Journal of Applied Sciences Research, 9(5): 3396-3401, 2013
ISSN 1819-544X
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Nanotechnology: A Technology for All Seasons

Iman Ghasemi, Omid Attarnezhad & Mohammd Reza Hosseini

Faculty of Management, Universiti Teknologi Malaysia (UTM), International Campus, Kuala Lumpur, Malaysia

ABSTRACT

Nanotechnology or nanotech allocates a variety range of problems and opportunities; not only different issues, but also different types of issues. This paper provides a quick overview of the problems and advantages created by nanotechnology, and demonstrates the claim that a wide range of ethical systems will be essential to deal adequately with different issues elevated by nanotechnology. It begins by debating the authority of nanotechnology as a technology, and then canvasses the risks that may be created by nanotech, and restates the need for the conscious development of collaboration between diverse organizations and fundamentally different ethics. Moreover, some prognostications about the social results of nanotechnology and the ethical issues it raises are discussed in the present paper. We set out features of nanotechnology that are necessary in deciding on its effect and dispute that nanotechnology will have consequential social impacts on, at least, the regions of health and medicine, the stability of power between governments and citizens, and also citizens and corporations. We also may pose philosophical questions about the sort of society we wish to make and the function that technology might play in it. This in turn will require developing institutions and processes that allow the public to wield real power in relation to technological trajectories. Our ultimate contention is that the immediate task established by the likely social impacts of nanotechnology is not so much to develop an ethics of nanotechnology that facilitates an ethical conversation about nanotechnology.

Key words: Nanotechnology, Nanotech, Technology, Guardian System, Commercial System

Introduction

The National Science Foundation defines nanotech as research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometer range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size. Just given the basic premises of nanotechnology, we can imagine the vast potential of this technology. Some of its more prominent benefits are in manufacturing, medicine and environment. With nanomachines, we can better design and synthesize pharmaceuticals; we can directly treat diseased cells like cancer; we can better monitor the life signs of a patient; or we can use nanomachines to make microscopic repairs in hard-to-operate-on areas of the body. With regard to the environment, we can use nanomachines to clean up toxins or oil spills, recycle all garbage, eliminate landfills, and reduce our natural resource consumption.

Nanotech will also have a large impact on the most mundane products. Carbon nanotubes (Buckytubes) are many times as strong as steel, and can also be used as wires, computer switches, chemical sensors, heat conductors, and for storing hydrogen. Silicon nanocrystals do interesting things to light; they can be used for biotech research, optical computing, and to make more efficient light bulbs. Nano-sized aluminum powder makes a better rocket fuel. Zeolites, materials with nano-sized holes, are useful in all sorts of industrial processes. The list goes on and on because every time we study something at the nanometer scale, we find new effects that are often amazingly useful, both for new products and in existing products. Even if we ignore the nano-robot scenarios, we will see unprecedented improvement in many of our current technologies, including computers and weapons. Even the conservative opinions about nanotechnology sound like a new industrial revolution.

The flip side to these benefits is the possibility of assemblers and disassembles being used to create weapons, be used as weapons themselves, or for them to run wild and wreak havoc. Other, less invasive, but equally perilous uses of nanotechnology would be in electronic surveillance. Weapon is an obvious negative use of nanotechnology. Simply extending weapon capabilities by miniaturizing guns, explosives, and electronic components of missiles would be deadly. However, by nanotechnology, armies could also develop disassembling to attack physical structures or even biological organism at the molecular level. A similar hazard

Corresponding Author: Iman Ghasemi, Faculty of Management, Universiti Teknologi Malaysia (UTM), International Campus, Kuala Lumpur, Malaysia
E-mail: mani_sengani@yahoo.com

would be if disassembling gets loose in the environment and started disassembling every molecule they encountered

Furthermore, if nanomachines were created to be self replicating and there was a problem with their limiting mechanism, they would multiply endlessly like viruses. Even without considering the extreme disaster scenarios of nanotechnology, we can find plenty of potentially harmful uses for it. It could be used to erode our freedom and privacy; people could use molecular sized microphones, cameras, and homing beacons to monitor and track others.

