# Digital Natives, Digital Immigrants

By Marc Prensky

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It is amazing to me how in all the hoopla and debate these days about the decline of education in the US we ignore the most fundamental of its causes. ***Our students have changed radically. Today's students are no longer the people our educational system was designed to teach.***

Today's students have not just changed *incrementally* from those of the past, nor simply changed their slang, clothes, body adornments, or styles, as has happened between generations previously. A really big *discontinuity* has taken place. One might even call it a "singularity" – an event which changes things so fundamentally that there is absolutely no going back. This so-called "singularity" is the arrival and rapid dissemination of digital technology in the last decades of the 20th century.

Today's students – K through college – represent the first generations to grow up with this new technology. They have spent their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age. Today's average college grads have spent less than 5,000 hours of their lives reading, but over 10,000 hours playing video games (not to mention 20,000 hours watching TV). Computer games, email, the Internet, cell phones and instant messaging are integral parts of their lives.

It is now clear that as a result of this ubiquitous environment and the sheer volume of their interaction with it, today's students *think and process information fundamentally differently* from their predecessors. These differences go far further and deeper than most educators suspect or realize. "Different kinds of experiences lead to different brain structures, " says Dr. Bruce D. Perry of Baylor College of Medicine. As we shall see in the next installment, it is very likely that *our students' brains have physically changed* – and are different from ours – as a result of how they grew up. But whether or not this is *literally* true, we can say with certainty that their *thinking patterns* have changed. I will get to *how* they have changed in a minute.

What should we call these "new" students of today? Some refer to them as the N-[for Net]-gen or D-[for digital]-gen. But the most useful designation I have found for them is ***Digital Natives.*** Our students today are all "native speakers" of the digital language of computers, video games and the Internet.

So what does that make the rest of us? Those of us who were not born into the digital world but have, at some later point in our lives, become fascinated by and adopted many

or most aspects of the new technology are, and always will be compared to them, ***Digital Immigrants***.

The importance of the distinction is this: As Digital Immigrants learn – like all immigrants, some better than others – to adapt to their environment, they always retain, to some degree, their "accent," that is, their foot in the past. The "digital immigrant accent" can be seen in such things as turning to the Internet for information second rather than first, or in reading the manual for a program rather than assuming that the program itself will teach us to use it. Today's older folk were "socialized" differently from their kids, and are now in the process of learning a new language. And a language learned later in life, scientists tell us, goes into a different part of the brain.

There are hundreds of examples of the digital immigrant accent. They include printing out your email (or having your secretary print it out for you – an even "thicker" accent); needing to print out a document written on the computer in order to edit it (rather than just editing on the screen); and bringing people physically into your office to see an interesting web site (rather than just sending them the URL). I'm sure you can think of one or two examples of your own without much effort. My own favorite example is the "Did you get my email?" phone call. Those of us who are Digital Immigrants can, and should, laugh at ourselves and our "accent."

But this is not just a joke. It's very serious, because the single biggest problem facing education today is that ***our Digital Immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language.***

This is obvious to the Digital Natives – school often feels pretty much as if we've brought in a population of heavily accented, unintelligible foreigners to lecture them. They often can't understand what the Immigrants are saying. What does "dial" a number mean, anyway?

Lest this perspective appear radical, rather than just descriptive, let me highlight some of the issues. Digital Natives are used to receiving information really fast. They like to parallel process and multi-task. They prefer their graphics *before* their text rather than the opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards. They prefer games to "serious" work. (Does any of this sound familiar?)

But Digital Immigrants typically have very little appreciation for these new skills that the Natives have acquired and perfected through years of interaction and practice. These skills are almost totally foreign to the Immigrants, who themselves learned – and so choose to teach – slowly, step-by-step, one thing at a time, individually, and above all, seriously. "My students just don't _____ like they used to," Digital Immigrant educators grouse. I can't get them to ____ or to ____. They have no appreciation for _____ or _____ . (Fill in the blanks, there are a wide variety of choices.)

