

Education for the Third Industrial Revolution

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# Education for the Third Industrial Revolution<sup>1</sup>

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## 1. A brief sketch of the argument

At the risk of sounding like a crass economist, I want to assert at the outset that one major purpose of the K-12 educational system is “vocational” in the broad sense. Specifically, the K-12 system is a mechanism for preparing cadres of 18-year-olds (many of whom will get some higher education first) to perform the tasks needed and remunerated by the U.S. job market (or of being easily trained to do so). To be sure, this narrowly economic purpose of mass public education is not the *only* reason to educate America’s youth; an educated citizenry presumably has other social benefits as well. But I believe it is an important purpose and, in any case, it is the perspective that guides this essay. Any reader who does not accept this initial premise can stop reading right now.

My second, and much more controversial, premise is that the needs of the U.S. economy are changing (that’s not the controversial part) in ways that are at least somewhat predictable (that *is* the controversial part). To be sure, I am not foolish enough to believe that we can predict *in detail* the mix of jobs that will be available in the United States in, say, 2028 or 2038 and then fine-tune the educational system to meet those demands. But I think at least two broad trends are clearly foreseeable.

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<sup>1</sup> Parts of this essay derive from Alan S. Blinder, “Offshoring: The Next Industrial Revolution?,” *Foreign Affairs*, March/April 2006, pp. 113-128, and Alan S. Blinder, “Outsourcing: Bigger than You Thought,” *The American Prospect*, November 2006, pp. 44-46.

First, machines will continue to take over more and more of the work that was previously done by humans, a process that has been going on since the dawn of the First Industrial Revolution. And these days, “machines” generally means computers of some sort, as some well-known research by Frank Levy and Richard Murnane, among others, has emphasized.<sup>2</sup> Loosely speaking, employment in jobs that can be routinized sufficiently that a computer can perform them do not have a great future. This will hardly be news to most thinking people.

But the second major trend—offshoring—is less obvious and far less well understood or commented upon. Its implications for the educational system are the focus of this essay. Specifically, the offshoring of formerly-American jobs to lower-wage countries—where they are done by *humans*, not by computers—is changing and will continue to change the menu of jobs available to American workers. In its more recent variants, in which service jobs as well as manufacturing jobs are migrating abroad, offshoring is enabled by the remarkable advances in information and communications technology (ICT). So, in a sense, the computer is driving both phenomena. Nonetheless, the two are different.

Note that, just as in the case of automation, the claim is *not* that we are heading for a world of massive unemployment as cheap foreign labor takes over the tasks now being performed by Americans. Rather, the claim is that offshoring will change *substantially* and *systematically* the *mix* of jobs available to American workers, just as automation has been doing for centuries.<sup>3</sup> To be more specific, I believe that 20-30 years from now the U.S. labor market will have (relatively) more jobs in what I call the *personally-delivered*

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<sup>2</sup> Frank Levy and Richard Murnane, *The New Division of Labor* (New York: Russell Sage), 2004.

<sup>3</sup> This is not meant to deny that there is also “reverse feedback” from the nature of the available workers to the mix of the available work.

*services*, and (relatively) fewer jobs in manufacturing and what I call the *impersonally-delivered services*. (These terms are defined more precisely below.) This proposition—stated boldly but vaguely here--needs much further elucidation and defense, which it will receive in Section 2.

If these first two premises are accepted, it follows that America should reform its K-12 education system, and perhaps higher education as well, in ways that make the schools prepare (relatively) fewer young people for jobs in manufacturing and impersonal service occupations and (relatively) more young people for personal service occupations. Furthermore, because there is a 13-year gestation period between the 5-year-old inputs of the K-12 system and the 18-year-old outputs, the time to start initiating these changes is *now*. The kindergarteners who enroll in the fall of 2008 will be the high school graduates of 2021, and they will graduate into a job market quite different from our own. We don't want to equip these kids with skills that will, by then, be in demand mainly in India and China (or will be supplied by computers).

