Looking Back and Moving Sideways

ORIGINAL PAPER DOI: 10.13135/2384-8677/1869

Looking Back and Moving Sideways: Following the Gandhian Approach as the Underlying Thread for a Sustainable Science and Education.

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Abstract.

In his 'Constructive Program', Gandhi proposed a re-thinking of social and economic structures, including educational processes, to achieve 'Sarvodaya, or 'benefit for all'. The pillars of Gandhi's vision were self-sufficiency, nonviolence and unity in a community which is first, and foremost a community of all living forms. In this contribution, we draw upon our encounters with some of the people who embraced and enacted Gandhi's ideals in rural communities in Southern India, to engage in a process of epistemological inquiry and reflection on the nature of knowledge and implications for pedagogical practice in science education. The key dimensions of community learning, multiplicity of perspectives and creativity in practical work set the basis for a science education which sustains the social, emotional, and spiritual as well as cognitive development of all students. Examples of activities with students at different levels of education are described as part of an ongoing, dialogical inquiry - guided by Gandhi's insights – aimed at developing reflexivity about one' s position in the global, ecological web. Reflection (or looking back) was taken as a central tenet of a process of research seeking to dialogue with other cultures and traditions to disclose opportunities for stepping sideways, diverting from established assumptions, and including science education within a sustainability view.

Keywords. Nonviolence; Gandhi; science education; techno-science; participatory processes.

ISSN 2384-8677 **DOI:** http://dx.doi.org/10.13135/2384-8677/1869

Article history: Submitted 13 November, 2016. Accepted 20 November, 2016

Published online: November, 22, 2016

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

Competing Interests: The authors have declared that no competing interests exist.

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***Perspective**: Theoretical and educational visions*

***Fields**: Social processes and structures, Human Sciences*

***Issues:** Environmental education, social and environmental justice*

Introduction

The fundamental concept of Sarvodaya described in 1942 by M.K. Gandhi in Hind Swaraj was the benefit of all, achievable through the autonomy of development for every Indian village: *"independent of its neighbours for its own vital wants and yet interdependent for many others in which dependence is necessary*" (Kumar, 2002, p. 109). Each village should be self-reliant, making provision for all necessities of life - food, clothing, clean water, sanitation, housing, education and so on, including all socially useful amenities required by a community. At the time of Gandhi's writing, when the Indian sub-continent was still under the British rule, words such as autonomy - *swaraj* - and *swadeshi*- independence would naturally resonate with nationalist aspirations. However, fundamental to Gandhi's idea of 'autonomy' or swaraj, was the desire to achieve self-reliance, for an autonomous being is self-sufficient, integrated with others but can provide for itself. As Johan Galtung recalled in a recent essay, then, as they are now, these were revolutionary ideas which effectively pointed to 'two civilizations', branching out from the core of the same land (Galtung, 2016). When India was setting off on the road of modernity, with its booming cities, militarization and unlimited trade, Gandhi's approach was focussed on needs, pointing to spiritual rather than material growth, with the provision of practical and lived-in examples (Harris, 1987). The two principles of swaraj and swadeshi were integral aspects of the practice of nonviolence, or *ahimsa;* non-duality, mind and spirit, human and non-humans, diversity and interdependency.

Amid the turmoil of 21st century, the expanding net of poverty, social deprivation, and environmental conflicts, affecting people and communities struggling to meet their basic needs every day around the globe, we wish to turn to Hind Swaraj with renewed attention. The process of globalization of goods which held the promise of raising standards of living and material satisfaction for everyone, has brought forward its inherent contradictions; the production of wealth at global scale can only be achieved for some, at the expenses of others. Connected to this, the concentration of scientific, economic, and political power in the hands of a few people is now constituted as the single, biggest threat to plurality and diversity in human communities (Martinez-Alier, 2002). In this scenario, Gandhi's thought has resonated at times explicitly, and other times implicitly, with debates on the contested relationships between science, technology, and social values (Ninan, 2009; Shah, 2012). Similarly, in the realm of our practice, Gandhi's ideas guided us through a process of re-examination of the nature of knowledge and more specifically, the role of science education in shaping models of development and views of the future. As we will explore further in this article, models of expertise were questioned and revisited in the light of ideas of community and participation. Recognition of our total dependence on the natural systems underpinned a process of mutual and personal inquiry with students, exploring a relational way of knowing.

A Dialogical and Reflective Inquiry

In this contribution, we wish to illustrate and re-tell some of our experiences of engaging with Gandhian thought in our educational practice. We will embark on this enterprise in the manner of what characterizes an *essai* (in the sense of the original French), as somebody who *tries* and an *attempt*. It is a choice of medium that as described by Pirrie (2015) develops dialogically, as a form of reflective conversation between writers and readers. It is a way of writing which we feel is akin to the way we gradually entered in contact and 'in dialogue' with Gandhi's ideas, by meeting and working directly with people who are providing "lived-in" examples of his practice. These encounters exposed us to a way of thinking and being in the world that was very different from our own. In our

practice, this was translated into the sustained effort of listening and entering into dialogue with our students, to involve them, literally, as the English word suggests, to *turn in*, become one with and part of the learning process. We were guided by Gandhi's ideas of Swaraj, as the development of the sense of self, in its multiple dimensions, which can only take place as part of active participation within a community (Sterling, 2009; Camino, 2011).

With this notion in mind, in this article we invite the reader also to be part of the unfolding dialogues, and to become witness to - rather than scrutiniser of - the works of a community of people searching together, in the manner of a collective inquiry. Initially and for several years afterwards, we worked together in Italy. More recently, we have come together to share feedbacks from parallel experiences that each one of us conducted in a different geographical context, respectively in Italy and Scotland. This long-term conversation between us supported our practice with the students and it enabled us to go deeper into the reforming educational value of the works of Gandhi and his followers. In this process, we also discovered affiliations with other authors and thinkers who, at different points in history and from different disciplines, have questioned the nature of knowledge and associated models of development. These ideas align with the advancement of a systemic perspective of the world (Volk, 1998), which is accompanied by a profound awareness of human knowledge and human existence as totally embedded activities, inextricably dependent upon natural systems.

In what follows, we narrate the progressive interlinking of epistemological reflections and educational practice which has characterized our activity in science education.