Digital Immigrants don't believe their students can learn successfully while watching TV or listening to music, because they (the Immigrants) can't. Of course not – they didn't practice this skill constantly for all of their formative years. Digital Immigrants think learning can't (or shouldn't) be fun. Why should they – they didn't spend their formative years learning with Sesame Street.

Unfortunately for our Digital Immigrant teachers, the people sitting in their classes grew up on the "twitch speed" of video games and MTV. They are used to the instantaneity of hypertext, downloaded music, phones in their pockets, a library on their laptops, beamed messages and instant messaging. They've been networked most or all of their lives. They have little patience for lectures, step-by-step logic, and "tell-test" instruction.

Digital Immigrant teachers assume that learners are the same as they have always been, and that the same methods that worked for the teachers when they were students will work for their students now. ***But that assumption is no longer valid.*** Today's learners are *different*. "Www.hungry.com" said a kindergarten student recently at lunchtime. "Every time I go to school I have to power down," complains a high-school student. Is it that Digital Natives *can't* pay attention, or that they *choose not to*? Often from the Natives' point of view their Digital Immigrant instructors make their education *not worth* paying attention to compared to everything else they experience – and then they blame them for not paying attention!

And, more and more, they won't take it. "I went to a highly ranked college where all the professors came from MIT," says a former student. "But all they did was read from their textbooks. I quit." In the giddy internet bubble of a only a short while ago – when jobs were plentiful, especially in the areas where school offered little help – this was a real possibility. But the dot-com dropouts are now returning to school. They will have to confront once again the Immigrant/Native divide, and have even more trouble given their recent experiences. And that will make it even harder to teach them – and all the Digital Natives already in the system – in the traditional fashion.

So what should happen? Should the Digital Native students learn the old ways, or should their Digital Immigrant educators learn the new? Unfortunately, no matter how much the Immigrants may wish it, it is highly unlikely the Digital Natives will go backwards. In the first place, it may be impossible – their brains may already be different. It also flies in the face of everything we know about cultural migration. Kids born into any new culture learn the new language easily, and forcefully resist using the old. Smart adult immigrants *accept* that they don't know about their new world and take advantage of their kids to help them learn and integrate. Not-so-smart (or not-so-flexible) immigrants spend most of their time grousing about how good things were in the "old country."

So unless we want to just forget about educating Digital Natives until they grow up and do it themselves, we had better confront this issue. And in so doing we need to reconsider both our methodology and our content.

First, our methodology. Today's teachers have to learn to communicate in the language and style of their students. This *doesn't* mean changing the meaning of what is important, or of good thinking skills. But it *does* mean going faster, less step-by step, more in parallel, with more random access, among other things. Educators might ask "But how do we teach logic in this fashion?" While it's not immediately clear, we do need to figure it out.

Second, our content. It seems to me that after the digital "singularity" there are now *two kinds* of content: "Legacy" content (to borrow the computer term for old systems) and "Future" content.

"Legacy" content includes reading, writing, arithmetic, logical thinking, understanding the writings and ideas of the past, etc – all of our "traditional" curriculum. It is of course still important, but it is from a different era. Some of it (such as logical thinking) will continue to be important, but some (perhaps like Euclidean geometry) will become less so, as did Latin and Greek.

"Future" content is to a large extent, not surprisingly, digital and technological. But while it includes software, hardware, robotics, nanotechnology, genomics, etc. *it also includes the ethics, politics, sociology, languages and other things that go with them.* This "Future" content is extremely interesting to today's students. But how many Digital Immigrants are prepared to teach it? Someone once suggested to me that kids should only be allowed to use computers in school that they have built themselves. It's a brilliant idea that is very doable from the point of view of the students' capabilities. But who could teach it?

As educators, we need to be thinking about how to teach *both* Legacy and Future content in the language of the Digital Natives. The first involves a major translation and change of methodology; the second involves all that PLUS new content and thinking. It's not actually clear to me which is harder – "learning new stuff" or "learning new ways to do old stuff." I suspect it's the latter.

