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Challenges and Opportunities

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Education Solutions to Prepare Students and expand the knowledge base in Developing Countries for Nanotechnology Opportunities

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Unifying Science and Education to Improve Human Performance in Developing Countries

Group 2

Evaluation of Current Nano Education in Developing Countries

The first step in the process will involve an evaluation by the Developing Countries of the current state of nano education in universities. Upon completion the information will be required for the online DATA BASE to be developed by ICS.

This will lead to the second step of research in their countries of current industries to determine supply and demand markets of prospective niche products that their current workforce could be trained to handle. This information will also be required for the online DATA BASE.

- Participating countries will provide a status report of their current course syllabus for nano science and applications which will be housed on an Interactive Internet Database.
- Participating countries will research current industries and workforce capabilities; look for supply and demand markets of prospective niche products for nanotechnology for Internet Database.

Short Term Solutions

Primary Solution #1: Education Workshops for Industry:

Upon reviewing the DATA BASE from each country, ICS can then proceed with the development of Education Workshops to introduce Nanotechnology to the top tier industries identified by each country. The workshop materials will be developed for the leaders in each country to handle the presentations, empowering them in communication skills with industry.

- Workshops will be developed for participating countries to explain nanotechnology niche opportunities to local industry.
- Partnering efforts to develop a specific research inquiry for a nanotechnology application that will fill the needs of local industry will be established by universities through the expertise of UNIDO and ICS.

Primary Solution #2: Technician Training

Participating universities in developing countries must take the lead to communicate with the identified industries in step one to establish skill levels necessary in the training of a local workforce. ICS will develop forms that can be used for this effort. ICS will also provide their expertise and guidance to developing countries based on the findings.

- Participating Universities will communicate with industry management to establish skills levels to train a local workforce for an application of nanotechnology which has been identified.
- UNIDO ICS will provide expertise and guidance to develop workforce technician training based on these findings.

Primary Solution #3: University Integrative Courses

UNIDO ICS will provide experts in various subject areas identified by the developing countries and offer to conduct teacher/student workshops for developing the new courses as identified. They will also provide fellowships to junior staff members from participating countries who wish to undergo training of six months to a year for these specific identified areas of a nanotechnology syllabus.

- UNIDO ICS will provide experts in various subject areas as identified by participating countries to conduct teacher/student workshops for development of new courses.
- UNIDO ICS will provide fellowships to junior staff from participating countries to undergo training of 6 months to 1 year for specific areas of nanotechnology courses.

Primary Solution #4: Exchanges between countries for specific research areas

- UNIDO ICS will organize and oversee exchanges between participating countries of teaching staff to share research data and lab experience opportunities.
- Participating countries will facilitate and honor the credits for exchange of students, post grad students and scientists between universities.
- UNIDO ICS will help establish internships for students with identified industries.

Primary Solution #5: Developing country collaboration

- UNIDOS ICS will help coordinate the sharing of resources between participating countries and create a resource bank of opportunities for cooperation and exchange with developed nations in specific areas identified.
- UNIDO ICS will help organize a mobile team to offer hands on guidance in research areas and coordinate resources and facilities targeted by the participating countries for specific projects.

Primary Solution #6: Guidance for Project Funding and Social Implications

- UNIDO ICS will offer workshops to designated teams from universities in project writing and the politics of funding requests.
- UNIDO ICS will offer workshops to universities of participating countries in the development and choice of scientific projects.

- UNIDO ICS will offer workshops to universities and industry to discern social implications and create public awareness of nanotechnology.

Long Term Global Nano Education

Primary Solution #1: Addressing education needs of young students in Grades K-12

- UNIDO ICS will organize meetings with UNESCO to discuss project development of Virtual Classroom experiences for grades K-6, with choice of Internet access or DVD programs for the classroom.
- UNIDO ICS will organize meetings with UNESCO to discuss project development of Interactive Virtual Nano Laboratory experiential learning for grades 7-12 with Internet access or DVD programs for classrooms.
- A mandate will be discussed to provide nano science education to children in all countries as a social responsibility.

Primary Solution #2: Partnering for resources

- **The NanoTechnology Group Inc.,** will partner with UNIDO ICS to gather K-12 curriculum developed as education outreach programs by existing nano centers and national laboratories in the United States and from all existing global members.
- These resources can be utilized in the Virtual Classrooms for Global Access extending the outreach to developing countries as partners.

Primary Solution #3: Utilizing Tools that have been tested and proven successful

The technologies in place for global communication through the Internet provide new opportunities to explore the visual elements of nature for all grade levels bringing back the wonder and awe that is inherent in a child's innocent perception while their minds are open to learning and their curiosity has no boundaries.