Witnessing Gandhi's Ideas of Knowledge, Technology and Education in Practice

Our encounter with Gandhi's ideas can be traced back to our involvement in activities of international cooperation with the Association for Sarva Serva Farms (ASSEFA) and the Land for Tillers' Freedom (LAFTI), which we had the opportunity to get to know and to appreciate for many years. Both organisations find their roots in the Bhoodan movement, established by Vinoba Bhave, in 1951, with the aim of securing an equitable distribution of the land as a basis for both social and economic development in rural areas (Bhave, 1955). Amongst Gandhi's followers, the writings of the economist J.C. Kumarappa were influential in raising awareness of the problematic linkages between human wellbeing and the large-scale, industrial development of the fifties. Driven by his vision of establishing a nonviolent basis for social organisation, Kumarappa recognised the early signs of the social and ecological disruption promoted by the capitalist system of production and consumption. At the time of the 'great technological acceleration' at the start of the twentieth century, Kumarappa perceived the inevitable consequences of spurring competitive production, which created false needs and demands: "*extension of markets in their turn call for the Army, Navy and the Air Force to control them in the interests of particular nations*" (Kumarappa, 1947, cited in Govindu and Malghan, 2005). Thus, for Kumarappa, wars were not simply a means to an end but a structural component of the global economic process, rooted within the disequilibria engendered by industrial, large-scale production (Kumarappa, 1938).

Many years have passed since Kumarappa first wrote about the critical interrelationships between science, technology, and economic power. Yet it is possible to find resonance between his earlier critiques and current debates on science and technology, and their role in promoting sustainability and development for all. At the start of the nineties, complex and controversial socio-environmental issues, such as the construction of nuclear power

plants, the problems of waste disposal, the risks and unknowns of genetic modifications called for greater debate on the very idea of development in western societies. The prospect of an increasingly technological future was confronted with mounting social inequalities and environmental instabilities; a situation calling for more awareness of the limits of the Biosphere and humanity's dependence on the natural systems.

In that same period, it was the year 2000, we were made aware of a controversy which involved local populations in Tamil Nadu and the owners of industrial prawn farms. The controversy was rooted in an intervention supported by the International Monetary Fund, the World Bank and the Food and Agricultural Organisation, which, upon advice of their scientific experts, sought to introduce a new farming activity that would revolutionise food production in Southern India. Tiger prawns reared intensively in aquaculture ponds were set to bring international trade and global economic growth. At the time, the issue became known to us through the actions of a Gandhian activist and member of LAFTI, Sri Jeganatthan, who brought the case of the social inequities and the environmental pollution caused by prawn farming to a hearing before the Indian Supreme Court in 1998. Jeganatthan involved people from the rural villages in nonviolent marches and rallies to expose the social injustices arising from the indiscriminate use of natural resources. The issue reached international attention and its analysis became a case study in context which helped us to reflect on a set of interrelated dynamics which appeared to be common to many cases of eco-injustices around the world (e.g. Martinez-Alier, 2002). The controversy involving indigenous people and the Government supporting oil extraction in Canada; local communities protecting their land from devastation caused by the mining company Vedanta in India, to name only two of many, are living examples of the struggles of people living in close contact with natural systems and who are seeing their ways of living eroded by the energy-hungry, ever-expanding forces of the global economy. Such instances brought us to reflect more critically on deeply seated conceptions of science as a way of knowing. Several questions guided our inquiry over the course of the years:

- How can we develop a way of knowing and acting in the world which enhances the sustainability of different ways of being and inhabiting the world?
- How can we develop educational contexts which enable the connection of knowledge to contexts and to the lives of people, in a process of creative and critical inquiry?

Such questions led us to explore the writings of Gandhi in dialogue with other authors who supported our reflection on the nature of science and technology, the role of the 'experts', the linkages between cognition and nature. Central to this inquiry was the dimension of power, cross-cutting human relationships with other living and non-living entities. We will explore this dimension first from an epistemological point of view. Then in the second part of the article we will introduce our methodological approach exploring the role of education in promoting more equitable and nonviolent ways of being.

Understanding Science and Technology from a Reflective Perspective - Epistemological and Ethical Aspects

Several commentators have referred to the nineties as a watershed moment in the philosophy of science (Turnpenny et al., 2010) with many writers devoting attention to the changing relationships between science and society. Funtowicz and Ravetz (1993) and Ravetz (1999, 2006a, 2006b) attracted our attention as careful observers and critics of the academic view of science as a 'truthful' description of the world. In their conceptualisation of *post-normal* science, Funtowicz and Ravetz (1993) drew attention

to the dimensions of complexity, uncertainty and unpredictability which characterise human actions in the environment. Socio-environmental problems akin to 'wicked problems' do not allow for simple solutions. Rather, they call for dialogue, between a multiplicity of legitimate perspectives.

The pluralist epistemology which accompanies the insights of post-normal science resonated with the contributions of other theorists from a range of diverse fields, from science studies, to anthropology, law, psychology, and neurosciences, all seeking to understand the changing conceptions of science and technology in face of ecological and social change. Post-normal science posed a challenge to the idea of 'science speaking truth to power' (Collingridge and Reeve, 1986; Gluckman, 2014), opening important and more general considerations about the nature of knowledge and how it can be more commensurate with the complexity of the world but also with the experiences and the needs of people (Saltelli and Funtowicz, 2014). To this regard, interesting contributions were also drawn from the fields of philosophy of technology and anthropology studies. Ihde (2009) pointed to the significant epistemological shift involved in recognising that science as we experience it in everyday life is effectively 'techno-science'. Differently from the idea of science as abstract knowledge, techno-science stems from the combination of scientific research and material networks, enabling real-time transformations of natural resources and services (i.e. Lenk, 2007). Like all technologies, techno-science operates as an extension of the body in the environment and in so doing, it operates as a medium through which human beings *relate with* and experience the world: "*concepts are created and manipulated in culturally organised practices of moving and experiencing the body*" (Hutchins, 2014, p. 429).

Differently from basic technological tools however, techno-science involves a large network of stakeholders and sets of super-systems operating at a large scale; its activity relies on conspicuous political and financial support (Lenk, 2007). In this sense, power becomes a significant dimension of techno-science. The power to move large fluxes of materials, energy and money, for example as it is the case for the construction of a transnational oil pipeline (Camino, 2016) or a nuclear power plant (Colucci and Camino, 2016); the power to affect communities and systems which are very distant both in space and in time. Techno-scientific operations are extensive and penetrate the deepest infrastructure of the biological and material world. Risks and uncertainties are part of the fabric of techno-science and while these dimensions are quasi-celebrated as 'pioneering', 'venture' and 'frontier' operations (Shah, 2012), some important ethical issues arise. A significant gap exists between the few who manipulate and to some extent, benefit from techno-scientific tools, and the many who bear the costs.