The commercial and guardian systems have developed a distinct and identifiable set of ethics. These ethics can be found in governments, police departments, and a variety of commercial organizations. The information ethics are a synthesis of the work of several authors. If you are not familiar with any organizations that operate by creating information and then giving it away, think of the friends who are avid hobbyists; chances are that they have written articles or put up web sites without being paid.

Reducing the Risks of Nanotechnology: Guardian Systems:

Today's supercomputers can be used for tasks of military significance, such as simulating nuclear explosions and cracking codes. These computers may be integrated with devices of varying degrees of sophistication, but a near-magical surveillance technology could be packaged into a tiny device. Even the mundane types of nanotech products may need to be controlled.

The more extravagant suggestions, such as "*gray goo*", can get quite scary. *Gray goo* is a kind of nanodevice that takes in biomass and turns it into copies of the *gray goo* device. In theory, if such a device was not countered, it could eat the biosphere. Fortunately, the design of such a device would be quite difficult. Furthermore, devices of the *gray goo* class would have no commercial or even military use, since more specialized non-replicating devices would be far more efficient. It is thus highly unlikely that anyone would build a *gray goo* or device that could run amok and become *gray goo* by accident. Also, military or commercial organizations would have little interest in building such a thing on purpose. However, the prevalence of computer viruses indicates that some people build things like this for fun.

Nanotech will provide benefits that are simply too good to pass up, including environmental repair, clean, cheap, and efficient manufacturing, medical breakthroughs, immensely powerful computers, and easier access to space. Of course, innovation will be necessary, but it must occur outside of the Guardian mindset. This is one of several reasons why a Guardian-only solution such as attempting to outlaw nanotech research cannot work. Instead, the guardians must be willing to allow a broad range of innovation, carried out by more than one type of organization, and then adapt the most suitable technologies to do their work.

Nanotechnology for Profit: Commercial Systems:

"Be thrifty. Be optimistic. Be efficient. Be industrious. Be honest". No, it is not the Boy Scout Oath; it is a few of the commercial ethics. Commercial organizations will work very hard to give people what they want or what they will pay for, which is frequently the same thing. If a product needs to be developed to satisfy a market, some companies somewhere will probably be working on it. Money can be a great incentive.

Commercial organizations must compete, but they are not allowed to use force-that is reserved for Guardian organizations. Therefore, they try to make their products better, and sell to more people. They are willing to invest in developing products, and making them easier to use, and making consumers aware of them. They are accustomed to collaborating and innovating, and to making and keeping contracts. Nanotechnology encompasses hundreds of new technologies, many of them quite specialized and quite useful. The development of all this potential requires an incentive. Moreover, commercial organizations will use the incentive of money to bring the benefits of nanotechnology to a wide swath of the population. Without the commercial system, many applications of nanotech would not be developed quickly. Long-term benefits, like hidden costs, are largely ignored by the commercial mindset.

Unlimited Benefits of Nanotechnology: Information Systems:

The invention of writing allowed information to be stored for later use, and even copied verbatim. The printing press made the copying process much easier and gave many more people access to the information. Computers, with networks and word processors, have reached another level. The cost of copying information is virtually zero. You can write a book yourself. Then email it to all your friends or put it on a web site for the whole world to see. It is only a matter of time until the manufacture of products becomes as cheap as the copying of files. Nanotechnology will help this process along, because the first practical self-duplicating factory will almost certainly be designed on the nanometer scale. A tabletop model might weigh two pounds, and use methanol as a raw material. The amount of methanol required to produce a new factory would cost less than a

dollar, and a well-designed factory could process that much material in an hour or so. Once one such factory exists, it and its copies can be used to make an unlimited number of tabletop factories that are cheap enough to give away. Building a new product would be as simple as emailing its blueprint to the factory which might be sitting beside your computer. Of course this would only be possible if the factories were not restricted to prevent their making free products.

Building a Nanotech Society: A Balance of Power:

Nanotechnology presents a large range of new problems and new opportunities. Commercial and information groups cannot be trusted to take appropriate precautions in every case, so a guardian approach is sometimes necessary. Likewise, guardian and information ethics do not create money; thus, commercial organizations must be involved in paying for large parts of the development and deployment of the technology. Finally, although guardian ethics include dispense largesse, neither guardian nor commercial organizations can be expected to create and distribute the almost limitless benefits that will be possible from vastly improved materials and manufacturing.

