Visions for Sustainability

Vision without action is useless.
But action without vision
is directionless and feeble.
Vision is absolutely necessary
to guide and motivate.
(Donella Meadows)

Interactions between different logical levels
produce phenomena unseen at either level.
(Gregory Bateson)

4

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Contents:

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VISIONS FOR SUSTAINABILITY is an indexed scientific journal published in open access by the Interdisciplinary Research Institute on Sustainability (IRIS). The journal promotes a debate on how the concept of sustainability can be addressed and applied in existing and foreseeable societies worldwide. Particular emphasis is placed on facilitating communication between researchers of different disciplines, supporting educational projects and examining the role of contemporary science in dealing with issues related to sustainability. Papers are welcome from researchers and scholars of natural, political, social and other sciences as well as philosophical and humanistic disciplines, and in particular from anyone wishing to make a contribution which combines multiple viewpoints. The aim is to host as wide a range as possible of multidisciplinary, interdisciplinary and transdisciplinary perspectives on sustainability. Discussions or comments on articles which have previously appeared in the journal are also welcome. All submissions will be refereed before publication.

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Visions for Sustainability N. 4: Beyond analytical perspectives

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***Perspective**: Theoretical vision*

***Fields**: Earth life support systems - Economy and technology - Social processes and structures*

***Issues**: Bio-geological equilibrium and ecological decay*

In Paris, just a few weeks after the terrorist attacks that in mid-November 2015 shocked once again the western world, the 21st UN Conference on Climate Changes (COP21) took place, in an attempt to make the whole world agree to a two-degree target for global temperature rise. Some members of civil society claim that the reactions displayed in Paris respectively to the manifestations of global warfare on the one hand and to climate change on the other, are contradictory and not sufficiently ambitious, in their granting of justice and rights to a small percentage of the world population. In some way, both the COP21 'deal' on emissions and the warlike retaliations look at powerful technical responses as the only available means and fail to take a more comprehensive view which includes - among global endangerments - the very human practices that modify environmental and socio-economical equilibria.

For example, the use of fossil fuels for manufacturing or for automotive engines release CO2 from the deep Earth in just the same way as industrial agriculture or intensive farming and fisheries. Likewise, agricultural workers from rural territories are pushed towards the already saturated routes of economic growth. The whole scenario of the Earth's disequilibria, which extends beyond greenhouse gases emissions, is of extreme concern. A shortfall in the regenerative capacity of the planet is also visible now for phosphorous and nitrogen cycles, together with the widespread distribution of toxic chemicals (amongst which pesticides make the largest share), and whose effects we only partially know. Meanwhile, the incalculable damage of warfare often brandished as an effect capable of guaranteeing security and control, is itself among the worst causes of the endangerments we face.

This issue of Visions for Sustainability seeks to propose a change of attitude by offering a variety of perspectives for dealing with what may appear as rather heterogeneous arguments.

A review of the nuclear power option, by Elena Camino and Laura Colucci–Gray, analyses the debate on atomic energy as a route towards a carbon-free world. The authors take the opportunity to offer a counter-argument to nuclear power by writing in reply to the study recently published by Qvist & Brook in PLoS/ONE, in May 2015. Camino and Colucci-Gray confute the promotion of "a large expansion of global nuclear power" by drawing on a wider set of interdisciplinary perspectives and sources to highlight the complexity of the issue, including social, political and educational implications, with the many contradictions and biases that are often involved.

Michele Cagol and Martin Dodman consider the relationship between the making and re-making of technological artefacts to promote sustainability, looking specifically at circuit bending. The authors reflects on the modification of electronic circuits commonly found in everyday appliances as an example of the necessary shift toward harnessing creativity and innovation in terms of re-thinking and re-using processes and products that are typical of human activity.

¬Vitalia Kinakh reviews initiatives across higher education institutions designed to raise awareness of sustainability, in particular the efforts promoted by the Head of School of Dentistry at the University of Manchester to foster understanding of social and environmental sustainability among graduates. She also explores data about students' perception of sustainability and their awareness of the benefits for dental practices to go green. The debate encompasses education for sustainable development through examining the possible ways of delivering it within the current dental curriculum.

Francesca Andreatta, Chiara Bolognani, Caterina Robol, and Martin Dodman look at the provision of schooling in children's' hospitals as an example of sustainable education. Since illness is often a cause of exclusion, the promotion of learning in environments that care for and cure children

is considered as a form of inclusive policy that promotes wellbeing as an integral part of a human sustainability paradigm. The characteristics of the hospital as a learning environment are considered and psychological and social factors addressed in terms of fostering resilience for a healing process in which learning plays a vital role.

Finally, Elena Camino, Lidia Larecchiuta, and Massimo Battaglia analyze the interconnections between environment, violence and nonviolence using a hypertext, accessible on the web, using data on the environmental impact of military actions and suggesting educational activities drawn from the perspective of nonviolent culture.

A special note in this editorial is for Svetlana Alexievich, Nobel Prize winner for literature, the first awarded to an author of writings devoted to living people. This issue of Visions for Sustainability contains no papers dedicated to her work, but we would like to emphasize the importance of the vision proposed by her oral stories, that allow the voices of people to tell the appalling, mishandled tragedies such as the defeat of URSS in Afghanistan, the disaster of Chernobyl and the collapse of soviet economy, using a plain and direct language unique within such literature.

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Cagol, M., Dodman, M. (2015) Circuit-bending and sustainability transitions. Exploring ways of re-thinking and re-using technologies. Visions for Sustainability 4: 13-21

Camino, E., Colucci-Gray, L., (2015). The nuclear power option: exploring boundaries and limits, asking open questions. Visions for Sustainability 4: 22-42

Camino, E., Larecchiuta, L., Battaglia M. (2015) Interconnections between environment, violence and nonviolence. Visions for Sustainability 4: 55-59

Kinakh, V. (2015) Supporting change for sustainability in Dentistry. Visions for Sustainability 4: 5-12

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Supporting change for sustainability in Dentistry

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Abstract. This article, firstly, reviews various initiatives over the last decade across Higher Education Institutions that are aiming to increase awareness of sustainability starting from making campuses green to educating for sustainable development. There is strong support from the Head of School of Dentistry at the University of Manchester and faculty buy-in to foster understanding and awareness of social and environmental sustainability among dental graduates. If plans to be made to further awareness of the principles which underpin sustainable development among dental students, we need to establish the baseline – where are we standing from?
The second part of this article will therefore explore data collected during the first Sustainability Talk about students' perception of sustainability and their awareness of the benefits for dental practices to go green. 140 students from year 3 and 5 took part in the Sustainability Talk in September 2014 and data was collected using 'clickers'. Data revealed that environmental aspects of sustainability are familiar to students on Dentistry courses at the University of Manchester. Analysis of data alludes to variations in perceptions among year 3 and year 5 students.
A forum to bring together dentists, dental businesses (e.g. Colgate, Dentsply), academics and students should be considered. The debate should encompass Education for Sustainable Development and how to effectively deliver it within the current dental curriculum.
Keywords: sustainable development, environmental issues, dentistry curriculum, student attitudes

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***Perspective**: Educational vision*

***Fields**: Social processes and structures*

***Issues**: Educational processes, Healthcare*

1. Introduction

As the UN Decade of Education for Sustainable Development (ESD) concluded in December 2014, it is imperative to review whether or not there is evidence to suggest that there is, as was the intention, an increasing environmental consciousness amongst practitioners across all disciplines. This article focuses specifically on how we can ensure that dental students acquire both the content knowledge and an awareness of the latest dental technologies to help them run both sustainable and profitable dental clinics.

Drawing on findings and recommendations from UNESCO (UK National Commission for UNESCO, 2013) and the Higher Education Academy and National Union of Students (Drayson et al 2013; Drayson et al 2014) the first part of this article will report on initiatives across Higher Education Institutions (HEIs) that are aiming to increase awareness of sustainability. The Higher Education Academy recommends that 'academics work with the wider academic community to build materials and approaches to embed sustainable development across curriculum and subject-specific disciplines where appropriate' (Drayson et al 2013, 5). The second part of this article will therefore, explore responses to the developing professional interests in delivering eco-friendly dental care in the UK and the fast growing trend for eco-dentistry in the U.S. using the School of Dentistry at the University of Manchester as case study.

2. Sustainable Development and Higher Education Institutions

The concept of Sustainable Development (SD) emerged almost three decades ago and it is centred around efforts to develop a more resource-efficient economy. One of the key findings of the 2014 report about 'Student attitudes towards and skills for sustainable development' by HEA & NUS underlines that 'two thirds of the surveyed students believe that SD should be included in their university courses – a belief consistently reported since the first survey taken in 2010-11' (Drayson et al 2014, 3).

The first stage of SD was about buildings and organisational change. Large investment in SD can be seen across the university campuses in the UK and US into buildings with many sustainability features, e.g. Department of Anatomy from University of Aberdeen, the College of Pharmacy of University of Rhode Island, Tufts University School of Dental Medicine. Furthermore, a prevalent number of universities also engage in sustainability through activities to make campus greener, such as sustainable travel, carbon and waste reduction, planting trees and vegetable gardens, promoting the use of refillable bottle and energy management. Needless to say, that these activities involve a community of staff and students. In addition a number of universities have created a dedicated sustainability office, for instance The Green Impact team at the University of Manchester. All these organisational efforts are captured by the People & Planet University League.

A similar initiative to P&P emerged in 2006, one year earlier, in the U.S., when the Association for the Advancement of Sustainability in Higher Education (AASHE) presented its first annual Campus Sustainability Leadership Award. To date 300 universities and colleges mainly in the U.S. (STARS Dashboard 2014) are using the Sustainability Tracking, Assessment & Rating System™ (STARS) to measure their overall sustainability performance and the best showcase their sustainability achievements on the AASHE website.

A second stage of SD is about creating students, who are motivated to act sustainably in their personal and professional lives. Educating for sustainable development is 'fundamentally about values, with respect

at the centre: respect for others, including those of present and future generations, for difference and diversity, for the environment, for the resources of the planet we inhabit' (UK National Commission for UNESCO 2010, 14). The Natural Sciences courses have strong sustainability curriculum content (Stewart, 2010; Horvath, Stewart and Shea 2013), but there is still uncertainty whether other disciplines foster Education for Sustainable Development (ESD).

3. Sustainability in Dental Education

Educating dental students for sustainable development takes on an even higher significance with the projection of 8.1 billion people on the planet by 2025 (UN, 2013). 8.1bn people multiplied by 32 teeth – it is a lot of work for dental professionals! On the other hand many environmental resources such as energy, clean water and soil are dwindling at a faster rate that can be replaced. According to data from the Eco-Dentistry Association 'between 66 and 75 % of the 120,000 U.S. dental offices still use traditional X-rays and require disposal of 4.8 mil lead foils and 28 mil litres of X-ray fixer every year' (Pockrass, 2010). If we take into consideration the other world's largest and populous economies such as China, the UK, Brazil, Russia and India, the amount of harmful waste generated by dental practices is overwhelming. For that reason students on dentistry courses need to acquire both: content knowledge and awareness about 'dental technologies' that help to reduce waste, save energy, how to 'operate an eco-friendly practice and make a difference to the bottom line' (Holland 2014, 10).

Faculty members at the School of Dentistry at the University of Manchester are conscious of the fact that the Dentistry curriculum is very tight and the addition of a new class session focusing solely on topics related to the environment, sustainability and social responsibility is unfeasible. Thus ESD should be taken forward as a holistic approach. In addition, the School also recognises the third key finding of the 2013 report by HEA & NUS that 'a desire to learn more about SD increases as respondents progress through their studies' (Drayson et al 2013, 4). Therefore before starting the audit of its curriculum the School decided to find out the level of sustainability awareness amongst year 3 (Y3) and year 5 (Y5) dental students. Data taken together with other evidence will give faculty the opportunity to guide change.

The data collecting process

Around 140 students from Y3 and Y5 attended the Sustainability event in September 2014, which aimed not only at surveying students but also to spread the word about sustainable best practices in Dentistry and NHS. The author is familiar with a number of publications (Herreid 2006, 44; Hoekstra 2008, 331), which discuss the efficacy of clickers as a useful data gathering tool for conducting education research. As a result The PowerPoint presentation was converted into an interactive demonstration using TurningPoint software and 'clickers' were used in order to capture students' responses. All students voted simultaneously and the presenter was closing the poll manually in 1 minute. The presenter did not encourage students to discuss their answers with each other, although it is possible, that some students had an opportunity to see how their neighbouring peers were voting. All questions were the multiple-choice questions and the 'attitude' questions had 5-point unipolar rate-scales. It is important to point out that responses cannot be linked to individual participants, thus all voting was absolutely anonymous. The response rates to all questions were high, but varied from 88% to 100% because some students refrained from answering certain questions. The collected data can only be streamed as data provided by Year 3 (Y3) and Year 5 (Y5) students.

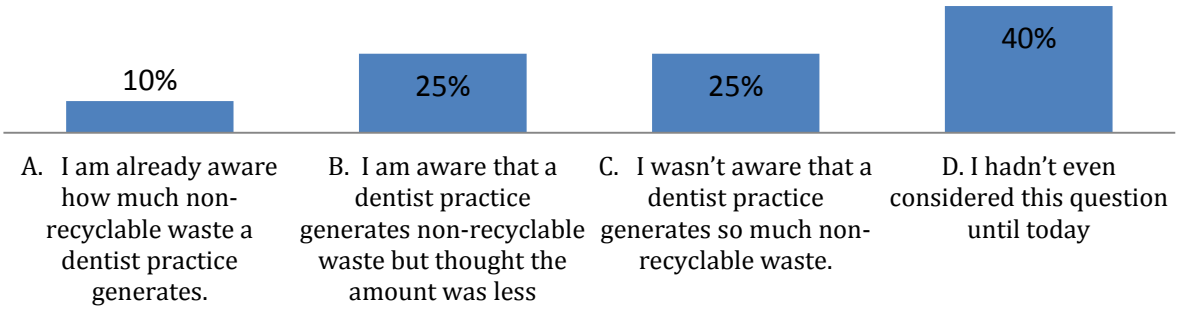

Figure 1. Year 3 responses to the question ' How aware are you about the amount of waste generated by a typical dental practice?

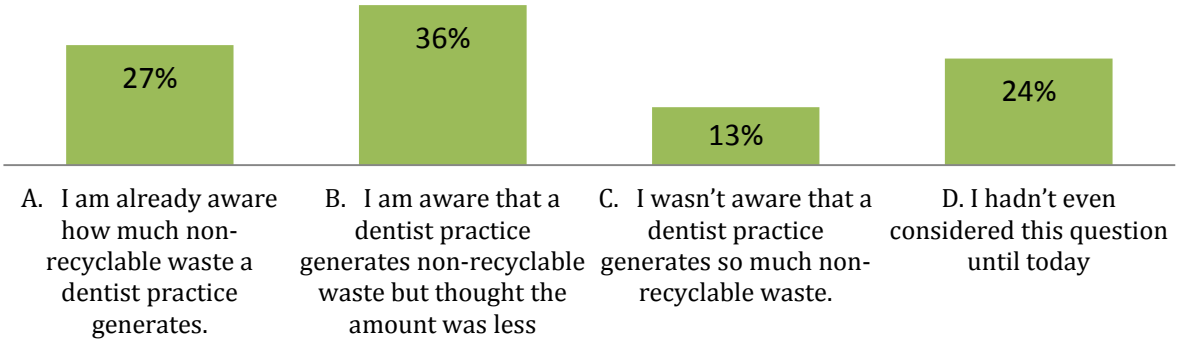

Figure 2. Year 5 responses to the question ' How aware are you about the amount of waste generated by a typical dental practice?