As reported by Galtung (1998; 2002) a contemporary Gandhian philosopher, energy-hungry techno-scientific activities bring forth models of economic, scientific, and social development based on power hierarchies and verticality, which separate people from communities, and human communities from nature. From a vertical point of view, nature, matter, and other people (!) will appear as inert, passive substances to be moulded by the superior human, scientific intellect. Conversely, as Galtung (2002) argued, a nonviolent approach would pursue horizontal, equitable relations based on empathy, affiliation with one another and dialogue. The way of nonviolence brings forth a corresponding ontological shift, whereby nature is re-framed as a space for co-existence and co-construction. Most importantly, the relational nature of nonviolence is founded upon the idea of continuity between oneself and the environment, a horizontal connection, as indicated by Galtung (2002).

Ethical and ecological behaviour will thus arise from direct and tangible experiences of nature, as it is "*natural affordances that will afford particular behaviours*" (Blok, 2015, p. 929). With the word 'affordances' from the Latin verb *ab-fero* - to bring something over towards oneself – the environment can take an active connotation. Affordances are not submissive and disposable in the eye of an onlooker. Rather they appear in their being at the point of encounter, when a stone can be a step to lift oneself upward, and a cover for a rabbit's hole. In this sense, affordances have the power to affect and being affected, in a web of interrelations, which are psychological, emotional, and bio-physical. Looking ahead, and filling the gap that exists between personal actions and ecological outcomes is by no means an exercise of predictive power but occurs through the development of an ethical position, the ability to feel and see oneself in somebody else's shoes, as *ahimsa,* "*Nonviolence, which is the quality of the heart, cannot come by an appeal to the brain"* (M.K. Gandhi, in Merton, 1964, p. 39).

So, key features of a way of knowing which recognises nonviolence and sustainability as central, epistemological tenets include: the interplay between mind and body, language and context, emotions and cognition, dialogue among people, and awareness of the interposition of exo-somatic tools.

Science, Technology, and Gandhi's Constructive Programme

Returning to Gandhi, we can see how the recognition of a mutual relationships between humans and nature aligns with the relevance of 'Swa' - or sense of itself – advanced by Gandhi in the Constructive programme (Gandhi, 1910; 1941). The autonomy of the self as in swadeshi, is expressed through the ability to act; however, action or agency are not simply psychological features or inner qualities of the organism, they arise in-relationship. Autonomy comes with responsibility, the ability to account for one's own actions within a community.

Moreover, Gandhi extended the idea of knowledge by emphasizing the value of 'working with the hands' as a form of education that was at the same time both for fulfilling human needs and for acquiring knowledge. Gandhi's early writings on the mechanization of society were anticipatory of the social and humanistic implications of contemporary philosophical critiques of techno-science, pointing to the impact that modern industry was having on humans' abilities to *understand* themselves and their own actions. By its very nature and definition, the industrial society aimed to significantly separate human beings from direct and purposeful engagement with resources and materials, reducing such engagement to the operation of machines housed in factories. Such separation becomes even greater today as the manipulation of technological/digital devices is directly connected to the global flows of extraction and consumption of resources, along vertical trajectories of political and financial power.

So, for young people today, who are increasingly urbanised and technologically connected through exo-somatic links with the world, promoting awareness of the increasing dependence of our knowledge on technological filters is of vital importance. In line with the suggestions provided by post-normal science, dialogue between a multiplicity of perspectives may be essentially encouraged to generate awareness of how different technologies shape the way in which we perceive and talk about problems and their solutions, and moreover, to acknowledge issues of power. In a similar way, in education, we were made aware of the necessity to introduce students to a much more dynamic view of scientific knowledge: no longer a series of well-organized, disciplinary-bounded truths about the world, but a dynamic and socially contingent interpretation of human relationships with the natural systems, encompassing controversial and conflicting positions.

Pedagogical Interlude: The Crucial Interactions Between Science, Values and Learning

Revisiting, and deconstructing the consolidated idea of science as an objective and neutral body of facts stimulated further reflection on the connections between science and values and particularly on the responsibilities of both scientists and teachers towards civil society. Science teachers play a crucial role in supporting the process of maturation of their students, who are already active players in their community. What 'narratives' of science education should be proposed when confronted with a scenario in which mainstream ideas of science are increasingly aligned and connected with images of technological progress and economic growth?

Nonviolence was offered to us as a reflective frame for our practice, highlighting the nature of the relationships between humans and other living and non-living things, with a view to transforming mainstream, often violent, paradigms of separation and control (which permeate and feature various fields of human activity) into a respectful and inclusive worldview, aimed at achieving Sarvodaya, or benefit for all.

In this respect, a nonviolent approach is rooted within the awareness of violence as a cultural dimension embedded in our infrastructures and institutions, from the design of our cities to the layout of our living and educational spaces. The ways in which our body moves and perceives give rise to linguistic and mental frames, which, in turn, influence how we think about others and the world. To this regard, the collaboration with a linguist, Martin Dodman (2014a, 2014b), was central to developing educational approaches recognising the centrality of language in building and shaping the ideas we hold but also as a means for developing reflexivity[1]. This recognition prompted us to explore the value of language not simply as a tool for externalising one's knowledge or ideas but most importantly, as a tool for occasioning reflection and developing new constructs. Awareness of language provides insights into the varied and transitory nature of ideas and views within each society (Camino and Dodman, 2009; Colucci-Gray et al. 2013). In science in particular, it helps to take cognisance of science and scientists as deeply embedded within the complex, evolving, and limited contextual reality on which we completely depend (Bateson 1980). It is through linguistic exchanges that young people become active participants in the process of learning However such process must not be simply focussed on the transfer of information - learning 'what' - but include all opportunities to explore issues and questions, looking at the "how" and "why" of current affairs, requiring everybody to take a stance and participate in making decisions (Colucci-Gray and Camino, 2014).

Thus, taking a global view of our experiences with students in educational contexts, we have become increasingly more aware of the opportunity to draw stronger links between our professional practice as educators and the practices of our colleagues in India - leaders of the Gandhian movements in various communities. They do not operate as chiefs or heads but more as facilitators and 'animators' in the way they would bring people together to engender personal reflection on their conditions and to sustain collective and constructive actions. Similarly, in the realm of our educational contexts, our effort was not so much that of imparting knowledge but to involve people in the complexity of their experiences, perceptions and sensibilities. Our choice of pedagogy was designed to stimulate the learning process, by

[1] We recognise here some similarities and alignment with Lev Vygotsky's ideas of language as a tool for sense-making and the notion of knowledge construction as a culturally mediated and situated process. Within the limitations of this article, we do not wish to further elaborate on this but we retain the core idea of learning as being both an individual and collective process. Thus language becomes a powerful tool for reflecting on the critical interface between individual expression and cultural discourses.

putting students in the role of active participants and sustaining ongoing reflection on our respective roles as people with different experiences involved in a communal search. Involving people in their biological, cultural and spiritual complexity, we sought to engender reflexivity and dialogue, with the power to influence existing modes of being and thinking in the educational system.