A Virtual Nano Class Room can be developed for online use and also be digitally produced on DVD for grades K-6, teaching the same principals that these young children are learning in China.

Textbooks cannot show this scale of nature but the tools are available to move education forward with virtual worlds to explore nature at the nano scale including online nano labs for interactive experiments that have been tested at the University of Basil in Switzerland. The designer of this teaching tool was Peter Fornero, who has stated that online nano labs could be developed for primary and high school students.

If we can follow the lead of China who has developed a Nano Playroom and Lab for grades 1-6, then by grades 7-9, students would be familiar with the scientific principles for observation; they would have an understanding of laboratory environments and would be prepared to explore the nano world with the virtual interactive nano labs. Chemistry

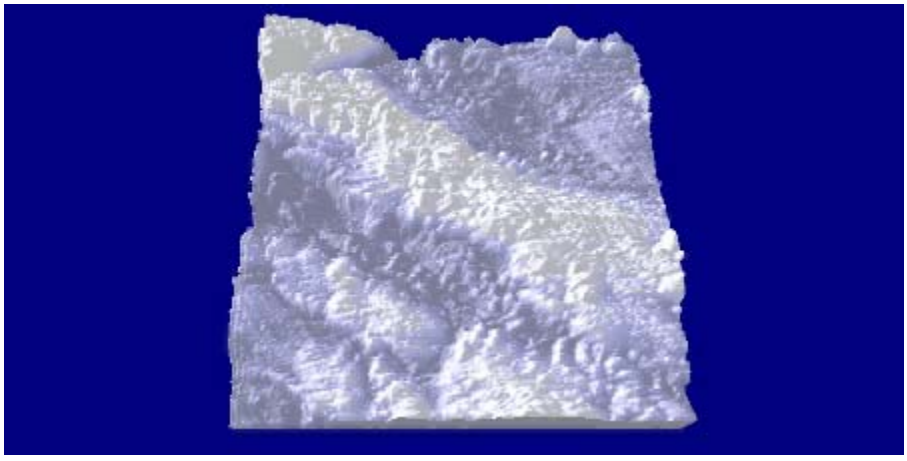
biology and physics could be introduced in these formative years in grade 8 and 9, along with Algebra 1 & 2, and an Introduction to Euclidean and Fractal geometry which would interweave all the normally separate subjects at an early age preparing the students for high school and college.

The new Nano Science Instruments illustrated can provide curriculum developers with the ability to design experiments for elementary classrooms using STM and AFM desk top scanners.

Cognitive Research has been performed in the last decade which points us in this direction for global education:

- Research by:
  Edward Tufte (1992) has shown that the human brain can absorb and process visual information much more efficiently than textual,
  numerical, and even diagrammatic data (Sheppard, 1999).
- Developing Virtual Interactive Classrooms for Global Access enhances human intelligence.

At the Nano Scale of Science 10^{-9} Nature becomes our teacher



Surface of platinum at the nano scale looks like snow capped mountains. These scans from the desktop tools are then animated to stimulate children's curiosity and imaginations as they view the ultra small and draw pictures that match the scenery in their world. This pattern recognition of surface structures introduces fractal geometry on both scales of measurement.

- Inclusive partnering of all countries will open this window into the mysteries of nature. Many new solutions to our current global issues will surface providing harmony and a new knowledge base for our children's future.

Specifics for Universities to Address

In order to accomplish these primary solutions in our short and long term sections the following section will outline areas that need to be addressed by all participants.

All these areas of science and technologies require a working knowledge of the nano scale and the quantum specific behavior of matter at that scale.

- Nano science and nanotechnology
- Biotechnology, biomedicine, genetic engineering
- Information technology and communications
- Cognitive Science and neuroscience

Subjects to Unify

In the case of nanotechnology, the thing that is different is the degree of integration between disciplines. Examples include electrical engineers interfacing with molecular biologists to design the computer of the future, and Army weapons experts working with the fabric industry to "weave" a nanofiber based bullet proof, light weight, camouflage uniform or medical students working with mechanical engineers to design DNA scaffolds.

In order to accomplish the unification necessary, we must look at the four major disciplines for this integration from primary grades through university level.

