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How can Science Produce Unequal Relationships: The Nanotechnology Metaphor

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Abstract

Modern technology is complex and interdisciplinary, used by many sectors, with an impact on everybody regardless of cultural background or societal status. Increasingly, debates are arising concerning the proper use of technology and the need for ethical considerations. The most recent technological developments concerning nanotechnology and related technologies have lead to a multitude of questions and concerns regarding the potential environmental, economic, and societal risks and how we manage these potential risks. This study seeks to explore the potential challenges of nanotechnology and the effects of the nanotechnological applications and developments in indirectly reinforcing global inequalities.

Keywords: Ethics, Nanotechnology, Regulation, Technology, Culture, Social, Science.

1. INTRODUCTION

"Nanotechnology is described as an emerging and interdisciplinary area of research with important commercial applications, and will, most assuredly, be a dominant technology in new-world economies" (Karkare, 2008).

Following in the thinking of Karkare (2008), this paper aims to dive deeper and explore some of the challenges and effects of the use and development of this fundamental technology in indirectly strengthening the unequal relations in the development, access and enjoyment of the advances achieved by this applied science.

1.1. Definitions

Nanotechnology is described as an emerging technology which operates with objects (atoms and molecules) focusing on a scale of approximately 100 nanometres and below[1] (Matthew Rimmer, 2012) (Bolonkin, 2009). Popular definitions also include the "*engineering of functional systems at a monoscale*" and "*the projected ability to construct items from the bottom up, utilising tools and techniques for high performance products*" (Karkare, 2008).

The definition and classification of nanotechnology remains a challenge to the scientific community, particularly in relation to regulation and surveillance of the practice (Matthew Rimmer, 2012). Currently a variety of organisations and scientists are using the term 'nanotechnology' to label almost any new cutting edge scientific technological development or product, for example, using the umbrella of nanotechnology to explain femtotechnology which is in fact a term to describe operations with matter of a "*femtometer range*" which is "*10-15 m, millions of times smaller than the nanometre scale*"(Bolonkin, 2009). How can we provide effective, inclusive regulatory systems if the definitions are unclear and extremely broad. This is further complicated by the interdisciplinary nature of science including the nanotechnology sector.

1.2. Surveillance and regulations

The development of nanotechnologies in small mobile laboratories reduces costs and increases the availability of new technologies. However there are greater difficulties surrounding the monitoring and surveillance of this sector. Does the need for increased surveillance lead to greater societal issues, such as the decrease in privacy for citizens and bring

[1] A human hair is about 100,000 nanometres wide (Karkare, 2008).

us further from a free society to a society not unlike Big Brother?

From the perspective of its social relevance, it is vital that we do not continue to avoid the discussions surrounding the reasons for why nanotechnological juridical frameworks have not yet reached an agreement in the regulation of its' use. We must ask ourselves why that up to this moment and given the potential risks it poses to human life, global governmental institutions have not addressed this issue with the seriousness it deserves.

This is not to say that no progress has been made. The ethics and public policies surrounding the sciences are continually in the global sphere of debate. For instance, in the magazine *Nature* which was published in Lovaina in 2004, it described policy stating that all nanomaterial producers must to provide toxicity studies on any and all new materials, following the current international risk guidelines (Altman, 2004). Another example is Monsanto, a chemical enterprise founded in 1901 in Saint Louis, Missouri in the USA, which produces and provides the largest number of transgenic seeds in the world. In 2012, Monsanto was fined $2.5 million for more than 1,700 violations to bio security regulations.[2] A worldwide controversy has been raised due to the already proven danger of Monsanto's products not only to human health, but to animals and our environment[3]. Unfortunately Monsanto has continued positioning its products in the global market.

It seems that the diversification of nanotechnological topics has merely caused a phenomenon of "distraction" from those that involve major social impact and need to be discussed around their potential dangers to humanity.

1.3. Regional instability and society

It is important to consider conflict situations when regarding the potential negative impact on society of new nanotechnology. When there is regional instability and new nanotechnologies are developed, what is their impact?

When we examine the government spending of some of the most powerful nations in the world, we can see that nanotechnology is believed to be key to military advancement. According to Foladori (2005), between 2000 and 2004, 26% to 31% of the federal funds in the USA was assigned to nanotechnology research directed to the military industry, aiming to build miniature explosives with a farther range and wider energetic density. Following the United States, Israel and China were found as key producers of military nanotechnologies during the same years.

