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## Teaching Nanoscience and thinking nano at the macroscale: Nanocapsules of wisdom

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### Abstract

One of the challenges for Nanotechnology is education, which is considered as a bottleneck for Nanotechnology development and implementation. This work contributes to nanoscale education by designing a wide variety of cutting-edge documentaries which assist high-educational level students in learning the underlying concepts of Nanoscience, the last advances and future prospects. In addition, documentaries seek to bring and disseminate the scientific activity of Nanotechnology to society. In this sense, the secondary goals of the proposed approach nanotech activity are: 1) Transfer of knowledge generated in the nanotechnology field and 2) The promotion of scientific culture and innovation between the public objectives. Based on the results observed in students' assessment and You Tube metrics, it was concluded that the developed of nanoscale based documentaries enabled a fast and efficient comprehension of complex concepts related to Nanoscience and Nanotechnology. In addition, the opinion of You Tube audience is highly promising and shows that You Tube and documentaries are an excellent channel to disseminate Nanoscience to society.

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## 1. Introduction

Nanoscience and Nanotechnology refer to the study, manipulation, engineering and application of matter, particles and structures on the nanometer (nm) scale ( $1\text{ nm}=10^{-9}\text{ m}$ ). Important properties of materials, such as the magnetic, electrical, optical, thermal and mechanical properties, are determined by the way molecules and atoms assemble at the nanoscale. Nanoscience and nanotechnology are at the forefront of modern research and they are considered the new revolution for 21<sup>st</sup> century.

Nanoscience education is still emerging, and unlike other areas of science education, there are some gaps to fill about how to teach the crucial ideas of Nanoscience and Nanotechnology (Blonder, 2012). It must be promoted new developments in nanoscience education materials as well as research into how graduate or even PhD students best learn nanoscience concepts to succeed in teaching the basics of nanoscale (Greenberg, 2009).

The continuous advance of nanomaterials science and its unprecedented application in more than 1800 nanotechnology-based consumer products, indicate that nanomaterials are crucial to develop new applications: biological tagging, medical diagnostics and treatment, solar energy harvesting, catalysis and electro-optical applications. Then, given the expected economic and social impact of nanotechnology products and the fact that many areas of application are still scarcely explored, it can foresee that industrial use of nanomaterials will continue to increase in future. However, one of the 'grand challenges' for nanotechnology is education, which is considered as a bottleneck for the development and implementation of the field (Roco, 2003). It is even foresee the situation where we may have the research results for new nanoapplications but without having skilled workers to translate them out of research centers (Roco, 2003).

Nanoscience and nanotechnology scientific disciplines are situated at the interface between physics, chemistry, biochemistry, biotechnology, materials science, medicine, microelectronics and computer science. Control of these disciplines therefore requires an academic and multidisciplinary scientific education. Then, it seems reasonable that a multidisciplinary scientific education is crucial to provide industry and research institutes with top quality experts. However, the physical infrastructure in nanoscale science is still in formation, being the multidisciplinary education one of the bottle necks (Roco, 2003). In general, the students use to have difficulties to understand the underlying scientific principles that lead the unique properties at the nanoscale (Muniz, 2014). And, what is more important, teachers also have difficulties in implementing high quality nanoscience and nanotechnology educational material to produce a deep understanding of nanoscience concepts (Greenberg, 2009). Considering the previous facts, there is a need of both thinking small and providing educational tools to assist in the knowledge transfer.

Online videos are considered to be useful in areas of science where records of complex laboratory demonstrations, or physical/chemical phenomena might be more effectively communicated than would prose (Kousha, 2012). For instance, the use of images and documentaries and the ability to share them through the World Wide Web has revolutionized scientific procedures, enhanced our ability to discover new things and offered new opportunities for education (Pasquali, 2007). Video is a valuable teaching tool because it can be used to show students things that would be otherwise hard to transfer in a limited period of time. In fact, an increasing number of scientists uses video to present their results at scientific meetings, during lectures or in their publications as online supplementary material. Then, it seems clear that the use of movies to understand the concepts and phenomena occurring at a world where the scale is far beyond our dimensions could ease Nanoscience teaching.

Consequently, this work has the main goal of contributing to nanoscale education by designing a wide variety of cutting-edge documentaries, named "Nanotechnology capsules", which assist high-educational level students in learning the underlying concepts of Nanoscience, the last advances, as well as the future prospects in new topics ranging from properties of nanomaterials to their societal impacts. In addition, "Nanotechnology capsules" seeks to bring and disseminate the scientific activity of Nanotechnology to society. In this sense, the secondary goals of the proposed approach nanotech activity are: 1) Transfer of knowledge generated in the nanotechnology field and 2) The promotion of scientific culture and innovation between the public objectives.

Next, it will be described the methodology applied and the most interesting information about the Nanotechnology capsules and their educational benefits.

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