Four Main Subjects to Unify

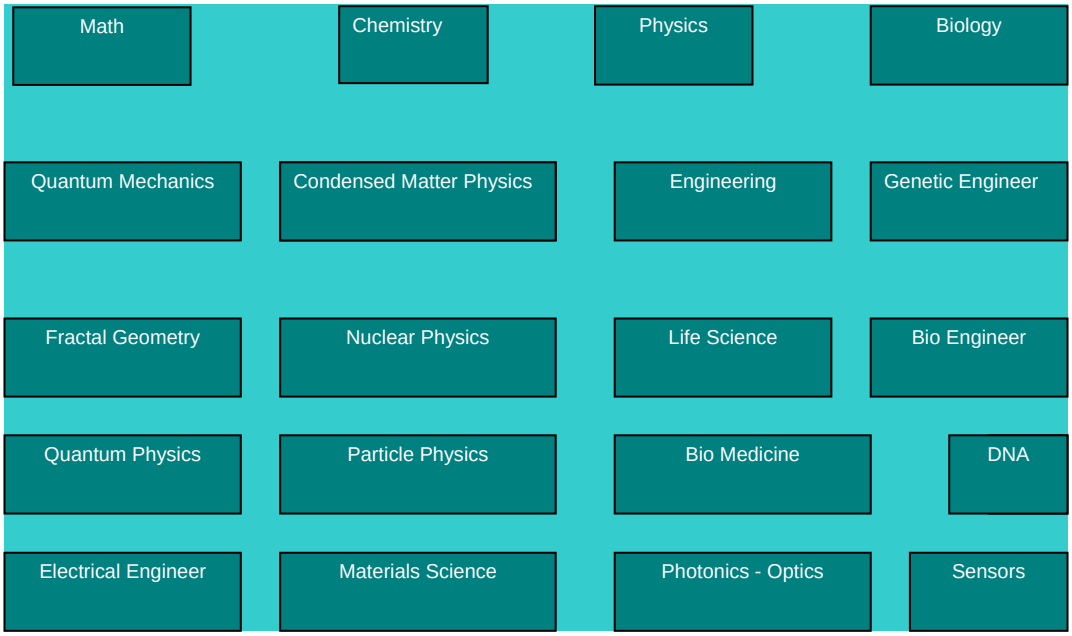
- Chemistry
- Biology
- Math
- Physics

Integration of second level

- Engineering
- Bio-Engineering
- Quantum Mechanics
- Materials Science

Expanded Subject Chart

This example shows the expansion into other areas of study that can develop from the four basic subjects.