Ideally, each organization involved in nanotechnology would be aware of its own ethics and the ethics of the organizations it interacts with, and make good decisions about which problems to tackle and which problems to leave for someone else. In practice, of course, organizations are usually not so self-aware, and even when they are short-sighted, self interest may tempt them to expand into areas where they have no competence. In the end, an organization that overreaches itself will find that its plans do not work; it will make ineffective and antisocial decisions, and will be out-competed by its fellow organizations and attacked by those it has encroached on. However, such a process may take much time and cause much destruction. Nanotechnology will be developed too quickly for such slow adjustments. If an organization manages to usurp power in an area where it does not belong to, and hold that power for even a few years, it may create an imbalance that tempts a radical and destructive solution. For instance, if no institution takes responsibility for forcibly preventing the worst abuses of the new technology, commercial liability will act to reduce the risks of any given design, and this may prevent disaster for a while. But as nanotech becomes more accessible, more pervasive, and more powerful eventually a security hole or design flaw will cause a breakdown and a vulnerability that can be exploited.. Likewise, if no institution is allowed to distribute nanotech-related information and products freely, clandestine and foreign institutions will spring up to do the job through creating a massive exchange of pirate designs and a security liability. If commercial activity is overly restricted by guardian interests, a black market will form.

Most organizations that attempt to deal with nanotech will not know why they act as they do or why they cannot successfully address certain problems. If not constrained externally, they will try and fail, perhaps creating significant waste or even tragedy. Yet the organization, the government, that normally does the constraining is itself limited in its ethics and its understanding of them. The design of our government includes many provisions, such as free interstate trade, that promote commercial activity. It even includes some activities, like the patent system, that promote sharing of information (although with a commercially significant incentive that limits the utility of the information). A century ago, the information ethic could be found largely in the scientific research community, which did not interact directly with commercial activities. More recently, however, the patent system appears to be supporting commerce more than information by granting a flood of poorly-evaluated patents. Furthermore, scientific research has also become more closely tied to commercial endeavor.

Ethical Issues of Nanotechnology:

In the 1980s, nanotechnology was considered as a revolutionary scientific and engineering venture that would invariably impact the existing infrastructure of consumer goods, manufacturing methods, and materials usage. Not surprisingly, those potential benefits have dominated scientific and mass media coverage of nanotechnology. However, any technology can be a double-edged sword, and environmental and safety concerns pertaining to the consequences of the development of nanotechnology only recently have been discussed in the mainstream media. The invisible nature of nanoscale materials has fed fears that nanotechnology will lead to a significant invasion of privacy. Prospects of micro locomotion, autonomous operation, and self-replication have fueled additional concerns that such a technology could spin out of control with dire consequences for society. The initial ethical issues associated with nanotechnology have to be identified along with discovery and development as it changes human lives and the way the world is. One needs to keep in mind three things before discussing ethics vis-a-vis nanotechnology:

First, as with any technology, there is nothing intrinsically good or bad about nanotechnology, it all depends on how it is used. Thousands of years ago, ancestors found that fire was good for staying warm, for sterilizing food and making it tastier, only to find out later that, it could also burn people, torch their houses and

ruin their crops. The initial purpose of most new technologies is always sound. However, often they are later found to have negative aspects as well. Therefore, when one explores ethical aspects of a new technology, it is wise to focus on the potential ill uses and negative side effects of the technology, in hope of identifying preventative measures.

Second, when it comes to discussing ethical issues in nanotechnology, they overlap with those of other technologies, including information and biotechnology technologies. As mentioned before, nanotechnology is diffused into all industries, the boundaries between technologies are collapsing, and the most advanced countries are focusing on fusing different technologies, especially information technology, biotechnology and nanotechnology. Nevertheless, a study of nanotechnology's ethical, environmental, economic, legal, and social implications are lagging far behind the science.