But what sorts of changes in the educational system are appropriate to that end? I am an economist, not an education specialist. And for this and other reasons, I can give only partial and incomplete answers to this important question. With all due modesty, and much is due, I share my preliminary thoughts and speculations on the indicated directions for K-12 education in Section 3.

Section 4 briefly summarizes the argument for readers in a hurry.

## **2. Offshoring and the next industrial revolution**

There have been two great industrial revolutions to date.<sup>4</sup> The first was the biggest.

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<sup>4</sup> Some historians prefer to count *three* because they consider the changes brought about by

As labor in the industrializing countries migrated from farm to factory, beginning in the late 18<sup>th</sup> century, societies were transformed beyond recognition. How and where people lived, the organization of business, the laws and practices of government, and—most germane to this essay--how societies educated their children all changed dramatically to accommodate an important new economic reality: Fewer people were earning their livings on farms and more were earning their livings in factories. The shift off the farm was massive. It has been estimated that in 1810 some 84% of the U.S. workforce was engaged in agriculture, compared to a paltry 3% in manufacturing. By 1960, the manufacturing share had risen to almost one-quarter and the agricultural share had dwindled to just 8%.<sup>5</sup> (Today it is under 2%.)

America reacted quite intelligently to the skill demands of the First Industrial Revolution by building what may have been the world's best system of mass public education. Although the country ironically adopted an agrarian-based school calendar (with a long summer "vacation" to raise and harvest crops), the K-12 system was aptly designed to turn out great numbers of literate and numerate workers for the nation's factories. And it was highly successful. Indeed, mass public education was one of the key ingredients in the recipe by which the upstart United States of America thrust itself into the forefront of industrialization.

But that was then and this is now. The prototypical American school still resembles too much a factory built on Tayloristic principles, even though factory work now employs only about 10% of the U.S. workforce. Think about it. Students enter the

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electrification and other remarkable technologies in the late 19th and early 20th centuries to have been a "Second Industrial Revolution". Others call this period the second stage of the First Industrial Revolution. I follow the latter convention, but nothing but my title hinges on the count.

<sup>5</sup> *Historical Statistics of the United States: Colonial Times to 1970*, Part I, p. 139.

building when the bell rings in the morning. They sit (mainly quietly) at their desks (which resemble workbenches) except for prescribed breaks, do well-defined assigned work much of which is highly standardized, and then leave when the bell rings in the afternoon—much like factory workers. This design builds in a not-too-subtle behavioral message. As Alan Lesgold, dean of the University of Pittsburgh’s School of Education put it, “For the industrial age, the hidden curriculum had components like following directions, showing up on time, respecting authority, and sticking to the standard modes of learning and doing.”<sup>6</sup> The problem is: The industrial age is over, and too few schools seem to have noticed its passing.

The *Second* Industrial Revolution, which is still in progress, is the massive shift of employment away from manufacturing and toward services. Oddly, the shift to services is still viewed with alarm in America and in many other rich countries, where people bemoan rather than welcome the resulting losses of manufacturing jobs even though new service sector jobs have sprouted up in greater numbers than old manufacturing jobs have disappeared. In round numbers, about 35% of American nonagricultural workers produced goods (principally, manufacturing and construction) in 1960 while 65% produced services. By 2007, only about 16% of America’s nonagricultural jobs were still in the goods-producing industries while 84% produced services.

This trend is worldwide and continuing. Between 1967 and 2005, the service sector’s share of total jobs increased by about 20 percentage points in the U.S., but by about 23 percentage points in Japan, about 26 points in the U.K. and Italy, and about 29 points in

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<sup>6</sup> Posted 8/1/2006 on “Dean’s Blog” at [www.education.pitt.edu/weblogs](http://www.education.pitt.edu/weblogs).