At present, it is not known if major regional bodies or countries, such as United States or the European Union, have reached an agreement regarding the assessment of the risks involved in the application of nanotechnology in the military fields, including in the field of communications, the use of sensors, intelligent devices and weaponry.

1.4. The environment and health

There are further concerns surrounding environmental issues, for example the development and distribution of materials without fully understanding the risks associated with them. This becomes increasingly relevant when considering the role of nanotechnology in the agriculture and food sectors.

A particular concern is regarding the risks of the so called "*grey gelatine*" (UNESCO, 2007) with the fear that nanotechnological devices are capable of being programmed for their own reproduction and, therefore, could "evolve," leaving our current global ecosystem as well as human beings at risk.

We can see other nanotechnological related dangers and consequences with clear negative social and environmental impacts in countries such as Ghana where nowadays expanding, unregulated dust-bins of digital waste produced by the world market exist, which impact human health and the environment (Agyei-Mensaha, 2012). It is important, as these nanotechnologies become more prevalent, to consider the impact of developing these new nanotechnologies and how to dispose of them without damaging the environment or risking contamination of land and water. We must also increase focus on their positive applications on reducing digital waste.

Evidently there are also many unknown areas regarding these technologies including those focused on improving the quality of human life. The 2004 report of The Royal Society and The Royal Academy of Engineering discusses the unforeseen consequences of utilising nanoparticles to decontaminate water or to dilute pollutants, given that the high reactivity of the surface in the nanoparticles could impact on living beings or alter

[2] According to civil society organisations, including Greenpeace, who are dedicated to following the development of the best scientific practices related to the environment.

[3] In accordance with authors such as Salvador Ortiz, Monsanto's controversy opened the debate towards a global Bioethics debate where "genetic modifications are seen as a cultural interventions which should to be assessed in their given context." (Ortiz, 2013). Monsanto's case has been taken up not only by scientific analysts, but by the civil society as a whole, organising so as to make visible their lack of ethics.

the natural processes of the ecosystems. This 2004 report suggests avoiding the use of such nanoparticles until potential risks are proven and assessed (Foladori, 2005). It is vital that more research continues into the potential dangers and consequences of these practices to not only health but also the impacts to the environment.

1.5. Beneficiaries and general impacts of nanotechnological developments

Questions surrounding who benefits from these nanotechnologies are key to consider. It is clear that nanotechnology can have various positive impacts. In 2004, nanotechnology was not considered a technological revolution (Peterson, 2004) even though it was used in a wide range of economic sectors to develop and market anything from cosmetics for different skins to high resistant golf clubs to products for the pharmaceutical and construction industries.[4] In that same year, enterprises researching nanotechnology, predicted that in 2010, earnings from the sale of these products could reach 500 billion dollars (Quintili, 2012). By 2012, there were indications that nanotechnology was responsible for the circulation of trillions of dollars globally (Quintili, 2012). In seven years, both the estimated and the real sum of each country's earnings from nanotechnology multiplied to a vast scale, unimaginable for many other nations.

However are these impacts only profit orientated? What is the focus of the nanotechnology regarding the society and its citizens?

During the last decade it has been call into question whether the technical benefits of nanotechnology will actually be able meet the needs of those who live in economically poor countries. Various NGOs have argued that the main multinational corporations (MNCs) control the production and how historically they have not orientated their efforts to satisfy the necessities of the most vulnerable groups or those in conditions of poverty. For example, patents in the agriculture sector in seeds and agri-food techniques which leave the small farmer holders at risk of marginalisation due to unequal conditions (Madeley, 1999).

The results of these technological advances, given the high costs of research and production, have been directed to small social groups/ minorities. Quintili (2012) describes the nanotechnological earnings as increasing the gap between the developing countries and developed countries. Wealthier nations including America, Japan and Germany are benefiting particularly from these nanotechnological developments as they conduct the bulk of the research with the highest number of nanopatents worldwide (Barpujari, 2010). So, with these increased advantages offered by the advancement in nanotechnology and the global and regional trade agreements, the global market competition conditions become increasingly difficult for developing nations. The attractive competitive stance that developing countries have regarding lower wages in many industries could soon become irrelevant as nanotechnology fills in the human resource gap more efficiently and cost effectively than employing a person would.