Before the talk students were asked to self-rate how environmentally conscious they are. Only 33% of Y5 and 13% of Y3 indicated that they 'very concerned with environmental issues in my community'. Nonetheless, 19% of Y5 and 16% of Y3 disagreed with the statement 'I think that I am better informed about environmental issues than most other people'. That shows a definite need for further events/initiatives, which promote environmental aspects of sustainability. 68% of Y5 and 78% of Y3 students showed familiarity with the term sustainability. This provides direct evidence of their ability to define sustainability. Data allude to variations in the level of awareness between Y3 (figure 1) and Y5 (figure 2)students as regards to the amount of waste a typical dental practice generates. Y5 students, who will graduate in 9 months and join dental practices across the UK as general dental practitioners, showed a greater level of awareness (27% and 36%) than Y3 students (10% and 25%). Furthermore, a predominant majority of students agreed that dental amalgam has the most potential for harm to the environment. The level of awareness is slightly greater amongst Y5 students (77%)(figure 4 compared to figure 3). Still almost half of students (Y3 and Y5 combined, see figure 5) indicated that they are either slightly or not at all aware of waste management and handling regulations applicable to dental practices in the UK.

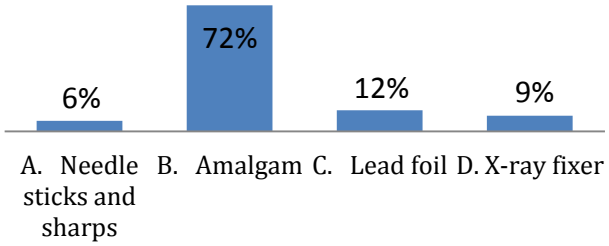

Figure 3. Year 3 responses to the question "Indicate which dental material has the most potential for harm to the environment"

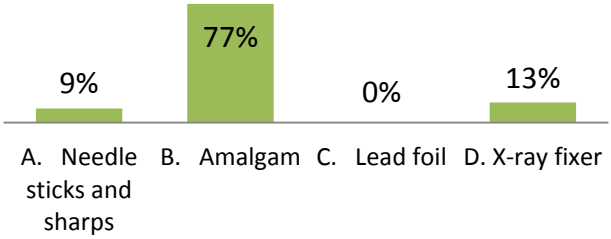

Figure 4. Year 5 responses to the question "Indicate which dental material has the most potential for harm to the environment"

A number of simple options, which dentists can and should implement if they would like to run eco-friendly dental practices, were presented, e.g. switching to a dry dental vacuum pump instead of wet pumps. That move will allow saving over 190 litters of clean, drinkable water per year! The other solutions include installation of an amalgam separator or converting to digital radiography. If our graduates will consider implementing these solutions, then as a consequence a dental practice does not have to deal with the disposal of lead foils and toxic x-ray fixer from conventional x-rays and to release mercury into the public sewer waters.

Since 2012 dental experts and the European Environmental Bureau (EEB) have campaigned about a phasing-out of the use of mercury in dentistry, both in the EU and around the world. In January 2013 the mercury treaty (UNEP 2013) was finalized, and included important provisions to reduce and eliminate mercury pollution by means of phasing down the use of dental amalgam (mercury fillings) in the EU countries.

The University Dental Hospital of Manchester enforces the separation of amalgam (mercury) before water is discharged. A large majority of our students understands that even if a dentist identifies a practice as mercury-free because they no longer place amalgam, s/he needs to have an amalgam separator. However, 23% of Y3 (figure 6) and 18% of Y5 (figure 7), who answered 'No', are still under misconception that if a dental practice is classed as 'mercury-free', then it does not need to have an amalgam separator.

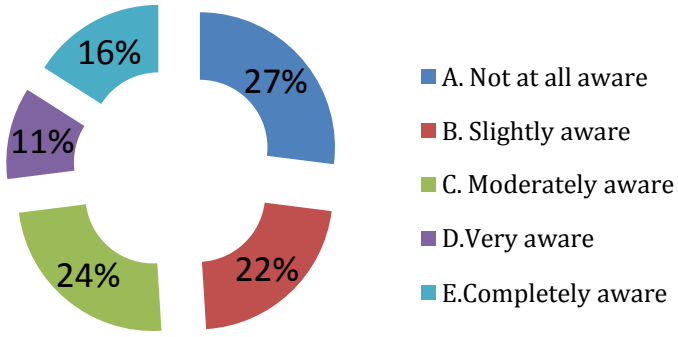

Figure 5. Responses to the question: 'Are you aware of waste management and handling regulations applicable to dentists?'

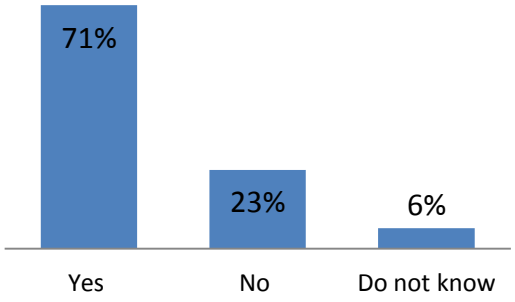

Figure 6. Year 3 responses to the question "Does a mercury-free practice still require an amalgam separator?"

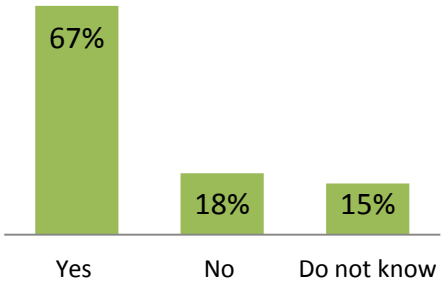

Figure 7. Year 5 responses to the question "Does a mercury-free practice still require an amalgam separator?"

As a part of the talk attention was also drawn to the cost-saving solutions from switching to energy efficient lighting and equipment, recycling with an eco-conscious waste management company and converting to reusable cloth.

At the end of the session students were asked to indicate which of the discussed solutions of 'making a dental clinic more eco-friendly' would they be most likely to implement in their future place of work. Y3 students (figure 8) signalled their preference for High-Tech Dentistry: using of a dry pump, the LED lamp in a chair unit, A-rated appliances in a dental practice (option A) as well as opting for digital radiography (option C). Arguably digital imaging and a purchase of a new dry pump or a new chair-unit have a significant up-front cost, however, once installed; a dental practice can save money in the long-run. Y5 students (figure 8) did not show preference for a particular solution. It is interesting to note that in contrast to only 8% of Y3, 27% of Y5 indicated that they are most likely to implement in their dental practice the use of reusable sterilization pouches or biodegradable consumables as well as bulk-buying of prophy paste.

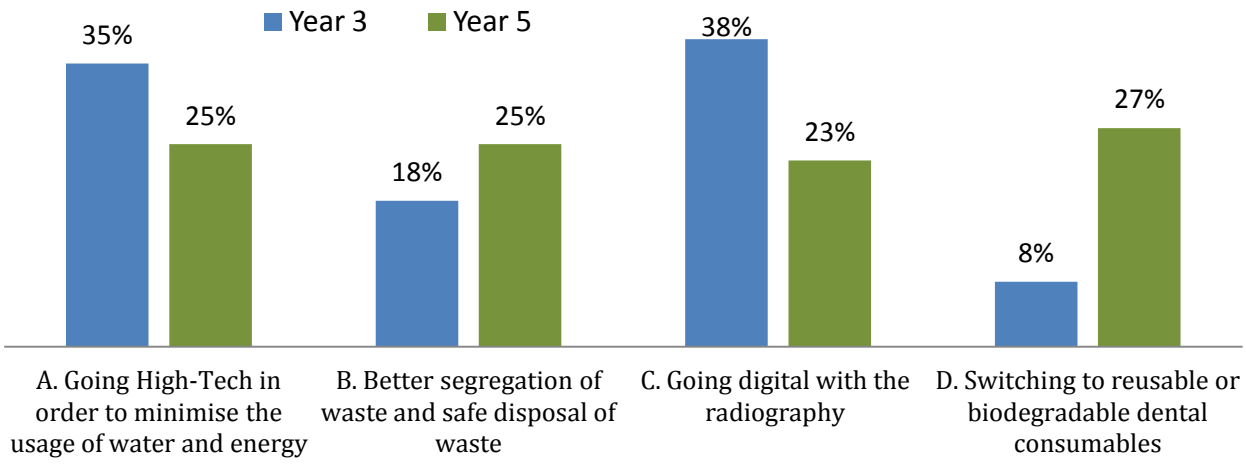

Figure 8. Responses to the question: 'Preferences for a particular sustainable solution'

4. Conclusions

The analysis of data is useful in identifying any educational needs, which can be addressed in the due course. The publication of a Sustainable Development Strategy for the NHS in January 2014 following drives all NHS providers to work towards becoming environmentally responsible with medical waste. As some students were uncertain about correct waste segregation, it would, therefore, be prudent to reinforce their knowledge and understanding about dental waste disposal, management and compliance. This was chosen as the follow-up topic for the next session in semester 2.

Environmental aspects of sustainability are familiar to dental students at the University of Manchester, however, data shows that there is still a great deal to do in an effort to foster understanding and awareness of sustainability within the Dental curriculum. For instance, to talk about the legal requirements relating to sustainability, to look into 'green' dental materials, to explore ideas that forward ethical issues and green skills at work.

In essence ESD is 'Education that equips students with the competencies and attributes that can enable them to contribute to a more sustainable future'. (Bone and Agombar 2011, 9) If Dentistry is aiming to become Green, then the next question should be: what should dental students be learning in relation to environmental and social responsibility? Below are areas where faculty members from the School of Dentistry are increasing opportunities for undergraduate students to learn about sustainability:

- Environment: the principles of prevention of dental disease - including social and environmental factors; legislation relating to sustainability of dental hospitals and dental practices; traditional vs digital X-rays; waste recycling;
- Society: providing dental services in Community clinics; manage special care patients and the elderly; promoting Volunteering Experiences in developing countries to Year 4 students;

In September 2015 all of The Manchester Dental School's first year students will take part in the Sustainability Challenge and explore issues of sustainability with students from other disciplines and Schools across the University.

It is therefore envisaged that academics and practitioners will engage in an informed discussion on how to help dental students to learn more about sustainability, so that later on in their professional career they will commit to using 'new innovations that will make the practice even more profitable and more environmentally sound' (Feuerstein 2013)

The author hopes that readers will engage further in this important topic by sending comments and examples of their own experiences in response to this article.

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Circuit-bending and sustainability transitions. Exploring ways of re-thinking and re-using technologies

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Abstract. This paper examines the relationship between circuit-bending - a form of adjustment of technological artifacts involving the modification of circuits in electronic devices - and sustainability. Sustainability is considered in terms of the wider context of socio-cultural and technological change and a necessary shift in patterns of human behavior related to harnessing creativity and innovation. It is argued that from both educational and environmental perspectives circuit-bending offers examples of re-thinking and re-using processes and products that are typical of human activity and which can be used to support a sustainability transition.
Keywords: circuit-bending, technology, creativity, innovation, sustainability

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***Perspective**: Educational vision*

***Fields**: Economy and technology*

***Issues**: Electronic wastes and pollution, Educational processes*

1. Introduction

The importance of considering sustainability transitions from multiple and interdependent perspectives - psychological, social, ecological, technological - is now recognized by an increasing body of literature as a fundamental component of the endeavor to identify necessary and possible shifts in patterns of human behavior. Current research is looking at ways in which human creativity and innovation potential can promote forms of resilience and transformability that are crucial for sustainability (Clark, 2001; Raskin et al., 2002; Walker et al., 2004; Chapin et al., 2010; Folke et al., 2010, 2011; Westley et al., 2011). In this context resilience is seen as "the capacity of a system to absorb disturbance and reorganize while undergoing change", while transformability is understood to be "the capacity to create untried beginnings from which to evolve a fundamentally new way of living when existing ecological, economic and social conditions make the current system untenable" (Westley et al., 2011: 763). This paper examines the activity of circuit-bending as one specific example of a transformative paradigm linking psychological, social and ecological aspects of the evolution of technology while combining elements of resilience and transformability.

Human creativity and innovation potential have always been inextricably linked to technological development. Technology can be seen as a composite made up of tools or appliances used to carry out actions, solve problems or provide recreational pursuits; of types and characteristics of knowledge-building processes for understanding, developing know-how and creating products; of material and immaterial cultural artifacts and corresponding value systems (Vergragt, 2006). Technologies and societies evolve together and there is a clear, albeit complex, correlation between the type and the rate of technological innovation, the scale it assumes and the impact it has on people, societies and their environments.

At the same time, human value schemes and the choices they produce play an important role in shaping technology, together with the social and economic interests that determine the inventions developed and the innovations implemented. Interpretative models such as Social Construction of Technology (SCOT) (Pinch and Bijker, 1987; Bijker 1995) and Actor Network Theory (Callon, 1986; 1987), examine aspects such as social actors and social networks and the definition of desirable visions for the future and responsibilities within innovation processes (Vergragt, 1998). According to SCOT theory, technological innovation is directed by the significance that "relevant social groups" ascribe to a particular technological artifact, giving rise to problem definitions within technological frameworks that in particular circumstances can lead to adjusted technological artifacts (Bijker, 1995).

One thing is the initial motivation for the development of a given technology, while quite another is the use to which it is put and subsequent and diverse uses that may emerge. Transformative paradigms involve innovation potential as the ideation both of new processes and types of production and new ways of re-thinking and re-using existing processes and products, thereby releasing new forms of potential previously hidden or undiscovered. Part of the relationship between invention and innovation must necessarily be finding new ways of using (technology as tools and appliances), but also of understanding and know-how (technology as knowledge-building), as well as of considering and valuing (technology as cultural artifact).

Circuit-bending is an activity which can be analyzed as a form of adjustment of technological artifacts that explores one of the possible intersections between art - principally, but not exclusively, music - and

technology, more specifically, analogical electronic engineering. The purpose is to creatively modify small devices, electronic battery-powered games or instruments, so as to obtain novel and experimental sounds and noises or invent new musical instruments. The aim is therefore not only to create new sonorities from simple electronic devices, which could be produced by elaborating on the audio signal emitted by a game keyboard, for example, or from any other kind of game that emits sounds through some analogic or digital effect (a delay, a distortion, etc.). On the contrary, the creative modification of the original sound object is an integral part of the aim. Circuit-bending means modifying an electronic circuit in order to alter its behavior. Indeed, for some, "the products created by the benders are less interesting than the process of their creation" (Fernandez & Iazzetta, 2011: 13).

2. Circuit-bending, innovation and creativity

From a technical point of view, circuit-bending is modifying the electrical circuits within electronic devices - substituting, adding, eliminating components, changing the connections within the circuit and/or connecting different circuits, adding elements which become part of the circuit - in order to obtain sounds and noises that are unusual and novel. This can be done with any of the interconnections between electrical elements and electronic components within the closed track of an electronic circuit: resistances (which slow down the flow of the electrical current), photo-resistances (which vary the strength of their resistance on the basis of the quantity of light they receive), potentiometers (variable resistances), capacitors (which accumulate and release current), integrated circuits or chips (complete integrated circuits encapsulated in a plastic casing), transistors (which control the flow of current between two poles through the current which arrives at a third pole), diodes (which permit current to pass in only one or both directions beyond a given electrical tension), leds (light-emitting diodes). Planning and assembling a functioning electronic circuit requires specific electrical and electronic knowledge together with programming and technical skills, whereas modifying an existing circuit does not necessarily presuppose any such previous experience. Indeed, circuit-bending was born as the result of an accidental discovery and its proponents have always striven to maintain this sense of spontaneity in exploring and experimenting for its own sake.

What is perhaps most interesting and innovative from the psychological, social and ecological perspectives is that "anyone can do it. You don't need to be an electronics guru or a shop genius. All you need is the ability to solder and to think outside the box" (Ghazala, 2005: 3). Moreover, since such an activity is the prerogative of anybody, every circuit-bender can proceed in potentially infinite creative ways. "Essentially, to bend a circuit you hold one end of a wire to one circuit point and the other end to another point. That's it! Place the wire upon the circuit in an arbitrary fashion, wherever you want, from here to there on the board. This replicates the pure-chance aspect that launched my first instrument as it shorted out in my desk drawer, and it is still the heart of bending. If you hear an interesting sound, you then solder the wire in place, putting a switch in the center of the wire so that the new sound can be turned on and off. That's pretty immediate!" (Ghazala, 2005: 4).

