Digital Technology and the Skills Shortage

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The computing profession has the means to demolish the present skills shortage.

Governments and businesses in many advanced countries complain about the current skills shortage. They blame it for high wages, lowered economic growth, outsourcing, the need to import skilled workers, the failure of medical care, the high rates of car accidents and unemployment, and pretty well any instance of technical malfunction and project failure.

The irony of this is that digital technology could be used both to raise the average skill level of most young people and also to depopulate jails by using the same technique to rehabilitate the misfits who so often end up there. To achieve this, however, our whole approach to education must be redesigned, the education profession reorganized, the school system remodeled, and parents constrained to share the responsibility for their children's education. Even then, it would take a generation for the investment to start paying off.

SKILLS

Skill and intelligence are closely related. Intelligence is perhaps best defined as the unconscious application of skill to the conscious solving of problems. Therefore, the more skill someone has in any area, the more intelligently that person can function. For example, the better a person understands and can manipulate numbers, the more intelligently they can solve numeric and mathematical problems.

Skill of any kind has several essential features: It develops through practice, is best developed early in life, and develops accumulatively. The accumulation widens skill while intensifying it. These features are well known to people who train athletes and musicians, but they apply to all kinds of skills.

Although there are many kinds of skills, the types overlap. Howard Gardner's multiple intelligences (*Frames of Mind*, HarperCollins, 1983) map onto multiple skills extremely well and give a basis for effective skill development.

There are three objective skills. *Spatial skill* applies to the perception, classification, and identification of objects. *Logical-mathematical skill* addresses the individual and collective properties of objects, and relates to numeracy. *Bodily kinesthetic skill* concerns the perception and use of one's own body.

Two skills—language and music—are abstract in that they deal with sequences of sound or movement. Two social or personality skills can also be defined: *Intrapersonal skill* helps people perceive and control their own thoughts and feelings; *interpersonal skill* lets them perceive and affect what others are thinking and feeling—it relates to orality.

That basic skills are best developed early is well recognized, but just how early is not well appreciated. The abstract skills start developing in the womb, and manufacturers have claimed success for devices that reportedly accelerate such learning (www.babyplus.com). In any case, the newborn baby is neurally undeveloped and thus requires training in very early childhood to establish the neural circuitry that forms the basis for later learning by synaptic modification. For example, the newborn child can barely see. Its visual system, comprising the nerves themselves and their connections, develops by extending the connections that sharpen an image and sloughing the connections that blur it.

Any kind of skill can have different qualities, ranging from unthinking reaction to purposeful action. For example, naming a well-known object can be done unthinkingly, but learning what a newly encountered word means requires conscious endeavor. Increasing skills lets a person do unthinkingly what would otherwise require thought, and to do thinkingly what otherwise wouldn't be possible.

DRILLS

People develop skills through drill and practice (Philip E. Ross, "The Expert Mind," *Scientific American*, Aug. 2006). At one time, most classroom activities in primary school involved this method. My 1940 Grade 1 report card lists the subjects taken as Reading, Spelling, Writing, Transcription, Written Arithmetic, Practical Arithmetic, Mental Arithmetic, Art, and Handwork. The skill levels attained in schools could be vastly

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Table 1. Renaming the consonants of the alphabet.

Voiced plosives	Unvoiced plosives	Voiced fricatives	Unvoiced fricatives	Fluids	Semivowels
B bib	T tut	V vꝏv	F fiff	M mom	W wꝏw
D dad	Q chatch	Z zuzz	S sass	N nen	Y yuy
J jꝏdge	K kick	C zhazh	X shꝏsh	L loll	
G gug			H huh	R rer	

increased by reintroducing that kind of skill training and by using digital computers rather than teachers to deliver and assess the drill.

Personal computers could be used for drill, but machines like game consoles and iPods would serve as well, if not better. Special software technology must be developed to enable cheap and fast development of drill programs for all kinds of skills at all levels that would run on any suitable machine. The programs would have to adapt the drill to an individual student's needs and inclinations, and it would need to store performance data to monitor each student and identify particular difficulties. Support for speech synthesis and recognition would be crucial, especially for very young children.

The following examples focus on the needs of very early learning and sketch only a few possibilities. The sketches are intended merely to suggest; professional trainers would not only need to find the most effective ways to do the suggested kind of training, but also to assess the learning child to find the mode and rate most effective for that student. Once the learner has acquired a taste for skill, the need to extend and reinforce it by drill can be expected to continue throughout schooling and beyond. To meet this need, the drill software technology must be adaptable and extensible.