Third, when one talks about ethics, it has different definitions for all individuals, and, in a broad sense, all nations. People perceive ethics with different weight based upon cultural background, people's belief systems, traditions, developmental growth, etc. Ethics has a lot to do with one's and the nation's moral philosophy. Hence, ethical perspectives on the development of science and technology can be influenced by family values, educational background, social learning, professional activities, religious beliefs, and individual needs. Therefore, ethical perspective is not something that is grasped at once, but grows with education, exposure and indirect/direct experiences. It takes time to gain ethical insights and grow one's own ethical views on the various issues derived from the development of science and technology. This is achieved through constant self-inquiry, and exploration of potential outcomes and their justifications. Until now, priority has been for development firstly, and ethical issues have been largely ignored. However, with time, many scientists, educators and researchers are identifying the need to look into the pertinent ethical issues of development.

Recommendations for Reinforcing Ethical Issues:

It is always better to go through the exercise of formulating solutions to potential ethical issues before the technology is adopted by society. An examination of ethical issues can prevent some negative consequences of nanotechnology that may arise; therefore, the ethical aspects discussed in this paper and potential solutions are based on the exploration, rather than actual implementation of any particular strategy. This task gives a starting point for an examination of the ethics of developing nanotechnology, and attempts to come up with appropriate policies that will aid in its development, so as to eliminate, or at least minimize damaging effects on society.

Developing Ethical Reasoning as a Grounding Task:

In most disciplines, education has progressed by establishing a foundation and then building pyramids of knowledge step by step. This has promoted enhanced departmentalization in academia, thus allowing each field imprinting its own way of thinking on its scholars. The attitude towards ethics may be different depending on cultural background and one's personal belief system. It is important to establish one's own philosophy on ethical thoughts as a grounding task, and gradually learn to engage the social effects of the technology that surrounds in daily lives. The daunting challenge of exposing students and prospective scientists to relative ethical issues is not an easy one. However, educators must be aware of what is required to prevent detrimental effects of technology, including the fostering of critical perspectives and logical reasoning of consequences, problem solving skills, and the ability to draw an ideal boundary between what is desirable and what is achievable in the technology. Developing a sense of ethics and individual perspectives should start as early as possible. What is presented to students has to reflect a balance between gain and loss based on their own philosophical stance.

In order for this to happen, secondary school teachers, counselors, and administrators also must be educated to formulate effective teaching strategies on ethics education. They have to be able to effectively present clear and thorough pictures of what science and technology can bring to human lives in both positive and negative lights. Early exposure of ethical concepts and their relevance to life should help to develop insights on deciding what is appropriate or not, when it comes to humans vs. technology.

Ethical Dialogue:

Around the world, ethical issues are dealt with much less than other issues related to science and technology development, which has played an important role for industrialization. Nonetheless, this leads to lack of dialogue on ethical quandaries and sound solutions. Therefore, dialogue between research institutes, granting bodies, and the public on ethical issues may be helpful. All aspects of development and its results need to be explored from different professional viewpoints. Initiating ethical dialogue is important in order to stimulate people's perspectives, and increase knowledge of potential dangers. One cannot separate the scientific, economic, education and industrial interactions. However, the intent should be to work in a collaborative effort

to meet the common goals of all concerned. Involvement of this kind will enable ethicists to consider whether there is a different belief system between those who have caught the vision of a world shaped by nanotechnology and those who have not. The need exists for an innovative mechanism to encourage professionals and industries to be aware of ethical consequences. For example, in order to provide medical care in an ethical and humane way, physicians need to be better educated about specific aspects of ethical medical practice. Routine bioethics education for medical students and resident physicians, and continuing medical education for practicing doctors should exist to accomplish this.

Education on research into ethical, legal and social issues needs starting as early as possible. This can be implemented at the university level. However, it can also be reinforced via research at all levels – from undergraduate summer students to graduate students, postdoctoral fellows, junior faculty and senior investigators. This can be done by presenting career awards, training grants and emphasizing the development of highly qualified personnel in large-scale grant applications. Capacity strengthening should also include different sectors and developing countries. Along with national growth, increasing comes in a variety of research grants and government funds available for research.