So we have to invent, but not necessarily from scratch. Adapting materials to the language of Digital Natives has already been done successfully. My own preference for teaching Digital Natives is to invent computer games to do the job, even for the most serious content. After all, it's an idiom with which most of them are totally familiar.

Not long ago a group of professors showed up at my company with new computer-aided design (CAD) software they had developed for mechanical engineers. Their creation was so much better than what people were currently using that they had assumed the entire engineering world would quickly adopt it. But instead they encountered a lot of resistance, due in large part to the product's extremely steep learning curve – the software contained hundreds of new buttons, options and approaches to master.

Their marketers, however, had a brilliant idea. Observing that the users of CAD software were almost exclusively male engineers between 20 and 30, they said "Why not make the learning into a video game!" So we invented and created for them a computer game in the "first person shooter" style of the consumer games *Doom* and *Quake,* called *The Monkey Wrench Conspiracy.* Its player becomes an intergalactic secret agent who has to save a space station from an attack by the evil Dr. Monkey Wrench. The only way to defeat him is to use the CAD software, which the learner must employ to build tools, fix weapons, and defeat booby traps. There is one hour of game time, plus 30 "tasks," which can take from 15 minutes to several hours depending on one's experience level.

*Monkey Wrench* has been phenomenally successful in getting young people interested in learning the software. It is widely used by engineering students around the world, with over 1 million copies of the game in print in several languages. But while the game was easy for my Digital Native staff to invent, creating the content turned out to be more difficult for the professors, who were used to teaching courses that started with "Lesson 1 – the Interface." We asked them instead to create a series of graded tasks into which the skills to be learned were embedded. The professors had made 5-10 minute movies to illustrate key concepts; we asked them to cut them to under 30 seconds. The professors insisted that the learners to do all the tasks in order; we asked them to allow random access. They wanted a slow academic pace, we wanted speed and urgency (we hired a Hollywood script writer to provide this.) They wanted written instructions; we wanted computer movies. They wanted the traditional pedagogical language of "learning objectives," "mastery", etc. (e.g. "in this exercise you will learn…"); our goal was to completely eliminate any language that even *smacked* of education.

In the end the professors and their staff came through brilliantly, but because of the large mind-shift required it took them twice as long as we had expected. As they saw the approach working, though, the new "Digital Native" methodology became their model for more and more teaching – both in and out of games – and their development speed increased dramatically.

Similar rethinking needs to be applied to all subjects at all levels. Although most attempts at "edutainment" to date have essentially failed from both the education and entertainment perspective, we can – and will, I predict – do much better.

In math, for example, the debate must no longer be about *whether* to use calculators and computers – they are a part of the Digital Natives' world – but rather *how* to use them to instill the things that are useful to have internalized, from key skills and concepts to the multiplication tables. We should be focusing on "future math" – approximation, statistics, binary thinking.

In geography – which is all but ignored these days – there is no reason that a generation that can memorize over 100 Pokémon characters with all their characteristics, history and evolution can't learn the names, populations, capitals and relationships of all the 101 nations in the world. It just depends on how it is presented.

We need to invent Digital Native methodologies for *all* subjects, at *all* levels, using our students to guide us. The process has already begun – I know college professors inventing games for teaching subjects ranging from math to engineering to the Spanish Inquisition. We need to find ways of publicizing and spreading their successes.

A frequent objection I hear from Digital Immigrant educators is "this approach is great for *facts*, but it wouldn't work for 'my subject.'" Nonsense. This is just rationalization and lack of imagination. In my talks I now include "thought experiments" where I invite professors and teachers to suggest a subject or topic, and I attempt– on the spot – to invent a game or other Digital Native method for learning it. *Classical philosophy?* Create a game in which the philosophers debate and the learners have to pick out what each would say. *The Holocaust?* Create a simulation where students role-play the meeting at Wannsee, or one where they can experience the *true* horror of the camps, as opposed to the films like *Schindler's List*. It's just dumb (and lazy) of educators – not to mention ineffective – to presume that (despite their traditions) the Digital Immigrant way is the *only* way to teach, and that the Digital Natives' "language" is not as capable as their own of encompassing any and every idea.