In line with the philosophical premises of our educational approach, also our mode of approaching research needed to be responsive to the overall aim of Swaraj. Our activities were informed by interdisciplinary literature but they were not designed to measure impact or assess an effect that was set a priori. Rather, the activities were conceived of as stimuli to create involvement and generate feedbacks for further reflection, encouraging participants - ourselves included – to explore problematic aspects and new questions arising from the discussion. In this regard, our research was mainly conceived as a form of reflective inquiry, supported by a range of tools which we applied in the process of learning and teaching to engender an interruption of normal perception, problematise everyday experiences, to support dialogue and further practice. In what follows, we will not be focusing on 'results' derived from an intervention, but we will articulate how feedbacks from participants supported new activities with a view of activating deeper levels of understanding and participation.

Experiences and Activities

From the beginning of our research and educational activity we were interested in an interdisciplinary approach to science education which promoted students' participation in knowledge building (Colucci and Camino, 1999). As we mentioned earlier, thanks to the personal acquaintance that we developed with Gandhian leaders, working 'in the field' with rural communities, we sought to formulate an approach to teaching and learning scientific topics which considered the epistemological elements highlighted earlier, namely, dialogue across a multiplicity of perspectives to generate participation, emotional involvement, and awareness of the limits of our knowledge and the limits of the biosphere. We worked together with students and teachers in a variety of different educational contexts: university students, including student teachers, as well as in-service teachers and school pupils at primary and secondary levels. Gradually, a number of new initiatives arose and developed, with reflections and experiences coming out of two different, but interacting, realms: 1. Dialogue between a multiplicity of perspectives centred on world issues around us; 2. Experiences in outdoor contexts, as essential components of a balanced development, especially for children, many of whom are currently deprived of direct contact with Nature. Here we provide some examples of our activities.

1. Dialogues Within a Multiplicity of Perspectives Centred on World Issues

The activities described in this section were developed largely with university students involved in the Degree course in Natural Sciences and in the Teacher Education Programme for Secondary teachers, both held at the University of Turin, in Italy. Participating students would either have science as a main subject in their preparation or would have graduated with a degree in a scientific discipline. The activities were introduced as part of courses designed to introduce them to debates on sustainability.

Perspective-taking and role-plays

As reported earlier, the nineties signaled an explosion of socio-environmental issues connected to scientific and technological interventions. Such issues were characterized by lack of agreement among experts holding different views, and clashes, sometimes with the explosion of violent conflicts, between different social groups. Martinez-Alier (2002) talked about the globalization of the poor to

describe the hardship experienced by many populations resulting from the intensive use and displacement of resources and environmental services. The complexity of the real world, along with the complexity of the multiple views held by the many actors involved (local communities, experts, politicians, but also other living beings!), led to controversies in which the multiplication of voices made it increasingly difficult not only to find the 'right' solution but also to put decision-making processes in place which would involve all stakeholders.

Drawing on the methodological premises of drama, we devised the position and experiences (including age, gender, background and interests) of characters who were involved as stakeholders in a range of such controversies (Colucci-Gray, Camino, Barbiero and Gray, 2006). One such case concerned the intensive production of prawns in aquaculture ponds and it involved Sri Jeganatthan and local farming communities in Tamilnadu, which we have reported extensively in other publications (see for example, Colucci-Gray, 2009). By taking part in the dramatized activity, students were 'involved' in a dynamic activity of participatory research, collating and sharing scientific, economic, and sociological data, discussing different options and listening to different points of view, in line with the process of nonviolent conflict transformation (Galtung, 1996; Colucci, Camino and Perazzone, 2001). The diagram presented in Figure 1 illustrates the range of educational opportunities offered by this type of trans-disciplinary activity.

As indicated in the diagram, the three levels of individual, small group and societal interactions are interdependent. If knowledge is not an abstract product but a process of ongoing interaction, involving the entire self, in its becoming in the world, it also means that knowing is directly linked to the webs of energy and materials crossing our body within the biosphere.

We can no longer perceive ourselves as singular individuals set against a context but we are organic forms arising from the nexuses of energy and material flows: "*the biological, environmental and social are thereby integrated within a unified framework of analysis*" (Marchand, 2010, p. 13). In this view, the enactment of a perspective in-role enabled people to share their knowledge while being exposed to a felt awareness of different ways of *inhabiting, being in* the world.

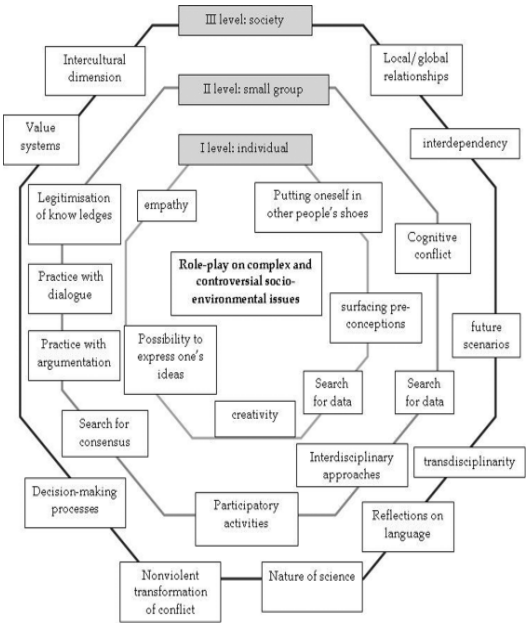

Figure 1 Multiple educational opportunities offered by role-play (from Colucci-Gray, 2009).

In the role-play activity illustrated above, students 'in role' used language to give meaning to their different experiences. The controversy was played out at different levels, because during the drama the students were 'inhabiting' their own local world as part of the wider sets of global interconnections which bring together – into the same view - different individuals and populations which are apparently very distant and very different. This process of learning was aimed at recognising ecological and economic interdependences within a

finite ecosystem, but it was also aimed at uncovering fundamental human needs, such as security, community, and shelter, which are shared across the living world. Achieving and integrating those concepts from 'inside'- through the simulated experience - may help students to intuitively grasp the reasons why Gandhi and Kumarappa thought that large-scale mechanized activities would lead to inequalities and inequities.

