

## ***Nanotechnology Education***

Universities such as Rice, Harvard, MIT and Cornell offer nanotechnology specializations at the graduate level. A full Ph.D. in nanotechnology is available from the University of Washington. In the UK, Cranfield and Leeds offer a Masters of Science in nanoscience and nanotechnology and in Australia, Flinders and the University of New South Wales offer a Bachelors of Science, just to name a few.

However, is it really feasible or necessary to offer a degree in nanotechnology? Nanotechnology represents the interdisciplinary nexus of all the science and engineering disciplines. What are they going to teach that is not already taught in other science disciplines besides a class introducing new nanomaterials?

How can you teach someone all the scientific disciplines at the graduate level? A student could be in graduate school for over 10 years. A minor in nanotechnology would not be as feasible as a minor in math or composite materials. A nanotechnology degree would demonstrate no more proficiency in understanding nanotechnology than having a comparable level physics or chemistry or engineering degree at either the undergraduate or graduate level.

Perhaps it's time to start teaching science with a completely different and interdisciplinary approach? This is necessary because Nanotechnology is not a specific discipline. It is an integrated way of observing and understanding behavior, all types of behaviors (electronic, chemical, physical, biological, mathematical, etc.), on the nanometer scale. Being able to observe nanoscale phenomenon shows these behaviors can now be seen to be more obviously interrelated.

Something interesting to note is that many university professors focusing on nanotechnology have teaching titles in two, seemingly to us, different departments. For instance, Naomi Halas is both Professor of Chemistry and Professor of Electrical and Computer Engineering at Rice University. She is also co-founder of Nanospectra Biosciences Inc, which is a nanotech company which could be also classified as a biotech company focusing on using gold nanoshells targeting and killing tumor cells. This is what nanotechnology is all about.

Offering a nanotechnology degree program is a great way to market to and attract potential students who will pay tuition. If it gets students interested in studying nanotechnology, I am not too hard pressed to complain...much. We don't have to call it a nanotechnology degree or major or minor but it is more attractive. A Nanotechnology degree program could be a traditional science and or engineering degree program with a focus on nanotechnology. This could mean that you would repackage the course requirements to include other departments.

Of course, all of us should be already exposed to basic math, chemistry, biology, and physics in our K1-12, shouldn't we? I was helping two bright K1-6 kids with their math homework when I made some interesting and distressing observations. One was an 8 year old who still didn't know their times tables and was about to embark on learning division. Upon further examination, this student was still counting on fingers for addition and subtraction. The other time was with an 11 year old who I found out could not understand a simple word problem that had to do with how many rolls of wallpaper would be needed to cover a room with certain dimensions. The student didn't understand how to apply what they had learned in math to solve a problem. These types of problem solving skills are necessary for understanding science. You cannot do much of the sciences without the math skills. I did not dig any deeper with regard to how well they really knew their sciences because I was afraid to find out how really bad it could be. What is happening to these children who are falling through the cracks in our education system? This was alarming indeed and probably not the first time these issues have been raised.

This is not to expect that all children will win science fairs and end up with PhD's in Physics, but a significant portion of them will become the investment bankers, venture capitalists, sales and marketing people, teachers, etc. who will be the enablers of nanotechnology breakthroughs to society. They will be the ones in the value chain to bring the improved products and lifestyle to be accepted by the consumer

market in the future. It is these same people who, with better grasp of basic science and math, will embrace responsible investments in nanotechnology.

In addition, the science industries do not pay as well as other occupations and is still having problems retaining its most gifted students. I've seen many a gifted Princeton PhD in Theoretical Physics go to Wall St. This is partly because of more attractive salaries but also because of the lack of positions available for them in academia. For even the most gifted students, the attraction to non-science majors is greater so the brain drain is still happening.

Perhaps even more basic is our responsibility to teach our children to think. This comes about by encouraging their questions and helping them to find the answers when we cannot answer them. It becomes just as important for the scientists to remember to question themselves since they are human and must remember they can be wrong. Richard Smalley, Nobel Prize winning physicist for discovery of fullerenes or buckyballs, advised young aspiring scientists that "the main thing you need to learn is doubt. Don't believe anything you're told without good reason and argument. Doubt underpins science." The type of doubt Richard Smalley is talking about advances science by making us question everything and everyone; it is a healthy skepticism. Sir Harald Kroto, who also shared the Nobel Prize with Smalley, said, "The key is to ask the right questions and check the answers."