SKILLS TRAINING

Where *Simulations* Are At Home

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The cohabitation of education and instructional technology has been turbulent if not outright antagonistic. By contrast, skill formation has had a far more benign interaction with all forms of instructional technology. In particular, simulation has been a tool used by trainers for a long while. In simulations, a concrete situation is reconstructed in what we now call a "virtual reality." Quoting Encyclopaedia Britannica, simulations are "in industry, science, and education, a research or teaching technique that reproduces actual events and processes under test conditions."

Trading Reality for Virtuality

Why would anybody want to replace the real world by a fake version? Essentially, there are at least three reasons:

1. ***Safety***. The real world is dangerous. Students should not risk their lives (or that of others) or get scared in the process of learning their trades.

2. ***Simplicity, ease and time compression*** achieved with the "virtual" version of training. Some experiments take a long time to set up and conduct. In others, the results are not so clear cut, due to too many unmanageable variables. Simulations can be a convenient and convincing way to synthesize the real world.

3. ***Economy***. Simulations can be less expensive than learning in the real world, particularly now that computers are increasingly inexpensive. Simulations may save on expensive labs or on consumables such as metal, electronic components or welding electrodes.

Flight Simulator

The first significant use of simulations was to train airplane pilots. The flight trainer was invented by Mr. Edwin Link in 1929. In aviation, the most forceful reason to use simulation is safety. At first, the Link Trainer was used to teach pilots instrument flight. But as simulators became more sophisticated and computers were introduced, the main use became a tool to teach pilots how to handle emergency situations. Pilots need to know how to react to life-threatening situations. Yet, turning off a turbine or disabling a rudder control in a jetliner in order to test pilot reaction is not a good idea. Modern flight simulators are multi-million dollar machines, often not much cheaper than real airplanes. But nobody thinks of costs when deciding to use them. The reason to resort to simulation is that it permits reproduction of conditions that, if reproduced in real flight, would be very dangerous. Thus simulators give pilots a chance to acquire the proper reactions under safer conditions.

Simulation of CNC Machines

Another very common family of simulations is those that reproduce the operation of numerically controlled machine tools (known as CNC machines). An apprentice will get to know a conventional lathe by handling it under controlled conditions, by machining initially simple parts, always being careful to keep the tool far away from the faceplate. Accidents happen. An extra turn of the lever and the tool may hit the turning plate. But a broken bit and a scratched faceplate in a learning lathe is not much of a loss. Yet, CNC lathes - that are programmed like a computer - cost several times more and are more prone to serious accidents. A wrong line of code may zoom the turret towards the faceplate, provoking a horrendous collision causing serious losses. Students are said to be traumatized by the crash and administrations have to write off the losses.

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Therefore, the obvious first idea was to couple the CNC to a simulator that would trace on paper the trajectory of the cutting tool. The drawing would immediately reveal an eventual mistake. Only after the simulation shows the program to be devoid of gross mistakes, can the real machine be used. With computers becoming more common, a monitor replaces the paper plotter. The obvious follow up development is software that simulate the entire process, dispensing with the real life lathe altogether. Clearly, this applies to milling machines and the whole gamut of CNC-controlled machine tools.

Today, computer simulations of CNC machines are very common, being quite sophisticated and inexpensive. If properly used, they can speed up the training and lower the costs significantly because trainees can learn much from them and they require a lot less supervision. Whether they altogether dispense with first hand contact with real life CNC machines is a controversial subject we need not be concerned with here. Let us only remember that the challenges of moving from a manual lathe to a CNC version resides at the programming end, not in handling the machine - which, once programmed, requires little human input in the first place. That being the case, it makes little difference on whether the programming is for a machine simulated in the monitor or a real life machine.

Simulators in Health

The use of simulators in health offers another promising avenue. There are programs that simulate a sick patient under very critical conditions. Medical students and nurses have to make quick decisions to save him. All the vital signs and other inputs usually available to doctors are given and the patient reacts to treatment in ways that simulate the human body. (See *The Use Of Technology For Learning And Skill Formation: A Medical Affair* in this issue of ***TechKnowLogia***)

Simulations for Troubleshooting

Another very common family of simulations occurs in electric and electronic circuits. Vocational schools frequently use panels where components are installed, reproducing the typical electric wiring, for example, of an automobile. After students understand the circuitry, the teacher may introduce faults in the circuit, either by disconnecting wires or by inserting malfunctioning components. Students have to troubleshoot the defective circuit and find the faults. Obviously, this is much more convenient and faster than working in real automobiles, where access to components and wiring is far more time consuming. In more modern versions, the defects can be introduced electronically, by means of central controls in the hands of the instructors. There are also simulations of defects in real life automobiles or tractors that have been wired to a computer that simulates the faults.