Even some of the most significant progress is situated in relation to wide manufacturing sectors where the workforce is dispensable, increasing the demand of raw materials from developing countries to developed countries, and generating an economic model with a high level of consumption for the few, and an increasing level of exclusion and poverty for the majority.

2. THE REGULATION OF NANOTECHNOLOGY: A DEBATE ON SOCIAL INEQUALITY

In 2014, four centuries since the microscope was invented, the global community has yet to have a comprehensive, multi sectoral, open debate regarding the regulation of technology, in particular nanotechnology. Why with the rapid developments in nanotechnology, the development of regulations has not kept up the same pace? A possible explanation, as described by Foladori (2005), is that nanotechnology is tied to economic impacts, as well as to the potential effects of the distribution of wealth, which can only be but unequal.

Over the years, we have seen many unforeseen impacts of new technologies and scientific advances, for instance technologies such as nuclear energy which was intended to produce cheaper and increased electrical power being used for the creation of weapons. Have these new nanotechnologies taken into consideration all their potential impacts?

Even though nanotechnology improves sustainability of natural resources, through the reduction in the use of non-renewable resources, by instead shifting demand to chemical elements for production, and aims to enhance medicine, agriculture and communication processes by creating mechanisms which reduce risks and costs in, for example, increased access and availability of nutritious food, or clean water, who is really gaining from these advancements? All these innovative products imply an investment and therefore, an economic profit, but in the private sector this can

[4] Though it is not an intention of this text to analyse these first companies, it is important to note that all of them are from the so called 'first world' countries, and their products are not of classified to meet basic needs. See Foladori (2005).

tend to be with very low direct economic returns leaving little social impact.

According to Chaparro's analysis of a range of the discussions that have taken place in the last ten years, it has been said that this applied science will save the planet and take advantage of the inexhaustible solar power, it will bring immortality and eradicate diseases (Chaparro, 2001). However, the socioeconomic reality and the state discourse reveal a contradiction. For example, in 2000, Spain expressed its desire to be at the forefront of the "small revolution" by developing personal spaceships that would allow voyages out of the Earth's orbit, while the United States continues to justify investing in new military strategies to develop less visible and more rapidly moving microelectronic mechanical devices, with the argument of avoiding collateral damages and terrorism. If these nations had applied technology to social wellness projects perhaps they might have responded differently to the global economic crisis in 2008 (Chaparro, 2001).

3. TECHNOLOGY, SCIENCE AND CULTURE

Now, if it is said that technology is the materialisation of science which designs and builds devices with a certain objective, then we can affirm that such an objective is culturally constructed. From there, it is essential to recognise the importance of ethics in scientific development.

If technology is a subset of science, science is intimately related to the culture. That is, culture is to science, what science is to culture, from there the well known triad quoted in all the areas of the knowledge: culture, science and technology.

Now, even though there are many definitions of culture, we can agree on four basic characteristics:

1) It is acquired knowledge.
2) It is socially shared and transmitted (Castro, 2012) by diverse agents and institutions, such as school, family and church.
3) It is manifested and concreted through language, which can be materialised in diverse discourses, among them (that of science).
4) It is inherent to social relations, or rather, it is present in all the areas of human life.

In brief, to say that there is no human being without culture is to sustain that there is no human being who has learned to live truly independent of others. It is to assume that the idea of being a "human being" is not the same in all the nations, nor in all ages. Culture is a historical construction and therefore, a political construct. The history of science demonstrates the above.

In the name of science, human rights have been denied and unequal relationships generated. We find evidence of this in the scientific discourses which have created a culture of denying, for decades, women's access to a formal education due to her gender, being considered adequate for nurturing others and for the reproduction of the human species[5] , or the arguments based on the colour of the skin, not only used by empires inside and outside of their colonies, but to which we are still *enslaved* as Fanon (1952) described in the fifties. If for Fanon the racial conflicts do not develop in a spontaneous way, where the black is a slave of his inferiority as the white of his superiority[6], for the purposes not only of this paper, but also for future reflections, we must consider that all conflicts, which we know are intrinsic to human relations, are generated within cultures, and in this sense, socialised, learned and sustained in arguments that materialise the culture which produces them, one of them being, as it has been said, that of science.

It is vital that we recognise the impact of the scientific discourses and their role in culture when developing new sciences and technologies, particularly in the nanotechnological sector where we have seen the rich and powerful overtaking and profiting on the weaker, poorer actors, where this scientific discourse is further enforcing the superiority inferiority global culture.