France.<sup>7</sup> The shift toward services has also led to numerous major changes in our lives—from television to the Internet to the decline of physical labor, to name just a few.

At the risk of some (but not much) exaggeration, the nation's K-12 education system never adapted to the Second Industrial Revolution. Yet we are now, I believe, in the early stages of a *Third* Industrial Revolution, often called the Information Age. The cheap and easy flow of packets of information around the globe has vastly expanded both the volume and variety of services that can be traded across national borders--and there is much, much more to come. Like the two previous industrial revolutions, the Information Age will require vast and unsettling adjustments in the way we work, the way we live, and so on. To cite one trivial but illustrative example, there is already a huge generation gap between those who “text” (a verb, if you're young; a noun, if you're old) and those who don't. But I want to focus on just one: the way we educate our children for the jobs that will remain in this country.

While the main labor-market story of the past 25-30 years was the growing schism between those who have college degrees and those who do not, I argued in a recent article in *Foreign Affairs* that the greatest problem facing the next generation of American workers may not be lack of education, but rather offshoring--the movement of certain jobs overseas, especially to countries with much lower wages, like India and China.<sup>8</sup> Of course, manufacturing jobs have been migrating overseas for decades. Nothing new here. But the recent wave of offshoring, that of *service* jobs, is something new—and different.

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<sup>7</sup> OECD, *Quarterly Labour Force Statistics*, various issues, and *Labour Force Statistics, 1985-2005* at [www.sourceoecd.org](http://www.sourceoecd.org).

<sup>8</sup> Alan S. Blinder, “Offshoring: The Next Industrial Revolution?,” *Foreign Affairs*, March/April 2006, pp. 113-128. A longer version, with appropriate scholarly footnotes and references, appeared as “Fear of Offshoring,” CEPS Working Paper No. 119, Princeton University, December 2005.

Traditionally, we have thought of service jobs as being largely immune to foreign competition. After all, you can't get your hair cut or your broken arm set by a barber or doctor in a distant land.<sup>9</sup> But stunning advances in communications technology, plus the emergence of a vast new pool of educated labor in Asia and Eastern Europe, are changing that picture radically. In the process, these forces are subjecting millions of presumed-safe domestic *service* jobs to foreign competition. And it is not necessary actually to *move* jobs to low-wage countries in order to restrain wage increases in the United States; the mere *threat* of offshoring can do the job.

Service offshoring is a minor phenomenon so far, but it appears to be growing very fast. I believe it will eventually equal or exceed manufacturing offshoring for three main reasons, two of which were already mentioned in Section 1.<sup>10</sup> The first is just arithmetic: There are vastly more service jobs than manufacturing jobs in the United States (and in other rich countries). Second, the technological advances that have made service-sector offshoring possible will continue to enlarge the range of services that can be moved offshore and will enhance their quality. Third, the number of, e.g., Indian and Chinese workers capable of performing service jobs offshore is certain to grow, perhaps exponentially.

For a while, it seemed that only American manufacturing workers and a few low-end service workers (e.g., call center operators) had to compete with hundreds of millions of people in faraway lands who were eager to work for what is a pittance by U.S. standards.

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<sup>9</sup> That said, in January 2008 the National Public Radio show "Marketplace" carried a story about remote monitoring of patients in intensive care units! And a Chinese-American entrepreneur told me of a Chinese company working on electronic control (from China) of lawnmowers cutting lawns in the U.S.

<sup>10</sup> The key distinction for this purpose is what workers actually do on their jobs, not whether their employers are classified as manufacturers or service firms. For example, General Motors' lawyers and accountants are service workers. So are the computer programmers at Microsoft, which is classified as a manufacturing firm.



But offshoring is no longer limited to low-end service jobs. Computer code is routinely written overseas and emailed back to the United States. So are tax returns and lots of legal work, though not the sort that requires face-to-face contact with the accountant or lawyer. In writing and editing this article, I communicated with the editors and staff of the Urban Institute only by email. Why couldn't they (or I, for that matter) have been in India? The possibilities are, if not endless, at least vast.