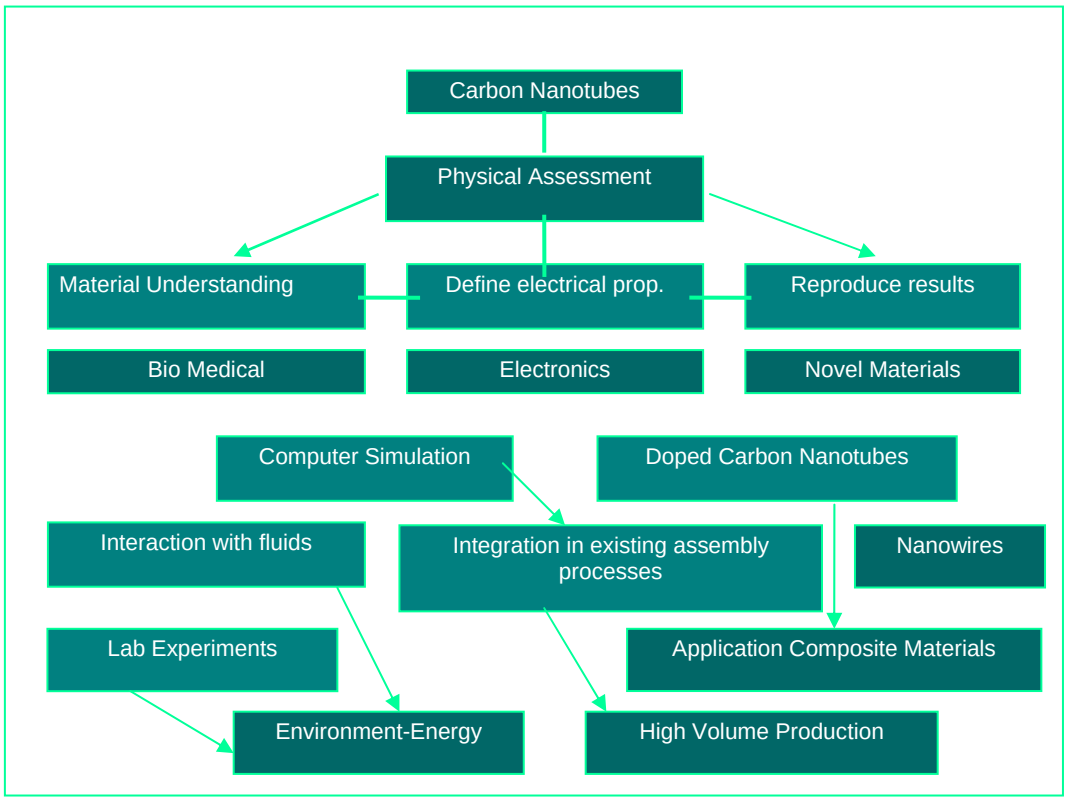


Interrelated Process for Industry

The Carbon NanoTube (CNT) is a perfect example of the inter-disciplinary and supporting work that has had an impact in at least 3 major market segments. When first discovered, the CNTs were a curiosity and a jumble of tubes within tubes, single walled tubes of many lengths and diameters. After the initial assessment of this "soot" and a repeatable experiment, the researchers at Rice began to characterize the material with regard to the physical properties. It soon became obvious that these carbon tubes were potentially many times the strength of steel at a fraction of the weight. And the headlines read " Elevator to the Stars Now Possible!" Of course NASA and others began to view this new material, not for an elevator, but for applications where low weight and high strength were critical. Over the last several years, carbon nanotubes have found their way into the hearts of material engineers and many structures, with several companies, worldwide, building high volume manufacturing facilities. The Rice University/Rick Smalley company Carbon Nanotubes Inc., (CNI) is a premier nanotech company as a result of the Nobel Prize winning discovery.

While the Rice scientists and others we investigating the mechanical properties of this material it was found that CNTs display interesting electrical properties as well. CNTs may be insulating or semiconducting dependent upon the "twist" in the nanotube and the diameter. This caught the attention of the electronics industry which is struggling with the optical principles to create smaller and smaller silicon based transistors.

Somewhat later, the medical field became involved with carbon nanotubes with great



potential as embedded capillaries or perhaps use in artificial kidneys or livers. However, the understanding of fluid flow through CNTs was embryonic. Medical researchers working with other scientists and computer models began to investigate the science of fluid flow through very small open cylinders. This research in turn fed back into the electronics and materials market segments. These studies in biological areas are now supporting the development of nanotechnology applications in the environmental arena with potential applications in water and air purification.

Finally the ongoing work in electronics and bio-medical are also beginning to influence applications in the energy sector, with embedded CNTs potentially leading to more cost effective solar cells and thin film development that will support thermoelectric energy. This interrelated process and transfer of information is shown in this diagram.

This inter-disciplinary nature of nanotechnology presents both the opportunity and the challenge in this exciting enabling technology and this aspect will impact researchers, business people and educators.

Technology Interfaces

The next aspect resulting from the integration of subjects involves the integration of technology interfaces. There is an overlap in the four main areas of nano, cogno, info, bio technologies already in the market place. Students studying the four main subjects will need a basic understanding of how these processes already interface in the world market.

- Cognitive studies of the neuron synapses in the brain are leading to new interfaces for humans with disabilities.
- Biomedical research is targeting direct drug delivery with nano devices.

- Nanomaterials and composites are appearing in many products from clothing to building materials that eliminate pollution.

- Quantum dots, millipede-nano storage, nanotubes and optical research will change information and communication markets.

All these technologies require the study of thermal, elastic, magnetic, electrical and optical properties of both solid and liquid substances.

Unification Benefits regarding Human Resources for Future

- Technology can harness natural processes to engineer new materials, biological products and machines from the nanoscale up to meters.
- Transforming tools including scientific instruments, analytical methodologies and radically new materials systems.
- Development of new system approaches based on complex hierarchical systems.
- Improvement of human performance through better understanding of the human body and tools for direct human-machine interface will open new opportunities.

Nano Education for the Future Workforce

Start-up companies, established industries and those who invest in them will all be impacted by the interdisciplinary nature of nanotechnology. Although implementation of nanotechnology will impact quality assurance and manufacturing processes, these impacts are secondary and further along the timeline.

Expanding curriculum in elementary through university level in the Science of the Small will encourage humanity to take the first step in shifting their paradigm to develop a skilled workforce to balance the wealth of developing nations while creating a global knowledge based society.

Summary

- Unified Science curriculum development for K-20.
- Projected completion 2010 for all grade levels with a 2006 start-up.
- Global acceptance and participation in education development will enhance the workforce in all countries for the next decade of 2011-2020.

Plans for community college and technical college course development to train technicians are in the planning stages, but with steady implementation, they can be accomplished also by 2010.

This is an important goal to reach if we are to have a functioning, knowledge-based workforce for the next decade, while preparing the next generation of scholars and scientists who will inherit the companies started in the early years. They will be stepping into the "age of Innovation".

Conclusion

Nanotechnology will impact every aspect of society and the global economy. It has the potential to revolutionize multiple industries and improve the quality of life for millions. It is an enabling technology which will impact all of the traditional scientific disciplines. Because of this impact, nanotechnology offers opportunities and challenges. We need to learn from and communicate clearly with each other in order to take advantage of the opportunities and wrestle with the challenges.