BEYOND NATIONAL STANDARDS AND GOALS:

Excellence in Mathematics and Science Education K-16

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Second Plenary Session Keynote Address

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MR. MARSHALL: Well, I am glad to have the opportunity to share this platform with Governor Romer and to be with all of you.

Let me state some propositions I would like to develop in greater detail. One of the most important of these is that, before we can compete successfully in a global economy, our people must learn to think for a living.

Unfortunately, an outdated assumption that rudimentary skills are sufficient for a lifetime of work still haunts the Nation’s education, industry, and labor systems. At an earlier time in our lives, basic skills were sufficient because the United States had no serious international competition and production had a larger natural resource content.

But today, when the latest technology is readily available to every country in the world, and where almost everything of value has a large knowledge content, high incomes depend heavily on higher-order thinking skills. In other words, all of our people now need to have the skills that previously were reserved only for the few managerial, professional, and technical workers in our society.

It has also become very clear—and I think this is an extremely important point on equity—that we will not have a world-class economy and a higher quality of life for most of our people, or perhaps even for any of our people, unless more people have higher-order thinking skills and all have access to these skills. A way to say that is: How well off we are going to be depends heavily on what kind of team we’ve got in this country and how we collectively are able to perform in the kind of world that we are in.

Math and science are central to these higher-order thinking skills, partly because of knowledge and content, that is, because of the subject matter itself, but also because of the habits of mind that math and science convey and inculcate in people. The intellectual competence about learning that comes from the mastery of math and science is extremely important to the learning of everything. The obverse of that is: If people believe they cannot master math and science, they also doubt their intellectual competence and, therefore, do not believe they can learn. Once they believe that, many people make it a self-fulfilling prophecy and are unable to enjoy the benefits of a higher standard of living.

It is also important to emphasize, however, that we should not view math and science as discrete subjects apart from life. The world does not divide itself up like we do university departments. We have to use math and science in all of our activities and should not conceive of it as a black box or a discrete subject that has little relevance to the rest of what we do.
Now, let me take those propositions apart. I think it is instructive to look at our history in order to see how we got to be the world’s leading economy during the early part of this century, what habits of thought we developed that cause us some trouble now (and what we should do about them), and, most importantly, what role a standards-driven education system will have in improving our learning systems.

There were three things that made the United States the world’s leading economy by 1926, and the first was having an abundance of natural resources when natural resources were much more important than they are now.

Second, the U.S. had a large and growing internal market, which made it possible to have mass production and economies of scale. That was the system that allowed us to easily improve productivity and living standards, as illustrated by the Ford Motor Company. Henry Ford reduced the cost of a touring car from $850 to $360 in 6 years, just before the first World War, with his mass production system.

Now, that mass production system organized work so that only a few people needed to manage and think, while most people did routine work that was fragmented so that you could get very good at, for example, putting Bolt No. 35 on a rear left wheel. This work was fairly automatic. The system minimized the importance of thinking for front-line workers and emphasized the importance of being able to do routine work. People had to be literate to work in Ford’s factory, because they had detailed instructions, but if you had basic skills and were willing to work hard, you could earn a very good living working for Ford Motor Company or for most other mass production industries. That mass production system was very important.

The third factor was supportive institutions and policies, since we had a system that permitted the growth of a large internal market. One of the supportive processes that contributed to the success of the American system was mass education. Henry Ford’s system was applied more rigorously to the schools than to any industry I know of, and the basic idea was to mass produce literates, take people right off the farm or the boat and transform them into literate people who could work on our farms and in our factories.

As a result of that system, we developed a reputation for having the world’s best-educated workforce. In fact, if you had conducted a poll in 1960 in the world and asked people who has the best educated workforce in the world, they probably would have said the United States of America.

I need not tell you that would not be the case today. There are very few people who would say the United States has the best educated workforce in the world. In fact, almost no knowledgeable observer would argue that point. Most experts would say we have the worst educated workforce among the major industrialized countries, especially for our front-line workers. The only people in our system who are world class are college educated and scientific people, not most front-line workers. But the mass production of education and products earlier contributed to the longest period of sustained prosperity equitably shared in human history, from the 1930’s and into the 1970’s.

Now the questions are: What happened to cause that system to come unglued, and why are we no longer necessarily regarded as the world’s most effective economy? We are still the world’s
richest economy, but we are not necessarily regarded as the system that other countries want to emulate in terms of our management system and the way we operate the economy.

Well, the main thing that happened was technology greatly undermined the causes of our traditional strength. How did it do that? The first thing it did was to greatly reduce the significance of natural resources, because the essential economic point about science and technology is that technological improvement is really all about substituting ideas, skills, and knowledge for physical resources.

That is illustrated by the work of Theodore Schultz at the University of Chicago, who got the Nobel Prize in economics for demonstrating that the return to human capital was higher than the return to physical capital. Schultz and his students pointed out that we have fewer physical resources in American agriculture now than we did in the 1920's, as we acquired less labor, land, and capital; yet we have tripled and quadrupled output, depending on the crop. Why? We substituted ideas, skills, and knowledge for physical resources.