What distinguishes jobs that cannot be offshored from ones that can? I believe it is that some services either *require* personal delivery (e.g., driving a taxi and brain surgery) or are *seriously degraded* when delivered electronically (e.g., college teaching—or so I hope!), while other jobs (e.g., call centers and keyboard data entry) are not.<sup>11</sup> That is the central distinction between *personal services* and *impersonal services*, which I mentioned earlier. To make the distinction more concrete, here are some examples, including both high-end and low-end jobs:

<u>Impersonal services</u>	<u>Personal services</u>
Radiologist	Internist
Security analyst	Investment banker
Tax accountant	Auditor (on site)
Computer programmer	Computer repairer
Telemarketer	Retail salesperson
Food packager	Grocery store clerk
Call center operator	Receptionist
Key-puncher	Bricklayer

With this distinction in mind, I have three main points to make about preparing our workforce for the brave new world of the future. These three points will set the stage for the next section's discussion of educational reform.

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<sup>11</sup> In addition, some jobs are tied to a particular geography—e.g., you can't be a farm worker in Nebraska from China.

First, the line that divides personal services from impersonal services will move inexorably in only one direction, as technological progress makes it possible to deliver an ever-increasing array of services electronically.

Second, the novel distinction between personal and impersonal jobs is quite different from, and appears essentially unrelated to, the familiar distinction between jobs that do and do not require high levels of education. For example, it is easy to offshore working in a call center, typing transcripts, writing computer code, and reading X-rays. The first two require little education; the last two require quite a lot.<sup>12</sup> On the other hand, it is either impossible or very difficult to offshore janitorial services, working in a fast-food restaurant, college teaching, and open-heart surgery. Again, the first two occupations require little or no education, while the last two require a great deal. There seems to be little or no correlation between educational requirements (the old concern) and how offshorable jobs are (the new one).<sup>13</sup>

This line of thought leads straight to my third point: We need to think about, plan, and probably redesign our educational system with the crucial distinction between personal service jobs and impersonal service jobs in mind. The reason is simple: While many impersonal service jobs will migrate offshore, the personal service jobs will stay here.<sup>14</sup>

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<sup>12</sup> Two caveats: First, some call center operators must have high levels of skill and education—e.g., the person you get on the phone when your computer malfunctions. Second, Frank Levy and Kyoung-Hee Yu (“Offshoring of Professional Services: Radiology Services from India”, unpublished manuscript, MIT, March 2006) have shown that, while technology permits the offshoring of radiology, regulations generally prohibit it. But this may change in time.

<sup>13</sup> I have explored this relationship systematically in Alan S. Blinder, “How Many U.S. Jobs Might Be Offshorable?,” Center for Economic Policy Studies Working Paper No. 142, March 2007. In my estimates, the rank correlation between education and offshorability is +0.08.

<sup>14</sup> Other jobs, including in manufacturing and impersonal services, will also remain here. I do not want to be misinterpreted (as I have been) as arguing that only personal service jobs will be available in the U.S. The point is that the *mix* will shift.

The implications seem startling at first. A generation from now, civil engineers (or at least those who must be physically present) may be in greater demand in the U.S. than computer engineers (who don't). Similarly, there might be more divorce lawyers (not offshorable) than tax lawyers (partly offshorable). Carpenters might earn more than computer programmers. I am not predicting any of these things; lots of factors influence relative demands and supplies for different types of labor. But it all seems within the realm of the possible as technology continues to enhance the offshorability of even highly-skilled occupations. And the school system should be aware of it.

### **3. Adapting our educational system to the job market of the future**

It is important to note that I am *not* suggesting that education will become a handicap in the job market of the future. On the contrary, to the extent that more education raises productivity, and that better-educated workers are more adaptable and/or more creative, a wage premium for higher education should remain. So it still makes sense to send more of America's youth to college.

