Opportunities and Protocol for the Teaching of Materials Science in Africa

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SUMMARY: During the last 30 years the world's materials around us have changed from - steel, concrete and wood to new materials with their own chemistry, and they constitute a large part of the manufacturing industry and our imports. Emphasis is on polymers, advanced materials for the electronic and medical industries and novel ceramics, amongst others.

Yet, a school leaver often doesn't know much, or anything, about steel, concrete or what a plastic bag is and how to recycle it.

There is an urgent need to address the improved teaching of materials science, especially in Africa [1, 2]. The NSF in America funded the Materials Science Department at Iowa University to create standards eight, nine and ten, i.e. senior high school, material science course. Sixteen teachers were used to write the notes and teachers manual. We are looking at the use of this course to promote materials science as a third matric science subject. We are of the opinion that this course could do much to improve science teaching in Africa and make the matric student much more conscious of materials around him/her.

This presentation (which in some form had been presented at various conferences) mentions what this course in materials science and macromolecules covers and, further what we can do and achieve with multimedia education at university level [3, 4, 5, 6, 7, 8]. It will be based on the courses: MATTER, from Chapman-Hall, developed by Liverpool University and Macrogalleria, developed by Prof. Lon Mathias at University of Southern Mississippi.

Introduction

At the UNESCO Associated Center for Materials Science, Institute for Polymer Science, University of Stellenbosch, we are engaged in the writing of courses for the teaching of polymer science at high school and university undergraduate levels. It may now be asked "Why do we need a polymer science course in addition to the science that

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now be asked "Why do we need a polymer science course in addition to the science that is already taught in schools?" The answer to this question is well summarized by the words of Dr Guilio Natta, 1963 Nobel Prize winner. He said:

"If our age was to be named for the materials that characterize it – as were the Stone Age and the Bronze Age of the past – it might be known as the Age of Plastics. For plastics, made of synthetic giant molecules, has become a dominating influence on modern society".

These words are more significant now than ever before as no other field of science has changed the world we live in more dramatically than polymer science has. Further, other materials with equal importance are being discovered all the time, as is illustrated by the following statement in Business Week of July 1991.

"By combining atoms in novel ways, scientists are creating materials that open up bold possibilities: pocket size supercomputers, superlight aircraft, superstrong corrosion-resistance alloys and flexible ceramics and many more. Over the next five years, the world is going to experience an exponential increase in science and technology originating from robotics, laser technology, fiberoptics and modern age materials. All the information known at the end of 1996 will be only one percent of the total amount of knowledge in the world by the year 2030".

This is exciting but, at the same time, shocking, when you realize that development will only take place in those countries in which people know how to use science and technology. The important question is "*How is Africa going to survive the technology age?*"

Statistics show that in developed countries, more and more routine work is becoming high tech. The USA, because of the education system put in place long ago, is heading for 80-90% non-labour-intensive high tech jobs. This ensures that advanced industries can be erected and developed in these countries. In Sub-Saharan countries, including South Africa, industries are labour intensive and the population is increasing faster than the natural resources can handle. We need to be heading towards the development of high tech industries by first re-educating our communities. This is because at the heart of the development of science and technology in any country stands education. It should also be remembered that science is an active process; it should be something that the students do and not what is done to them. When this happens, science can be enjoyed and the students should show more interest in what they are learning and doing.

In a world filled with the products of scientific discovery, scientific literacy has become a necessity for everyone.

- Everyone needs scientific information to make choices that arise daily
- Everyone should be able to engage intelligently in pubic conversations and debate about important issues that involve science and technology
- Everyone deserves to share in the excitement and personal fulfillment that comes from understanding and learning about the world of science
- More and more jobs are demanding advanced skills, requiring that people should be able to learn, reason, think creatively, make decisions and solve problems. An understanding of science and the processes of science contribute in essential ways to these skills.

If one is in an industry-type job then you need to be familiar with a certain level of scientific information to be able to make educated decisions i.e. one must be literate in a scientific sense.

Education of workers in South African companies is therefore very important, especially nowadays. The ideal is that everybody should at least be able to read and write and ultimately understand why he or she does a job in a particular way. They should enjoy their job, while, simultaneously and consequently, being more productive.

Why do we need to teach polymer science in schools?

Education of young people in materials science at school level is considered very important since materials constantly surround today's children. To illustrate this, let us now look, from a child's point of view, at his or her immediate environment. From the moment a child arrives in this world he/she touches, sees and handles different types of materials without knowing the difference. Materials are part of every facet of both his and his parents lives e.g. clothing, toys, books, modern home appliances, sport equipment, packaging, and magazines. Nowadays, especially, children are bombarded with questions and statements on the ozone layer, the greenhouse effect, acid rain, recycling, pollution, and space programs. Our cities are actually modern materials science jungles. Is it fair then that a child, whose world includes all these things, is not taught material science at school? How does a child know which material would best suit his/her needs?