Knowing as 'crossing' the living world

Acknowledging the role of an individual's embodied experience during the process of knowing, or more widely, *acting* and *being* in the world, is to allow for individuals to 'join in', to self-direct, to formulate their own meanings. This way of knowing is more akin to Gandhi's view of seeking truth, not so much as finding the end-point, the ultimate resolution, but rather as the ongoing process of self-disclosure and acknowledgement of one's inherent dependence upon others and the world. From this perspective, becoming knowledgeable is not a matter of assembling information, looking for the ultimate proof of evidence, but a form of dynamic action, as knowledge is being formed in everyday activities, knowing being co-terminous with our movement *through* the world… the life-giving ground, the paths along which wayfarers move, and the medium of air, wind, and weather in which we exist (Ingold, 2010). Returning to earlier discussion on the embodied nature of cognition and the knowledge we gain through different technologies, we can re-appraise our position towards the natural world, dramatically shifting from a state of 'by-stander' to a state of 'inhabitants' or 'participants' who share in the life-paths of others.

In this respect, also some of the common words we associate with our knowledge activities can be re-thought so as to account for the biological and enacted dimension of knowing. For example, one such important concept is that of 'seeing', a word that we commonly associated with knowing as we see 'somebody's point of view' and as primates evolving in what is a mainly visual world, it is through 'seeing' that we communicate and know. So, 'to see' is sometimes used to describe the act of focusing on something or framing something, which can be thought of as the physiological and psychological capturing of the reality within one's own field of vision. Seeing is about what is right there, in front of the onlooker. Another way of seeing however is 'seeing as valuing', where the act of seeing is dependent on *what* is seen and is a psychological capturing affected by prior knowledge and personal attitudes. In this form of seeing we are discussing what is and what is not noticed, how prominence might be given by the *seer* to certain things and downplayed in the case of others. Seeing can also be interpreted as an empathetic capability, where we might talk of seeing someone else's point of view, or taking someone else's bio-physical and value perspective.

From the field of arts and design, Hirst (2013) stresses the importance of "thinking more complexly about visibility' (p. 41). He explains the importance of this lesson as relating to four key understandings:

- That vision is more than a physical or sensory function.
- Learning how vision and thought affect our seeing and understanding is indispensable for a student of art and design, as it would be for a student of science and any other problem solving discipline.
- The need to highlight the distinction between collections of visual materials (how we visually select, simplify, and compare elements) and its context (including placement and memory).
- The importance of emphasising that to see clearly, we must not only look more closely at visual objects and images, but also learn to imagine and interpret what's not visible. (microscopic to cosmic)

On this basis, the act of drawing becomes a means for understanding how the student's own way of seeing is mapping their thinking, an insight into their perspectives (Hirst, 2013). Thus, seeing is to observe what is there in a new way, and seeing is also recognising the way in which things are seen by others. However, as Masschelin warns, to see (or in his term gaze) is not about arriving at a liberated or critical view, but about liberating or displacing our view, *'it is not simply about becoming conscious or aware but becoming attentive, paying attention'* (Masschelin 2010 p.2), displacing one's gaze. These reflections allowed us to explore further the power of perspective-taking introduced in the role-play by drawing on visual methods as a means for increasing students' awareness of their own framing and their own thinking. A new set of activities was devised to enable participants to explore and to draw connections across new and possibly unanticipated dimensions of the problems and to apply new concepts, as in the following examples.

Interlinked ecosystems

Vignettes prove particularly effective in generating open questions and engaging students in shared inquiry about the multiple-meanings conveyed by different ways of seeing. The cartoon of Fig. 2, for example, was presented to all students at the beginning of a lesson as the basis of a task inviting them to '*give a title, write a caption and list some topics of the life sciences which have relevance for the depicted scene*'. The stimulus provided by the iconic message of the vignette elicited a variety of interpretations from participants.

In the analysis, the richness of students' explanations and contributions provided cues on underlying views and value systems (e.g.: 'natural world against modern world'; 'equilibrium between production and consumption'; "North and South"). With regards to this vignette, interpretations which appeared to be in opposition with one another were also selected and shared with participants. This way of working made an impact on the participants by raising their awareness of a multiplicity of alternative views and by fostering their interest in listening to the voices of others. It is important to note that this activity was not to be taken as a premise for stimulating counter-oppositions and argumentation aimed at selecting the most convincing and/or truthful statement. Rather it was introduced to stimulate an initial awareness of the limitations of any single interpretation. We refer here to the power of humour, as proposed by Bateson (1980) to uncover one's own cultural framings and thus to generate learning potential from the process of enacting dialogue between a plurality of ways of seeing to recognize, in line with Hirst (2013), what is not visible, the unspoken, the unsaid, the assumed and the accepted. Stimuli from the vignettes encouraged students to think about the puppeteer as a metaphor for power: the power of those who can move large-scale flows of materials around the world; but also the power of the students who become aware of themselves and their role as consumers and inhabitants of the living web.

Figure 2 Interlinked ecosystems. Courtesy of Massimo Battaglia

Following a similar approach, the following activity was aimed at taking a reflexive stance towards the flows of energy and matter in the ecosystems involved.

Oil Eaters

Some authors maintain that we—as inhabitants of modern industrial societies—can be defined as "oil eaters." Why? In your opinion, is the sentence to be interpreted literally or figuratively?

This activity is part of a research strand that we have been pursuing for many years, raising awareness of the role of science teachers in promoting understanding of socio-environmental problems (Camino, Barbiero & Marchetti, 2009). Thinking in terms of energy flows and matter transformations (e.g. Smil, 2008) in following the chain of processes of food production and consumption can be very useful for understanding that the consequences of the energy crisis are not only manifested in the transport and industry sectors (Jones, 2001).

By reflecting with students on the energy flows and matter transformations connected to food production, it gradually emerges that it takes energy not only to transform matter, but also to acquire, transport, store and even use energy. Such invested energy may be compared to "returned energy," and a powerful conceptual tool can be applied to address the problem in terms of quantities: EROI (Energy Return On Investment) is the ratio between the energy delivered by a process (for example, the calories of a given food) and the energy that is being used directly and indirectly in that process (to grow, harvest, transform, transport the food product, as delineated by Cutler, 2004). This activity has the potential to trigger further reflections on the 'hidden energy costs' involved in human production and consumption activities and which give rise to depletion of resources in places which may be geographically remote or outside the realm of one's consciousness.