Towards the end of the 1960s Ghazala accidentally created a short circuit in a small portable amplifier, which began generating interesting noises and whistles. After a few attempts and experiments, also by adding some switches, he succeeded in controlling the short-circuit and thereby giving birth to circuit-bending, even though he did not coin the name until 1992 (Collins, 2009; Ghazala, 2004).

> *In my drawer a small battery-powered amplifier's back had fallen off, exposing the circuit. It was shorting out against something metallic, causing the circuit to act as an audio oscillator. In fact, the pitch was continuously sweeping upward to a peak, over and over again. Opening the drawer I discovered the amp, my genie lamp. I immediately thought: If this can happen by accident, what can be made to happen purposefully? If this can happen to an amp, not supposed to make sound on its own, what might happen if one were to short out circuits that already make a sound, such as keyboards and radios and toys? (Ghazala, 2004: 97).*

Although Ghazala is the inventor of circuit-bending as we know it today, many others can be seen as working within the same innovative tradition. Particularly significant examples can be identified in Michel Waisvisz, the inventor of Cracklebox, who produced "the first mass-produced electronic musical instrument that incorporated the player's skin as the primary variable component in a sound-generating circuit" (Collins, 2009: 76), Louis and Bebe Barron, who invented a highly volatile approach to electronics in which Louis provided current for circuits built by Bebe so that they produced sounds up to the moment when they caught fire, John Cage, who experimented with mechanical/acoustic-bending at the piano, David Tudor, who experimented with the use of contact microphones, Alvin Lucier and Gordon Mumma[1] .

There is certainly no single genre or style of music that can be linked with circuit-bending. A bent toy instrument can be used in a passage of drone-music[2], a sequence in a piece of pop music or as way executing Beethoven's Für Elise. At the same time, there are some characteristics typical of circuit-bending: the sounds produced by the bent instruments endeavor to be as alien as possible, in the sense that they have not been heard before and are unusual, often inevitably noisy, unstable, unpredictable. This very instability and unpredictability is what characterizes circuit-bending music. "Circuit-bending transgresses the boundaries of what is considered music because it uses unrefined, unstable, and unconventional sounds that are often irreproducible and set in compositions with little discernible structure" (Naficy, 2010: 23). Moreover, "the ethos of circuit-bending entails involvement with an object which is never fully under control […] benders also manifest a disregard for perfectability, appreciation for creative mistakes, and de-centering of intention" (Naficy, 2010: 25).

In the majority of cases, such instruments do not have a defined and stable tuning (since this has been tampered with at the level of the circuit) and so it is more difficult to play melodies that follow precise musical scales. In this respect, there are two principal expressive possibilities for circuit-bending instruments: experimental music, largely improvised and with a strong aleatory component, such as noise, drone and glitch, or repetitive music (from the point of view of melody or rhythm) that use sequences inside the bent instruments or patterns based on samples of sounds. Every bent instrument is as such unique, with its own individual characteristics, which can change in the course of time or indeed cease to exist. At the same time, some electronic devices lend themselves particularly well to modification and offer interesting examples of expressive potential, by now well documented. Examples include "Speak and Spell" from Texas

[1] Important exponents of circuit-bending today include Phil Archer, John Bowers, Nicolas Collins, Joker Nies, Knut Aufermann, Xentos "Fray" Bentos, David Novack, Vic Rawlings, Sarah Washington, Chris Weaver, Dan Wilson, Patrick McCarthy e Tommy Stephenson (Roth Mobot), Tim Kaiser, Kaseo, Steven Buck.

[2] A minimalist genre based on sustained or repeated sounds, notes or tone-clusters known as drones.

Instruments, the sampler keyboard Casio SK-1 and the mini keyboard Casio SA2.

3. Circuit-bending, resistance, resilience, transformability

Circuit-bending has become increasingly widespread principally in those countries "where surplus electronic materials are cheap and widely available in the form of trash" (Naficy, 2010: 2) and has also come to be considered part of the worldwide Do It Yourself (DIY) movement (Fernandez & Iazzetta, 2011). From this perspective, circuit-bending combines elements of rebellion, anti-consumerism, political critique and opposition, transgression, subversion and resistance. In his ethnographic study Naficy (2011) examines the way in which circuit-bending can be considered a form of resistance. Circuit-benders oppose the "built-in limitations" of commercial products, the "rapid product turn-over combined with planned obsolescence", and use their inventive capacity to "circumvent the power of the market to determine access on the basis of income, by producing their own objects" (…). In this way, circuit-bending constitutes a kind of resistance with political implications and particular significance for sustainability transitions:

> *Circuit-bending is trangressive of socio-cultural and economic norms in at least four analytically separate ways: 1) it transgresses manufacturer-designed use, function, and recommendations; 2) challenges popular conceptions of what is an instrument and who is or can be a musician; 3) introduces novel elements producing novel experiences; and 4) expands the horizons of what is considered possible on a personal and social level (Naficy, 2010: 17).*

If we consider in particular the first point, circuit-bending can be seen as a form of transgressive resistance to the corporations and manufacturers of battery-powered electronic devices for sound production. This kind of resistance brings with it an (apparent) contradiction and two benefits. It is often held that benders combat the very productive systems that manufacture the "raw material" on which their activity depends. In fact, the question posed lies at the heart of any process of improvement in that the very action of trying to improve something means that it is considered to be improvable, something less than an original idea or a project to be realized. Circuit-bending simply sets out to modify and improve something that benders believe can be criticized, something which is essential to the very existence of circuit-bending itself and, more in general, to the ingenuity that lies at the heart of human creativity and innovation. The argument is parallel to that proposed by Wittgenstein that philosophy exists only because there are philosophical problems to resolve. Otherwise we would feel no need for it (Wittgenstein, 1953). By the same token, circuit-bending exists because there are circuits to bend, accepted customs and practices to be transgressed and transformed.

The benefits of circuit-bending can be analyzed from the educational and the environmental perspectives. Even though no specific electronic knowledge is necessary, the spread of this activity almost inevitably leads to greater interest in electronic engineering and music through a desire to immerse oneself in projects that are more difficult and complex and therefore motivate learning by involving practitioners in a process of learning by doing. As Collins (2009) puts it: "In contrast to the laborious analytical work that had previously accompanied most electronic engineering, even in hobbyist and musical circles, this philosophy is tremendously liberating for the first-time hacker. But after the thrill of "how" wears off, some of us ask "why?" Accordingly, many younger artists gain access to circuitry through classic bending activities, but then

move on to diversify their electronic portfolio: interconnecting toys, combining handmade circuitry with bent toys, hacking other found technology (effect pedals, video circuits, mechanical devices), writing software, etc." (Collins, 2009: 277). In this respect, the dividing line between bending and hacking becomes extremely thin. "'Bent' means you have no idea what you are doing when you open up the circuit; 'hacked' means you have some idea" (Collins, 2009: 106). "Circuit-benders continue to parallel the hacker ethos in their appreciation for knowledge and learning through active engagement, and in their strong association of learning and improvement" (Naficy, 2010: 28).

Circuit-bending is thus a process of active learning through which experimenting promotes the desire for knowledge-building rather than a mere application of what has previously been learnt. Understanding electronics derives directly from its utility in the realization of one's own projects. "Circuit-bending is currently being taught all over the world to people of all ages. MIT has a program teaching grade school kids to bend (imagine kids learning experimental electronic instrument design at the age I was learning in school to play a plastic flute)" (Ghazala, 2005: 4). It is highly likely that children who build their own electronic instruments will be more motivated to learn music than by being required to play a plastic flute. The learning is directed towards the achievement of an objective and the motivation is thus enhanced as children open games they wish to modify, endeavor to change the values of some electronic components, build bridges within the circuits using their fingers and connecting resistances, potentiometers, etc. Initially they may not be fully aware of what they are doing, but gradually the desire to understand and improve the results of their project leads to an information gathering process, asking for advice and explanations from more expert practitioners, seek on-line experiences narrated by others who have modified the same game, eventually buy or download an electronics manual or publication on electronic music.

Very few manuals exist which are dedicated to circuit-bending. The two principal sources are Nicolas Collins, Handmade electronic music: the art of hardware hacking and Qubais Reed Ghazala, Circuit-Bending: Build Your Own Alien Instruments, but there are many on-line tutorials and videos or guides to how to modify particular electronic devices[3]. This too is a specific characteristic of circuit-bending and its approach to learning by doing and cooperating within real and virtual communities. The principal means of spreading circuit-building is through open workshops in which it is very rare to find teachers who tell students what to do, what to connect or what outcome to aim for, but rather, in a similar way to a hackerspace, novices, amateurs, engineers, technicians and musicians meet and share knowledge and experiences.

The environmental benefits concern the re-using of objects destined to become waste that is difficult to dispose of. "Circuit-benders reduce waste related to high levels of consumption and turn-over by reusing and repurposing" (Naficy, 2010: 36). Electronic toy devices are indeed part of a system of production that is unsustainable at the level of waste production. "Old" products are ever more rapidly replaced by new ones, made to be more desirable and with higher levels of performance. The fate of the old devices is generally that of being abandoned rather than recycled. Disposal of plastic and electronic parts is extremely difficult. Thus circuit-bending offers an example of a sustainability transition strategy. Products considered at a

[3] http://www.anti-theory.com/soundart/; http://getlofi.com/blog/; http://cargocollective.com/secretmedialab/SML-Hacking-Manual-v0-3; http://circuitbenders.co.uk/tips.html; http://casperelectronics.com/finished-pieces/circuit-bending-tutorial/

certain point obsolete - which had perhaps a highly dubious function even at the outset (not only for the benders) - are reused, thereby not becoming waste, through being modified and transformed into something better (at least for the benders), an example of up-cycling, the highest form of recycling, which unites reusing to refashioning. Although the actual quantities of electronic waste that can be reduced by circuit-bending as it has thus-far been practiced are inevitably limited, its potential for enhancing relationships between the psychological, social and ecological aspects of sustainability (Rossi & Dodman, 2015a, Rossi & Dodman, 2015b) are considerable when it is seen as a possible precursor of future and diverse ways of bending.

Circuit-bending can therefore be considered a form of resistance to a certain type of market, society and aesthetic. It is transgressive from various points view - economic-productive, social, artistic-cultural - and anti-political - in the sense that it is disinterested, without the commitment or sense of mission of the hackers (Naficy, 2010: 33). At the same time, it produces, almost unintentionally, educational and environmental benefits. Nevertheless, we must be aware of its limits. Technology advances, but the thought processes that are the basis of productive systems, the cultural choices concerning the use and the functions that the technological devices should have (above all, for marketing reasons) do not necessarily evolve and risk remaining within a perverse loop. Today people can enjoy the same unchanging and vacuous television programs with ever more excellent quality video and audio. Internet enables users who wish to do so to switch from pornographic films to videos of enchanting kittens infinitely more quickly than a few years ago. Listeners can access an immense variety of music of the lowest artistic quality. Obviously not everything is to be dismissed as trash, yet it becomes ever more difficult to resist or to avoid that which seems dubious, stupid or even dangerous, ever more easy to become glued to a large, high-definition screen offered through a home-theatre system than with a small cathode-ray tube television set, to remain immersed in an inane video-game, to wander almost indefinitely within immense shopping centers.

Moreover, circuit-bending provides an excellent example of the process of inhibition of resistance through technological advance. The evolution of technology - more specifically, the miniaturisation of electronic components and increasing integration of electronic functions within a single chip - circuit bending becomes more difficult and even impossible. Towards the end of the 1980s the techniques for assembling electronic components on printed circuits changed, moving from Through Hole Technology (THT) to Surface Mount Technology (SMT). With THT components are soldered to the printed circuit by passing "legs" through holes in the circuit board, whereas with SMT components are directly soldered onto the board's surface. Moreover, the components used in the SMT become increasingly miniaturized. Thus it becomes ever more difficult to find bending points and remove, add or substitute components. Miniaturisation also permits the production of chips that integrate and unite increasing numbers of functions that previously were distributed over different components, thereby reducing the possibilities of modification. Often, the miniaturized circuits are printed directly on the card and covered by a drop of epoxy resin, rendering what is inside the blob impossible to modify. As Collins writes:

> *Circuit Bending has changed since Reed Ghazala coined the term. One factor has been toy technology's shift toward greater integration of functions onto a single chip. At the end of the last century, control of a toy's various functions (making sound, blinking lights, reading switches, defining the clock speed, etc.) was typically*

> *distributed amongst several different integrated circuits and associated components, and benders delighted in messing around with the myriad connections between those components. Now integration has reached the point that everything is controlled by a single malevolent-looking black blob (Collins, 2009: 277).*

When it is no longer possible to obtain electronic toy devices from the 1980s - already, for example, it is not easy to find a "Speak and Spell" on a market stall or on eBay - circuit bending, as we know it today, will cease to exist. Not because resistance to a certain type of market, society, aesthetic, is no longer necessary. Quite simply this type of resistance will no longer be possible. Thus the environmental benefit will no longer be possible to obtain, while business will continue to produce ever more unsustainable electronic devices. Circuit-bending will therefore have to reinvent itself, find new ways of bending, or vanish. Hacking and DIY will continue to exist, but the very specific form of resistance created by circuit bending will be inhibited by technological advance.

4. Conclusions

We may draw some conclusions both from the emergence and the fate of current circuit-building, considering it as a relatively small-scale, short-term experiment in resistance, yet with important implications and highly interesting potential for analogous initiatives, an experience which exemplifies the need and the way to find new forms of resistance together with move to more radical ways of changing behaviors and harnessing creativity and invention. Circuit-bending can be seen as an expression - albeit limited - of resilience in terms of the capacity of human and technological systems to absorb disturbance and reorganize as well as transformability in terms of creating new beginnings and ways of living.

From both educational and environmental perspectives, circuit-bending provides models for re-thinking and re-using processes and products typical of human activity. The term itself, with its emphasis on the progressive form of the verb and thereby a vision of reality as dynamic and process-based (Dodman, 2014), provides a powerful metaphor for human activity seen as learning through experimenting and creating, thinking through making (Ingold, 2013) and thereby building new knowledge. If sustainability and its necessary transitions are not points of arrival, but rather ways of being, based on resilience and transformability, then newly-discovered ways of bending will always be a part of human learning processes that are capable of enhancing our awareness of the relationship between technology as the use of tools and appliances, as knowledge-building processes and as value-bearing cultural artifacts.

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The nuclear power option: exploring boundaries and limits, asking open questions

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Abstract. In this article we take up on the debate spurred by a recent paper published by Qvist & Brook on PLoS/ONE (May 2015), in which the Authors encourage 'a large expansion of global nuclear power'. We approach the topic from a variety of perspectives, drawing on a variety of sources, in order to highlight the complexity of the issue and the social, political and educational implications of presenting the nuclear option as a plain, linear, rational choice.
Adopting the paper by Qvist & brook as a 'case in contest' we develop a critique of conventional scientific research. We argue that for all scientific studies, authors should specify clearly and correctly the boundaries of the system under consideration which in turn, will determine the range of experimental data being collected. Results should be clearly separated from the conclusions which, in fact, are inevitably influenced by personal interpretations and collective imaginaries, which often remain unchecked.
Scientists and referees of scientific journals therefore have a great responsibility when dealing with complex and controversial issues, because their voices can influence both the public and policy makers alike. By virtue of the idea, still deeply rooted in the Western world, that science describes reality, scientific evidence is deemed to 'speak truth to power'(Wildavsky, 1979). Consequently, a model of governance by numbers (Ozga, 2015) seeking to be informed by the promises of scientific certainty (Nowotny, 2015) fails to recognize the areas of uncertainty, the multiple questions which yield opportunities for disclosing alternative imaginaries and visions for sustainability. Drawing on the insights offered by feminist epistemologies, and the educational tools here derived, we point to a reformulation of the role of science education in growing democratic expertise that is, the ability of the public to unmask the value and worldviews underpinning the 'products' of science by taking into account the wider, socio-cultural and socio-material discourses in which such products are embedded. We encourage the educational system to pay greater attention towards equipping young people with reflexive abilities and conceptual tools which are appropriate to cope with the global, socio-environmental conflicts of our time.
Keywords: Nuclear plants, uncertainty, imaginaries, epistemological reflection, educational tools

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***Perspective**: Educational vision **Fields**: Economy and technology*

***Issues**: Educational processes, Globalised industrialisation and global product, Bio-geological equilibrium and ecological decay*

1. 'Energy security' as a major theme of our time

In May 2015, a research paper was published in PLoS/ONE by two scientists – S. Qvist, from Sweden and B. Brook from Tasmania. The authors advanced a positive vision about the prospects of developing a worldwide use of nuclear power energy. As first stated in the abstract, they claimed that they have been able to "demonstrate" the potential for a "large-scale expansion of global nuclear power", by drawing on empirical data collected over three decades in France and Sweden.