But over the next generation, *the kind of education* our young people receive may prove to be more important than *how much education* they receive. In that sense, a college degree may lose the exalted "silver bullet" status it acquired over the last generation. Over the past 25-30 years, "stay in school longer" was excellent advice for success in the U.S. labor market—almost all the advice you needed. But looking forward over the next 25-30 years, more subtle occupational advice may be in order. "Prepare yourself for a high-end personal service occupation that is not offshorable" is a more nuanced message than "stay in school." But it may prove to be more useful. And notice

that many well-paid jobs that are not offshorable—such as carpenters, electricians, and plumbers--do not require college degrees.

The hard question is how to make this more subtle advice concrete and actionable. With educational gestation periods of 13-17 years and more, educators and policy-makers need to be thinking *now* about the kinds of training and skills that will best prepare today's children for their future working lives. Specifically, the premise with which I opened this essay implies that it is essential to educate America's youth *for the jobs that will actually be available in America 20-30 years from now*, not for the jobs that will, by then, have been moved offshore (or be done by machines).

Some of the personal service jobs that will remain in the United States will be very high-end (e.g., doctors), others will be less glamorous though well-paid (e.g., plumbers), and some will be poorly-paid (e.g., janitors). Educational specialists, teachers, principals, and others need to think long and hard about the types of skills that will best prepare future workers to deliver high-end personal services, and how to teach those skills in our elementary and high schools. The latter will, of course, imply changes in the way we train teachers.

What might a new K-12 curriculum look like? I do not pretend to have well-thought-out answers, much less a set of detailed lesson plans to offer. But the central principle is pretty simple: We want to emphasize the development of skills that a computer cannot replicate and that an educated Indian will have a hard time doing nearly as well as an American. To me, that suggests emphasizing things like creativity, inventiveness, spontaneity, flexibility, interpersonal relations, and so on—not rote memorization

Thus I think the fetish with *standardization* is a vestige of the First Industrial Revolution that needs to be (largely) jettisoned as quickly as possible. A team of education scholars from the University of Wisconsin has stated that, “Theories of learning and instruction embodied in school systems designed to teach large numbers of students a standardized curriculum are dinosaurs in this new world” (of free-flowing information technology).<sup>15</sup> Saying that does not imply that we should stop teaching our children how to read and write. But I think it does, for example, mean that the central thrust of No Child Left Behind is pushing the nation in exactly the wrong direction. I am strongly in favor of accountability. But the nation’s school system will not build the creative, flexible, people-oriented workforce we will need in the future by drilling kids incessantly for standardized tests in the vain hope that they will out-memorize a memory chip. If there are to be standardized tests—which we may need for accountability’s sake—they will have to be quite different from the ones to which we are accustomed.

Lesgold, an expert on artificial intelligence, observed that our educational system does not exploit the comparative advantages of humans over machines. Instead, he wrote:<sup>16</sup>

almost all of the assessments prevalent in education measure capabilities that machines often have as well. It is not unusual, for example, for a school system to have as its math goals teaching the younger child to emulate a \$5 calculator and the older child to emulate a \$100 graphing calculator. But, if that’s as far as we go, our kids will face stiff competition from machines. Perhaps it’s time to think about what our children will need to be more valuable than a computer when they go out into the world.

He suggests three arenas in which humans outperform computers: “the ability to solve emergent and novel problems,” “being a quick learner,” and “bridging between different bodies of knowledge.” And I’d like to add a fourth, which is encapsulated by that

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<sup>15</sup> David Williamson Shaffer, Kurt R. Squire, Richard Halverson, and James P. Gee, “Video Games and the Future of Learning,” *Phi Delta Kappan*, October 2005, p. 110.

<sup>16</sup> On Dean’s Blog, posted 8/1/2006.

kindergarten grade we all got for “works and plays well with others.” The ability to interact productively with other people will become increasingly important in a world of personally-delivered services.