The activities described so far place emphasis on the power of interactive pedagogies which harness prior knowledge, memories, and collective frames to stimulate new ways of seeing and to integrate differential experiences and perceptions. The activities, however, were also indicating the effort required to displace one's gaze from 'the nature out there' as an abstract concept, removed from us, to 'the nature within', to recognise our inherently 'grounded' biological position within the biosphere.

In the following set of examples, we aimed to explore more closely the role of the body in enabling participants to recognise themselves as part of the natural world and in mutual interdependence with other living forms. In line with the ideas expressed earlier on embodied cognition, multiplicity of perspectives and awareness of the filters we pose upon perception, the following set of activities illustrates the power of knowing through the body to develop awareness of one's affiliations and complex, bio-physical entanglements with the natural world.

2. Childhood Memories and Experiences in Natural Contexts

Retrieving Memories of Childhood

It is common for young people to develop a perception of scientific knowledge as the knowledge of *something,* rather than knowledge that is socially constructed and negotiated. Teaching strategies that are heavily reliant on explanation and demonstration contribute to *"thingifying"* views of science (and of the world itself), often generating a sense of alienation, if not fear, toward nature. However, the emotional dimension of knowing nature plays an important role that, perhaps, has been underestimated in our increasingly urbanized society. We mention here briefly an activity that we have been proposing for many years to future secondary school teachers and which has provided outcomes that continue to move and encourage us in our educational work.

After a short moment of silent concentration, we ask student teachers to write down a vivid recollection from childhood that is connected to nature and to explain why it has remained

so strongly impressed in their memory. What follows are two examples of their comments.

- *Afternoons spent at my uncle and aunt's country house in Sicily. A swing made of a wooden board and hanging from a tree—the wild asparaguses, the places where I was running.*
- *The colour of the bluebottles, which I have never seen any more in the fields. I was going looking for them on my bicycle.*

What is remembered is generally associated with complex experiences, an element of intense sensory perception (colours, smells), a human presence (children, friends, and grandparents) and a dimension of doing (running, building, hiding, rolling). Such memories trigger strong emotions, a sense of astonishment for having temporarily forgotten about them and a desire to narrate and to share.

Triggering memories of nature points to the importance of engaging the senses but also to recognise how learning as a process is also a profoundly embodied experience. Unfortunately, the *thingifying* experience of learning science (Colucci-Gray and Camino, 1999) is also a means for *thingifying* the body, described as an accumulation of parts, and static. With a view to formulating an understanding of sustainability as a process of actions in the world, in the manner of Gandhi's Constructive, action-orientated programme, a renewed understanding of the body in action was also required.

We, human bodies

The literature which asserts our profound relationship with the natural world and the fundamental role played by nature in our ability to express ourselves as social and creative beings is extensive and ever-growing. Within the realm of sustainability studies, some authors give great importance to the competences that can be developed through direct contact with nature, through sensorial awareness, without the mediation and cultural transfer of information (Boeckel, 2013). In this respect, Arne Naess was a great anticipator of these ideas and recognised the mutuality of affiliation between human self and nature for loving ourselves is inextricably linked to loving and valuing that which we believe should support us. As recalled by Thomas Weber (1999), the new environmentalism in the form of deep ecology very closely mirrors Gandhi's philosophy.

Through science, however, we have become accustomed to adopt as much as possible an objective and neutral approach towards what we set out to know. 'The human body' is no exception and it is through the objective and 'clinical' attitude that both scientists and doctors relate to the body, as an object set against a background, a part isolated from the rest. It is also through the same approach that the body is often considered in school, however much we – and each one of us as human beings – know the body in many other ways because of the experience we have of it as subjects. The adoption of a reflexive approach, as a way of looking directed towards oneself, has produced sophisticated understandings of the 'essence' of the body in other cultures. Particularly the Hindu and Buddhist traditions over the course of millennia have elaborated inquiry techniques and practices of control of the body leading to a rich set of 'first person' knowledge (Wallace, 2000). As indicated by Ricard (2003), a French biologist who became a Buddhist monk - "*the texts of Buddhist contemplative science are precise, clear and coherent. […] Their methodology is rigorous, and their findings corroborate those of others and stand up with just as much strength as any mathematical reasoning."* (p. 231)

In our educational practice, we try to involve students not only and not so much at the level of content (which we draw upon to provide examples, summary diagrams and further readings) but at the level of their own interpretive schemas. We encourage them to view and to interpret the body in many different ways and to integrate the different approaches to build a rich and complex view

in which their creative and personal experience plays a central part. An interesting challenge for educators is to help students to 'recompose' their own 'ecological self' by developing the insights provided by scholars. For example, Joanna Macy, in the early nineties, proposed to extend the boundaries of one's own body, which [*...] is being replaced by wider constructs of identity and self-interest-by what you might call the ecological self or the eco-self, co-extensive with other beings and the life of our planet. It is what I will call "the greening of the self"* (Macy, 1990, p. 53).

As Thomashow puts it *(*1996, p. 3), *ecological identity refers to all the different ways people construe themselves in relationship to the earth as manifested in personality, values, actions, and sense of self. [...] The interpretation of life experience transcends social and cultural interactions. It also includes a person's connection to the earth, perception of the ecosystem, and direct experience of nature.*

In this light, our 'lessons' on the human body are structured in such a way to involve and to include everyone and to offer the possibility for everybody to play a part so that 'a plurality of legitimate perspectives' can be gathered. This kind of approach is interdisciplinary by its very nature, in that it draws upon and makes connections between physics, biology, chemistry, but also linguistic insight and philosophical reflection.

In the following section, we will outline some of the sequences that we have tried out with university students (and which are variably connected with one another):

- language and ideas of the body
- embodied cognition

Language and ideas of the body

Researching the metaphors which are used to describe and explain the human body can help to uncover underlying paradigms and worldviews. Thus, the body can appear to us, from time to time, in different ways (with some important consequences):

Table 1 Metaphors for understanding the body

container (with 'parts' contained within)
machine (requiring 'fuel' – food – in order to 'perform', through movement, sport etc.)
slave (executive the commands of the mind)
chemical factory (transforming matter through metabolic processes)
river (a dynamic reality, crossed through by flows of energy and matter)
system (made of different organizational levels which are mutually interacting)
manifestation of uniqueness (expression of a unique package of genes)
witness (of a family history)
treasure box (containing traces of an ancient evolutionary process)
cluster (of cells)
ecosystem (inhabited by billions of other creatures)
opportunity for expression (through dance, sport, music, singing ...)
autopoietic machine (able to self-construct by drawing upon resources in the external environment)
multi-layered structure (according to yoga tradition: thin, causal, coarse body)