Another illustration is that people working in the human capital tradition of Theodore Schultz have tried to ask the following question and answer it with the best tools available to us, and that is: What accounts for improvements in productivity? That is the key, of course, to improvements in wealth and improvements in our standard of living.

What they found, fairly uniformly, is that 80 percent or more is due to ideas, skills, and knowledge or to technology and human capital; 20 percent or less to physical capital, i.e., machine capital; and zero to natural resources. So what previously was an important advantage has in many ways become a serious disadvantage.

It is not a coincidence that many countries with very limited natural resources are doing very well. They were forced by geography and history to develop their people, which is the key to success in the world that we are in today. Science and technology also globalized our economy and, therefore, took away the advantages of mass production. Mass production was available to American companies because they had the American market to themselves. Now they don't. Everybody has the American market and, therefore, what was previously an advantage has suddenly become a disadvantage if companies are unable to adjust to the economic realities of this world.

And what are those realities? The main reality is that you have got to be competitive now. What does that mean? Well, economists don't agree on a lot, but we agree that when it comes to being competitive, you as an individual, a state, a nation, or a company have two choices. You can either compete by reducing your income, mainly by cutting wages, or you can compete by being more productive, and that is it. There are no other options.

In the United States, because we have not had a strategy, we have backed into low-wage policies as a way to compete. The low-wage strategy is a loser in the minds of most people, because, first, there are always countries with lower wages, but this option also implies lower and more unequal incomes and wages. We already have the most unequal distribution of income of any industrialized country, and it is becoming more unequal. Why? Well, mainly because the people who have the higher-order thinking skills are doing very well. Most of our people are
not. Only 25 percent of our people are college educated, and they will do relatively well, but most people who are unable to compete in this world will not be able to do very well.

A very important limitation of a wage strategy is that it limits the extent to which you can improve your income, because the only way you can do it is to work harder, and there is a limit to how hard people can work. With declining real wages, the only way we have sustained family incomes in the United States is with more women working. Now, that is obviously self-limiting. There are not many families with another wife to put into the workforce, and the slowdown in the growth of our workforce means that the whole country will be in trouble, unless we change.

The other option is improving productivity, which gets us closer to our story, because what that really means is to substitute ideas, skills, and knowledge for physical resources, which puts you on a very steep earning and learning curve. We don’t even know what the limit to that is, because we really never have tried it, but we know that it’s very steep and much less limiting than trying to pursue the low-wage strategy.

If you are going to be more productive, though, you have to do some things. First, you have to have a strategy. The reason we have a low-wage strategy in this country is not because we had a big debate and said let’s go for low wages. It is because we didn’t believe in a strategy. A productivity strategy requires high performance work organizations that emphasize quality, best defined as meeting your customers’, students’, or clients’ needs. Henry Ford’s factory was producer driven. Henry Ford is reported to have said that you could have any color car that you wanted, so long as it is black. Obviously, nobody would say that today, because we are in a consumer-driven world, and once you concentrate on your students and your customers, you change the operation of the whole system. Quality therefore becomes extremely important.

Second, we have to think about efficiency in the use of all of our resources. Economies of scale caused us to be lazy and to build in a lot of slack that we can no longer afford. We had too many people, a large bureaucracy, to run the system, and that has become inefficient. We had inventory, because we made the assumption we are going to make a lot of mistakes. That builds in inefficiency. Now we have to have productivity in the use of all of our resources.

Third, we also must have flexibility. Our traditional system tried to get security through contracts and rules and regulations. In the world that we are in today, we get security through flexibility and adaptability, not through contracts and rules and regulations, and that is a very difficult thing for a lot of people to understand.

Fourth and finally, you need to have what we have come to call high-performance organization. What does that mean? First, it means you have a lean, participative management system, because information technology is inherently decentralizing. It is best used at the point of production, as the Soviet Union learned, as General Motors is learning, as most of our institutions are learning and, therefore, it is very inefficient to use it from a central point.

Second, you have to develop and use leading edge technology and have highly skilled workers. Why? For a very simple proposition: The old model used standardized technology and unskilled labor. Obviously, that work will not be done in high-wage places. We are not going
to pay American workers $10 or $15 an hour to do the same work on the same machines that you can get done in Mexico for $1 or $2 an hour. That technology will seek out those low-wage places.

The question for all of us is: What do you do about that? The initial reaction for a lot of Americans is, well, we will automate, we will make these machines idiot-proof, and we will have Star Wars and illiterates. Wherever that was tried, it was a disaster. Why? People have to give wisdom to the machines. People have to improve the performance of the machines and, therefore, the basic model is smart machines/smart people, not smart machines/untrained people.

What kinds of skills have we found from our work all over the world that we need? Well, the list is now uniformly accepted almost everywhere. The first thing you need to be able to do is to impose order on information, because the machines give us a lot of information. If you don’t know what to do with the information, it is worse than not having it. If you know what to do with it, you can improve whatever you do. You can run a better household, be a better teacher, improve the quality of products, and solve problems; therefore, those math and science skills of imposing order on information become very important.