So if Digital Immigrant educators *really* want to reach Digital Natives – i.e. all their students – they will have to change. It's high time for them to stop their grousing, and as the Nike motto of the Digital Native generation says, "Just do it!" They *will* succeed in the long run – and their successes will come that much sooner if their administrators support them.

*See also: Digital Natives, Digital Immigrants Part 2: The scientific evidence behind the Digital Native's thinking changes, and the evidence that Digital Native-style learning works!*

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## Digital Natives, Digital Immigrants, *Part II:*

# Do They Really *Think* Differently?

By Marc Prensky

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*Different kinds of experiences lead to different brain structures.*
-Dr. Bruce D. Perry, Baylor College of Medicine

Our children today are being socialized in a way that is vastly different from their parents. The numbers are overwhelming: over 10,000 hours playing videogames, over 200,000 emails and instant messages sent and received; over 10,000 hours talking on digital cell phones; over 20,000 hours watching TV (a high percentage fast speed MTV), over 500,000 commercials seen—all before the kids leave college. And, maybe, *at the very most,* 5,000 hours of book reading. These are today's "Digital Native" students. [1]

In *Digital Natives, Digital Immigrants: Part I,* I discussed how the differences between our Digital Native students and their Digital Immigrant teachers lie at the root of a great many of today's educational problems. I suggested that Digital Natives' brains are likely *physically-different* as a result of the digital input they received growing up. And I submitted that learning via digital games is one good way to reach Digital Natives in their "native language."

Here I present evidence for why I think this is so. It comes from neurobiology, social psychology, and from studies done on children using games for learning.

## Neuroplasticity

Although the vast majority of today's educators and teachers grew up with the understanding that the human brain doesn't physically change based on stimulation it receives from the outside—especially after the age of 3— it turns out that that view is, in fact, *incorrect.*

Based on the latest research in neurobiology, there is no longer any question that stimulation of various kinds actually changes brain structures and affects the way people think, and that these transformations go on *throughout life.* The brain is, to an extent not at all understood or believed to be when Baby Boomers were growing up, *massively plastic.* It can be, and is, constantly reorganized. (Although the popular term *rewired* is somewhat misleading, the overall idea is

right—the brain changes and organizes itself differently based on the inputs it receives.) The old idea that we have a fixed number of brain cells that die off one by one has been replaced by research showing that our supply of brain cells is replenished constantly. [2] The brain *constantly* reorganizes itself all our child and adult lives, a phenomenon technically known as *neuroplasticity*.

One of the earliest pioneers in this field of neurological research found that rats in "enriched" environments showed brain changes compared with those in "impoverished" environments after as little as two weeks. Sensory areas of their brains were thicker, other layers heavier. Changes showed consistent overall growth, leading to the conclusion that *the brain maintains its plasticity for life.* [3]

Other experiments leading to similar conclusions include the following:

- Ferrets' brains were physically rewired, with inputs from the eyes switched to where the hearing nerves went and vice versa. Their brains changed to accommodate the new inputs. [4]
- Imaging experiments have shown that when bind people learn Braille, "visual" areas of their brains lit up. Similarly, deaf people use their auditory cortex to read signs. [5]
- Scans of brains of people who tapped their fingers in a complicated sequence that they had practiced for weeks showed a larger area of motor cortex becoming activated then when they performed sequences they hadn't practiced. [6]
- Japanese subjects were able learn to "reprogram" their circuitry for distinguishing "ra" from "la," a skill they "forget" soon after birth because their language doesn't require it. [7]
- Researchers found that an additional language learned later in life goes into a different place in the brain than the language or languages learned as children. [8]
- Intensive reading instruction experiments with students aged 10 and up appeared to create lasting chemical changes in key areas of the subjects' brains. [9]
- A comparison of musicians versus nonplayers brains via magnetic resonance imaging showed a 5 percent greater volume in the musicians' cerebellums, ascribed to adaptations in the brain's structure resulting from intensive musical training and practice. [10]