Specific guidelines and regulations to prevent misuse of nanotechnology should be formulated with participation of non-governmental organizations (NGOs). NGOs need monitoring the rapid development of science and technology and to make improvements in environmental and human-friendly science by taking part in policy-making, execution, and evaluation in science and technology – fields dominated by government, businesses, and the science and technology elite. NGOs should develop models to activate civil participation in science and technology policy-making. They should enable the public to access reliable and understandable information on technological innovations, and be able to participate in public and private decision-making concerning technological developments and their implementation. There should be a specific NGO assigned to work with ethical concerns of technology development. Rapidly growing investment in the field calls for emphasizing the role of civil watchdogs for nanotechnology-related policy and research for government and business. At the moment, NGO's in Asia deals with reported issues other than ethical ones. As of now, not many ethical issues have emerged. There is a need to activate civil participation in social arguments on the enactment of laws to reduce the risks inherent in modern science and technology, particularly, in nanotechnology.

Conclusion:

There are many strategies to formulate effective solutions for ethical concerns in nanotechnology. First of all, understanding the overall importance of ethics is the grounding job. One's ethical perspective is based on one's philosophy and personal belief system. Therefore, developing a sound belief system is an important task for education beginning at a very early stage. School education can include ethics classes to stimulate students to develop insights on what ethics is all about and how it relates to human lives. Another way of reinforcing ethical thought and education would be ethical dialogue between different parties and countries both at the national and international level. At the national level, scientists, researchers and the public should communicate in terms of how the outcome of technology development influences humans living. Internationally, voices of advanced countries and beginners in nanotechnology should exchange views. Expert advice should be shared about how to prevent predicted negative outcomes and where to draw the line in terms of how far to go with the technology. At the national level, non-government organizations can play an active role in doing research. At the public level, science museums and centers can play an effective role in educating students and citizens in terms of how best to introduce various sides of science technology related to humans.

References

Allen, G., 2005. The Economic Promise of Nanotechnology. *Issues in science technology*, 21(4): 55-56.

Arnall, A., 2003. *Future Technology, Today's Choices Nanotecchnology, Artifical Inteligence and Robatices; A Technical and Political and Institutional Map of Technologies*. Green peace Enviromental Trust. London, UK.

Scheufele, D.A., E.A. Corley, T.J. Shih, K.E. Dalrymple, & S.S. Ho, 2008. Religious Beliefs and Public Attitudes toward Nanotechnology in Europe and the United States. *Nature Nanotechnology*. 4: 91-94. DOI: 10.1038/nnano.2008.361

Fisher, E., 2007. The Convergence of Nanotechnology, Policy and Ethics. *Advances in Computers*, 71: 273–296. DOI: http://dx.doi.org/10.1016/S0065-2458(06)71006-3

Fisher, E., 2007. *Social and Policy Issues in Nanotechnology*. Unpublished Note, 5th CINT User's Workshop Albuquerque, NM, 16-17.

Lewinski, N., 2005. *Nanotechnology Policy and Environmental Regulatory Issues*. WISE Intern Rice University. Agust 1, 2005, Washington,1-37.

J. Appl. Sci. Res., 9(5): 3396-3401, 2013

National Science and Technology Council, 2007. *The National Nanotechnology Initiative*. Washington, USA: Office of Science and Technology Policy.

Phoenix, C., 2002. Ethical Administration of Nanotechnology. Nanotechnology News. Retrieved from http://www.nsf.gov/home/Grssprogm/omb_nifty50htm

Phoeix, C., & M. Trader, 2003. Three System of Action: A Proposed Application for Effective Administration of Molecular Nanotecchnology.

Pritle, Z., 2007. *Democratization Nanotechnology: Intersecting the Philosophy of Science and Science Policy.* Unpublished PhD Dissertation. The Barett Honors College.

Rikowski, R., 2004. *Teaching Ethical Issues in Information Technology: How and When*. Unpublished PhD Dissertation. London South Bank University, UK.

Shapirn, P., & J. Wang, 2008. *Monitoring and Analysis of Polices and Public Financing Instrument Conductive to Higher Levels of R&D Investment: The Policy Mix Project.* Technology and Innovation Policy Georgian of Technology. University of Manchester, UK.