The experimental approach, the extended time scale of the study and the neat delimitation of the focus of analysis (that is, the production of electricity) are by all means the warrants for classifying this contribution as 'scientifically correct' ... but this is true only in appearance.

Currently, the level of international interest in the production of nuclear power is quite high, even if the trend is declining. According to the World Bank (Kessides, 2010) more than 40 developing countries have recently approached United Nations officials to express their interest in starting nuclear power programs. China, Japan, the Republic of Korea, and India are forecast to display the highest growth in the Asian region. Information updated to 2015 (World Nuclear Power Reactors & Uranium Requirements, November 3rd) indicate that in this area 37 reactors are under construction, and 91 approved. However, there is a growing incertitude about the feasibility of the plants being proposed.

In this context, the relevance of the topic and – as stated by Qvist and Brook (2015) – the current outlook for the world "to meet the most stringent greenhouse - gas mitigation targets" (p 1) makes this paper a powerful flag for the proponents of the nuclear option in the upcoming Conference of Parties (COP21), to be held in Paris from 30 November to 11 December of this year.

COP21, also known as the 2015 Paris Climate Conference, for the first time in over 20 years of UN negotiations will set out to achieve a legally binding and universal agreement on climate, with the aim of keeping global warming below 2°C (UNEP, 2015).

According to Mike Fowler, of the Clean Air Task Force, in his introduction to The Nuclear Decarbonization Option (2012) "Nuclear energy provides more than 40 percent of all low-carbon electricity generated in the world today" (p. 7). Nuclear energy is also set to increase its contribution as a major low carbon energy source, with 66 civil nuclear power reactors under construction in the world (World Nuclear Association, 2015), while newly advanced reactor designs may offer substantial improvements in speed of construction, safety, waste management and control on risk proliferation (Walsh, 2013).

These data however are not confirmed by other authors: the International Energy Agency (2015) gives a 34% value for nuclear low-carbon electricity (data from 2012). As Jonathon Porritt underlines in his foreword to the World Nuclear Industry Status Report (Schneider & Froggatt, 2015), "there's been no diminution in the intensity of the debate about the role of nuclear power in tomorrow's low-carbon world. Indeed, it seems to become more intense by the day" (p 9). Well aware that people read the same data in very different ways, leading to very different conclusions, Porritt underlines the critical role played by this Report in informing both experts and lay people by means of longitudinal dataset and scrupulous attention to detail.

The question posed by Porritt at the end of the foreword clearly reveals his anti-nuclear position: "how long will it take before these seemingly inextinguishable hopes in the promise of nuclear will be finally

overwhelmed by the delivered realities of an alternative model, which gains momentum not just year on year, but month by month?"(p 11).

For us as educators this is a key question and a tall responsibility. How can we deal with the "nuclear energy issue"? What meaning do we give to the expression 'energy security'? It appears that controversy exists between a reading of nuclear power as a reliable provider of clean energy 'secured' for the future and a reading of nuclear power as a 'false' security which may not deliver to the extent which people may hope or expect.

A number of writers such as Levy-Leblond (2003) had identified some of the common patterns of change in contemporary scientific practice which are linked to wider patterns of social change in the global, neo-liberal economy. Amongst such processes we find:

a. The rise of uncertainty which is endemic to research but also to wider decisional processes; some authors (Beck, 1992) have referred to this social condition as 'risk society';

b. The growth of an economic rationality which is increasingly invoked to act as a filter for uncertainty;

c. The redefinition of the time dimension through the extensive role of expectations, forecasting tools, scenario-building and 'real-time' communication technologies which are converting the future on some sort of 'extended present' (Jasanoff, 2014).

As indicated by Nowotny (2015) the cunning of uncertainty is inextricably linked with notions of the future and vision of sustainability, yet such visions can only become intelligible to us as we become to identify the subjects, scenarios and contexts of their actions. On such basis, we approached the debate on nuclear power option by attempting to go deeper into the analysis of the paper authored by F. Qvist & B. Brook, and by deconstructing the epistemological and ontological premises of their argument to uncover the complexity of the issues involved. Following on the stimulus offered by J. Porritt, we argue that it is a responsibility for educational institutions to support greater analysis and debate in order to draw out the opportunities for alternative propositions.

2. Scientific research in the global, socio-environmental context: questions of identity and expertise

The reading of this article generated many questions for us, which we endeavored to answer through an extended documentary review, consulting websites, blogs as well as scientific articles and data sheets from a variety of sources. In the following sections, we wish to share with the readers some of the questions driving the analysis and the answers we tentatively gave. We locate our work within the wider frame of current debates in the epistemology and sociology of science discussing the role of 'evidence' as a means for governance (Ozga, 2015) and for the regulation of interactions across different social policy domains. Notably, the idea of 'science speaking truth to power' (Wildasky, 1979) is being challenged by a growing number of philosophers and sociologists of science who are stating the importance of acknowledging the changing nature of science and technology which are no longer (and they have possibly never been) simply laboratory investigations. Rather, science and technology are the stuff that makes our lives, as the Earth is being turned into a one, single global laboratory. From this perspective, science and technology are better understood as 'performative practices' (Barad, 2007) that is – as matters of intervening rather than representing (p. 54). In this view, all theorizing in science like in other fields of

knowledge cannot be separated from the entangled apparatuses of power relations, democracy, world citizenship and, as Galison (2000) continued: "what is at stake is always practical and more than practical, at once material-economic necessity and cultural imaginary" (Galison, 2000, cited in Barad, 2007 p. 55). Inquiring into the performative practices of science is at the same time a process of reflexive interrogation of one's own society and culture and a key task for education. From this perspective, we began by trying to clarify the socio-cultural background of the authors as inherent dimension of their research.

Who are the authors, and what is their expertise?

Staffan A. Qvist works at the Department of Physics and Astronomy, Applied Nuclear Physics. Amongst his most recent publications, we find contributions on nuclear power with the most recent one dealing with fuel assemblies (Qvist, 2015). Qvist also published papers with a more interdisciplinary approach, dealing with socio-scientific and environmental issues. As an example, he explored the possible environmental and health impacts which may be associated with the phasing-out of nuclear energy (Qvist & Brook, 2015). The paper written in collaboration with W. Barry Brook deals with a controversial and complex problem that concerns not only the academic community but the civil society at large: in fact – as the two Authors underline – the entire world community is a 'stakeholder' in nuclear issues.

Barry W. Brook is Professor of Environmental Sustainability, University of Tasmania. His specific field of research is Ecology. He recently collaborated on a paper looking at the interaction between the dispersal of organisms and landscape structure (Fordham et al., 2014). Similarly to Qvist, Brook cultivates also broader interests, which are developed in parallel with his specific professional competences. In 2010, he wrote together with Ian Lowe the book "WHY vs. WHY™ Nuclear Power, in which the two authors engage in an exchange head-to-head, each presenting 7 key reasons for why one should say yes/no to nuclear power" (Brook & Love, 2010).

In 2014, he co-published an interdisciplinary paper dealing with the physical and economic aspects of the nuclear power option in the journal Applied Energy (Hong et al., 2014).

So, from reading the biographies of the authors we can ascertain a level of both disciplinary and interdisciplinary expertise, demonstrated by their scientific publications. We also recognize the authors' engagement with wider issues of public understanding and communication of science by means of their writings addressed to a more general audience interested in socio-scientific and environmental debates. By means of their professional affiliation, the authors are working within two countries members of the Organization for Economic Development (OECD) which is concerned with raising standards of technological innovation "and make better use of human talent to clear the path for higher and more inclusive productivity growth" (OECD, 2015, p. 3). We will now look at the design of the study conducted by the two authors to trace the influence of the background information in shaping their views of the future and of sustainability understood as a scientific and technological option.

What are the most significant variables that the authors measure/consider?

In conducting their study, the Authors focus on a set of key variables: CO_2 emissions, Gross Domestic Product (GDP), production of electricity from nuclear plants, power generated by reactors and cost of various components (building and running costs, delivered energy costs).

The choice of variables is crucial in every scientific report: it informs readers about the field of the research, and it relates the issues addressed with the expertise of the researchers. In this particular case, the two authors are experts in basic science, Physics and Ecology. Due to the interdisciplinary nature of their investigation however, the authors also make extensive use of variables that are typical of other areas such Economics and Sociology. Interdisciplinary studies themselves require inputs from other disciplines, as well as from various categories of citizens: the lives and destinies of many and diverse people in the world are concerned with and likely to be affected by the growth of global nuclear power, both in terms of anticipated benefits and risks. Referring back to Barad's (2007) notion of science as a performative practice, which well exceeds the boundaries of the laboratory, such notion supports an approach to complex and controversial issues (such as the case of nuclear power), which seeks to involve a plurality of subjects (the 'stakeholders') in the making of decisions. The performative nature of techno-science cannot be disentangled from ethical discourses. Some scholars have also referred to this approach as the 'post-normal' science approach (e.g. Funtowicz & Ravetz, 1993). In this view, epistemological considerations cannot be disentangled from views about the world and the values we hold. In particular, it is the key, metaphysical assumption of science as representation that views the world as composed of individual entities with separately determined properties that is being questioned. In complex, socio-environmental issues such reductionist tenet leads to inevitably and inherently partial views, which are embedded in the parameters and knowledge boundaries of the 'investigators': we shall discuss such points later.

The socio-economic context as a frame for research design

Following the standard scientific practice, the authors specify the boundaries of the system they analyzed. Admittedly in this case, the spatial boundaries of the issue are global: F. Qvist and B. Brook envisage a 'worldwide' substitution of fossil fuels fired electricity to nuclear-produced electricity. The time range is also clearly defined: the empirical investigation is based on data collected in two countries (France and Sweden) from 1960 to 1990, and provides projections about the future for up to 25-34 years.

By reading the article however, other boundaries emerge, which are not as clearly spelled out: these are spatial, temporal and conceptual exclusions which necessarily affect the choice and interpretation of the data and the inferences and conclusions which are derived, as we will observe in the next sections.

The two authors take the growing demand for electricity worldwide as a starting point for their study. The supply of electricity from nuclear plants therefore, obtained with low production of CO2, would allow for "a rapid expansion of economic activity and prosperity in the poorer regions of the world" (p 2). The authors are the implicit (and possibly unaware?) spokespersons of a specific worldview, which lays trust in the benefits of unlimited economic growth. Such view, however, has been challenged by a growing number of researchers within the scientific community worldwide who ascertained since some decades that the rate of consumption of natural resources exceeds the regeneration capacity of the biosphere: the concept of ecological footprint, introduced in the early 90s (Wackernagel & Rees, 1998) explains in a simple and clear way the physical impossibility for continued and fair economic growth on a finite planet, such as the Earth.

Qvist & Brook also signal, actually, that there are "poorer regions" in the world: also this vision is now largely superseded by social and economic statistics, reporting that greater wealth and expanding areas of poverty are simultaneously present in most countries. Such inequality is a result of an increase in power supply over time that was unfairly delivered, and it is doubtful that further production of electricity may actually solve it. There are in fact real problems for the distribution of electricity from centralized and highly militarized centers, such as nuclear plants, as compared to low power sources, which are decentralized and widely distributed over the landscape. From the analysis conducted so far, it is apparent that the projections for 'an expansion of nuclear power worldwide' as it was advocated by the two authors is embedded within a particular frame which in the main equates 'development' with material production and consumption, but which appears to 'exclude' ways of living that are not aligned with the Western, urbanized model, and which appears to disregard the limits of the Biosphere.

It is notable the similarity between the narrative advocating for the expansion of nuclear power in order to achieve global benefits and the narrative that already back in the seventies supported the experiments for nuclear agriculture undertaken by the International Agency for Atomic Energy (Hamblin, 2015). As reported by Hamblin, such experiments were deliberate attempts to modify the performance of agricultural systems by nuclear-induced mutations. Yet the evidence supporting their success was contested. What this case shows however was the crucial role played by the overall narratives of development that were used as a justification for the research:

> *"through the efforts of a cadre of officials beginning in the 1960s, to elevate the status of mutation plant breeding, first supporting a small transnational community of researchers in industrialized countries, and then trying to bolster the field's legitimacy by claiming victories for atomic energy in aiding the developing world"* (Hamblin, 2015, p, 408).

We will now turn our attention to the requirements for a more holistic and critical analysis of the case for nuclear power by drawing in a more extended set of parameters and perspectives.

3. Revealing entanglements of energy, people and materials: dealing with unspoken, unrecognized boundaries

The analysis conducted so far allowed us to gradually uncover the entangled nature of scientific research as enmeshed with material, practical and cultural practices. Far from achieving a single representation of the issue, we can see that the 'results' produced by Qvist and Brook – and which are apparently presented as the 'products' of a research protocol – appear to be located on the dotted trajectory of a 'discursive' move. Discourse as understood by the social sciences equates to perspective, that is, the portion of reality which 'comes into view' for the person that is viewing or intervening. By their very nature, each discourse – such as economic growth, energy security – cast a shadow over other aspects of reality, which are masked and/or prevented from view, but which are, nonetheless, integral part of the same reality. The discourse of economic growth for example may be supported by data pointing to the reduction of CO2 emissions, as in this case. Yet, other components of the system, located at different scales, in different disciplines, are necessarily left in disguise – or cut out (Barad, 2007) depending on the knowledge, awareness, values and even intention of the investigators.

In a previous study, we described an approach for drawing upon the range of

disciplinary lenses in the natural sciences as a means for re-composing a holistic view, to highlight what is left out of the frame (Colucci-Gray et al., 2013; Colucci-Gray & Camino, 2014). Starting from the assumption that scientific language displays elements of continuity with everyday language, it is possible to deploy scientific ideas as 'metaphors' that is as linguistic devices which, by means of figures and images derived from a different domain, enable an observer to access portions of reality normally removed from direct experience (Lakoff and Johnson, 1999; Konopka, 2002). As such, metaphors retain in themselves the cultural background of the 'viewer' and express the particular biophysical, temporal and value positioning embedded in the way in which the observer puts oneself in relation with what is being viewed. In poetry, as well as in science, the linguistic dimension is the prime methodological frame through which a study is conceived and conceptualized. In this view, scientific ideas such as energy flows, matter cycles, webs and boundaries may be conceived not simply as concepts (as are commonly used in Physics, in Ecology and Biology), but may be deployed as 'conceptual tools' for analyzing and discussing a complex issue. Such of these concepts may be used as tools for a further analysis of the methodology adopted and data presented by Qvist & Brooks (2015).

Conceptual tool 1: Energy and Matter flows

"The operation of a nuclear reactor does not emit greenhouse gases or other forms of particulate air pollution" (Qvist & Brooke, 2015, p. 2). The authors take into consideration the working phase of a nuclear power. In this analysis, they are neglecting the fact that the construction of a nuclear reactor requires exceptional amounts of energy and materials (i.e. cement), whose production necessarily releases CO2 in considerable quantities. In nuclear energy systems, the major construction inputs are steel and concrete, which comprise over 95% of the material inputs. The construction of existing 1970-vintage U.S. nuclear power plants built around 1970 required 40 metric tons (MT) of steel and 90 cubic meters (m3) of concrete per average megawatt of electricity (MW ave) generating capacity (Peterson et al., 2005). The building phase is also energy-consuming because of the need to operate powerful machinery and equipment. Hence the time-frame adopted by the authors, while extended over thirty years – did not consider the different phases of construction, functioning, and seemingly, of disposal of waste and decommissioning of the power plant.

