Trends in Nanotechnology Knowledge Creation and Dissemination

Nazrul Islam, Cardiff University, Cardiff, UK

ABSTRACT

This article explores trends in nanotechnology knowledge creation across scientific disciplines and technology domains, and helps to understand the dissemination of nanotechnology knowledge. In relation to intense global competition in nanotechnology, this study exhibits a forward-looking approach in characterizing nanotechnology research and development trajectories. This research adopts hybrid research methodology, including both quantitative and qualitative methods. The findings imply that nanotechnology knowledge creation and dissemination trends have appeared to bridge divergent disciplines, emphasizing the importance of collaborative research networks among scientists to co-create, share and disseminate nano-knowledge across groups, institutions and borders.

Keywords: *Hybrid Research Method, Nano-Knowledge Creation, Nano-Knowledge Dissemination, Nanotechnology, Scientific Disciplines*

INTRODUCTION

Nanotechnology comprises one of the fastest-growing research and development areas in the world (National Science and Technology Council 2006). Like many areas of scientific and technological exploration, nanotechnology exists on the borders between disciplines including physics, chemistry, materials science, biology, medicine, ICT and engineering. It has been nearly half a century since Nobel Prize winner Richard Feynman advocated widespread nano-scale research by delivering his famous speech "There's plenty of room at the bottom" in 1959, through which the nanotechnology concept first captured the world's attention. Nanotechnology is a field prioritized and promoted by governments worldwide and is a subject of importance in all basic science and engineering fields, for sustainable economic development and has potential to provide comfort and safety for people everywhere. Nanotechnology is regarded as an evolutionary field which emerged from the increased miniaturization of microelectronics and microtechnology in research, development and innovation. It can be predicted that in the coming era, nanotechnology will play a central role in a variety of industries and key technologies, in areas of strong societal need, such as energy (e.g. fuel cells, solar, nuclear), biotechnology and medicine (e.g. drug delivery, tissue replacement, directed therapies), information and communications technology (e.g. pervasive computing, data storage, leisure, personal communications) and water and environmental remediation (Roco 2002). In the near future, it is

DOI: 10.4018/ijnmc.2013100104

likely that this small scale technology will have the ability to fundamentally change the way almost everything is designed and manufactured, from automobile tires and tennis racquets to air purifiers and life-saving vaccines[1].

As a science based innovation, nanotechnology represents a multi-disciplinary field of research and development since it requires multi-disciplined networked research (Meyer and Persson 1998; Islam and Miyazaki 2009), education and an improvement in the level of human skills performance; it also requires input from, amongst others, chemists, physicists, materials scientists, biologists, engineers and pharmacologists. No clearly defined boundary for nanotechnology has surfaced due to its nano dimension, which randomly affects various technological domains and scientific disciplines. As it concerns a field on the cutting edge knowledge in practice, this study explores trends in the development of knowledge in order to gain a better understanding of the process of knowledge creation and dissemination in the emergent nanosciences and nanotechnologies. In particular, it seeks to ascertain how nano-knowledge has been co-created across disciplines and domains, and seeks to understand the attributes that are likely to enable them to be disseminated.

The rest of the chapter is structured as follows. This introduction is followed by a brief explanation of nanotechnological research approaches and their characteristic differences to other advanced technologies. A hypothesis and a research framework for nanotechnology knowledge creation and dissemination are proposed and the research has been carried out to prove it by a thorough analysis using both quantitative and qualitative data.

CHARACTERISTIC DIFFERENCES OF NANOTECHNOLOGY

Nanotechnology is a field of scientific constellation and practice in which different scientific disciplines are involved and new knowledge is produced for the sciences involved, as well as for society as a whole. Significant developments in nanotechnology are spreading across the diversified fields of ICT (for faster and smaller processors, higher-density data storage), medicine (for faster drug development, quicker diagnosis, improved drug delivery, better prosthetics), the environment (for pollution control, water purification and clean energy) and materials (for stronger engineering materials, better catalysts, coatings, paints and lubricants, and improved surface properties like scratch-resistance and optical switching) (CRISP/OST Foresight 2001). The decisive factor is that new functionalities and features for the improvement of existing products or the development of new products and application options result from the nanoscalability of the system components alone (Malanowski et al 2006). These new effects and versatile application possibilities are predominantly based on the ratio of surface to volume in atoms and on the quantum-mechanical behavior of the elements of nanomaterials.

It should be noted that all nanotechnological research is geared to two basic strategies, (a) the *'top-down' approach*: miniaturization techniques – decomposition into the smallest manageable entities starting from micro-technology by using techniques (e.g. energy beam and mechanical micro-machining, electro-physical and chem-processes, lithographic methods) that are particularly predominant in physics and physical technology; and (b) the *'bottom-up' approach*: building macrostructures – allowing for the re-engineering of materials at nano-level by using techniques (e.g. assembling, imprinting, electrostatic techniques, laser trapping, sol-gel, colloidal aggregation) that primarily feature in chemistry and biology. Figure 1 illustrates a snapshot of the *top-down* and *bottom-up* processes. The introduction in the market of nanotechnology applications has already occurred and its industry applications are vast and diverse, as materials can be transformed on a very small scale. Virtually all today's commercial nanotechnology is provided by the adoption of the top-down