We are only at the very beginning of understanding and applying brain plasticity research. The goal of many who are—such as the company Scientific Learning—is "neuroscience-based education." [11]

## Malleability

Social psychology also provides strong evidence that one's thinking patterns change depending on one's experiences. Until very recently Western philosophers and psychologists took it for granted that the same basic processes underlie all human thought. While cultural differences might dictate what people think *about*, the *strategies* and *processes* of thought, which include logical reasoning and a desire to understand situations and events in linear terms of cause and effect, were assumed to be the same for everyone. However this, too, appears to be wrong.

Research by social psychologists [12] shows that people who grow up in different cultures do not just think about different things, they actually *think differently*. The environment and culture in which people are raised affects and even determines many of their thought processes.

"We used to think that everybody uses categories in the same way, that logic plays the same kind of role for everyone in the understanding of everyday life, that memory, perception, rule application and so on are the same," says one. "But we're now arguing that cognitive processes themselves are just far more malleable than mainstream psychology assumed." [13]

We now know that brains that undergo different developmental experiences develop differently, and that people who undergo different inputs from the culture that surrounds them think differently. And while we haven't yet directly observed Digital Natives' brains to see whether they are physically different (such as musicians' appear to be) the indirect evidence for this is extremely strong.

However, brains and thinking patterns do not just change overnight. A key finding of brain plasticity research is that brains do *not* reorganize casually, easily, or arbitrarily. "Brain reorganization takes place only when the animal pays attention to the sensory input and to the task." [14] "It requires very hard work."[15] Biofeedback requires upwards of 50 sessions to produce results. [16] Scientific Learning's Fast ForWard program requires students to spend 100 minutes a day, 5 days a week, for 5 to 10 weeks to create desired changes, because "it takes sharply focused attention to rewire a brain." [17]

Several hours a day, five days a week, sharply focused attention—does that remind you of anything? Oh, yes—video games! That is exactly what kids have been doing ever since *Pong* arrived in 1974. They have been adjusting or programming their brains to the speed, interactivity, and other factors in the games, much as boomers' brains were programmed to accommodate television, and literate man's brains were reprogrammed to deal with the invention of written language and reading (where the brain had to be retrained to deal with things in a highly linear way.) [18] "Reading does not just happen, it is a terrible struggle." [19] "Reading [has] a different neurology to it than the things that are built into our brain, like spoken language." [20] One of the main focuses of schools for the hundreds of years since reading became a mass phenomenon has been retraining our speech-oriented brains to be able to read. Again, the training involves several hours a day, five days a week, and sharply focused attention.

Of course just when we'd figured out (more or less) how to retrain brains for reading, they were retrained again by television. And now things have changed *yet again*, and our children are furiously retraining their brains in even newer ways, many of which are antithetical to our older ways of thinking.

Children raised with the computer "think differently from the rest of us. They develop hypertext minds. They leap around. It's as though their cognitive structures were parallel, not sequential." [21] "Linear thought processes that dominate educational systems now can actually retard learning for brains developed through game and Web-surfing processes on the computer." [22]

Some have surmised that teenagers use different parts of their brain and think in different ways than adults when at the computer. [23] We now know that it goes even further—their brains are almost certainly *physiologically different*. But these differences, most observers agree, are less a matter of kind than a difference of degree. For example as a result of repeated experiences, particular brain areas are larger and more highly developed, and others are less so.

For example, thinking skills enhanced by repeated exposure to computer games and other digital media include reading visual images as representations of three-dimensional space (representational competence), multidimensional visual-spatial skills, mental maps, "mental paper folding" (i.e. picturing the results of various origami-like folds in your mind without actually doing them), "inductive discovery" (i.e. making observations, formulating hypotheses and figuring out the rules governing the behavior of a dynamic representation), "attentional deployment" (such as monitoring multiple locations simultaneously), and responding faster to expected and unexpected stimuli. [24]

While these individual cognitive skills may not be new, the particular combination and intensity is. We now have a new generation with a very different blend of cognitive skills than its predecessors—the Digital Natives.