In South Africa the only material science presently offered to a high school child is metals. Modern materials like composites, ceramics, polymers, concrete, semi-conductors are not even mentioned! Children at high school level are totally unaware of what the chemical industry does. They think of it as the cause of environmental pollution problems. Little or no easily understandable reference materials on modern material science are available to children. The only available information is in the mass media and they are often more concerned with sensation rather than facts or education (e.g., the misconception about polystyrene causing a hole in the ozone layer).

Locally (as well as internationally) we are experiencing a decline in the number of matriculation students and school leavers entering the chemical industry. The next question to ask is:

Why does only a minority of top students at high school level make career decisions favouring the chemical and technological industry?

The problems we experience may be the following:

- Present high school science curriculums have not kept up with recent scientific and technology developments in the scientific and industrial world.

- The chemical industry has a poor image. It has not tried to dispel news items on pollution – of both water and air, amongst others. It has tended to always play a defensive role rather than an educational one. School leavers are therefore disinclined to be interested in science as a career. They do not consider the chemical industry as an attractive potential employer.

- The science curriculum for high schools is too theoretical, with minimal practical content, if any.

- Pupils and students are trained only to pass examinations and **not** to develop an interest and awareness of the vast and amazing world of science around them.

- There is often a lack of basic equipment such as electricity, water, gas and chemicals to demonstrate basic scientific phenomena.

- There is often a lack of financial support for school science programmes and for sponsoring science teachers. Investment in the future of science and technology is ignored.

- There is a shortage of qualified science teachers specializing in appropriate and relevant fields of science and education. Further, one teacher is often obliged to teach chemistry, physics, biology and also agriculture, and for a meager salary

- Often the teachers themselves are not adequately qualified.

<u>How do we therefore address the lack of appropriate material science knowledge in countries in Africa? How does one bring technology to combined First World and Third World societies? How does one establish awareness, at least at high school level, of the science around us?</u>

The answer may lie in the following:

- Inexpensive teaching aids that is now available. These are now on offer in South Africa and include student and teacher manuals.

- The media, although it is good is very restricted.

- The television screen, for years now the most important consumer of quality time.

- The Internet that is now available. It intrigues us by combining information, speech, pictures and communication [9].

- The compact disc is available on which multimedia information can be easily and safely distributed.

Why use multimedia as an instruction material?

All too frequently a child is found in front of the TV set rather than in front of his books [10]. Buy him a computer and see how enthusiastic he is about using it, especially if it is multimedia! Give him access to the Internet and see how fast his interest develops into new spheres, some of which were formerly unheard of [11].

Basic computer access must be the objective, to bring quality and effective learning to students. If you think about quality distance-education, training of teachers, availability of quality and updated information on modern science and technology, the computer is, without doubt, the most useful instrument available to us. However, the mere 'putting down' of information on a CD – ROM or the Internet will kill the interest of any child or adult (many of us remember boring science classroom experiences).

Multimedia really grabs the attention of young scholars. It is what we need for education, and should include the following: sound, colour, animation, video clips and demonstration of practicals. All these should be part of a multimedia presentation to make science learning an exciting experience, far from the deadness of textbook practicals. There is a need for *computerized multimedia materials science programmes.*

South Africa, also standing in the midst of these technological changes, has its own unique opportunities regarding the teaching environment. Locally, in any radius of approximately ten kilometers, there exist schools with highly advanced computerized educational facilities, compared to schools with equipment just to serve basic day to day needs. This is one of the reasons why the current ratio (according to statistics) of learner to computer in the Western Cape, South Africa, is approximately 160:1 (in comparison with the USA 5:1 and Europe 15:1) [12]. The need for educational programmes accessed via CD-Rom and at a more advanced stage via the Internet, is more than relevant at this stage.

What is being done about it?

At the UNESCO Center, at the Institute for Polymer Science, a polymer science course has already been launched. A source material for teachers is entitled "The Wonderful World of Plastics" (created by T du Toit, for the Plastics Federation of South Africa). The course was introduced to science teachers at fifteen schools. In a week's time at least 15 000 students were reached with information, interesting facts and some practical experience about the world of modern materials. In addition to the computer programme, the course includes the following: a set of transparencies, a video and a suitcase of equipment for demonstrations and experiments. The following is the summary of what the course contains:

Where does it come from? What are polymers From monomers to polymers Crude oil to ethene molecules Cracking process	**Basic Polymer Chemistry** Crystallinity Structural shapes of polymers Addition and condensation processes Thermoplastics and thermosets
Processing Blow moulding Thermoforming Extrusion Rotational moulding Injection moulding	**Identification and Classification** Practical tests on different materials in everyday use Designing with polymers
Plastic Materials PVC Polystyrene Polyethylene Poly propylene Rubber PET	**Caring for the Environment** Facts and statistics on trash Landfills Ozone layer, green house effect Degradation Re-use, recycle, reduce

One of the major problems for a science teacher is that a subject like materials science education is a specialized field, and to start teaching polymer science, without proper knowledge, can be a daunting task. The introduction of Outcome Based Education in South African schools created the opportunity to incorporate courses on relevant and interesting subject matter to broaden the knowledge of both teacher and students. Obstacles to the integration of polymer science concepts and examples into the existing curricula are:

- The lack of polymer-related material textbooks and other relevant resources;
- Lack of time to gather and prepare this specialized information on such a level for school children to enjoy and have a learning experience;
- Availability of apparatus and chemicals to have hands-on experience of materials; and
- Financial support to implement quality science programmes.

The objectives of this multimedia programme on synthetic polymer materials is to assist in fulfilling some of the targets mentioned above to be a successful science teacher:

- To provide information on synthetic materials. These materials are used in different forms, in a variety of places and have different applications in our current industry, making the science experience more than relevant;
- To give correct answers on frequently asked questions about synthetic polymer materials:

  Where does it come from?

  What is it made of?

  Where is it used?

  Can it be recycled?

  Is it detrimental to our health and the environment?
- To stimulate the user to learn more about plastic materials specifically and modern materials generally;
- To contribute to effective teaching providing the teacher with correct and relevant resources on synthetic polymers; and
- To save time for both teacher and student.

Where does the multimedia polymer science course come from?

Work is being done to develop material science courses for high school by a number of groups. One of these groups is lead by Prof L Mathias at the University of Southern Mississippi in the USA, who is involved in the development of material science courses for high schools. One of these courses is Macrogalleria, which introduces polymer science in the form of shopping malls at different levels. A level deals with a different section of polymers. For example, the first level is introduction to polymers (and the shops in this mall have items all made of polymers), the second level is how polymers are made (with the shops representing the different polymerization processes) and includes the animation of the polymerization processes. Another level deals with characterization of polymers and so on.

In collaboration with the University of Southern Mississippi, another Macrogalleria course was developed and translated into French. At the UNESCO Center, Stellenbosch University, it was translated into Afrikaans, and is now being used by us for 2nd and 3rd

year undergraduate students. Information on this programme is available on the Internet at the following address:

http://www.psrc.usm.edu/macrog/index.html

Another group involved in the development of course materials on computer is at the Department of Material Science and Engineering at the University of Liverpool in the United Kingdom. They have developed an excellent material science programme that has been on the market since 1995. The MATTER (Materials Teaching and Education Resources) programme has some of the following modules available:

- An introduction to Electrons in Crystals
- An Introduction to Phase Diagrams
- Thermodynamics of Phase Diagrams
- Mechanics of Composite Materials

More information on this programme can be obtained at the following Internet address:

http://www.liv.ac.uk/~matter/home.html

What is being done in South Africa?

Information on material science covers a wide range of topics, including polymers, concrete, composites, semi-conductors, ceramics and metals. Some of the material already developed at the UNESCO center, Stellenbosch, are Giant Molecules the Virtual Teaching Encyclopedia of Macromolecules which is available on the Internet at the following address:

http://www.sun.ac.za/unesco/Conferences/HomePage/_private/Encyclopedia.htm

The Giant Molecules course is an introduction to polymer science and includes course material and experimental work. The experiments are demonstrated and up-to-date information on how to carry them out is given. Ceramics is also an introductory course giving information on ceramics.

Conclusion

We have a new multimedia processing team who has created industry multimedia instruction programmes for workers, a course for the Internet - giant molecules. The team is presently putting an Honours course in Materials together and is finalizing the high schools multimedia course, "Fun with Polymers" [13].

The University of Southern Mississippi, USA, has already developed a materials programme for use in high schools and after some modifications the University of Stellenbosch in South Africa is now implementing translation into Afrikaans.

Young people and teachers, in need of knowledge on modern materials welcome course material that is relevant and contains up-to-date science information. Outdated science curriculums cannot be taught to children living in a world that moves at an ever-increasing speed in the fields of science and technology.

With current global environmental and political scenarios, it is critical to develop a suitable education programme now. The magnitude of such a programme limits its ability to succeed at first attempt so an interactive approach should be taken, especially where children are involved. In the African context it is also crucial that the community should be involved. There should be a synergistic effort by the community and the education authorities to provide children with the best possible science education that brings theoretical education into practice. The chemical industry as a potential employer of science students should also be consulted and involved.

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