History has shown us that the great movements proclaiming social benefits usually are in the habit of representing certain interests which can tend to be unequal for much of our society. There are many examples of this which include the case of nuclear power, from the post-war period, which brought the promise of abundant and cheap energy and the green revolution in the 1960s and 1970s which promised to end world hunger. In recent times, biomedicine and genetic engineering continue promising to find

[5] Authors such as Bourdieu (1998), debate the '*biologisation'* of society, describing the prevalent belief that women and men ought to fulfil certain social roles given by their nature, in other words, behaviours that are completely cultural become "*biologised*." One example of this '*biologisation*' is the feminising and masculinising of university enrolment, since this conception persists in many societies where professions such as nursing are in high demand among women, and engineering by men.

[6] Many anthropologists and sociologists continue developing studies on the impact of the colonial discourse of our time. Many of these decolonizing theories aim to unravel the process by which otherness and subalternity have been constructed based on historical and deep-rooted societal inequalities, disseminated by the various imperialistic discourses. See Fanon (1952).

the cure to all our ailments, all this in a global context where poverty and inequality are the only items that are democratically expanding (Foladori, 2005). Beyond the opinions such statements deserve, it is necessary to question in a more emphatic manner all those scientific discourses that promise, hand in hand with the private and public global capitals serving the power groups, to fight for the most deprived: the sick, the hungry, the prisoners, the underdeveloped and the excluded, the "others" and the "different". What are the underlying motives? And who is giving them their agenda?

4. THE LOSS OF "INNOCENCE" IN SCIENCE'S IMPARTIALITY

Research related to the use of nanotechnology is conducted in virtually all scientific domains. In fact, one of the main problems in generating international agreement concerning nanotechnological vigilance and regulation, is the diversity of the applications, domains and approaches involved.

Recently, studies, including UNESCO (2007), which focused on biotechnology and genetically modified food have described undisclosed interests in a range of sectors of scientific research, and have alerted the global community of the urgent need to legislate and regulate the practices and technological applications, that were previously considered of unquestionable purity, and of which, according to science's ethical postulate, results were considered unequivocally beneficial for the majority of the world's population.

In many diverse fields, scientists have lost objective conditions to lead their research in an autonomous way due, in part, to the involvement of the market, i.e., the involvement of capital and private interests in the development of such research and in the application of the developed materials in commercial products. Since the global financial crisis began nanotechnology has been seen by investors as a way of making large sums of money in short spaces of time. Schummer (2005) describes the profit focused ideology of *'nanobusiness'* to include headlines of '*Small stuff, Big Business*' and '*The Next Big Thing is Very, Very Tiny'*.

For many social sectors, nanotechnology represents a technological revolution that, as already mentioned before, could solve many of humanity's most serious problems (UNESCO, 2007) and, even though it is commonly presented as a clean and thoroughly beneficial technology, its use is increasingly controversial and debated, with for example UNESCO, in its 2007 report *Ethics and Politics of Nanotechnology*, recognising the negative impact of nanotechnologies on health and environment. In general terms, the scientific practices made possible by nanotechnology in respect to former more classical practices, assume the need to address issues relative to the innocuousness, toxicity and repercussions to the environment. There is a possible differentiated impact on the social sphere, which goes beyond the technical, the improvement, the regulation and even the results known up to now, as quoted in the UNESCO's report, since it involves aspects that are endangering the sustainability of the planet and of human life.

5. CONCLUSIONS

We have explored some of the key ethical and socio-economic challenges surrounding nanotechnology and how the development, applications and access of nanotechnology can strengthen inequality. The discussions and examples outlined in this paper can serve as a structure which can demonstrate the need to include a social approach and to rethink the ethical commitments in the development of nanotechnology, and above all, to consider who or what are the appropriate institutions in charge of taking global decisions, given that international organisations continue to be led by countries that invest more in military activity than in resolving social inequality. Here we need to consider that promoting the military use and development of nanotechnology, implies the reinforcement of inequality in the social structures and the basing of our social organisation on military power.