## What About Attention Spans?

We hear teachers complain so often about the Digital Natives' attention spans that the phrase "the attention span of a gnat" has become a cliché. But is it really true?

"Sure they have short attention spans—for the old ways of learning," says a professor. [25] Their attention spans are *not* short for games, for example, or for anything else that actually interests them. As a result of their experiences Digital Natives crave *interactivity*—an immediate response to their each and every action. Traditional schooling provides very little of this compared to the rest of their world (one study showed that students in class get to ask a question every *10 hours*) [26] So it generally isn't that Digital Natives *can't* pay attention, it's that they *choose not to.*

Research done for *Sesame Street* reveals that children do not actually watch television continuously, but "in bursts." They tune in just enough to get the gist and be sure it makes sense. In one key experiment, half the children were shown the program in a room filled with toys. As expected, the group with toys was distracted and watched the show only about 47 percent of the time as opposed to 87 percent in the group without toys. But when the children were tested for how much of the show they remembered and understood, the scores were exactly the same. "We were led to the conclusion that the 5-year-olds in the toys group were attending quite strategically, distributing their attention between toy play and viewing so that they looked at what was for them the most informative part of the program. The strategy was so effective that the children could gain no more from increased attention." [27]

## What Have We Lost?

Still, we often hear from teachers about increasing problems their students have with reading and thinking. What about this? Has anything been *lost* in the Digital Natives' "reprogramming" process?

One key area that appears to have been affected is *reflection*. Reflection is what enables us, according to many theorists, to generalize, as we create "mental models" from our experience. It is, in many ways, the *process* of "learning from experience." In our twitch-speed world, there is less and less time and opportunity for reflection, and this development concerns many people. One of the most interesting challenges and opportunities in teaching Digital Natives is to figure out and invent ways to *include* reflection and critical thinking in the learning (either built into the instruction or through a process of instructor-led debriefing) *but still do it in the Digital Native language.* We can and must do more in this area.

Digital Natives accustomed to the twitch-speed, multitasking, random-access, graphics-first, active, connected, fun, fantasy, quick-payoff world of their video games, MTV, and Internet are *bored* by most of today's education, well meaning as it may be. But worse, the many skills that new technologies *have* actually enhanced (e.g., parallel processing, graphics awareness, and random access)—which have profound implications for their learning—are almost totally ignored by educators.

The cognitive differences of the Digital Natives *cry out* for new approaches to education with a better "fit." And, interestingly enough, it turns out that one of the few structures capable of meeting the Digital Natives' changing learning needs and requirements is the very video and computer games they so enjoy. This is why "Digital Game-Based Learning" is beginning to emerge and thrive.

## But Does It Work?

Of course many criticize today's learning games, and there is much to criticize. But if some of these games don't produce learning it is *not* because they are games, or because the concept of "game-based learning" is faulty. It's because *those particular games are badly designed.* There is a great deal of evidence that children's learning games that *are* well designed *do* produce learning, and lots of it — by and while engaging kids.

While some educators refer to games as "sugar coating," giving that a strongly negative connotation—and often a sneer—it is a big help to the Digital Natives. After all, this is a medium they are very familiar with and really enjoy.

Elementary school, when you strip out the recesses and the lunch and the in-between times, actually consists of about three hours of instruction time in a typical 9 to 3 day. [28] So assuming, for example, that learning games were only 50% educational, if you could get kids to play them for six hours over a weekend, you'd effectively add a day a week to their schooling! Six hours is far less than a Digital Native would typically spend over a weekend watching TV and playing videogames. The trick, though, is to make the learning games compelling enough to actually be used in their place. They must be *real* games, not just drill with eye-candy, combined creatively with *real* content.