Some numerical data can help us to understand our complexity, which is derived from multiple organisational levels, from molecules to cells and apparatuses, but also from the co-existence and exchanges with our own 'guests' *(*Giordan, 1999): "*A billion of living things, far larger than the number of body cells, inhabit our body... each one of us is hosting a large variety of species (more than 50.000): a real zoo indeed! Some of them are strolling freely over the surface of our skin, others are more 'integrated' within the*

intestine and the mucosae. In 99, 99% of cases, cohabitation is peaceful…"[2]

'Feeling' and recognising ourselves as ecosystems is a helpful way to learn to 'decentre', to develop an 'eco-centric' view. This is an additional view of our own body, which becomes part of the repertoire of views we already hold. While the activity was originally conducted with university students and prospective teachers, the same activity can be proposed to secondary school students, interpreting the list of metaphors, and enriching the list with some of their own. In this way, the plurality of legitimate views becomes richer.

Embodied cognition

From the activities conducted with the students on their understanding of the body, we moved into the realm of primary education, working with a schoolteacher and her class. One of the obstacles to learning which is increasingly expressed by teachers in recent years is the difficulty of students to 'focus' attention. Young people are lively, intelligent, and they generally bring to school a wider set of information and cognitive skills as compared to those shown by their older siblings. Yet, they struggle with concentrating, they are restless. To deal with this problem creatively, we have directed our attention towards the interaction between mind and body. Silence was the threading theme of a series of activities proposed by a primary teacher to help her pupils (9-year-old children) to achieve serenity, develop attention, and entering contact with the natural environment. As part of the activity, the children periodically met Dida, a Zen monk, for a few weeks. No reference was made to religious views, only the suggestion to encounter 'silence'. *"Sitting still with a correct body posture (this posture enables us to keep still so that there is time for experiencing a deeper contact) our breathing is calmer; by breathing calmingly also the mind is calmer; and here it is, in the quiet space of body-mind-breathing, in a natural and spontaneous way, serene attention emerges, observant and open participant in the non-separation of phenomena of which we are integral part"* (Ferrando et al, 2005).

Here is the comment - one of many - of a girl, Rachida, who writes: *"... to me silence means that when I put my left hand over the right hand and the two thumbs get closer I feel that I am 'holding' silence. Hence for me it is as if I was 'praying' that silence that I hold in my hands. When I sit to being in silence I feel all concentrated, as if I was a tree, with the feet on the ground and the head in the sky..."*

Multiple relations and relations everywhere

Drawing on the insights offered by Gregory Bateson, the process of learning cannot be disentangled from the ecosystem of relationships that are material, social, biological, genetic, and evolutionary and in which we are immersed. In his book, Mind and Nature, Gregory Bateson (1980) asks us to consider: "*What pattern connects the crab to the lobster and the orchid to the primrose and all four of them to me? And me to you?"* (p.8). Bateson's insights into 'thinking relationally' invite us to carefully consider patterns of relationships across time and across space, as occasions to develop our awareness of being part of a system of mutual relationships that we define and by which we are continuously defined. Through the development of a set of cards, we drew on the opportunities offered by a flexible tool for encouraging students to think about the multiplicity of roles performed by living things in the ecosystems (Figure 3). As we illustrated earlier, however, being in-role also means being part of a web of relationships, exchanges, and interdependences. This activity was first developed in Italy, by Elena Camino, as a stimulus for teachers reflecting on the limitations of classifications as tools for gaining knowledge of the world. It was then adapted by Laura Colucci-Gray, in a science education course offered to future primary teachers in Scotland. The aim was to encourage participants to acquire

[2] Authors' translation from the original French.

consciousness of the limitations of description, and the tendency of formal school science education to 'thingify' the world with crystallized concepts. Abstract knowledge, provided as a set of consolidated notions, is disconnected from real experiences and most importantly from the nature of living processes, which are always in ongoing and dynamic flux. The first activity "What relationships?" asked students to identify relationships connecting the pictures on the two sides of the sheet (Fig. 3).

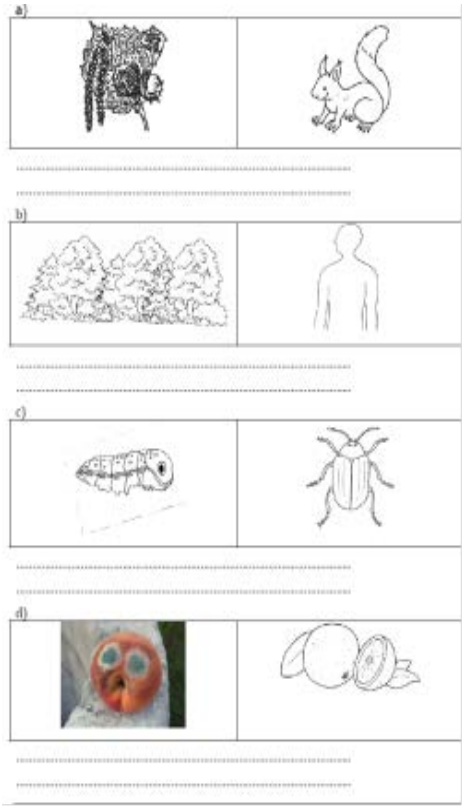

Figure 3 Relationships everywhere

The activity proved challenging for participants who were not used to thinking about the interactions that exist - in time and in place - between organisms which are normally conceived of being separate as they are placed in different categories (i.e. plant/animal). Also, when thinking about ecological relationships, students tend to be more accustomed to identify 'feeding relationships' (the nut eaten by the squirrel) while they were less familiar with thinking about behavioural patterns, e.g. competition, collaboration, support or companionship, such as the case of the beetle and the bug, or transformations occurring over time (ripening and rotting of fruits).

This activity was planned as a springboard for students' creativity, to encourage them to explore new ways of seeing, as commented below:

- *I realised that different organisms are a lot more related than I thought;*
- *I enjoyed the irony of fir and fur. It means the same thing for different things.*
- *I enjoyed thinking about the different animals in details; I found it difficult to think of non-obvious relations; I realised that even the most dissimilar things relate.*

Further to this activity, Scottish students were encouraged to extend their 'relational view' to include themselves within the web of relationships, through their bodies, in the living world. The activity with cards became an organising tool for the facilitator to connect ecological concepts which are normally covered in science, with learning outdoors, as a new curricular area in the Scottish primary curriculum. So, students were invited to go outside to undertake a series of experiential tasks (Fig. 4), which are reminiscent of some of the activities described earlier, recognising the body as a system and becoming aware of the flows of energy and materials crossing the body at all times. Their body became an instrument for building new knowledge about the world and their own position within it.

