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NSC Promotion of Internet Science Education

Following the completion of the "Computer-Assisted Learning" project, the NSC began implementing the "Internet Science Education" research project at the beginning of the 1998 fiscal year. The focus of this project is on the learning/instructional environment for the scientific subjects taught in elementary and middle schools. It seeks to integrate the results of research in such areas as distance education, computer-assisted study, and science learning, and pool the efforts of psychologists, computer experts, and science educators. The following are some of the key research areas of the project:

1. Research on the Online Science Learning Environment

An appropriate learning theory is being developed for every system, and diverse learning systems are being developed for the Internet. Each learning system includes the following: (1) A learning resource base providing relevant data for queries; (2) a science knowledge structure environment; and (3) a learning database. The goal of this effort is to develop a virtual science learning museum on the Internet in which all citizens can study science.

2. Research and Development of Web-Based Science Education Evaluation and Testing Systems

Web-based science education evaluation and testing systems will take advantage of the Internet to perform all types of evaluation, testing, and survey tasks. Planned work includes: (1) evaluation and testing of science learning levels, (2) evaluation of interest in science learning, and (3) survey of science attainment and degree of concern about science.

The following is an introduction to major subprojects:

1. "Application of the Internet to Enhancing Middle School Earth Science Education" integrated project

The General Principal Investigator of this project is Professor Yi-ben Tsai of the National Central University Institute of Geophysics. The project is being conducted at eight departments at National Central University, including the Center for Teacher Education Program, Department of Information Management, Department of Information Engineering, Institute of Astrophysics, Institute of Space Science, Institute of Atmospheric Physics, Institute of Applied Geology, and Institute of Geophysics. In addition, a number of enthusiastic teachers from Chien Kuo High School, Taipei First Girl's High School, Chung Shan High School, Cheng Kung High School, Wu Ling High School in Taoyuan, and Hsinchu Experimental High School have been invited to help realize this innovative Web-based educational experiment.

The project has been underway for two years, and its initial focus has been on high school earth science. The basic framework is that of a "cooperative special topic learning model, " and the online learning environment being developed includes the following features: (1) Several riddles in each subject serve to motivate students, and questions strengthen students' ability to question and think; (2) a jigsaw puzzle-type group approach is used to divide students into subject groups and expert groups for discussions, boosting their ability to work on scientific questions in teams; (3) students use conceptual diagrams drawn before and after study to depict their learning growth; students compare diagrams drawn by teachers and their peers to assess their own progress, achieving the goals of self-affirmation and self-examination.

Topics that have been completed so far include the topic of debris flow in the geology classroom, the topic of earthquakes in the geophysics classroom, the topics of typhoons and frontal systems in the atmospheric science classroom, the topic of comets in the astronomy classroom, and the topic of the ionosphere in the recently-added space science classroom. In order to check the feasibility of curriculum design, high school students have been found to cooperate in pre-testing each topic. The Web address of this project is http://140.115.80.145.

2. Arthur Empire—Internet Virtual Classroom (IVC)

This project was developed by the Multimedia Communications System Laboratory and Department of Information and Computer Engineering at

Chung Yuan Christian University, and is directed by associate professor Jia-Sheng Heh. It consists of a set of cooperative multi-person, multi-computer virtual classrooms for synchronous and non-synchronous learning established on the WWW and BBS systems. An experimental virtual classroom web site called the "Arthur Empire" has been set up. This "empire" provides two learning environments named the "Royal Library" and the "Round Table."

The Royal Library is a learning environment offering the tools that teachers need to design instructional curricula and construct an entire learning environment in which students can study according to their personal needs.

The Round Table is a skills training area providing a carefully-designed virtual experiment platform allowing learners to perform simulated experimental manipulations. This platform bridges the gap between theory and reality, and allows training to be conducted in an environment where it is unnecessary to worry about obtaining laboratory equipment and maintaining safety. Learners can practice skills under completely safe conditions and then go on to operating real equipment after they have achieved mastery. The Web address of this project is http://maiga02.ice.cycu.edu.tw/~bbs/.