No definitive solution is yet available for the disposal of radioactive waste. Even temporary solutions such as those adopted so far require significant consumption of energy and matter and so does the dismantling of a nuclear power plant. Taking into consideration the whole supply chain of electricity production which may be obtained from nuclear plants, it is evident that the choice of nuclear power still involves production of large amounts of CO2. A reasonable approximation is 66 g CO2 /kWh (Kleiner, 2008). A comprehensive analysis on the environmental impacts associated with a variety of nuclear power technologies and systems through a meta-analytical process called "harmonization" (Warner & Heath, 2012) led to the conclusion – drawing from life cycle assessment literature - that published median, interquartile range (IQR), and range for the pool of Greenhouse Gases Emissions from the Light Water Reactor were estimated at 12, 17, and 110 grams of carbon dioxide equivalent per kilowatt-hour (g CO2-eq/kWh).

According to The National Renewable Energy Laboratory (NREL, 2015) the reported data show that nuclear power is similar to other renewables with regards to the total life cycle of Greenhouse Gases Emissions.

Conceptual tool 2: Geographical boundaries, from local to… global?

"The operation of a nuclear reactor… has been proved by historical experience to be significantly expanded and scaled up" (p.2). By citing Sailor et al. (2000), the authors draw on the geographical limitations of expanding, for example, hydrological power or chemical energy from biomass. However, by focusing on the positive experiences of the past, and looking at the problem from a European perspective, it appears that the two scholars are circumscribing their attention to France and Sweden: they neglect to mention the failure of two major nuclear power plants, Chernobyl and Fukushima as cases from which to take lessons. Similarly, there have been many instances of temporary closure of nuclear power plants due to breakdowns and malfunctions. The historical experience of the two, selected countries that are being mentioned (France and Sweden) seems to provide the basis for an expansion worldwide, thus using two significantly different geographical boundaries - namely a Eurocentric view – to evaluate the 'historical experience'. Interestingly, also when they make considerations about economics – and possibly mainly when talking in economic terms – the boundaries of the arguments become global. According to the Authors, "it is considerably easier to buy plants and nuclear fuel internationally today" (p. 5). They appreciate the chances offered by an 'open and competitive' market for the production and sale of nuclear energy. In this context, there are only few players and even less is the number of people or agencies holding nuclear technologies. The supply of technologies and fuel, then, is more akin to an almost absolute, monopolistic market. It is reported that two-thirds of the world's production of uranium from mines is from Kazakhstan, Canada and Australia. In 2014, eleven companies marketed 88% of the world's uranium mine production (WNA, 2015). Hence, the extrapolation of future projections regarding a world-wide expansion of nuclear power as pronounced in the title of the paper is phenomenally reduced to a few countries and a few players holding the strings of what is deemed to be a powerful, wealth-generating technology.

Conceptual tool 3: parts within systems. Widening the frame from economics to ecology

> *"Despite the uncertainties associated with the economics and logistics of recent nuclear expansion, the current global unit cost and construction-time of nuclear reactors are actually quite comparable to the Swedish experience" (p. 5).*

The Authors present their evaluation of the economic aspects of the nuclear option making reference to the Gross Domestic Product (GDP). This option hides a significant conceptual boundary: development is understood in the narrow sense of material accumulation which is apparently disjointed from the support ecosystems. Because of these limitations, the validity of this indicator as a proxy for desirable pathways of development has been questioned on several occasions and by many authors.

Mainstream economists assume that GDP is an expression of 'well-being' of a population or a country, but this indicator does not consider how economic outputs contribute to the quality of people's lives, and it does not measure the quality of the environment. Many scholars argue that GDP is a poor measure of social progress because it does not take into account harm to the environment. Herman Daly and John B. Cobb (1989) developed the Index of Sustainable Economic Welfare (ISEW), which they proposed as a more valid measure of socio-economic progress, by considering various other factors such as consumption of non-renewable resources and degradation of the environment. Robert Costanza et al., in the introduction to a paper of 2009, argued that *"This paper is a call for better indicators of human well-being in nations around the world.*

We critique the inappropriate use of Gross Domestic Product (GDP) as a measure of national well-being, something for which it was never designed" (p 1).

One would expect that a physicist and an expert in "Environmental sustainability" would not rely on the GDP indicator, by ignoring how this indicator was created and what are its implicit assumptions. More in line with the words of Nowotny (2015), the science community appears to be under pressure by policy-makers and funding councils to deliver benefits when in fact, complex situations are often uncertain and promises are difficult to maintain. In this case, the focus on one, single economic indicator is a short answer to the bigger question as to which research and which benefits society is really seeking. Once again, the methodological framework of the study appears to be enmeshed with values at the very point of origin, that is, the point of selection of the field under investigation.

Conceptual tool 4: Time.

How long is… long term?

Qvist & Brook (2015) claim that *"There is also a larger and more open fuel-supply market"* (p 5). In addition to overlook the condition of near monopoly of nuclear fuel, in this statement we notice once more the power of economic discourse in foregrounding economic sustainability by overshadowing long-term ecological and social impacts. Data on the availability of uranium clearly indicate that, just like fossil fuels, also this type of fuel will eventually be depleted as it is a non-renewable resource. According to Michel Dittmart (2013): *"Historic data from many countries demonstrate that on average no more than 50-70% of the uranium in a deposit could be mined. An analysis of more recent data from Canada and Australia leads to a mining model with an average deposit extraction lifetime of 10±2years. This simple model provides an accurate description of the extractable amount of uranium for the recent mining operations. Using this model for all larger existing and planned uranium mines up to 2030, a global uranium mining peak of at most 58±4ktons around the year 2015 is obtained"* (p. 792). This researcher asserts that without a plan for reducing the number of nuclear power plants in the short term, *"some countries will simply be unable to afford sufficient uranium fuel at that point, which implies involuntary and perhaps chaotic nuclear phase-outs in those countries involving brownouts, blackouts, and worse"* (p 792). So here is another 'limit' that Qvist & Brooke have not taken into consideration, despite the extensive documentation now available on the 'uranium peak' (Energy-watch-group, 2013): the time interval that they have considered is too short to give a realistic picture of the situation.

Time scales and life-cycles

Another approach to looking at the issue is to include a cyclical dimension to time which takes into account local, smaller cycles within their respective transformations. In this view, let us analyze the following statement, which draws a connection between time and money: *"Global data does not suggest that nuclear plants are necessarily significantly more expensive (as a fraction of the total economy) or time-consuming to build now than in the past, if efficiently managed*" (p.6). In the light of the specific cultural lenses which have been revealed and shown to permeate the study, it is legitimate to ask what are 'global data' which are being presented? Indeed, by drawing on the considerations conducted so far, we can see that information on costs of nuclear plants will vary greatly depending on the time boundaries that are put around the system: so for example, when considering the whole life-cycle of a nuclear power plant, the total economic costs are much higher than the sole running costs . Moreover, the growing complexity of the construction phase of nuclear power plants will impact significantly on the costs: the construction of Olkiuoko

plant in Finland, started in 2005, will end up in 2018; Flammaville nuclear plant, begun in 2007, will enter into operation in 2018.

In addition, if social and environmental costs are added, an estimate of the actual costs becomes very difficult to achieve. In the present situation of global political instability the costs allocated to security systems are definitely increasing. Moreover, high charges (which are often not recorded) are derived from socio-environmental conflicts that for decades have seen many people (in India, USA, Australia, etc.) oppose to the extraction of uranium ore from the mines in their territories. Extraction processes in fact account for serious health and environmental impacts, as evidenced in the Report published by Raeva et al. (2014).

So a more nuanced and textured picture of the problem may be gained by widening the boundaries of the analysis and including human and environmental externalities in cost assessment.

4. A hidden connection: water availability and consumption

The most common types of nuclear power plants make use of water for cooling the system in two ways: to convey heat from the reactor core to the steam turbines; and to remove and dump surplus heat from the steam circuit. Water usage depends on the thermal efficiency of the plant, and on the temperature of the water: in Southern countries larger heat exchangers and condensers are required as compared with the Northern hemisphere (e.g. Sweden).

Water consumption of a nuclear plant ranges – depending on the type – from 0, 52 to 2, 36 liters/kWh. If any thermal power plant needs to be sited inland, the availability of cooling water is a key factor in the choice of location, due to environmental concerns (i.e. local warming of aquatic ecosystems) and competition with the demands of local populations (World Nuclear Association. Cooling Power Plants, 2015). For example, In France, all but four of EdF's[1] nuclear power plants (14 reactors) are inland, and require fresh water for cooling. Eleven of the 15 plants built inland (32 reactors) have cooling towers, using evaporative cooling, while the other four (12 reactors) use rivers or lake water directly. With regulatory constraints on the temperature increase in receiving waters, this means that during very hot summers the output generation may be limited. In the U.S., plants making use of direct cooling from rivers must reduce power in hot weather.

Forecasting of building nuclear power plants in countries with tropical climates, and in continental areas prone to drought, clearly raises problems, which are not mentioned in the analysis conducted by the two authors.

5. How much energy and how high the power? For what purposes? For which users?

Energy driver of changes

Since the global diffusion of Blue Marble, the photo of our planet taken by Apollo 17 in December 1972, the boundaries of the planet have become, even perceptually, visible. However, a collective vision still dominates: it is the view of the Earth's resources as endless, with limitless possibilities for man to tap into these reserves.

An extensive scientific documentation of the biophysical limits of the Earth has been presented and updated, in recent decades, and has been widely reported by the media. The carrying capacity of the planet has been exceeded in the 80s of the last century (Wackernagel et al. 2002). In 2009, a group of 28 internationally renowned scientists identified and quantified the first set of nine planetary boundaries within which humanity can continue to develop and thrive for

[1] Electricité de France

generations to come. We have already exceeded three limitations of 'safety', and we lack suitable measures available for other two parameters (Rockström et al. 2009). Crossing these boundaries could generate abrupt or irreversible environmental changes. Respecting the boundaries reduces the risks for human society of crossing these thresholds. In 2015, an international team of 18 researchers maintained that four out of nine planetary boundaries have now been crossed as a result of human activity, (Steffen et al. 2015); moreover the scholars introduced novel entities (e.g. organic pollutants, radioactive materials, nano-materials, and micro-plastics) as plausible variables to be checked, with yet unknown tipping points.

According to these results, not only the resources are limited, but it is limited the ability of the planet to 'manage' the transformations produced by human activities: in addition to the increasing levels of CO2, well known to the public for the effects on the climate, transformations of global reservoirs of nitrogen and phosphorus are taking place, and these are modifying the overall balance of the biosphere. The main driver for such huge planetary transformations is energy, mostly from fossil fuels: energy to excavate, to transport, to transform… Thanks to high density fuels, the engines' power has increased, andtransformations of ecosystems have taken place with increasingly accelerated pace.

Yet the idea persists that we need more and more energy: Global energy consumption is expected to double or triple over the next century, as millions of people achieve more modern living standards, which requires that we produce energy in ways that are cleaner, cheaper, and less intrusive on wild places (The Breakthrough Staff, 2014).

Which type of energy, and for whom?

In addition to questioning the amount of energy that is globally needed, and the impact of using such energy, a key question to be asked is 'for the benefit of whom'? As noted by Eric Rondolat (2015) the needs of 1.1 billions of people may be very different from the needs of the rich minority of the population: "we live in a world where 1.1 billion people – more than one in seven – still do not have access to electric light. […] Light poverty and the millions of associated deaths are avoidable – the technology to balance this inequality is all around us and taken for granted across most of the world. In those countries blighted by light poverty, the difficulty lies in administering the cure, not in creating it."

Centralized, high power energy sources imply a top-down control, and an extensive and efficient distribution network. Vaclav Smil, one of the leading experts in energy studies and author of a recent book on Power Density (2015) notes that "modern civilization has evolved as a direct expression of the high power densities of fossil fuel extraction" (p. 8). He argues that "our inevitable (and desirable) move to new energy arrangements involving conversions of lower-density renewable energy sources will require our society — currently dominated by megacities and concentrated industrial production — to undergo a profound spatial restructuring of its energy system" (p. 11) .

A scenario that Qvist & Brook do not consider, therefore, is that of a redistribution of sources and delivery systems, and a redistribution of the uses of electricity amongst social groups.

6. Risks, uncertainties and stakes

As indicated earlier, one of the key features of the article presented by Qvist and Brooke (2015) is that of drawing on data from apparently carefully conducted studies to argue for the expansion of nuclear power worldwide. It is also apparent however that the authors are presenting their work within a politically charged context in which science is expected to inform the action of policy-makers and the public in general. As it was reported by Petty and Cacioppo (1986) expert thinking differs greatly from lay people's thinking with regards to the need for fact-findings and information. In such case, attitudes of lay people and more generally , non-expert – tend to be shaped by the common sense routes, that is, what people perceive to be 'safe' and 'viable'. In this context, argumentation is not so much about winning the case and holding the truth as it is about persuasion, winning minds … and the hearts of people by means of appeals to what appears to be practically sensible and relatively risk-free within a given value-framework. We can identify some of these strategies used in the paper by Qvist and Brooke (2015). As reported earlier, one of the key rhetorical strategies used is to override uncertainty: "Despite uncertainties …" (p.5). By keeping the boundaries tightly focused on single variables and by overriding the geographical, political, social and environmental nuances of the global context, risk assessment and uncertainties are underplayed by the two authors, except for a nod to the absence of problems in the two countries studied: France and Sweden. Yet it is well-known that the nuclear option for the production of electricity presents numerous types and degrees of risk, uncertainty and ignorance.

Along the production chain of nuclear energy, there are well identified environmental impacts and risks for human health in several communities living close to uranium mines (e.g. Chareydon et al., 2014).

The option proposed by Qvist & Brook, of a system of 'free market' (therefore oriented to private investors)[2] can exacerbate the security and safety problems at various points of the supply chain: for example, the social and environmental impacts of digging for uranium ore but also the risks incurred during transport to power plants; other risks include the safety of the plant (the functioning of the reactors but also the good functioning of control and alarm systems); safety of evacuation plans in case of accidents which may occur from natural causes (earthquakes, for example) or human causes.

The increased production of energy from nuclear sources assumed by the authors ("*nuclear power can be added at a rate of about 25 kWh/y/y/1k$-GDP, which, if multiplied by current global GDP […] amounts to ~1500 TWh/y/y":* p. 5) could make it increasingly problematic to identify suitable sites. In India, for example, the planned construction of a nuclear power plant in Gorakpur, a town 160 km from Delhi (with its 17 million inhabitants), would make it impossible to evacuate residents in case of emergency (Newsclick, 2013). Equally difficult would be – in densely populated areas – to deal with hazards of radioactive emissions due to breakdowns or malfunctions. Moreover, the proliferation of nuclear plants would cause a surge in the production of radioactive waste, for which no country in the world has yet found a solution for a permanent disposal.

The present global socio-political instability is accompanied by growing and increasingly stringent security measures, mainly against possible terrorist acts. Any privatization (partial or total) of the nuclear plants would leave a gap in legislation and organization, in

[2] The recent liberalization of the electricity market in many countries has made the economics of nuclear power generation less attractive, and no new nuclear power plants have been built in a liberalized electricity market (Wikipedia)

the face of harm to human health and to ecosystems' integrity.

Another aspect related to security and safety is concerned with the possible deployment of waste material containing uranium for the production of nuclear weapons. One economically profitable way for "disposing" the by-products of the enrichment of Uranium for the production of nuclear fuel has been devised by the military sector for decades: the surpluses of depleted uranium have been used to construct part of armored vehicles and bullets with high penetrating power, with devastating environmental and human consequences (Al-Muqdadi & Al-Ansari, 2013; Fettera & Von Hippelb, 1999; U.S Department of Veterans Affairs, no date).

The partnerships between nuclear, civilian and military fields are a hot topic, which would require the adoption of laws to be enforced by those in charge of nuclear plants – both public and private.