What might a new curriculum geared to these emerging job-market realities look like, concretely? I’m a college teacher who has never designed a grade-school curriculum, and I’m not about to start now. So I’ll stick to some high-level ideas. The task of reform clearly starts in the elementary schools, where we need to develop our youngsters’ imaginations and people skills as well as the traditional “reading, writing, and ‘rithmetic” that was so essential to the First Industrial Revolution. It is time we recognized that Frederick Winslow Taylor did not foresee the Third Industrial Revolution. While our kids do need to learn basic literacy and numeracy, sitting quietly at ersatz factory benches is probably not the best way to prepare them for the more free-form Information Age, especially not young boys who have a hard time sitting still anyway.

Instead of rote drills on questions with pat answers that can be graded by optical scanners, perhaps we should be posing more *novel* and even *ill-defined* problems that have no simple answers—questions that can be wrestled with productively and that, though they have no “right” answers, certainly have better and worse ones. Such questions would, of course, typify the work and social environments in which all of us actually live.

More *group activities* and *interactions* may also be essential components of the new curriculum--including, where appropriate, grading the *group’s* performance rather than the *individual’s*. As one concrete example, playing sophisticated *video games* (not zapping aliens or stealing cars!) may prove to be a useful part of a revised K-12

curriculum. Shaffer *et al.* (p. 105), for example, have urged educators to “look at [certain types of] video games because they create new social and cultural worlds—worlds that help us learn by integrating thinking, social interaction, and technology.” (See below.) They might have added that children *enjoy* playing such games and throw much mental energy into them.

In the same spirit, John Seely Brown, the famed computer scientist who for years ran Xerox’s remarkable Palo Alto Research Center, has noted that “most folks who write about game play seldom talk about the *social life* around the edge of the game. Yet that’s where most of the thinking, planning, trading of arcane knowledge bits and learning actually occurs.”<sup>17</sup> (Note the two words I have italicized.) As I read thoughts like these, I can’t help but think that (a) computers may never be able to do these things well and (b) workers in far-off lands with different cultures will have a hard time competing with home-grown talent on turf like this.

These new types of education probably need to be continued and made more sophisticated in the secondary schools, where, for example, good communications skills also need to be developed. Shaffer *et al.* (p. 105) emphasize that what they call “epistemic games” are “personally meaningful, experiential, social, and epistemological all at the same time.” These games emphasize, e.g., learning-by-doing and experimentation, which are part of the comparative advantage of humans, rather than rote memorization, which is not. Furthermore, playing what they call “massively multiplayer” online games, “in which thousands of players are simultaneously online at a given time, participating in virtual worlds with their own economies, political systems, and

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<sup>17</sup> John Seely Brown, “New Learning Environments for the 21<sup>st</sup> Century,” paper presented at the Forum for Higher Education, Aspen, 2005, p. 17. Brown was clearly thinking of older children—high school or even college age.

cultures...can also be a thoroughly social phenomenon ... because playing [them] means developing a set of *effective social practices*” (p. 106).<sup>18</sup>

In the same vein, although he was thinking about college rather than high school students, Brown (p. 67) argues that “learning by doing with others offers students the opportunity for in-depth enculturation into a particular practice, where one *learns to be* a physicist, social scientist, historian, etc., in contrast to just *learning about* such professions.” He advocates de-emphasis of the traditional lecture model for college science classes in favor of “an active learning approach, that is, a highly collaborative, hands-on environment, with extensive use of desk-top experiments and educational technology” (p. 73). Again, these sorts of educational practices would exploit and develop the advantages that young Americans have over both computers and young Indians.

I hasten to add that these ideas for K-12 curriculum reform are by no means mainstream, much less do they represent anything that would be called an emerging consensus. They are best thought of as somewhat renegade ideas that may yet be supplanted by better ones. But I think they merit serious consideration. And, as I’ve emphasized, the time is *now*.