The numbers back this up. The Lightspan Partnership, which created PlayStation games for curricular reinforcement, conducted studies in over 400 individual school districts and a "meta-analysis" as well. Their findings were increases in vocabulary and language arts of 24 and 25 percent respectively over the control groups, while the math problem solving and math procedures and algorithms scores were 51 and 30 percent higher. [29]

Click Health, which makes games to help kids self-manage their health issues, did clinical trials funded by the National Institutes of Health. They found, in the case of diabetes, that kids playing their games (as compared to a control group playing a pinball game) showed measurable gains in self-efficacy, communication with parents and diabetes self-care. And more importantly, urgent doctor visits for diabetes-related problems declined 77 percent in the treatment group. [30]

Scientific Learning's *Fast ForWard* game-based program for retraining kids with reading problems conducted National Field Trials using 60 independent professionals at 35 sites across the US and Canada. Using standardized tests, each of the 35 sites reported conclusive validation of the program's effectiveness, with 90 percent of the children achieving significant gains in one or more tested areas. [31]

Again and again it's the same simple story. Practice—time spent on learning—*works*. Kid's don't like to practice. Games capture their attention and make it happen. And of course they must be practicing the right things, so *design* is important.

The US military, which has a quarter of a million 18-year-olds to educate every year, is a big believer in learning games as a way to reach their Digital Natives. They know their volunteers expect this: "If we don't do things that way, they're not going to want to be in our environment." [32]

What's more, they've observed it working operationally in the field. "We've seen it time and time again in flying airplanes, in our mission simulators." Practical-minded Department of Defense trainers are perplexed by educators who say "We don't know that educational technology works—we need to do some more studies." "We KNOW the technology works," they retort. We just want to get on with using it." [33]

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So, today's neurobiologists and social psychologists agree that brains can and do change with new input. And today's educators with the most crucial learning missions—teaching the handicapped and the military—are already using custom designed computer and video games as an effective way of reaching Digital Natives. But the bulk of today's tradition-bound educational establishment seem in no hurry to follow their lead.

Yet these educators know *something* is wrong, because they are not reaching their Digital Native students as well as they reached students in the past. So they face an important choice.

On the one hand, they can choose to ignore their eyes, ears and intuition, pretend the Digital Native/Digital Immigrant issue does not exist, and continue to use their suddenly-much-less-effective traditional methods until they retire and the Digital Natives take over.

Or they can chose instead to *accept* the fact that they have become Immigrants into a new Digital world, and to look to their own creativity, their Digital Native students, their sympathetic administrators and other sources to help them communicate their still-valuable knowledge and wisdom in that world's new language.

The route they ultimately choose—and the education of their Digital Native students—depends very much on us.

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**Notes**

1. These numbers are intended purely as "order of magnitude" approximations; they obviously vary widely for individuals. They were arrived at in the following ways ( Note: I am very interested in any additional data anyone has on this):

   *Videogames*: Average play time: 1.5 hours/day (Source: "Interactive Videogames, *Mediascope*, June 1966.) It is likely to be higher five years later, so 1.8 x 365 x 15 years = 9,855 hours.

   *E-mails and Instant Messages*: Average 40 per day x 365 x 15 years = 219, 000. This is not unrealistic even for pre-teens – in just one instant messaging connection there may be over 100 exchanges per day – and most people do multiple connections.

   *TV*: "Television in the Home, 1998: Third Annual Survey of Parent and Children, Annenburg Policy Center, June 22, 1998, gives the number of TV hours watched per day as 2.55. M. Chen, in the *Smart Parents Guide to Kid's TV*, (1994) gives the number as 4 hours/day. Taking the average, 3.3 hrs/day x 365 days x 18 years = 21,681.

   *Commercials*: There are roughly 18 30-second commercials during a TV hour. 18 commercials/hour x 3.3 hours/day x 365 days x 20 years (infants *love* commercials) = 433,620.

   *Reading*: Eric Leuliette, a voracious (and meticulous) reader who has listed online every book he has ever read (www.csr.utexas.edu/personal/leuliette/fw_table_home.html), read about 1300 books through college. If we take 1300 books x 200 pages per book x 400 words per page, we get 10,400,000,000 words. Read at 400 words/that gives 260,000 minutes, or 4,333 hours. This represents a little over 3 hours/book. Although others may read more slowly, most have read far fewer books than Leuliette.