Finally, many data are available that highlight the extremely low risk of incidents of nuclear power plants, comparing them – incorrectly – with the percentages of risk events and activities in which, however, the stakes are dramatically lower. An example may help to understand, and refers to the calculation of the ecological footprint of nuclear plants: this is a parameter cited to emphasize the environmental performance of this kind of energy production. According to Martin Nicholson (2013), when compared to coal, natural gas, and renewable energy sources, nuclear is the most land efficient, energy-dense source of power, with the lowest usage of construction materials per unit of energy generated per year, and one of the least expensive in terms of levelized costs[3]. Evaluating these different aspects of the 'footprint' demonstrates that nuclear is one of our most viable solutions to readily de-carbonize the economy. However, the picture changes significantly in the event of incidents. By itself, nuclear fuel makes relatively few demands on biological productivity when contained, but intentional and accidental releases of radioactive materials can seriously compromise human and environmental health. Failures of nuclear power plants can appropriate large bio-productive areas by making them unsuitable for human use for extended periods. The meltdown of Chernobyl has completely removed a 170.000 hectares as a ''zone of alienation'' from economic turnover and restricted activities on hundreds of thousands of additional hectares since the 1986 accident and possibly for thousands of years into the future (Wackernagel & Monfreda, 2004). On the Fukushima nuclear plant crash, no data are available on the changes affecting land and sea components of the ecological footprint, but "*there is evidence of a plume of increased concentration of Cesium-134, and other radioactive elements that have been observed at unprecedented levels, spreading out some 5,000 miles into the Pacific toward North and South America"* (Neill, 2015, blog entry). The Woods Hole Oceanographic Institution reported that a sample of ocean water taken off the coast of Vancouver, British Columbia on August 2014 tested positive for cesium-134, one of the radioactive elements released as a result of the Fukushima disaster (Ecowatch, 2014).

Products emitted during Fukushima plant crash are adding 'novelties' (Steffen et al., 2015) to the global cocktail of organic, chemical and radio-debris that are loading the Earth reservoirs, with unknown and unpredictable effects on human and ecosystem life.

Qvist & Brook, neglecting the elements of risk, uncertainty, indeterminacy and ignorance that are present in the nuclear power option, are fully immersed into the epistemology of

[3] Levelized costs: a measure of a power source which attempts to compare different methods of electricity generation on a comparable basis (from Wikipedia)

representation which is anchored to an imaginary of control (Benessia & Funtowicz, 2015). The consequences that lie outside quantitative and statistical models are therefore, unpredictable and unforeseen; they are defined as unintended consequences, and conceived of as anomalies. However recent crises, ranging from the 2010 Deepwater Horizon accident in the Gulf of Mexico to the Fukushima nuclear disaster in 2011 and more recently, the case of the French Nuclear giant Areva having been accused of bribery in Namibia (Finnan, 2015), illustrate the vulnerability to corruption of complex technological systems and the hubris of quantitative-based expert studies which ignored what they chose to ignore.

7. Responsibilities in publishing, disclosing and communicating research

The reading of this pro-nuclear article prompts several reflections about the responsibilities of publishing and dispersing "demonstrations" such as those presented by Quist and Brook: *"Here we demonstrate the potential for a large-scale expansion of global nuclear power to replace fossil-fuel electricity production, based on empirical data from the Swedish and French light water reactor programs of the 1960s to 1990s"* (p 1).

The first level of responsibility obviously rests with the authors themselves: in this case they not only provide data, but devote a substantial part of their text (explicitly extrapolating regional data) to provide suggestions for extension of the nuclear power option on a global scale, by drawing an implicit parallel between countries that have the most diverse, geographical, political, economic and social situations.

Moreover it is not clear – in their paper – where the line is placed between data and opinions. On the first page of the article the authors have declared that no competing interests exist, even though the professional commitment of Qvist suggests at least his 'passion' for nuclear installations; the pro-nuclear commitment of Brook clearly emerges from reading the presentation he offers about himself in his blog (Brave New Climate, 2015).

Referees too have a responsibility. PLoS/ONE uses anonymous peer review to determine whether a paper is technically sound and worthy of inclusion in the published scientific record. The opinion of reviewers is supplemented by that of the Academic Editor who takes into account the reviewers' comments, the PLoS /ONE Criteria for Publication and the editor's own assessment of the manuscript. In this process, an ongoing interrogation of the contribution that the paper will make to the academic community and the likelihood that the paper will be cited are key aspects of the decision-making process. Positive answers to such questions would reveal if the paper is likely to find consensus and if the level of the paper meets the expectations for quality set by the journal and the peer academic reviewers. In the case of this paper, we note from the front page of the publication that the article was submitted by the two authors on August 25th, 2014, accepted on February 26, 2015 and published on May 13, 2015. At no point in the process it is indicated when or whether the paper had been revised and resubmitted in revised form.

The third subject bearing responsibility is the mainstream academic community, which mainly values a disciplinary approach to problems, and the submission of quantitative data and statistical analysis of high technical standards, rather than questioning the context of research and the social and environmental implications of the conclusions.

Finally, a further responsibility is to be charged on science communicators, who draw the information from articles, published in scientific journals, select what they regard

as most important and then 'translate' it to the public emphasizing the aspects they find most interesting and exciting. At the same time the quality of the source is acknowledged: it is the scientific information, which is taken to be objective and neutral, according to the mainstream imaginary.

Thanks to the proliferation of channels to reach the public (websites, blog, tweets as well as journals offering accelerated and open access routes to publication) these 'translations' are sent round to a much wider and varied audience as compared to a few years ago: communicators – thanks to a clever choice of language in their piece – can easily convey improper, partial or biased information.

Given the importance of the issue, the article written by Quist and Brook had an immediate echo in the popular press: the linearity of the approach and the ease of the conclusions offer a very effective tool for the proponents of nuclear energy as a means of choice for the production of electricity. Authors claim that: *"our modelling estimates that the global share of fossil-fuel derived electricity could be replaced within 25–34 years. This would allow the world to meet the most stringent greenhouse-gas mitigation targets."*(p 1).

Soon the article is quoted in the Blog "Real Clear Science" (02 Jun 2015) by Danny Clemens, who claims: "*World can Rid Itself of Fossil Fuel Dependence in as Little as 10 Years*". The paper by Quist and Brook is then quoted by David Biello on Scientific American (September 2015): "*The World Really Could Go Nuclear. Nothing but fear and capital stand in the way of a nuclear-powered future*".

Finally, citizens and readers also have a responsibility. At this level however the problem extends upstream to the political responsibilities involving the educational system. This aspect is critical and it has been considered in detail elsewhere (e.g. Ravetz, 1997).

8. Towards participated research and shared 'expertise'

The paper by Qvist and Brooke concerns an issue – energy production and the implications on climate change – which owns relevance and scope far beyond the 'technical' data reported by the authors. It is a complex and controversial issue, where facts, interests and values are intertwined and interdependent.

Since the early 90s of last century two scholars, Silvio Funtowicz and Jerry Ravetz, attempted to systematize the features of such problems from the epistemological point of view, andsuggested some suitable methods for addressing them. Their perspective strongly questioned the consolidated view of science as neutral and objective research on the material world, offering undisputed provision of reliable knowledge. Such knowledge, compounded into disciplines and expressed quantitatively has been invoked as a source of legitimate and rational input for informing action and governance. According to the two scholars however, a more inclusive methodology for managing complex, science-related issues is "Post-Normal Science (PNS)", which rests on a three-fold distinction amongst different types of problem-solving practices, based on the severity of either of the two attributes, systems uncertainties and decision stakes:

> *"The modern programme of scientists teaching truth to power, deducing correct policies from incontrovertible facts, is, in the environmental field, in tatters"* (Ravetz, 2003, p 64).

PNS focuses on aspects of problem solving that tend to be neglected in traditional accounts of scientific practice: uncertainty and value loading. When either system uncertainties or decision stakes are severe, we are in the domain of PNS; in such circumstances the quality-assurance of the whole process requires an 'extended peer

community' including all the relevant sorts of concerned lay persons. (Funtowicz & Ravetz 1993, Funtowicz & Strand, 2011).

When problems are complex and controversial, Funtowicz and Ravetz suggest to extend the circle of persons able to contribute positively to solve similar problems, beyond those traditionally 'authorized', i.e. scientists. For these new problems – they claim – the maintenance of quality depends on open dialogue amongst all those affected. This they call is an 'extended peer community', consisting not merely of persons with some form or other of institutional accreditation, but rather of all those with a desire to participate in the resolution of the issue. Under these new conditions, the appropriate style will no longer be rigid demonstration, but inclusive dialogue.

It took 25 years before the ideas of Funtowicz and Ravetz, which have more recently developed and enriched by many other scholars, could take hold in the scientific community. Even if the PNS approach is still being resisted by the academic world, there are an increasing number of publications which build on the 'post-normal' approach (as shown by the site of NUSAP net) and seek to address scientific and socio-environmental problems by a multiplicity of viewpoints, and involving a variety of stakeholders.

9. Energy and equity

"*Inputs from all involved*": if the kind of problems we face globally requires the contribution of all involved, it is necessary that the subjects whom so far have been expropriated and excluded from view, are identified and listened to. 'Expropriation' is the term that Jerry Ravetz uses to illustrate a condition shared by poorer sectors of what some have called the 'majority world', but it is also a condition shared by Nature at large (Ravetz, 2006). The poor are often indigenous communities and rural people, who are expropriated, dispossessed from their villages and lands when 'progress' needs to build a dam or a nuclear power plant, to dig a mine, to start a new industry taking over their landscape. And what does it means that Nature is expropriated? The pressure that human economy exerts on the environment is regulated by the levels and patterns of material and energy flows between the sphere of economics and the biosphere. Such energy flows essentially consist in the transfer of power from Nature to Man, leaving nature degraded and depleted in the process. The corporate-driven consumer classes, in the North as well as in the South, have the power to bring the bulk of the world's natural resources to their service.

EJOLT, a global research project bringing science and society together to catalogue and analyze the ecological distribution conflicts and to confront environmental injustice, has produced and continuously updated the Atlas of Environmental Justice, an online platform that allows browsing by commodity, company, and type of conflict. Taking a look to the Atlas one may have an idea of the extent, number and variety of conflicts that are going on between powerful and powerless in the context of socio-environmental issues.

Sustainability of the ecosystems requires reducing the overall level of resource flows, in particular the primary flow of materials and energy on the input side (Sachs, 1993, 1999). At the level of ethics, this approach involves the realization that fundamental human rights must take precedence over all other activities, including the realization of one's own, non-fundamental rights. Applied to ecological subsistence rights, this means that the right to living must take precedence over the non-fundamental resource needs of other agents. Subsistence needs to come before luxury needs (Sachs, 2003). Boosting economic growth is less important than securing livelihoods for the impoverished (Sachs, 2002).

So, the expropriation of Nature can be reversed by reducing the material and energy flows that mainly transform the natural into the artificial, leaving ecosystems degraded, squandered and polluted. Drawing inspiration from our biosphere, high power energy plants should be reduced, and energy sources decentralized. The expropriation of the poor can be reversed by recognizing and protecting their rights to live in healthy and thriving ecological and social systems.

10. Conclusions

Within the framework of post-normal science, science is far from being the simple domain of experts. Rather, scientific research and communication interfaces with the broader political, social and cultural sphere. In this view, even for 'non-expert' citizens it is possible to develop some competencies for a critical and reflective reading of scientific articles by acknowledging what is brought into focus in light or what is being hidden, underplayed and left in the shadows. The conceptual tools we have adopted in the analysis of the paper by Qvist and Brooke may offer some guidance when questioning boundaries of space, time, language and disciplinary focus. For example, one can check whether there is evidence of interdisciplinary approaches and integrations across various perspectives. A powerful tool is that of inquiring into the input and output flows of energy, materials and information underpinning the events and processes under consideration: in fact, despite the prospects of 'decoupling' the natural world from the artificial one (Blomqvist et al., 2015) within the Earth System, every component is inevitably interdependent and interconnected with others.

Moreover, being aware that "*for a given value-based position in an environmental controversy, it is often possible to compile a supporting set of scientifically legitimated facts*" (Sarewitz, 2004, p. 389), it is worth searching for the worldviews and related discursive narratives that are being expressed (often implicitly) by scholars in writing their papers.

We suggest moving the analysis and consideration of research papers upstream, to the level of the aims, values and selection of significant variables in the research process.

UPSTREAM research questions may be formulated according to the underlying worldview and they can be unmasked with some key, reflective questions:

- What kind of relationship is assumed to exist between humans and nature?

- Which are or what should be the most meaningful variables to be investigated?

- Who is entitled to participate in the research?

Such analysis can thus be used to make considerations DOWNSTREAM, involving questions about different concepts of risk, uncertainty and ignorance and which provide different answers to the question "what if?":

- How will natural systems react?

- How shall we cope with unforeseen outcomes?

- Who will benefit and who will suffer from any possible harm or damage?

Answering these questions may help to read the article by Quist & Brook (and many more...) in a new light.

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Sustainable education for children who are ill: Promoting wellbeing in hospital learning environments

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Abstract. In this paper we look at the provision of schooling in hospital for children who are ill and consider it as an example of sustainable education. Since illness is a potential cause of exclusion, we start from the perspective of promoting learning in hospital as a form of inclusive educational policy. We than consider wellbeing as an integral part of a human sustainability paradigm and examine both the characteristics of the hospital as a learning environment and psychological and social factors involved in fostering the resilience and the transformability necessary for a healing process in which learning can play a vital role.

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***Perspective**: Educational vision*

***Fields**: Social processes and structures*

***Issues**: Educational processes*

1. Introduction

Devising and implementing educational policy is one fundamental way in which a society invests in its own future. Current educational paradigms generally assert that policy should promote educational systems that enable all of a society's members to develop their learning potential to the maximum possible extent, to be able to build personal life projects and to make a full contribution to society itself. Through education a society shapes the future of both its individual members and its collective self. Education must therefore be sustainable in order for society to be sustainable. As Sterling puts it, sustainable education is "an educational culture […] which develops and embodies the theory and practice of sustainability in a way which is critically aware. It is therefore a transformative paradigm which values, sustains and realizes human potential in relation to the need to attain and sustain social, economic and ecological wellbeing, recognizing that they must be part of the same dynamic" (Sterling, 2001:22).

In recent decades educational paradigms have also increasingly emphasized the need for policies designed to promote integration for those who risk segregation, inclusion for those who risk exclusion. Integration and inclusion are not just questions of equity and justice for individuals but also of the integrity, wellbeing, vitality and therefore sustainability of society itself. Illness is one of a number of potential causes of segregation and exclusion. Yet all children have a right to education regardless of their health. In this paper we look at one particular feature of educational policy and practice - the provision of schooling in hospital for children who are ill - that is designed to guarantee that right.

Concern about the effects of hospitalization and studies of ill children in hospital and their needs begin with the work of Robertson (1958) and Platt (1959). Subsequently organizations such as the *European Association of Children's Hospitals* (EACH) and the *Hospital Organization of Pedagogues in Europe* (HOPE) have stated that "children shall have full opportunity for play, recreation and education suited to their age and condition and shall be in an environment designed, furnished, staffed and equipped to meet their needs" (EACH, 1988) At the same time there has been a gradual recognition of how this provision for education must also be considered an integral part of caring for children, curing illness and bolstering the healing process itself (Filipazzi, 2004).

We consider wellbeing as a key aspect of such provision and relate it to two terms that are recurrent in sustainability literature: resilience and transformability (Clark, 2001; Raskin et al., 2002; Walker et al., 2004; Chapin et al., 2010; Folke et al., 2010, 2011; Westley et al., 2011). If resilience is seen as the capacity to reorganize and maintain integrity in the face of perturbations while undergoing change and transformability as the capacity to develop new ways of being in order to make change sustainable, then the challenge of building learning environments in hospitals able to promote wellbeing, resilience and transformability is a clear example of an important goal of sustainable education. Resilience is reacting to illness, living with it and treating it, managing to sustain the effort and maintaining occasions for learning even in adverse conditions. Transformability is getting better, helping to get better, improving efforts and abilities to do so, learning in and through situations of adversity.

