In the '50s and '60s engineering students used slide rules and textbooks, while calculators and labs were the preferred learning modes for would-be engineers in the '70s and '80s. But even the most sophisticated calculators and the most challenging labs aren't fascinating enough to stimulate the interests of today's engineering students, many of whom were raised on Game Boys and other computer diversions.

That lack of stimulation is one reason undergraduate and graduate enrollments in engineering and science are on the decline. "The way engineering courses are taught is not exciting," says Ahmed K. Noor, director of Old Dominion's Center for Advanced Engineering Environments and William E. Lobeck chair in advanced engineering environments. He notes that current education techniques are fragmented and focus on near-term product development. "Unfortunately, many faculty still use old methods of teaching. That's what we need to be concerned about. This is an information technology/computer game generation. We need to make learning very rewarding and equally entertaining – more entertaining than computer games."
Along with a drop in enrollments in science and engineering, aerospace and high-tech industries are being hit with a shortage in their workforce. For example, 24 percent of NASA's 10,643 engineers and scientists are eligible to retire in the next four years and more than 54 percent of the science and technology workforce is over 45 years old.

To counteract those statistics, the increasing cost of conventional education and the need for lifelong learning, Noor is proposing bold new approaches for workforce development, in which universities would pool their resources to develop elaborate learning modules, virtual classrooms and Web learning portals in revolutionary technology areas not currently available in educational curricula. It's a one-of-a-kind project that is giving Old Dominion University an opportunity to be a leader in this groundbreaking work.

Hierarchical Research and Learning Network

Noor envisions the formation of a Hierarchical Research and Learning Network (HRLN), which would create intelligent knowledge organizations in revolutionary technological areas. Those organizations would consist of NASA, government resource groups, university consortia, industry, technological providers and professional societies. To that end, Old Dominion has received a $2 million NASA Langley Research Center grant to lead a prestigious group of universities to enhance aerospace workforce training through the synergistic coupling of leading-edge technologies such as nanotechnology, biotechnology, information technology, high-performance computing, modeling, simulation and visualization, high-capacity communication, human performance, reliability/risk management and virtual product development. Other universities in the eight-member consortium include Massachusetts Institute of Technology, Georgia Tech, Cornell, Syracuse and George Mason universities, the University of Florida - Gainesville and the University of Illinois at Urbana-Champaign.

According to Noor, the network would significantly enhance instruction in the aerospace industry and would be a cost-effective way to prepare engineers and scientists. Configured as a neural network mimicking neurons in the brain, it would provide advanced learning environments and facilities using interrogative visualization, multimedia, intelligent software agents, virtual reality, multimodal and adaptive human-computer/communication technologies.

“There is a definite need for rethinking education and training aimed at lifelong learning,” Noor says. “In the past, the goal was to bring performance up to satisfactory achievement of work tasks. Now there’s a need for more understanding and skills to adapt to new and rapidly changing technologies.”

Development of the network begins with the formation of learning modules and virtual classrooms. Noor notes that learning objectives have previously focused on the transfer of information through lectures, note-taking, books and CDs. But that’s not enough. He adds that the goals of education must include knowledge and skills acquisition, with special attention paid to shaping the critical thinking skills of the learner. “The development of critical thinking and creativity skills is very much missing from education today.”

Three Learning Environments

To enhance these skills, Noor and other consortium members are developing three types of advanced learning environ: synchronous and asynchronous expert-led learning environments, self-paced individual learning environments and collaborative learning environments.

In expert-led learning environments, faculty inspire and motivate students to delve more deeply into the subject instead of simply reciting facts through a lecture. “To spend time writing equations and giving details is a very big waste of time for the instructor and the learner,” he contends. “A very small percentage of learners find that it’s at the right speed for their comprehension.”

While there will always be a place for the faculty lecture, Noor wants professors to consider the most effective use of both their and the students’ time in order to make the subject more appealing.

“Faculty are not merely information transmitters. They act as course managers, as motivators and coaches to give a broad overview of the topic and to show its diverse applications,” Noor says. He encourages the use of advanced multimedia and 3-D immersive multisensory facilities to stimulate students’ interest, and he advises professors to end their lectures with penetrating “what if” questions that help develop critical thinking skills. During the next lecture, the class can analyze the answers to those questions.