3. Tsinghua Web-Based Science Museum—A Web-Based Virtual Science Museum

This project has been underway for 16 months and is directed by Professor Yi-long Huang of the National Tsinghua University Department of History. The "Tsinghua Web-Based Science Museum" was established last year (1997) under this project. The museum is dedicated to the promotion and popularization of scientific knowledge, and provides a large number of displays concerning astronomy, biology, physics, science history, and nature conservation, etc. At a time when Chinese-language resources on the Internet are still in short supply, this site offers abundant content that can serve as supplementary teaching material for all school levels. It also can play the role of an Internet knowledge navigator, giving the general public a rich supply of interesting and easy-to-understand scientific knowledge. Furthermore, the site also presents fascinating, popularized accounts of selected research results from the domestic academic community.

The Tsinghua Web-Based Science Museum currently provides more than 60 exhibits on different topics that are open to public browsing. Each exhibit includes a guidance page summarizing the exhibit's content and background information, insuring that visitors understand the exhibit's organization and content before they begin their tour. The museum has also established a "Science Hall of Fame" introducing the life story and contributions of famous domestic and foreign scientists and offering a query function. In addition, the museum is planning to establish "News of This Month" and "New Developments in Science" sections in collaboration with *Science Monthly*. These sections will present recent progress and happenings throughout the science world, allowing the public to keep up with scientific and technological developments. The museum's web address is http://vm.nthu.edu.tw.

Results of an NSC-Sponsored Cutting-Edge Research Project—"Spectroscopy and Chemical Reactions of Free Radicals in Atmospheric and Combustion Chemistry"

While countless molecules and reactions are involved in atmospheric and combustion chemistry, unstable molecules commonly termed "free radicals" play a particularly important role. Because of their highly reactive nature, free radicals serve as the initiators for many chemical reactions. For example, many of the stable molecules found in air are activated by reaction with the hydroxyl radical (OH) before entering into complex chains of reactions. The decomposition of ozone in the atmosphere is likewise catalyzed by free radicals. An understanding of the chemical reactions of free radicals is therefore a vital part of atmospheric and combustion chemistry, and this understanding must include reaction kinetics, reaction mechanisms, and reaction branching ratios. Research on free radicals is typically performed by (1) experimental chemists who study individual free radical reactions in the laboratory, (2) theoretical modelers who couple various chemical reaction parameters with physical parameters (such as transport and meterology) to create models, and (3) analytical chemists who make measurements of the concentration of various molecular species at different times and in different reaction zones. The complementary work of these three types of specialists can give us a better understanding of what goes on during chemical reactions. Nevertheless, laboratory work is the most indispensable link.

While free radicals are a key element of many chemical reactions, they are extremely difficult to study in the laboratory. Because of their high reactivity, it is not easy to prepare free radicals in high concentrations. And their very short lifetime typically causes them to vanish completely in less than a microsecond (one-millionth of a second). Because most conventional research methods are inadequate to study free radicals, a number of extremely sensitive and selective detection techniques have been developed. Studying free radical reactions is a great challenge for scientists, but the findings they generate may make a direct contribution to the welfare of humanity.

Spectroscopy is the most sensitive and least disruptive method of detecting free radicals. The development of laser technology has enabled many breakthroughs in atmospheric and combustion chemistry as lasers have supplanted the conventional light sources once commonly used in spectroscopy.

The laser chemistry laboratory of National TsingHua University's department of chemistry was founded 17 years ago when Prof. Yuan-Pern Lee returned to Taiwan. The laboratory's research team includes Prof. Lee, Prof. I-Chia Chen, and Prof. Po-Yuan Cheng of TsingHua University; Prof. Niann-Shia Wang of National Chiao Tung University; and Dr. Bing-Ming Cheng, Dr. Su-Yu Chiang, and Dr. Ying-Yu Lee of the Synchrotron Radiation Research Center. With the ongoing support of the NSC, the Chung Shan Institute of Science and Technology, National TsingHua University, and the Academia Sinica, the aforementioned laboratory has been performing multi-faceted research on the spectroscopy, reaction kinetics, and chemical dynamics of free radicals. As one of a series of cutting-edge research projects that the NSC has sponsored in recent years, the NSC provided key support that enabled the research team to develop two new and sophisticated methods for detecting free radicals. It is expected that these methods will have very wide applicability in the future.