Evidently the development of these nanotechnologies is not guided with the focus on the welfare of the majority of the world's population, and that the research approaches in use are centred on the drive for increased profits in developed nations over the needs for development in developing and transition nations. The distribution of wealth and equal access to the benefits of technological science in general, and the applications of nanotechnology in particular, are far from the social sphere, largely in part due to the established economic relations as well as the public and private interests involved in its development and maintenance. To date, nanotechnology needs large economic investment which most of the time is made by the states or multinational corporations, and the benefits of these activities do not translate to diminishing poverty or marginalization. In the case of the developing countries it is extremely difficult to possess the necessary infrastructure and the pertinent financial mechanisms to join the contemporary "technological revolution".

From the socioeconomic perspective it is necessary to define nanotechnology based on the social implications of a scheme of unequal technological development, where the least favoured countries will be on the fringes of such technology, and this, according to the experts, could redefine the international division of labour, with clear disadvantages for the poor countries, whose exports are based on raw materials or on the low cost of their workforce (Foladori, 2005). We are facing

processes of national and social polarization which we thought overcome and we have only started to glimpse its social impact on the concrete social reality, which shows a tendency to the concentration of wealth in the hands of a few and the increasing impoverishment of the large world majorities.

We can see that there is an urgent need to design normative frameworks for the development of products based on this technology, so as to protect the global population. The development of regulations need to include not only a focus on the technical concerns regarding nanotechnologies but also the socio-cultural concerns. It is vital that future studies focus on the ethical aspects of the development and applications of nanotechnologies with continued research into cultural and socio-economic impacts and only then will we really begin to understand and overcome these potential risks.

6. BIBLIOGRAPHY

Agyei-Mensaha, S. and Oteng-Ababioa, M. (2012), "Perceptions of health and environmental impacts of e-waste management in Ghana", in International Journal of Environmental Health Research, Volume 22, Issue 6. pp 500-517.

Altman, J. and Gubrud, M. (2004), Anticipating Military nanotechnology. IEFFF Technology and Society Magazine. Numero editado por E.J. Woodhouse, vol. 23, núm 4. pp. 33-40.

Bolonkin, A.A. (2009), "Femtotechnology: Nuclear Matter with Fantastic Properties", in American Journal of Engineering and Applied Sciences, Volume 2, Issue 2, Pp 501-514.

Bourdieu, P. (1998), La domination masculine. Paris: Éditions du Seuil.

Castro, F. A. (2012), Nanotecnología, cltura y sociedad:ética y desarrollo sotenible: IX Encuentro Internacional de Intelectuales y Artistas en Defensa de la Humanidad. Rio de Janeiro, pp.1-25.

Chaparro, E. (2001), Nanotecnología, secretos ocultos e inmortalidad: REDcientífica. España. ISSN: 1579-0223.

Fanon, F. (1952), Piel negra, máscara blanca: Editorial Abraxas, Buenos Aires. pp. 192

Foladori, G. and Invernizzi, N. (2005), Nanotecnología, ¿beneficios para todos o mayor desigualdad?: International Nanotechnology and Society Network, pp. 1-16.

Karkare, M. (2008), Nanotechnology. Fundumentals and applications, IK-International Publishing Hause, New-Delhi.

Madeley, J. (1999), Big Business, poor people. The impact of transnational corporations on the world's poor. Londod, Zed Book.

Matthew Rimmer, A. M. (2012), Cosmo, Cosmolino: Patent Law and Nanotechnology. In: A. M. Matthew Rimmer, ed. *Intellectual Property and Emerging Technologies: The New Biology.* Cheltenham: Edward Elgar Publishing Limited, pp. 255-292.

Ortiz Sánches, S. and Vargas Hernández, J. (2013), Análisis del capital reputacional de la innovación tecnológica cuestionada. Caso Monsanto, RAGC, Brasil, V.1, Num.2, pp.67-86.

Peterson, C. L. (2004), Nanotechnology: from Fenyman to the Grand Challenge of Molecular Manufacturing: IEEE Technological and Society Magazine, 23 (4), pp. 9-14.

Quintili, M. (2012), Nanociencia y nanotecnología... un mundo pequeño, Cuaderno 42, Centro de Estudios en Diseño y Comunicación. pp 125-155 ISSN 1668-5229.

Schummer, J. (2005), "Societal and Ethical Implications of Nanotechnology: Meanings, Interest Groups, and Social Dynamics", in Techné: Research in Philosophy and Technology, Joseph C. Pitt (ed.), Vol. 8, no. 2 (Spring)

UNESCO. (2007), Ética y política de la nanotecnología: Organización de las Naciones Unidas para la Educación y la Cultura. pp. 27.