Noor also believes that faculty expertise combined with distance learning could lead to bigger and better learning opportunities.

“There are lots of experts across the United States, so why not have group-distributed teaching of courses,” he asserts. “At a typical institution there won’t be an expert in every aspect of the course he’s teaching, but you can find experts across the country to contribute to the course.
The quality of instruction goes up, and it lightens the teaching load.”

Noor tested his theory in spring 2002 by leading a course on virtual and synthetic environments that was taught by 10 instructors at eight institutions. “The result was very positive,” he says. “The course got good evaluations because we brought the experts to them. By bringing in experts in each topic of the course, we put together something much better. That’s something we should very vigorously pursue. It would reduce teaching loads and improve the quality of teaching.”

**Self-paced Learning**

However, learning is not limited to the classroom. Self-paced individual learning environments provide a major part of the students’ education and give new meaning to the word homework. As part of their course materials, students would receive motivational software programs that not only teach details not covered in lectures, but also provide an element of excitement, similar to that found in computer games. “The student can sit down and learn at his pace in a non-threatening, supportive manner,” Noor says, noting that the program has tutorials and other options geared to students’ various learning speeds. Students can also use the program in private, a benefit for those who may take longer to grasp a concept. “The student will not be ashamed if he needs more time. If one takes one hour to learn and another takes four hours to learn, so be it. Some students are embarrassed to ask the instructor to repeat the information. Here you will not be embarrassed. You can go very slowly.”

Using self-paced learning environments, students explore the details of a topic, study the physical phenomena and simulate real-world applications. Tools for these environments include 3-D holographic displays, smart computing devices that are aware of their surroundings, users and their positions; real-time sharing, remote control and simulation of NASA experiments; and information technology and extensive use of intelligent software agents mimicking humans that can assess students’ comprehension levels and identify necessary remedial actions.

“You’d be talking to that agent and immediately get what you want,” Noor explains. “You’re communicating with a computer as if the computer is a person, so that would be very entertaining. You would have natural language communication with an intelligent agent.” In addition, the software has 70 different English accents, allowing the student to choose the pronunciation with which he is most comfortable.

Noor is also developing software that would read students’ facial expressions to determine if they are puzzled by the material. And, along with IBM, he is developing an “emotional mouse” for the learning environment. The mouse has sensors to measure the temperature of the user’s finger, moisture on the finger, hand movement and pulse rate to indicate anxiety levels. “From all of these attributes your emotional state can be determined,” he says. “If the person is depressed, we would try to get the computer to cheer him up and not load him with a lot of information.”

**Collaborative Learning**

In collaborative learning environments, tele-immersion facilities would be used to connect geographically dispersed interdisciplinary teams of instructors and students to allow them to work on complex technological systems. Going beyond video conferencing, these environments would include state-of-the-art multimedia and visualization facilities, intelligent software agents, multisensory and multimodal interfaces and intelligent knowledge management facilities. Developing a Hierarchical Research and Learning Network is undoubtedly a very ambitious and unique project, but it’s one that Noor believes is necessary not only to
better prepare future engineers and scientists to respond to leading-edge technologies, but also to enable universities to remain competitive. He notes that universities are already facing competition from learning technology providers and professional societies such as the Association of Mechanical Engineers, which offers virtual campus distance learning, and the Institute of Electrical and Electronics Engineers, which has established distance-learning campuses for its members.

“Because of the advanced learning technologies and the new learning paradigms, I believe that we’ll find the landscape of universities changing significantly in the next 10 to 20 years,” Noor says. “Some more traditional universities that forgo these paradigms will be left by the wayside. Unless universities get their act together and provide themselves with a competitive edge in learning and capitalize on these resources, they will find themselves out of business.” Noor adds that he anticipates universities will be sharply reduced in size in the next 20 years.

However, Noor believes Old Dominion is breaking new ground in its leadership role in the HRLN consortium. “We are a pathfinder,” he says. “Whatever we develop, many others will be doing. What we’re talking about is doable.”

“This is an information technology/computer game generation. We need to make learning very rewarding and equally entertaining – more entertaining than computer games.”

— Ahmed K. Noor