1. Prof. Yuan-Pern Lee has successfully used the newly-developed "two-color resonant four-wave mixing" technique to detect many exceedingly unstable energy states of CH radicals—some of which have lifetimes of only a few picoseconds (10^{-12} second). The two-color resonant four-wave mixing technique involves letting two beams of laser light with an identical frequency (i.e. color) and one beam of a different frequency intersect at a small point from specific angles. Non-linear effects caused by the laser light create a fourth beam with the same frequency as the third. If any laser light is absorbed by molecules, the intensity of the output laser beam will be greatly amplified. Scanning the frequency of the input laser light therefore allows researchers to know the point at which resonant absorption occurs, and can thus be used to pinpoint the energy states of molecules. Because this technique takes advantage of the phenomenon of the spatial interference of laser light, it is very well-suited to detecting unstable energy states. But because the experimental setup involves four (or even five) laser beams, utilizing this technique requires that many technical challenges be overcome. There are few laboratories in the world today that are capable of using this method to detect free radicals. The CH free radical energy levels detected by Prof. Lee using this method are two or three times as numerous as those that previously could be detected using other methods, and have brought about a better understanding of the free radical's electronic states. In the future this technique will play an important role in various aspects of photochemistry research.

2. Conventional Fourier transform infrared spectroscopy is only applicable to continuous events and is not suitable for detecting transient signals. However, highly-reactive free radicals frequently require transient detection. The step-scan Fourier transform infrared spectrometer developed during the last few years are generally only capable of transient detection of emission spectra, and are unable to detect species that do not emit light. Besides using this type of emission spectroscopy in photochemistry research, Prof. Lee also developed a techniques to measure transient gas-phase absorption spectra. Prof. Lee was the first to make this breakthrough, which allows him to detect free radicals that do not emit light. After it becomes more mature, it is expected that this method will make a large contribution to research on the spectroscopy and reactions of free radicals.

Frontier Research Project in Blue-Green Optoelectronic Materials and Devices

The three primary colors of red, green, and blue are required altogether to compose the full spectrum of color. Lacking any one of them, a full-color display will not be possible. However, blue-emitting semiconductor devices have been absent for a long time until recently when breakthroughs were first accomplished on GaN blue emitting devices in Japan.

Both coherent light sources, such as lasers, and incoherent light sources, such as light emitting diodes, in the blue-green region have found important applications in various areas. These include applications in high-density optical storage devices, such as DVD, full-color panel displays, high-density televisions (HDTV), sensors, man-machine interface, and underwater communication. Lasers with even shorter wavelengths in the UV region also play key roles in some newly developed industries in Taiwan, such as precision manufacturing and nanometer IC processes. All of this development indicates that blue-green light emitting devices will play vital roles in the next generation of opto-electronic industry. It is estimated that the world-wide market of blue LEDs and LDs will exceed 2 billion US$ in value. These semiconductor devices and components can very well fit into the developing infrastructure of our optoelectronic industry.

Presently, Taiwan is the third largest production nation in manufacturing visible LEDs, only behind Japan and the United States, and about 90% of the laser pointers in the world are made in Taiwan. These facts indicate that we have well-established capability in producing and manufacturing high-brightness red and amber LEDs and LDs. For the coming age of full-color displays and multifunction video disk information systems, developing semiconductor devices operated in the blue region is essential.

The optoelectronic committee of National Science Council (NSC) has chosen the blue-green optoelectronic materials and devices as one of the technology excellence research subjects. The goal is to develop continuous blue-green laser diode light sources and compact nonlinear optical components for the new generations of DVD-ROM/RAM, as well as high efficiency and high energy UV and XUV laser sources. The research will include both fundamental studies and application development in the area of related optoelectronic materials, devices, and modules. Three research teams include professors from National Central University, National Chiao Tung University, and National Taiwan University, have been seclected for the first year program. The total budget is around NT$ 30 million, and over 65 researchers are involved. The objective of the National Central University's project is to establish the epitaxial GaN growth and related LED and LD process capability, and, thereon, to develop the blue laser diodes for the next generation DVD storage devices. National Chiao Tung University already have experience in LED process and GaN and GaInN material growth. Their work includes epitaxial growth and fabrication of various blue-emitting nitride devices, as well as optoelectronic and microstructure characterization of AlGaInN materials. The National Taiwan University team, with the assistance from National Chung Cheng Institute of Tech , will utilize the molecular beam epitaxy technique to fabricate blue-green lasers, LEDs, and other novel optoelectronic devices.

The final goal of this technology excellence program is to develop prototype blue LEDs and LDs and introduce them into the industry in three years, so as to propel our optoelectronic industry into a full-spectrum age. The success of this project will greatly enhance our future competitiveness in the optoelectronic information technology.

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