1. Stretching and warming up
2. Looking for evidence of existing relationships
3. Myself in relationship: walk around a tree for 1 minute
4. Stand up against a tree for 1 minute
5. Push against a tree as strongly as you can…
6. Open your mouth and breathe the air…
7. Stand still…
8. Playing hide and seek…

… and respond to the question: what relationships?

Figure 4 Experiential tasks to perform outside

Throughout the course of the activity students commented on their knowledge, sensations, and surprises derived from direct exposure to the environment:

> *I discovered there was a relationship between the air and the fumes from the road. I could taste the chemicals;*
>
> *I discovered that when you take the time to observe with your senses you see things you do not normally see;*
>
> *…energised! Fresh air is so good for you! You are closer to nature than you think. You just choose to ignore it.*
>
> *I discovered that if you taste the air and think about it then you can actually distinguish the air.*

Conclusions

Ideas about knowledge

The fierce critique by Gandhi of Western society[3] is widely known to many people, as is that of modern science and technology expressed from the beginning of the nineteenth century in the text *Hind Swaraj* (Gandhi, 1909). Less known, and only recently acknowledged (Diwan & Lutz, 1985; Visvanathan, 1997; Prasad, 2001; Anup San Ninan, 2009), are the numerous arguments proposed by Gandhi and by those following in his footsteps, such as Kumarappa and others, which highlight the close interconnections between science, economics, social relationships and education in the rapidly developing technological society.

One of the scholars who took on the task of extending the field of 'Knowledge Swaraj'(KICS, 2009) - Amit Basole – refers back to the concept of lokavidya (loka = folk; lore = knowledge), a term pointing to the body of knowledge held by a society. It is not only, nor principally, an abstract body of consolidated knowledge, but rather the knowledge which is implicitly held by the community, extensively drawn upon for practical activities that are often considered to be of marginal importance. It is a body of dynamic knowledge which enables people to adapt to new and changing life circumstances: *"The lokavidya perspective recognizes that ordinary life is a centre of knowledge production and not merely an 'implementation' of knowledge generated elsewhere"* (Basole, 2009, p. 10).

With their holistic view, Gandhi and his followers were precursors of many of the considerations expressed throughout the nineteenth century by individual Western thinkers, who were often isolated and 'working against the current' (e.g. Bateson, 1980; Illich, 1973, 1981; Martin, 1979, 2005; Sachs, 1987; Schumacher, 1998). As pointed out by Ravetz in a recent essay*:*

"In the present period, Gandhi's message has (so far) been less diluted than some of the others. Let us make a list of the attributes of a science based on Satyagraha, focused on ourselves. These include awareness: of one's own ignorance and propensity to error; of the readiness to learn from anyone, be they a student or a citizen; of responsibility for the unanticipated consequences of one's discovery

[3] This civilization is such that one has only to be patient and it will be self-destroyed (Gandhi, 1909)

or invention; of the possibility of doing evil in the name of good; and of the contradictions that afflict anyone who faces the corrupting pressures of power or responsibility" (Ravetz, 2006 a, p. 16).

In this view, the project of Swaraj brings together ideas of humility, uncertainty, collective dialogue and self-emancipation within a view of economic development which takes account of change and respect for others:

"The process of integrating non-academic actors in knowledge production for attaining social goals is central […] reflexivity and social accountability refer to both researchers and involved stakeholders, and to the interactions between them. This type of reciprocal and critical reflexivity can only occur through mutual learning". (Polk & Knutsson, 2008, p. 645)

Educational practices

As we tried to illustrate in the course of this article, the ideas of Gandhi and his followers made an important contribution to educational practice. As Prasad (2001) underlines, the popularisation of science, according to Gandhi, was not a linear transfer of knowledge from the expert to the layperson, but had to be necessarily a collaborative effort, in a process of mutual benefit for all involved: "It *is clear that in Gandhi's Nai Talim, science education was not to proceed by pursuing islands of excellence in a sea of mediocrity. Work was to be done on the base of education so that no hierarchies of knowledge were created between the scientists as experts and the people. He wanted a proliferation of scientists and engineers in the villages, an increase in India's scientific manpower that would not be measured by the number of university degrees in science, but in creating scientists who would be true servants of the nation" (*Prasad, 2001).

Central to the educational programme outlined by Gandhi is manual, practical work[4]. In Gandhi's anthropological and pedagogical conception, the spinner (*charkha*) is the symbol of nonviolent practice, the spearhead of a slow, silent and peaceful revolution, and yet gifted with an irresistible power of casting songs of hope for humanity's future in its advancing. From a strictly educational point of view, manual activity is proposed as a component of teaching and learning that goes - hand in hand - with all other disciplines, providing a solid structure for developing every process of knowing. From this, an innovative and fascinating approach emerges, which proposes teaching elements of history, geography, numeracy and geometry by means of embodied experiences and practical work. It is through practical work that people can become aware of the entanglement of time, activity and resources as it can be experienced through different modes of living. It is also through practical work that people can find opportunities to create something new from what is already there and existing, gaining fulfilment and self-actualisation.

The Gandhian approach to scientific research and science education can also be recognized in the thoughts of a leading western researcher, Brian Goodwin, who made key contributions to the foundations of bio-mathematics, complex systems and generative models in developmental biology. He was one of the prominent scientists who suggested that a reductionist view of nature will fail to explain complex features: *"[…] the university concept will have to be radically rethought in terms of an education process that provides people with the practical skills needed to support their local community as well as an understanding of the cultural history that has brought us to the present moment of transition. […] there will be a*

[4] *"Our education has got to be revolutionized. The brain must be educated through the hand. If I were a poet, I would write poetry on the possibilities of five fingers. Those who do not train their hands, who go through the ordinary rut of education, lack music in their life." M.K. Gandhi, Harijan, 18-2 '39, p.14-15*

diversity of learning possibilities within this system, appropriate to different individual interests, but they will all be grounded in a common understanding of ecological and cultural principles as expressions of a creative process in which everything is engaged, human and non-human, animate and inanimate" (Goodwin, 2007, p. 337).

Practical skills, diversity of learning possibilities, an understanding of ecological and cultural principles, creative process, cooperative dimension… these are the principles which guided our practice. These are also the key terms of an approach that – stemming from Gandhian thought – we wish to encourage and promote so that it can spread - sideways - within our globalized societies.

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