Objective skills

Drill for learning spatial skills primarily extends vocabulary. Learners acquire the names for displayed objects and their properties. Drill would introduce, say, a specific cat from various angles and induce the child to say its name. Then different cats could be used to teach the use of the word *cat*. Then different species of cat could be used to teach their names and the broader meaning of cat. And so on. The learner should be able to ask simple questions about the object being studied, and this could lead to different areas of learning either immediately or later on. As another example, in conjunction with musical skills development, students could learn the names of notes and the instruments used to produce them by drill.

For logical-mathematical skills, drill primarily extends the ability to reason about systematic properties. Learners acquire the names for numbers by learning to say—or, for large numbers, guess—how many objects are displayed. Then, if the drill displays dogs and cats together, the learner could be asked how many cats, then how many dogs, then how many animals altogether—thus learning to add.

Drill for body-kinesthetic skills extends the use of the body. The simple voice-responsive drill for early spatial skills would combine with improving pronunciation and could be used to improve listening and seeing. Drill for use of the limbs and the body as a whole would require attachments to the basic drill machine: for example, a stylus for teaching writing and drawing.

Abstract skills

Drill for musical skills extends the ability to recognize and produce rhythms and tunes and to learn and compose poems and songs. Drill for language skills extends the ability to understand and speak phrases and sentences, to read and spell, then to understand and compose extended text.

Digital technology offers an awesome potential in the language area. Children could be taught to read their own language in more than one writing system. Evidently, they could also learn other languages easily by starting early, and, arguably, they should be taught the local sign language. Circumstances allowing, children can learn much more than they are presently allowed to and much earlier, although some things would need to be done differently.

For early reading and writing, for instance, vocal interaction must be at the letter level. For this purpose, the present names of the letters in the alphabet are unsuitable, and schemes like *alpha/bravo* and *able/baker* go too far the other way. Single syllable names are needed, ones phonetically distant from each other, ideally with each name of a consonant different from every other in at least three phonetic features. In the exemplary Table 1, *a* stands for the vowel in *back*, *u* for the vowel in *buck*, and ꝏ for the vowel pair in *book*.

The letters C, Q, and X are peculiar, and thus have peculiar names, otherwise the names suggest the notional sound. The vowels left over are best named after their long notional pronunciation, without rhotacism. Thus, A = ah, E = air, I = ear, O = awe, and U = ooh. Simplicity is the virtue here, but to prevent them running together, two consecutive vowels will need to be separated by a *th*, as in *th*in, when spelling words out.

Social skills

Family and schools bear the responsibility for developing social skills. Some drill, however, could be of great assistance.

Drill for intrapersonal skills could increase self-awareness by conversation, as did the legendary Eliza program, by teaching psychological and anatomical vocabulary and by tracking and advising on personal health and hygiene.

Drill for interpersonal skills has tremendous potential for reversing the present trend to inorality, which is of great concern in many societies where children start school unable to converse. But in a way, the drill for other skills provides a basis for building interpersonal skills by amplifying the number of things that children can do together. For example, drill could be used to teach children their parts in choir singing or playacting.

SCHOOLS

Using machines to deliver drill and practice as I've described makes radical change necessary for both schools and the teaching profession. To begin training from very early childhood means that a new branch of the teaching profession will be needed to work with parents, even from before the child's birth, to help them deliver training, handle special problems such as autism and dyslexia, and manage the transition from learning entirely in the home to learning also in a school.

Primary schools would need to be changed drastically. With most skill learning done by machine, the teacher's role would be to monitor that skill learning and create activities in which students can apply those skills intelligently. Many of these activities would be done socially so that social skills and intelligence develop as well. Because basic skill learning will proceed at a different pace for different students, fixed classes and curricula become counterproductive. Primary school teachers will thus need different training and will assume different responsibilities.

When it comes to later schooling, the changes resulting from primary school transition will mean even greater changes, but these are more difficult to predict. Some possibilities are canvassed in Chapter 3 of my book, *Computers and People*, "Computers and Education" (Wiley, 2006).

Drill and practice has been denigrated in many circles for decades, especially teaching circles, where it is usually dismissed with a sneer as *drill and kill*. This is partly because delivering such instruction is boring and trivial for teachers. Computers can do so much better and at the same time remove teachers from the role of judges. Part of the reason is that it's seen as boring for the students. But what bores older children can greatly interest younger children. Further, the same digital technology that makes videogaming addictive can make drill and practice addictive.

The benefit could be enormous. A modest 5 percent per year increase in skill acquisition would double the skills otherwise learned in the first 15 years of life, and this is modest indeed, especially for the very early years. A feasible 10 percent per year would do the same in about half the time, and triple the skills in around 12 years.

Adopting such a program would be expensive and socially difficult, but given the problems looming for the next generation, the survival of the human race could well depend on the technology such an increase in skills would make possible. ■

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