In such cases, simulations are a convenience to recreate in a training environment the kind of situation that is likely to happen in real life. Like in the case of the flight simulator, in a short time interval, it packs together events that would take much longer to occur spontaneously. If one were to learn in real automobiles how to troubleshoot faults, infrequent defects could fail to appear during the training cycle of the apprentice.

Simulations for Manual Dexterity

A less usual form of simulations are those that teach manual dexterity without incurring the costs of consumables. For instance, arc welding requires a steady hand to keep the electrode at a constant distance from the parts being welded. At the same time that the hand has to move at constant speed, it has to adjust for the distance, as the electrode shortens. This operation requires hundreds of hours of practice, burning expensive electrodes. There are contraptions that simulate a welding machine and permit significant savings in consumables.

The Electronic Bench

Perhaps the most impressive developments are coming from the use of computers to simulate electrical and electronic circuitry. One can use a mouse to pick up electronic components in a virtual storeroom and connect them in any way desired. A virtual battery or power supply is then connected and the circuit energized. It will display the properties of a real system, from turning on a light bulb to far more complex roles. Then, using a virtual multi-meter or oscilloscope, the student can make any measurement in this circuit, as if it were a real circuit. The Electronic Bench is the best known software of this type. With it, or with other similar programs, one can quickly assemble an infinite variety of virtual circuits and watch them work. This not only avoids damages to real world components, but the speed of assembly is much greater, even compared to panels where no soldering is required.

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Software to Simulate Hardware

At the limit, in digital electronic simulations, the student can build a computer that works just like in real life. The parts are picked up with the mouse and connected, creating digital circuits, starting from flip-flop gates, and/or switches and moving up to more complex microprocessors. In so many words, on the screen of a computer one can assemble and operate a computer. The software simulates the hardware. Ultimately, this is no different from a major thrust in real computer design, i.e. the use of software to simulate or, as said in the industry, to emulate hardware.

Where to Draw the Line

As an increasing fraction of the tasks requiring training involve electronic circuits and components, the frontier between the real thing and simulations is becoming blurred. Take, for instance, imaging. In the realm of silver halide photography, when shooting a still or movie picture, by pressing the shutter button, one unleashes an irreversible process, consuming film, chemicals and photographic paper. Studio photographers use Polaroid film to check results, before committing themselves to a more expensive process with real film. This is already a sort of simulation of results by means of a quick and less expensive alternative.

However, in digital photography, the very idea of simulation loses its sharp edges. One can record and re-record indefinitely the images, without consuming anything. Retouching an image or negative with fine brushes required a steady hand and errors could be irreversible. By contrast, working with PhotoShop one can "undo" anything and everything. The border between reality and simulation becomes blurred and immaterial, in contrast to the tangible difference between the simulation of a CNC machine and the real thing.

In Conclusion...

Overall, contrary to academic education, which is always at odds with new instructional technology, vocational training has had a long history of easy-going coexistence in such matters. Rejection is less frequent and there is a long history of use of simulations. Low and behold, not all simulations are equally popular with trainers. Flight simulation has been part and parcel of pilot training. But the highly intriguing and realistic Electronic Bench (or its equivalent) is not so widely used. The same is true with welding simulation, which offers significant potential for saving consumable electrodes.

One possible explanation is that richer schools are under little pressure to cut costs while poorer schools have access neither to simulations not to information about them. It may very well be that conservative trainers shun those varieties of simulations that merely reduce costs but add little realism of efficiency to the training.

To sum up, simulations in skills training have a long history. Trainers have welcomed them, in contrast to academic education where rejection is so common. Overall, it is a conspicuous case of successful use of technology in learning. Resistance from conservative groups seems to concentrate in areas where the benefits are purely economical rather than in the level of learning.