Many documents have long underlined how the complex question of the health of a person cannot be addressed from a uniquely biological point of view but is rather to be seen an integration of numerous physiological, psychological and social factors (WHO, 1946). A parallel, more recent, development concerns the emergence of the

idea of "human functioning" based on the idea of the wholeness of the person (WHO-ICF, 2001) and consequent approaches to creating environments that facilitate that functioning, thereby promoting wellbeing. If a sustainable educational process requires schooling in hospital, what factors are particularly important in creating the wellbeing necessary to render schooling in hospital sustainable? In the first part of our paper we examine the features of the hospital as a sustainable learning environment and in the second part we consider some particularly significant psychological and social factors.

We base our analysis and conclusions primarily on participant observation, an approach designed to grasp the essence of the daily existence of the people who live in an environment, their perceptions and their relationships (Bogdewic, 1992, Kawulich, 2005). As Douglas affirms: 'When one's concern is the experience of people, the way that they think, feel and act, the most truthful, reliable, complete and simple way of getting that information is to share their experience' (1976: p.112). The observation was conducted in children's hospitals or pediatric units in hospitals in the area of Trento and Bozen in Italy, near Zagreb in Croatia and in Akron, Ohio, USA. The overall period of observation was from the summer of 2013 to the autumn of 2014 and comprised periods of observation that varied in length from hospital to hospital, ranging from intensive observations of specific children for a few days or weeks (with both mild and serious illnesses and short-term and long-term hospital stays) to longer and more extensive observations focusing on various aspects of the functioning of the hospital environment and the interaction between children, parents, teachers, other educational and social services figures and hospital staff over a period of months. The age range of the children was from 3 to 15 years old. The more intensive observation involved in particular 8 children, their parents and 6 teachers.

Our objective is in no way to make general comparisons of an evaluative nature between different environments, but rather to gather qualitative data that can inform such a study and reflection on problematic aspects. Alongside the field notes taken during observation while participating in the learning activities conducted together with teachers and children, other instruments used for data gathering included a questionnaire for the medical and nursing staff and interviews conducted with teachers, parents and children (alone in their own child patient rooms). In this paper we have used the data to obtain general perspectives and not elaborate a formal triangulation of points of view. In particular our concern was to involve the children directly in expressing on their own subjective feelings and experiences and not base our considerations only on our observation or adult input. The right and the need of children to express themselves and their views is clearly stated in the UN's Convention on the Rights of the Child (1989). Educational research has at times been accused of being more concerned with validity and reliability of data rather than with children themselves (Greene, 2007, 2008) and of not adequately taking account of children as active agents within their environments (Hood, Kelley, & Mayall, 1996). In the following discussion of our findings we have thus incorporated some examples of what children told us, as well as examples of what teachers and parents said.

2. A sustainable hospital learning environment

In attempting to offer some answers to our initial question about factors that create wellbeing, we modify one key word in Kurt Lewin's (1936) assertion that human behavior can be analyzed as a function of the relationship between a person and his/her environment and propose the following equation: Wellbeing = f (Person, Environment). Maintaining schooling while in hospital is of vital importance in terms both

of ensuring that educational opportunities are not lost and of promoting wellbeing as an essential component of the healing process. If wellbeing is a function of the relationship between people and their environments, then a hospital environment is clearly particularly problematic from this point of view, since the very fact of being there is a traumatic experience both because of the reasons why the child is there and the characteristics of the place itself. Being in hospital produces a profound trauma for children primarily because they can experience great difficulty in understanding and elaborating the reasons for being placed in such an environment. As one teacher put it: "The most important thing is to listen to the children and try to help them understand with simple words". These psychological and emotional difficulties combine with others concerning the sphere of interpersonal relationships (the child is still basically dependent on the family from which s/he is "taken away") and the cognitive dimension (a child in hospital may lack many of the normal surroundings and stimuli present in daily family and school life. A number of children expressed their discomfort in terms such as, "I miss my bedroom and my toys", "I haven't got my toys and I can't run in the garden", "At home I always played at being an explorer and I've explored everywhere, but here no". This determines the need to create special conditions that promote wellbeing for the child. As one child put it: "Thank goodness there's school here. I always ask my teacher to give me different things to do and she does it because she knows I like exploring".

The peculiarity of school in hospital is determined by two main characteristics: the children suffer from different types of illness and attend this school for a period of time that is both very variable and unpredictable. As a result, the teacher in particular must endeavor to create a learning environment as much as possible capable of responding to the particular needs of each child. Such an environment can be considered in terms of four variables present in any environment of whatever kind - space, time, people and activities - each of which provided the basic focus for our participant observation and other forms of data gathering.

Space is a variable that exerts a considerable influence on a child's life and learning experience. The way space is structured reflects the pedagogical idea underlying a learning environment and particularly significant is the way a teacher organizes space in terms of furniture, materials and instruments, flexibility and functionality, accessibility and usability, in order to render each of these components of the environment welcoming, accessible and usable by all of the children present. In hospital, provision for rooms dedicated to educational and recreational activities is of great importance. "Where possible, the hospital learning environment must have a clear spatial collocation that is different from the child's hospital room. In this way, the child can recognize it as having the characteristics of a school, a place that is welcoming and reassuring in which habitual activities take place" (Benini, 2004, p.74). However, some teachers report that this is not always respected. One teacher said that "the space allocated to the school is sometimes too small and not sufficiently respected by hospital staff" and others echoed her words.

Time is also an important variable for the child's wellbeing and learning in terms of the relationship between linearity and cyclicality, duration, rhythm and flexibility. In particular the cyclical unfolding permits the prediction of events and the perception of reassuring points of reference. A learning environment in hospital therefore requires a daily routine that takes account of the necessary timetable of hospital staff, the planning and conducting of learning activities and, above all, the life rhythms of a child who is at one and the same time in hospital and at school.

The people present in the hospital as a learning environment are clearly a variable of vital importance in terms of relationships and communication, roles and actions. They constitute a group that is highly heterogeneous in terms of roles and functions, formed by individuals with competences that are as diversified as they are interdependent in terms of working together toward a common goal - that of providing a complete care for the child. Particularly important is their awareness of the importance of working as a team in order to realize the synergies necessary for creating wellbeing both for the child who is ill and for themselves as professionals working in highly stressful conditions. The activities planned and conducted are clearly an equally significant variable, in terms of the areas of the hospital in which they take place, the people who participate, the rules or conventions that govern them, what types of activities are proposed, how they are structured and what kinds of experiences they permit children to have, how they contribute to the building and the putting into practice of an educational approach, a learning curriculum and particular methodological choices by teachers. Each one of these aspects involves providing learning experiences with particular attention to psychological (in particular, affective) and social (in particular, interpersonal relationships) factors.

3. Psychological and social factors

There is a clear relationship between various forms of wellness: welcoming, wellbeing, getting well, and also doing well in terms of roles that are played and achieving well in terms of outcomes produced. As a fundamental point of departure, the provision of schooling in hospital highlights the importance of creating a welcoming learning environment in terms of sustaining children in respect of their affective needs. The affective dimension is an indispensable component of all learning (Corao & Meazzini, 1978) and the relationship between affectivity, welcoming and wellbeing is central to every aspect of the learning environment and the activities and experiences that are a vital part of it.

In any educational context, for a child a welcoming learning environment is much more than being given a place at school, being shown how everything is organized and being helped in getting to know the other children. Nor is welcoming only a question of the first few days or the beginning of the morning at school. Welcoming is a key concept in early years education (Staccioli, 2009), a complex methodology of working, a way of being and acting, the ability of the adult to create opportunities whereby children can build a sense of personal identity, become the protagonist of their own learning, feel they are valued, given support and comfortable in the school surroundings. Welcoming means encouraging the gradual development of positive states of being and promoting personal and social competences. Whereas at school the activities are often principally designed to create a sense of membership of and participation in a group, in hospital the need is to counterbalance the destabilizing effects of that environment (Loiodice, 2002) and render it welcoming. Much depends on being able to create positive interpersonal relationships. For the teacher, the difference between teaching in hospital and “normal” school-based situations consists of having to face “often in massive doses, situations characterized by extreme discomfort” and having to draw on “existing knowledge and a capacity for personal introspection, in order to build relationships, all within an environment that is often disorienting and destabilizing” (Benini, 2004, p.75). The question of relationships is thus of paramount importance. As Sterling affirms: “An ecological view implies putting relationship back into education and learning” (2008, p.66, emphasis in original).

In a large body of multidisciplinary literature, ranging from relationship science to systems thinking, relationship is seen as a primary vector for evolutionary and ontogenetic human development and emphasis is placed on the influence of interpersonal relationships on individual human development (Berscheid, 1999, Reis et. al. 2000, Andersen & Chen, 2002). The individual exists by being in relationship (Galimberti, 1991) and "interpersonal relationships are the foundation and theme of human life" (Reis et. al. 2000, p.884). Within a hospital the challenge is that of how to promote healthy relationships between all the actors in the face of illness and stress, maintaining a dynamic equilibrium between providing for and satisfying diverse needs and promoting wellbeing and learning (both personal and professional) for all the actors involved. In formal educational agencies such as schools the principal actors can be identified as the child as learner, the teacher or educator, the family and the peer group. Within the pediatric unit of a hospital these actors become the ill child, the medical and nursing team, the teachers and the family.

The ill child has to face a situation that has various complex aspects: the illness itself, the distance from home and personal possessions, the need to adapt to a new environment, undergo often painful treatment and maintain a relationship with parents who are very likely to be stressed and anxious. Habitual interpersonal relationships undergo a sudden change and the trust hitherto placed in particular people as stable points of reference can vacillate (Mangini & Rocca, 1996). Being admitted to hospital is almost inevitably a sudden and traumatic event in which relationships change, parents are no longer in charge of or able to take control of any situation, and moreover various forms of autonomy, often only recently acquired, are severely reduced. In such a critical situation it is necessary to rebuild a network of relationships within a structure whereby the child interacts with medical staff, parents and teachers within the overall context of a hospital in order to render the stay in hospital sustainable for all involved.

In this context, the wellbeing of the child will depend on the ability of the hospital staff - the new and strange adults with whom the child must enter into relationship, each one with a specific role and particular competences within a multidisciplinary team - to adopt a global approach in order to take care of as well as cure. Relationships between all the actors as well as between the actors and the patient are of paramount importance for the wellbeing of the child. Each actor must possess competences within the spheres of interpersonal dynamics and affective needs that are related to the concept of the composite professionalism necessary in order to both care and cure, so as to avoid concentrating on solely sectorial or specialist interventions and maintain a focus on the wholeness and the bio-psycho-physical unity of the child. Communicative competences, based on the ability to use a plurality of different types of language in order to mix body, visual, sound and human language (Dodman, 2014a) in an appropriate way, are also essential both for the creation of good working relationships within the team and for interacting with the child. The entire care and cure project must be seen as a network operation based on the principle of social solidarity and mutual sustaining recognized and considered by every member as vital for achieving a common goal.

In this respect, our participant observation focused on the relationships between highly trained and specialized professionals and ill children and their parents. The underlying question posed is that of how ways of behaving towards and relating with the child in hospital can influence positively or negatively the patient's wellbeing. For example, "a doctor should make the effort to shed the austere presence that is often imposed by the professional role s/he plays

and enter into the world of the patient, a world full of fears, ugly monsters and pain" (Dato, 2002, p. 39). What emerges is how the various actors (teachers, parents, nurses and doctors) work together to satisfy in the best possible way the varying needs of each child, giving however priority to the aspects concerned with medical care. In this respect, not all are fully convinced of the need for schooling in hospital: In the words of one parent: "Personally what interests me is that my son gets better. […] The teacher is very kind and willing […] but I don't think the children should overdo it and get tired doing all the activities she proposes. After all, they are ill and they need rest!". At the same time there is a clear recognition on the part of teachers of how caring for and curing the child requires dealing with both physical and psychological needs since together they constitute interdependent aspects of hospital treatment, in particular because the latter will already have been inevitably damaged by illness and by being taken to hospital. As one teacher put it: "Here with children who are ill and frightened the most important thing is to create a positive relationship based on trust". And in the words of another teacher: "There can never be too many smiles in hospital".

The child needs to be surrounded by people who encourage positive attitudes and promote positive experiences. In the words of the title of the project of one of the hospitals: "Like this, I'll get better more quickly!". Above all, the emotions of the child play a determining role as factors that can facilitate or impede reaching a state of wellbeing. The observation conducted shows how the burden of responsibility for helping the child to understand and cope with his/her emotional states often rests on the shoulders of the teacher. As one child put it: "This morning I had a pain here, here and here. And feeling sick gave me a tummy ache too. Then I went to my teacher and she made me laugh. I didn't feel sick any more but I still had a tummy ache because I laughed so much!".

The various actors necessarily tend to perceive the child in particular ways. For the doctor the child is the child-patient, for the parent, the ill son/daughter, for the teacher, the learner-patient. The challenge for all is that of how to integrate these perspectives in a holistic view and approach. The resilience of children, parents, medical staff and teachers are interdependent. For example, even children can show understanding of parents' excessive preoccupation and how the teacher can counteract this. As one child put it: "My teacher sent my mum to have a cup of coffee so we could get on with working together!". At the same time, new forms of relationship between children and parents can emerge. In the words of one child: "Here I can play with my mum too. At home she never plays with me and she goes away as soon as we arrive at the village school".

While suffering and stress clearly afflict primarily the children in hospital, the adult professionals who care for them may also suffer considerably and have great difficulty in maintaining resilience and transformability while facing situations that are constantly problematic and stressful, dealing with and treating risks of burnout.

Burnout is a syndrome of emotional exhaustion, depersonalization, and reduced personal accomplishment that can occur among individuals who do 'people - work' of some kind. It is a response to the chronic emotional strain of dealing extensively with other human beings, particularly when they are troubled or having problems. (Maslach, 2003, p. 2).

The emotional burden and the stress factor that a teacher must be able to manage when working in a hospital can sometimes become excessive and potentially uncontrollable. In many hospitals the figure of the psychologist has a vital role to play in situations where their support is necessary to help medical personnel, parents and teachers cope with the pain and the chronic emotional strain of

the complex relationships in which they are frequently directly involved or to which they are constantly exposed. The burnout syndrome can be a particular risk for hospital teachers for two main reasons: their close involvement in terms of the suffering and loneliness that often characterizes this profession together with a lack of recognition and support both from medical staff and other school-based colleagues (Kanizsa & Luciano, 2006). The teacher in the hospital, in fact, because of the peculiarities that characterize such a work environment, is sometimes considered as a teacher apart and different from those who work in a "normal" school and can suffer considerably from a sense of isolation.

Maintaining contact between the hospital-based school and the school usually attended by children who are ill is important for teachers in both institutions, as it is for children in hospital and their classmates. A child writing to his friends describes the experience of a visit to his hospital by Spiderman and the games played together and then finishes: "I want to come back to school to be with you all". At the same time, as one teacher affirms: "It's very important also to work with the classmates and help their teacher explain their friend's illness to them […] helping children to come to terms with illness itself […] as well as delivering letters and gifts to keep them in touch".

4. Learning in hospital

The attempt to provide significant learning experiences in such a difficult environment is clearly a challenge for the teacher working in hospital.

For the teacher, taking account of the length of the stay, the type and load of the treatment needed, the multiple and diverse interventions on the part of the hospital staff, the variable levels of presence of the parents, all requires a considerable flexibility in daily organizing time, space and activities in terms of the differing needs of the children s/he works with. The task is very difficult, but it represents an intriguing challenge for the teacher who is thus forced to go beyond safe and unchanging methodological choices and assume a position of constant research for new strategies and ways of working (Kanizsa & Luciano, 2006, p. 47).

If the basic goal of schooling has always been that of promoting an optimal relationship between teaching and learning processes and the outcomes of these processes have always been and will necessarily continue to be redefined, such redefinition is particularly complex within a hospital learning environment. Within infants and primary education, recent decades have seen increasing emphasis on building constructive relationships and promoting cooperative learning practices via authentic and challenging learning activities in which children are led to experiment and reflect on their experience and through which values such as inclusivity and mutual respect are cultivated, in which they discover and build ways of knowing, doing and being, activities which foster proximal development, based on the importance of diversity and equity, where perceptions and cognitions meet and are compared.

