Computer graphics used in first-year physics

Computer graphics are no longer minor variations on the theme of computer-based educational materials. At the University of California, Irvine, the work of the seven-year-old Physics Computer Development Project is almost entirely dependent on the graphical capability of its hardware. Other projects have made contributions in this field, yet not for the primary goal of developing learning materials in physics, as at Irvine. These include projects sponsored by the University of Illinois at Urbana-Champaign, Dartmouth College, the Mitre Corp and the Illinois Institute of Technology.

A key concern at Irvine is the visual representation of materials in a dynamic mode, such as the cathode-ray-tube displays accompanying the Project's terminals. The materials developed at Irvine include exercises, proofs, on-line quizzes with help sequences and student-computer "dialogs." These dialogs are illustrative of the Project's philosophy.

The physical sciences terminal room at the University of California, Irvine, is open to students day and night. Alfred Bork (left) is seen discussing results of an on-line exam with a student.

A dialog called MOTION, an "F=ma" world that the student may explore freely, is one of the most widely used dialogs in beginning classes at Irvine. In the MOTION dialog students control the force laws, equations, constants and initial conditions. Intuitive understanding is stressed in these exercises, which are by nature self-paced. Alfred Bork, who is director of the Project, explains that a physical system, such as a planet going around a pair of suns, is easily represented in a lecture format by showing the actual configuration in space. A unique advantage of computer graphics is its capacity to give visual information regarding, for example, the velocity space of this system, where the two components of velocity are plotted against each other. The students may manipulate the variables and thereby develop a more intuitive understanding of the behavior of the system. At the same time, they have an analytical approach available in the classroom.

A feature of the dialogs is that students are shown a map of the area they are learning. This map illustrates the blocks of material to be covered, the pedagogical organization, and indications as to which material is optional and where the student may use an alternate information source. The programs therefore are not only self-paced, but also they are self-directed and self-evaluative.

Bork's group has a primary orientation to physics education, yet an on-going concern for them is the usefulness of their software in other fields and with other systems. At present the Irvine programs are used in remedial mathematics, ecological studies, chemistry and various subjects in the UC Irvine Medical School. The Project encourages faculty at other universities to contribute authored materials—a summer workshop was organized at Irvine in 1974 for this purpose. Even though the courseware itself is not easily exportable to other systems (because of the differing hardware and programming languages), the ideas, especially the ones that work well with students, have been successfully utilized by numerous colleges and universities. The Project is funded by the National Science Foundation and the University of California.

Several other organizations in the US have also made contributions to the field of computer graphics in education.

The PLATO Project at the University of Illinois at Urbana-Champaign has made graphics an integral part of its system since 1960. More than 3500 hours of tested materials in over 100 subject areas (including some 100 hours in physics) have been produced by users of PLATO, and they are being utilized by many institutions around the country. Graphics is such a high priority for the PLATO Project that Bruce Arne Sherwood, assistant director of the Computer-Based Education Research Laboratory, has said that any organization would be making a "serious mistake" if they limited computer-assisted instruction to text terminals, even though display-type terminals are currently more expensive.

One institution with a long history of efforts in this field is Dartmouth College, which has had student terminals and an active program for 15 years. Arthur Luehrmann, assistant director for academic computing, is responsible for computer development at Dartmouth. He has found that an algorithmic approach to learning is an effective supplement to the analytical one in teaching physics concepts in first-year courses; moreover, he feels that students are able to acquire skills for self-teaching with this approach and the aid of a computer. His current concerns include the creation of syntax (or program statements) for graphics in the BASIC language as a way of making graphics more accessible to students. In the future, Luehrmann hopes to adapt a computer-retrieval system for the purpose of calling up graphics—the applications of this would range from astronomy to art-history instruction.

The TICCIT Project, which was established by the Mitre Corp with NSF support, has been engaged in the technological development of hardware that is compatible with graphical displays. The system employs color displays, audio systems and videotapes. Most recently the Mitre Corp has been developing a means of creating programs through the use of on-line writing.

Independent modular supplements to the physics curriculum, which are computer-based and self-instructional, have been produced at the Illinois Institute of Technology for use in chemistry, physics and mathematics. Support funds from the NSF and Exxon Education Foundation have been almost exhausted and we were told by Harold Weinstock, professor of physics, that they are submitting a proposal for more funds to complete the project and evaluate the work. —BCC