is essential for science education to contribute to this, but also give particular attention to, and if necessary rebuild, those relationships with the natural environment that are increasingly being interrupted or lost. Central to this enterprise is the establishment of empathetic contact or 'affiliation', as expressed by Wilson's biophilia hypothesis - stemming from a spontaneous process of learning, developing from the moment of birth, involving all the senses through which we can receive input, and mediating the construction of the neuronal network and the motor system of every human being.

... and responses from science education research

In light of such a complex scenario, the responses from science education research are multiple and varied. Most commonly, prevailing dominant narratives are transferred across the different levels of education through curriculum choices, assessment and selection procedures and the preparation and support available to teachers (Ryder, 2015). From the perspective of sustainability education there are both opportunities and tensions involved in promoting inter and trans-disciplinary work, requiring pedagogical models which value dialogue across disciplines and partnerships between different stakeholders working across formal, non-formal and informal learning environments. The five papers included in this issue are drawn from a range of educational contexts across five countries. Each paper offers a particular perspective on the future and the opportunities offered by science education.

In the paper by Branchetti et al., “The I SEE project: An approach to futurize STEM education”, the authors discuss an approach seeking to ‘futurize’ science education by introducing pedagogies designed to encourage pupils to ‘imagine’ the future through ‘future-scaffolding skills’ such as strategic thinking and planning, risk taking, thinking beyond the realm of possibilities, managing uncertainty, creative thinking, modelling and argumentation. In the context of secondary school education in Italy, still largely characterized by transmissive models of teaching and learning, the authors argue that science education should be seen as a means to encourage the participation and involvement of the pupils, to engage their points of view and ideas, develop their talents and build a community of learners – including the teachers and the researchers – working together on a common task. Within this perspective, a critical aspect concerns the ability to promote and maintain a focus on sustainability. What disciplines are involved and how can they feed into and out of each other? To what extent are conventional views and *expectations* of science and technology being discussed and/or challenged?

Within the context of higher education in Austria, Ilse Bartosch presents a study on “Learning about energy: A real-life approach challenging the present culture of science & engineering”. The author discusses the opportunities involved in STEM education to engage with real-life, applied contexts, thus embracing *design* as a pedagogical disposition for addressing sustainability issues. She underlines the influence of political and economic structures and the need to call into question established mainstream ideas about STEM and to engage creatively with experiences able to bring forth new ways of thinking. Students are part of a community of practice developing dialogical and collaborative practices. Such community can be seen as having emotional, biological and ecological dimensions giving rise to an expansion of the realm of experience which entails a shift of perspective from being detached from the environment to being part of it (Zweers, 2000).

The two papers from Portugal by Monica Baptista and Pedro Reis, and Australia, by Paige et al., both illustrate the value of projects involving primary children taking action in relation to environmental issues and developing first hand knowledge of the world around them. In “Let’s save the bees! An environmental activism initiative in elementary school”, Baptista and Reis place emphasis on the importance of becoming scientifically informed and scientifically literate through direct experience. Such a position is well-documented in the literature through the rise and development of citizen science approaches at different levels of education. The study points to the opportunities to develop citizens who are knowledgeable about their own environment and are thus able to contribute to research on conservation. We note here how citizen science approaches are now extremely diversified in the ways they promote engagement with scientific research as well as inter-generational learning in the community. The involvement of technology in such initiatives has been key to their expansion, by enabling large collection of data and extending to a variety of users. Both articles bring to mind the reflections expressed by Hannah Arendt in relation to the question of ‘style’. According to Arendt (1994), the way in which we think and seek to understand the world is intertwined with the ways in which we allow our different *experiences* to surface. Hence, there are important considerations to be made about the ways in which science education interrogates the quality and processes of inclusion and participation of other people, views and modes of knowing and relating to the world.

In “Futures in Primary Science Education – connecting students to place and eco justice” Paige et al. address this point by recognizing that students’ views on science and technology are embedded in a broader social context. Hence their visions of the future offer an insight both into their hopes and fears, and are likely to have important implications for them personally and for society. There is also compelling evidence from psychology that our expectations for the future not only affect how we see reality but also contributes to building

reality itself. Hence views of the future and citizens' knowledge are not to be reduced solely to its scientific components. Such recognition opens the way to a greater array of approaches in science education which may engage students' cognitive as well as practical skills, as a way of giving meaning to one's aspirations and abilities in relation to desired futures, and not simply ones that are predicted or feared.

In "Science Education Futures: Science Education as if the Whole Earth Mattered", Donald Gray takes inspiration from eco-psychology in order to articulate a framework for a science education which seeks to facilitate a dialogue across different disciplinary fields in order to encourage an all-encompassing vision of sustainability. It is argued that the starting point for this process is primarily experiential and contextual: "*if the self is expanded to include the natural world, behavior leading to destruction of this world will be experienced as self-destruction*" (Roszak et al., 1995, p.12). Such a vision entails a change of perspective, one which both acknowledges the ecological boundaries of the biosphere (Rockström et al., 2009) and engages the creative and imaginative faculties of human beings. By extension, this leads to an education which goes beyond the acquisition of scientific knowledge and skills to develop a wide range of interrelated abilities: affective, empathetic, linguistic, physical and relational.

A science education seeking to promote community and the active participation of pupils, teachers and researchers can thus be interpreted 'ecologically' as a process which enable us to participate in the self-ordering of nature, instead of acting, and thereby interfering with it, as if from outside, as is the common point of view of the technologies of control. Yet, "such a mode of participation is not at all self-evident or 'natural' (Zweers, 2000, p.153). Rather, it is an existential process of self-realization in relation with others. We conclude here with the Heideggerian idea of being human as 'dwelling', that is, a form of attending to, cultivating and being in the environment:

Being-in-the-world means to live among things with which one is ordinarily and

proximally familiar, to dwell in places that afford possibilities for being and involvement with others, to see one's self thrown and projected (a potentiality to be), and to stay in a place that one cultivates by making space for things, projects, and beings and safeguarding them or showing care toward them. These are the structural features of being-in-the-world in its average everydayness, that is, the conditions that are necessary for the enjoyment of being in the normal course of things (French, 2015, p. 352).

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