Increasingly, information work is group work. We have turned putting Bolt No. 35 on over to a robot, and now people are involved in group work, and that means interpersonal and communication skills become extremely important.

Third, and often neglected, one of the most important skills anybody can have in the world we are in today is learning skills. It is amazing how little attention traditional mass production schools give to learning. Very few people have ever had any systematic instruction in learning. Very few of our schooling processes give much evidence that they understand how people learn. Yet, we have learned more about learning in the last 10 or 15 years than in all of our previous history. And if people are able to learn, they are able to deal with change or to assimilate technology. If they are efficient learners, they can improve whatever kind of work they are doing. Learning therefore becomes a very important skill.

Another higher-order skill is the ability to deal with ambiguity. One of the problems with our learning systems is we often teach people that there are answers in the back of the book. Well, in life there are no answers in the back of the book, so you must be able to deal with the ambiguity. You have got to be a self-manager. You have got to have an experimental frame of mind to solve problems and learn and develop new information. All of this, of course, means that you must give heavy attention to the kinds of habits of mind that we get from math and science.

Now, another characteristic of a high-performance system often overlooked in many activities, including in our learning systems, is a positive incentive structure. There are two kinds of incentives, basically. One is negative, which means you do what I want you to or I will punish you, and we use that a lot in our systems. You will never get excellence with that incentive. A second is perverse, and we have a lot of that. Perverse means you do what I want you to and I will punish you. You see, most American workers believe—and we have polling data to show this—that if they improve productivity, they will lose their jobs. Well, that is a perverse
incentive. Many of our schools allocate money on the basis of average daily attendance for a couple of weeks in October.

We used to do that in Texas. We would put on contests during those weeks to get people to show up, and if you did, you could win a door prize. After that, we didn’t care if you showed up or not. And guess which students we hoped didn’t come back? The ones who needed it most. Now, that is a perverse incentive, if you are worried about dropouts. Incentives are very important in our learning systems and we need to pay a lot of attention to that.

Now, our learning systems have a lot of problems, and let me just mention those, and then list the things. Governor Romer has done a good job of talking about the importance of standards, so I won’t spend a lot of time on that. But let me tick off what seem to me to be the major problems that we face and what role a standards-driven system could play in that.

First, as he emphasized, our most important learning system is the family, and we have a larger proportion of children in poverty than any other industrialized country. And with some amazing exceptions, poor families ordinarily are not good learning systems. The good news is that we can cause them to be better learning systems by involving parents in the learning process.

Second, our schools are still geared to mass producing literates, and we do a fair job of that. They are not geared to turning out people with higher-order thinking skills.

We have more tracking in our system than any major industrial country I know of, and yet we tend to be against tracking. Now, why do we have tracking? We don’t wait until they are teenagers in the United States to track them. We start doing it at birth. Then when people get in school, we decide some are going to college and others aren’t, and we see that those that are going to college get courses that prepare them for college, and those that we don’t think are going to college are put in the general track or the vocational track and don’t receive higher-order thinking skills.

We also do almost nothing for people who are not going to college. We have the worst career preparation system for non-college students of any major industrial country. We do more for people who are going to college, but less for people who are not. The success of the American economy will depend mainly on what we do for people who aren’t going to college, and no more than 30 percent of our workforce will be college educated by the year 2000.

Now, what do we need to do? The answer is that we need to have high standards for people who graduate from high school, and we need to create standards for occupation for people who are not going to go to college. We also need to remove the financial barriers to people getting an education, because, oddly enough, we have more barriers than most of our major competitors. In Germany, education is a free good, because they believe what we learned from our GI Bill and what Ted Schultz and his students discovered through scientific research; that is, the return to human capital is higher than the return to physical capital.

What role would standards play? First, of course, it would eliminate tracking. If we had high standards everybody had to meet, then we couldn’t track, and schools would be responsible for ensuring that people met those standards.
Second, you would have some way to measure the restructuring of a school for higher performance, because the high performance system applies to schools just as much as it does to companies and for the same reasons. We need to decentralize the work of teachers and create incentives for people to make student achievement the main objective of schools.

Third, we need to provide motivation for students to learn. You see, in our system, if you are not going to college, there is no motivation to take science and math or to make good grades. If we had high standards, there would be motivation.

Fourth, we should provide information to people about what the system is doing and improve the efficiency of the whole system by linking learning systems.

Standards are important elements in systemic efficiency. Why? Well, we spend the first two years of college in this country doing what most countries consider to be high school work. Why? Because there are no standards for graduation from high school. If we had high standards, we would have more efficiency. Many companies spend a lot of money teaching subjects that should have been taught in high school. Why? Because there are no standards. Company training programs could be a lot better, if we had standards and if the employers knew what was required of students before they leave high school.

We therefore need a standards-driven education system if we want to be a world-class country with high incomes, and it would be hard to think of a subject that is more important for our national standing in the world, as well as the personal quality of life for our people.

Thank you.