Building such characteristics in a hospital learning environment is particularly difficult because the participants in the teaching learning process are subject to constant change, both in terms of number and age, and each one has particular medical needs that are subject to change during the period spent in hospital (Perricone, Polizzi, & Morales, 2005). The teacher is the same person but the members of "the class" vary from day to day. At the same time, emotional aspects such as fear of the unknown on the part of children who undergo experiences that are invasive, often physically, and at times painful and repetitive, can be very difficult to confront. One particular aspect of the role of the teacher is to create a protective and intimate

space based on mutual respect and trust and on familiar activities such as play and story reading in which the child can feel reassured (Michelon, 2007). As one child put it: "I prefer the room where we go to school because the teacher shuts the door and keeps other people out. In my bedroom there are always people coming and going!" In this way the teacher offers both occasions for learning and for expressing and overcoming personal dis-ease. As another child expressed her feelings, "My teacher is really good and is always there when I want her". In the words of a mother: "What the teacher does is help my son to let off steam and not think about his illness".

The school in hospital becomes a kind of workplace constantly reconstructed and where learning can take place through various forms of free expression in activities that are capable of temporarily transporting the child out of the hospital, a place almost inevitably felt to be restriction or even a kind of prison. In the words of one child: "My teacher has always got lots of things for us to do". The principle of learning by doing becomes particularly significant (Edwards, Gandini, & Forman, 1995), through which the child builds relationships with the teacher as an adult and with other children with whom he is also able to share his experiences as a patient. Story reading, conversation, play and creative workshops (Kanizsa & Luciano, 2006) are thus a significant part of all learning experiences. Group work is necessarily organized with the children present in any given moment and inevitably involves children of different ages working together. This kind of work creates conditions whereby older children can help those that are younger, sharing information and building knowledge together, negotiating levels of investigation and areas of interest, careful attention to individual dispositions and abilities in assigning tasks, collaborating and cooperating, with particular benefits for the development of personal and social competences.

Particularly beneficial are workshops based on pictorial or manufacturing activities in which children can participate in diverse and individual ways on the basis of their different ages and types of illness. Such activities can channel energies in positive directions and be therapeutic in that they offer varying forms of safety valves for externalizing dis-ease at a physical level (offloading negative energy caused by being ill and confined in hospital) and at an expressive level (through the activity of creating something, the child can free himself of or share with others experiences, pain and needs of various kinds). Within the learning experiences what children seek is often not so much the learning activity typical of school but rather the opportunity to interact and converse with other children and with adults. As time passes the teacher is increasingly able to calibrate the learning activities proposed and also, in the case of a long-term stay, work together with the child's normal school on planning schemes of work. Above all, creative activities help overcome the sensation and the fear of being un-able, frail and alone, in the hands of others and subject to their will.

5. Conclusions

Sterling proposes four descriptors for sustainable education, considered as "educational policy and practice which is sustaining, tenable, healthy and durable". It is sustaining in that "it helps sustain people, communities and ecosystems", tenable in that "it is ethically defensible, working with integrity, justice, respect and inclusiveness", healthy in that "it is itself a viable system, embodying and nurturing healthy relationships and emergence at different system levels", durable in that "it works well enough in practice to be able to keep doing it" (2008, p.65).

Schooling in hospital can be seen as a highly specific, interesting and pertinent example of each of these descriptors in terms of the characteristics of sustainable learning

environments. Space, time, people and activities are all important and interdependent variables in creating an environment that is sustaining for all the people who interact in the hospital as a community and a socio-ecosystem, above all the children who are there because of illness. A child forced to leave familiar home surroundings and spend time in hospital needs to find within the new environment the presence of a daily routine, relationships and activities that provide fundamental affective, symbolic and concrete values. Although it takes place in unknown, anonymous and ascetic surroundings, schooling in hospital must aim to keep alive and active the child's sense of personal identity in that every new patient comes not just with an illness but also a particular way of being in the world, a part which is healthy and will create resilience and be determining in the process of getting well again.

Illness can have significant and debilitating consequences both in the short and long term. Making schooling in hospital tenable is of vital importance in terms both of ensuring that educational opportunities are not lost and of promoting wellbeing as an essential component of the process of healing. There is inevitably a high level of variability between levels of seriousness of illness and kinds of cure or even chances of recovery and lengths of time spent in hospital, yet provision for all is a clear example of an ethical imperative based on integrity, justice, respect and inclusiveness. Although involving children who are ill, schooling in hospital must also be healthy, inasmuch the environment is in itself a factor in healing and within this context the teacher has the vital role of providing the professional competences necessary both to sustain the children's sense of personal identity and counter the risk of regression in terms of their development and learning processes.

Providing personalized, enjoyable and motivating learning opportunities as an integral part of children and young people's stay in hospital promotes both solidarity and empowerment. It is particularly important to consider not just the part of the child that is ill but also that which is healthy and needs to be supported and nourished since it will vital for healing the ill part. Rendering it durable is a question of providing adequate in-service training for specialists who work there, maintaining an environment capable of facilitating their work as a team and fostering collective and individual resilience so as to keep up levels of engagement and effort and withstand shocks and stresses during transformative healing processes.

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Interconnections between environment, violence and nonviolence

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Abstract. This paper presents an hypertext, accessible on the web, with a research on the environmental impact of military activities and wars, and with some suggestions for interdisciplinary activities in educational contexts, drawn from the nonviolent culture and perspective.
Keywords. War; violence; nonviolence; environment

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***Perspective**: Educational vision*

***Fields**: Earth life support systems*

***Issues**: Social processes in the globalized world*

1. Research on conflict and peace

Johan Galtung is one of the fathers of Peace research (or Peace studies). In 1959 he founded the International Peace Research Institute (PRIO); in 1993 he was a founding member of TRANSCEND International, the global nonprofit network for Peace, Development and the Environment. Since 2000, he is Rector of TRANSCEND Peace University, the world's first online Peace Studies University.

Galtung is not only a theoretical scholar, but he has been involved many times in processes of nonviolent conflict transformation. His work offers also many 'case-studies' to help understanding the deep interconnections between means and ends in the search for peace.

In a book published in 1996, "Peace by peaceful means", Galtung provides a broad overview of the ideas, theories and assumptions underpinning peace studies, and he offers a theory of Peace, Conflict, Development and Civilization. According to Galtung, a basic formula for promoting and achieving peace implies empathetic attitudes, nonviolent behavior and creativity in order to overcome contradictions between values and goals at the heart of conflict (Galtung et al., 2000).

Most of the books written by Galtung offer useful diagrams and schemes that may help readers to organize their ideas on the vast and still so little investigated issue of the relationship between violence and nonviolence.

The following table was created by putting together key ideas from the readings of Galtung, and it provides a summary of the different forms of violence he identified.

		Needs				
		Survival (Denial leads to death)	Well-being (Denial leads to poverty and illness)	Identity (Denial is alienation)	Freedom (Denial is repression)	Ecological balance
Micro and meso level	Direct violence	Murder	Mutilation, siege, sanctions, poverty	De-socialization, Re-socialization, second class citizens	Repression, imprisonment, expulsion	Destruction, plunder
Macro and mega level	Direct violence	Extermination, holocaust, genocide	Silent holocaust	Spiritual death	Gulag	Ecocide
Micro and meso level	Structural violence	Intensive exploitation (A)	Weak exploitation (B)	Penetration, segmentation	Marginalization, fragmentation	Pollution, unequal use of resources
Macro and mega level	Structural violence	Blocks and sanctions		Desocialization of own culture, resocialization in another's	Imprisonment / deportation	Climatic change, oceans acidification
Micro and meso level	Cultural violence	Devaluation	Marginalization	Denying the chance of Non Violent conflict transformation	Denying the right of each person to develop and express his/her talents	Denying the relationship of dependence of mankind from nature
Macro and mega level	Cultural violence		Denying the right to non hazardous jobs	Racism	Denying the right to commons (air, water, land…)	Denying the biophysical limits of our planet

2. Environmental violence

More recently, in 2013, Rob Nixon published a book titled "Slow Violence and the Environmentalism of the Poor". Even more recent is the book by Bruce E. Johansen, "Eco-Hustle! Global Warming, Greenwashing, and Sustainability" (2015).

These two authors focus on aspects and expressions of violence occurring within environmental contexts: the denial of environmental justice, and the environmental un-sustainability of corporate enterprises. Their insights can be located in the last set of rows and columns to the right in the above table.

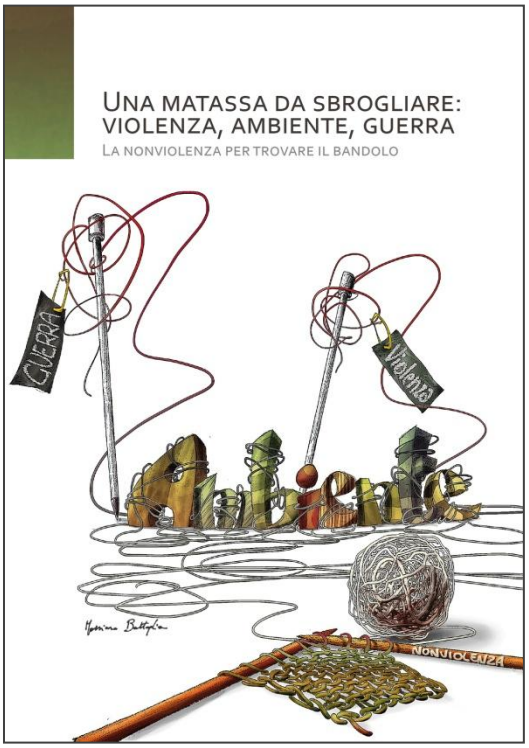
Slow violence… Eco-hustle… Unusual terms, which help us to reflect on the hidden forms of violence, which do not occur in an explosive way, such as murders or bombing raids, but they affect human communities and natural systems that host them in an equally destructive way, spreading over and expanding on often unexpected temporal and spatial scales.

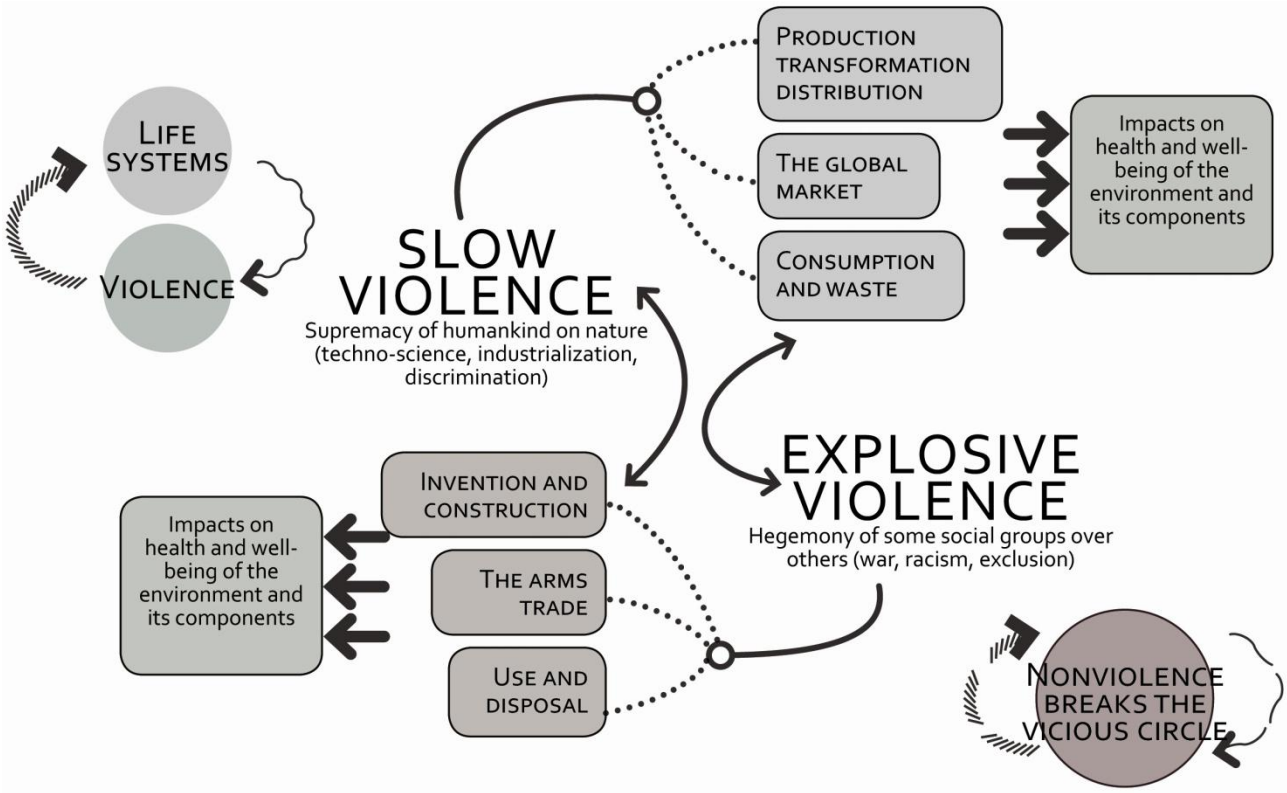
Thanks to Galtung and many other scholars who were inspired by him - Peace Studies have spread and have become specific lines of research at international level in many universities. However, a well-defined field of study addressing in a systematic way the violence towards natural systems and the impacts on the lives of the communities (human and non-human) that depend on those systems is still lacking. This field of study may engage researchers trained in different disciplines to come together: from experts in natural sciences to jurists, from epidemiologists to economists and artists.

In turn, teachers and educators should take responsibility for the development of students' awareness of the interdependence of all life on Earth and of the biophysical limits of our planet. Moreover they could help young people to develop the skills and competences to recognize the different forms of violence (often indirect and hidden), and to act in order to build peace: positive peace explores the tension towards a more equitable society, and nonviolent peace is aimed at overcoming – by peaceful means - violence against people and against nature.

3. Suggestions for educational pathways

In Italian schools and universities (with few exceptions) the story of nonviolence and peace building are not present as subjects of study and research. Many teachers - while themselves pleading for a more 'peaceful' society – struggle with the design and implementation of activities in classroom settings (or in university courses) that include environmental conflicts and approaches to peace. With a view to support them with some hints, we have developed a book which is published as hypertext and it is accessible from the web, that offer the nonviolent perspective as an alternative to the dominant view (Camino et.al. 2015).





The conceptual map shown here illustrates some of the main issues addressed.

In the first part, the hypertext presents an introduction to the concepts and studies of peace and nonviolence, followed by the results of a research on 'Environment and war'. Next, some constructive perspectives are proposed about inventing and building peace. The book includes an extensive bibliography and links to useful websites (more than 450 voices).

In the second part of the hypertext, we present some proposals for interdisciplinary pathways, along with methodological suggestions, conceptual maps and pictures. Some of titles include: "The ecological footprint of war", "Chemical weapons", "Climate changes"; "Socio-environmental conflicts in India"; "The century of uranium".

The first version of the hypertext was completed in June 2015. Given the extreme relevance and topical interest of the issues dealt with, we are planning to publish regular updates. Moreover, in the hope of involving many educators, and create a small community of teachers and researchers engaged in these issues, we aim to host comments, summaries of experiences, suggestions that arise from those who have tried to test some of the proposed paths.

One of the best ways to arrive [to peace] is through dialogue, or rather, not just one dialogue, but thousands, at every level of society, repeated over and over again, coming up with as many ideas, and actions, for peace as possible. What is then needed is to act, and to keep acting, building, working, to empower

ourselves, our communities, and the world, for the promotion of peace by peaceful means, refusing to surrender to the logic of violence, to accept violence, or to practice violence against others. A struggle in which peace is both the goal and the way (Galtung et al, 2000).

Inventing peace is a method, a technique to redefine the way we see others and ourselves. Inventing peace means inventing the ethical ways to imagine the world differently (Wenders & Zournazi, 2013).

Readings

Camino E., Larecchiuta L. & Battaglia M. Una matassa da sbrogliare: VIOLENZA, AMBIENTE, GUERRA. La nonviolenza per trovare il bandolo. Hypertext (www.assefatorino.org).

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