# The eyes of the schoolchildren glisten with anticipation. Their fingers arch lightly over their computer terminals, waiting to tap out solutions to ever more difficult problems appearing on the screens before them. Any schoolteacher would be thrilled by such concentration and receptiveness. But these children are not in school; they're playing games in a video arcade.

Today's schoolchildren have grown up immersed in a world of computers and other information technologies. They play video games; they listen to music on digital compact disks; they help their families program the computerized controls of videocassette players. These experiences have given children a different way of interacting with information compared with previous generations. Many familiar communications media—including television, movies, radio, newspapers, magazines, and books—are essentially linear. The users of those media have little if any control over the information they receive. They follow the flow of information from beginning to end along a path determined in advance by the providers of the information.

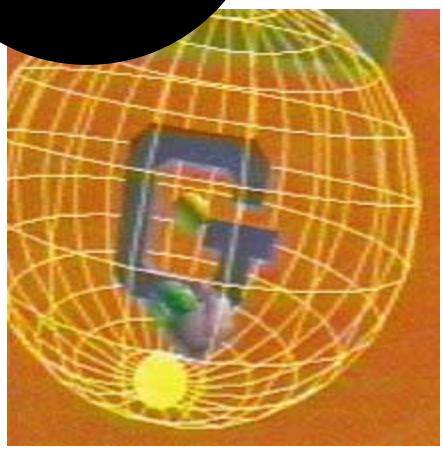
With today's technologies, the consumers of information can engage in dialogues instead of simply absorbing monologues. They can interrupt and redirect the flow of information. They can modify the complexity of information, the speed at which it is communicated, and its manner of presentation. They can control the elements of sophisticated multisensory experiences, combining audio, video, text, and graphics into a single immersive reality.

Information technologies are making it possible to create realistic new worlds filled with previously impossible experiences. In the virtual physics laboratory being developed by researchers at George Mason University and the University of Houston, students don a head-mounted display, headphones, and a data glove to enter an artificial reality where the laws of physics are under human—not nature's—control. Using the data glove, students move a disembodied hand through a room filled with simple physics experiments. They can turn gravity off or create antigravity and watch the effects on their surroundings. They can eliminate friction or slow the passage of time. With further develop-

**"The technology gap between schools and the rest of the world is real and it is growing. Whether we like it or not, the increasing pervasiveness and vitality of this technology is changing the expectations of our children and their world view. Schools of the future could look dramatically different from those we attended. If we plan carefully, if we bring teachers along with us and implement new technology wisely together with other needed reforms, learning could be dramatically better."**
—Frank Press, President Emeritus, National Academy of Sciences



## THE NINTENDO GENERATION



**Using a data glove, students plugged in to the Virtual Physics Laboratory can use this globe to aim the force of gravity in any direction—including straight up. Immersion in artificial but plausible worlds such as this challenges students' preconceptions and can impart an intuitive understanding of complex phenomena.**

**Reader Rabbit, an animated cartoon character in a series of games developed by The Learning Company, rewards players who spell simple words, match rhyming words, and learn the alphabet.**

**Such games, which combine vivid animation with constant interaction between the player and the computer, represent a powerful learning tool that is underused by schools.**

ment of the lab, students will be able to ride a light ray to experience relativity or participate as a molecule in a chemical reaction.

This kind of experience can be one of the best possible forms of education. Cognitive research has confirmed a commonsensical conclusion: students learn best when they are engaged with what they are studying, when they are making decisions, when they are thinking critically. In the Virtual Physics Laboratory, for example, students are constantly choosing how they want to interact with the computer-generated reality. By experiencing how the laboratory responds to their actions, they can gain an understanding of physical phenomena that is difficult to convey through traditional physics textbooks and laboratories.

Today there is a large and growing gap between the scant technology available in most schools and the rich technological environments students experience away from schools—and the gap is growing as societal change accelerates. Seventy-five percent of Americans now work in service and information jobs, with nearly half of all Americans involved in the generation, dissemination, and use of information. New technologies are creating workplaces where creativity, cooperation, and critical thinking are valued at all levels of an organization. If American education cannot equip young people with the skills they will need in an information-based world, they will not be able to play a productive role in society.

> "The coming levels of interactive technology hold the potential–if we take advantage of it–to create order-of-magnitude changes in productivity in American education."
> –David Britt, Children's Television Workshop

What can fill the technology gap between the in-school and out-of-school environments? It would be far too expensive to outfit every classroom with the most advanced technology. Instead, schools need to take advantage of the technology that increasingly permeates society. Doing so calls for rethinking many of the basic ideas behind education.

> "We must take advantage of students' interests in technology. . . . We must learn to use the technology students play with daily as educational resources."
> –Dorothy Strong, Chicago Public Schools

The technology to meet this challenge already exists and is in use outside of schools. This report is not about putting more computers into schools. It is dedicated to the idea that schools have to be reinvented to take advantage of the technology that is already ubiquitous in our everyday lives.

> "Kids are much more motivated to play games and use computers outside of school because of the level of interactivity. They have to make decisions frequently–every second or so–so they stay in charge. In school, if you're listening to a teacher lecture, you may only have to make a decision every half hour."
> –Joseph Smarr, Student


Video game or educational program? The engagement offered by state-of-the-art educational software (left) differs little from that offered by a Sega Genesis game (above).

**Children have always been explorers, born with the ability to interact and learn about the world. But children today are growing up in a different world. Those between the ages of 3 and 18—and especially children entering school today—are being hailed as the "Nintendo Generation." They live in a world that is increasingly interactive, communications intensive, and knowledge based. They are standard bearers in the technological revolution, having never known anything else. Because of their ease in and with the information age, society needs their active involvement and interaction.**

**The changes going on today create an opportunity and necessity for a transformation in the way our schools function and our children are taught. If we cannot teach our children how to play and work in this world, our children will remain at risk. Education must be based on a model that is appropriate for an information-driven society. We must prepare children for a future of unforeseeable and rapid change.**