2. Paul Perry in *American Way*, May 15, 2000.

3. Renate Numella Caine and Geoffrey Caine, *Making Connections: Teaching and the Human Brain*, Addison-Wesley, 1991, p.31.

4. Dr. Mriganka Sur, *Nature*, April 20, 2000.

5. Sandra Blakeslee, *New York Times*, April 24, 2000.

6. Leslie Ungerlieder, National Institutes of Health.

7. James McLelland, University of Pittsburgh.

8. Cited in *Inferential Focus Briefing*, September 30, 1997.

9. Virginia Berninger, University of Washington, *American Journal of Neuroradiology*, May 2000.

10. Dr. Mark Jude Tramano of Harvard. Reported in *USA Today* December 10, 1998.

11. *Newsweek*, January 1, 2000.

12. They include Alexandr Romanovich Luria (1902-1977), Soviet pioneer in neuropsychology, author of *The Human Brain and Psychological Processes* (1963), and, more recently, Dr. Richard Nisbett of the University of Michigan.

13. Quoted in Erica Goode, "How Culture Molds Habits of Thought," *New York Times*, August 8, 2000.

14. John T. Bruer, *The Myth of the First Three Years*, The Free Press, 1999, p. 155.

15. G. Ried Lyon, a neuropsychologist who directs reading research funded by the National Institutes of Health, quoted in Frank D. Roylance "Intensive Teaching Changes Brain," *SunSpot*, Maryland's Online Community, May 27, 2000.

16. Alan T. Pope, research psychologist, Human Engineering Methods, NASA. Private communication.

17. *Time*, July 5, 1999.

18. *The Economist*, December 6, 1997.

19. Kathleen Baynes, neurology researcher, University of California – Davis, quoted in Robert Lee Hotz "In Art of Language, the Brain Matters " *Los Angeles Times*, October 18, 1998.

20. Dr. Michael S. Gazzaniga, neuroscientist at Dartmouth College quoted in Robert Lee Hotz "In Art of Language, the Brain Matters " *Los Angeles Times*, October 18, 1998.

21. William D. Winn, Director of the Learning Center, Human Interface Technology Laboratory, University of Washington, quoted in Moore, *Inferential Focus Briefing* (see 22).

22. Peter Moore, *Inferential Focus Briefing*, September 30, 1997.

23. *Ibid.*

24. Patricia Marks Greenfield, *Mind and Media, The Effects of Television, Video Games and Computers*, Harvard University Press, 1984.

25. Dr. Edward Westhead, professor of biochemistry (retired), University of Massachusetts.

26. Graesser, A.C., & Person, N.K. (1994) "Question asking during tutoring,". *American Educational Research Journal*, 31, 104-107.

27. Elizabeth Lorch, psychologist, Amherst College, quoted in Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference*, Little Brown & Company, 2000, p. 101.

28. John Kernan, President, The Lightspan Partnership. Personal communication.

29. "Evaluation of Lightspan. Research Results from 403 schools and over 14,580 students," February 2000, CD ROM.

30. Debra A. Lieberman, "Health Education Video Games for Children and Adolescents: Theory, Design and Research Findings," paper presented at the annual meeting of the International Communications Association, Jerusalem, 1998.

31. Scientific Learning Corporation, National Field Trial Results (pamphlet.) See also Merzenich *et al.*, "Temporal Processing Deficits of language-Learning Impaired Children Ameliorated by Training" and Tallal, *et al.*, "Language Comprehension in Language Learning Impaired Children Improved with Acoustically Modified Speech," in *Science*, Vol. 271, January 5, 1996, pp 27-28 & 77-84.

32. Michael Parmentier, Director, Office of Readiness and Training, Department of Defense, The Pentagon. Private briefing.

33. Don Johnson, Office of Readiness and Training, Department of Defense, The Pentagon. Private briefing.