As we think about preparing our youth for the labor market of the future, more vocational education is probably also in order—maybe much more. After all, nurses, carpenters, and plumbers are already scarce, and we’ll likely need many more of them in the future. Since much vocational training now takes place in community colleges, those institutions also need to adapt their curricula to the job markets of the future.

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<sup>18</sup> I have one worry: To the extent that the social interactions are electronic, the resulting talents can also be provided by offshore labor.



In our present culture, most of these occupations are viewed as “a step down” from those that require a college degree. But the economics of the labor market might change that. As an example, I have taken to asking audiences to whom I speak the following question: In 25 years, whom do you think will earn more in America, the average computer programmer or the average carpenter? It used to surprise me, but no longer does, that most people choose the latter. The people get it.

As noted above, it is probably still true that we should send more kids to college and increase the numbers who study science, math, and engineering. But we need to focus on preparing more college students for the high-end jobs that are unlikely to move offshore, and on developing a creative workforce that will keep America incubating and developing new processes, new products, and entirely new industries. Offshoring is, after all, mostly about following and copying. American needs to lead and innovate instead, just as we have in the past. Brown’s ideas, cited above, are relevant here.

#### **4. Summary**

This essay is predicated on the notion that one main purpose of a nation’s school system is to prepare its youth for the world of work. That premise implies that the nature of education should evolve along with the nature of the skills demanded of the workforce. Indeed, since there are such long time lags between the five-year-old “inputs” into the school system and the high school and college graduates who emerge 13-17 years later, education should be designed with the nature of *future* jobs in mind—to the extent that is possible. That last phrase, however, is a major qualification, since the future will always be elusive.<sup>19</sup>

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<sup>19</sup> According to a wise old maxim, “One thing you should never predict is the future.”

Yet it is the claim of this essay that at least two aspects of America's job market future *are* broadly predictable. First, computer and telecommunications technology will continue to advance rapidly, making more and more jobs offshorable. And second, countries like India and China will continue to produce massive numbers of new skilled workers capable of performing these tasks. These two powerful trends, working in tandem, seem likely to shift the demand for U.S.-based labor strongly away from *impersonal services* (and manufacturing) and toward *personal services*.

Unfortunately, the K-12 school system still seems mired in the First Industrial Revolution, for which it was well-designed to turn out cadres of factory workers—an occupation group that has now dwindled to just 10% of the U.S. workforce and is destined to shrink further. Even as the Third Industrial Revolution (the Information Age) proceeds as a breakneck pace, the Tayloristic principles that define so much of factory work are still all too dominant in the design of our nation's school system.

The touchstone principle for a new K-12 curriculum is easy to state but perhaps hard to translate into concrete terms: We need to prepare our youth for high-end personal service jobs by developing skills that a computer cannot replicate and that an educated foreign worker will find difficult to emulate. That general idea suggests, among other things, moving away from the rote memorization that is so strongly emphasized by current standardized tests. Instead, we must focus more on teaching such things as creativity, spontaneity, communication, and interpersonal relations.

The new curriculum for the Information Age must emphasize attributes and skills in which we humans hold comparative advantages over machines and in which we Americans hold comparative advantages over, say, Indians. To me, that suggests a style

of teaching and a curriculum that features (in addition to reading, writing, and arithmetic) communication and interpersonal skills, group interactions, puzzle solving, learning by doing, experimentation, and perhaps even epistemic video games. Quite clearly, any such thorough-going revamp of the K-12 curriculum will also require new ways to test students and new ways to train teachers. All these things will take time to develop and implement. Which is too bad, because we really don't have any.

As the First Industrial Revolution took hold, America radically transformed and democratized its educational system to meet the demands of an emerging industrial society. The effort bore exceptional fruit. But this is not your father's economy any more, much less your grandfather's. If we are to meet the challenges of the Third Industrial Revolution, we may need to do something like that again.