Entrepreneurship
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Lecture 37
Education and Entrepreneurship – Part 2

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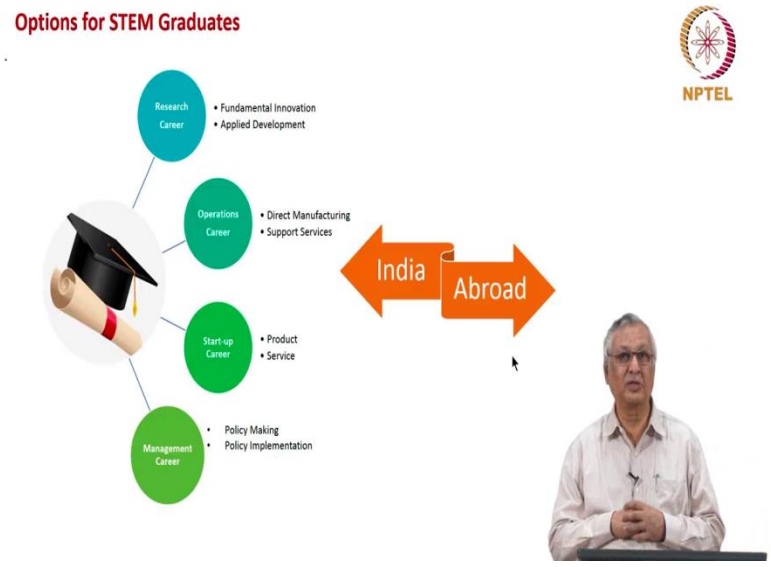

Now when we look at the options for STEM graduates, as I said, there are huge a number of options. One is the research career, where you work on fundamental innovation, you work on applied development. Second, there is an operations career, where you work on direct manufacturing or you provide support services. When we say support services, services such as information technology, quality assurance, quality control, regulatory affairs, logistics, and then general clinical practices in respect of pharmaceutical companies, sales and marketing services, etc.

Then we have a start-up carrier, where you look at a product or service and taking to the market. And the fourth option of career could be management, where whole lot of influence will be in terms of making policies, monitoring policy implementation and even administration. These options could be in India or they could be abroad. So, the number of options are available for STEM graduates, but the start-up career is one which we are focused on as we go through.

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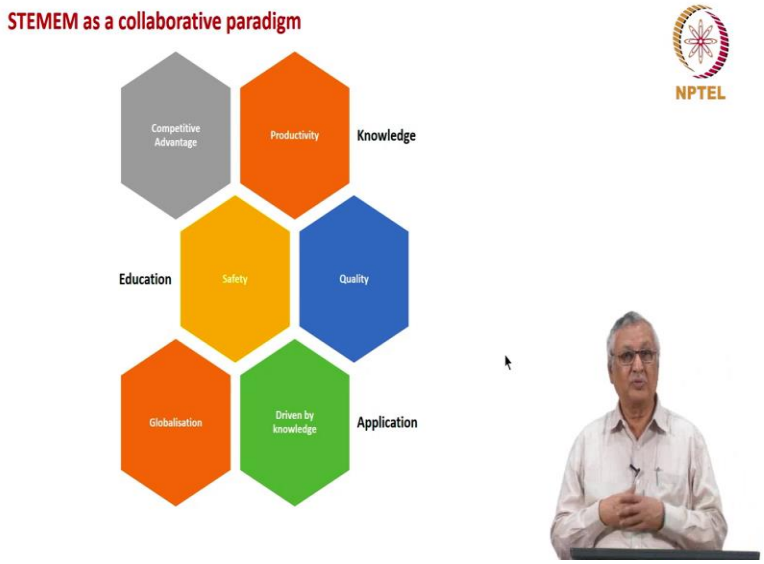

Now when we talk about STEM, we can also look at EM as additional factors. What are EM? Signifying, E signifies Enterprise, M specifies, signifies Management. As a collaborative paradigm, it provides competitive advantage, because you are computational in your thinking, efficient in your execution. You also get productivity, you assure safety, you assure quality and you are able to apply the knowledge which you have and then you are able to globally adapt yourself to the overall requirements.

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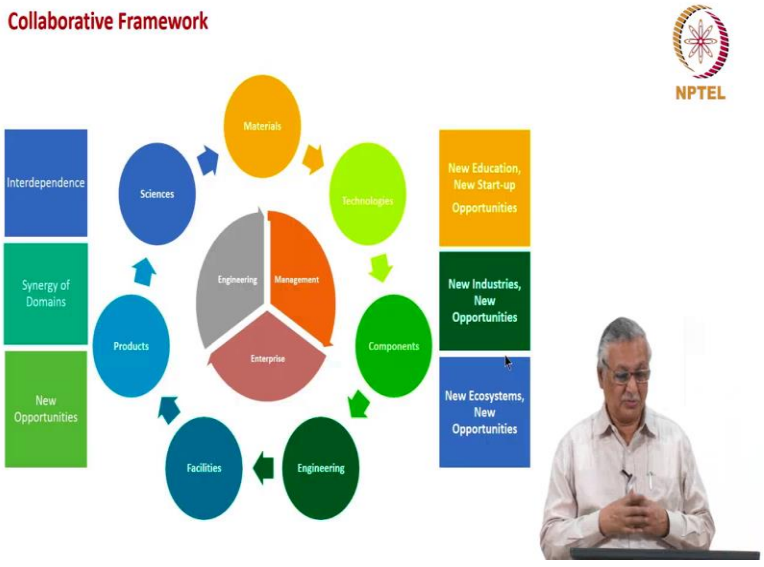

Now, let us see how this collaboration occurs. We have got materials, basic material sciences. They get converted through technologies into components. The technologies could be component technology or competent manufacturing technology. They are then engineered through facilities into products and they get delivered. So, this entire aspect of engineering, management and enterprise in a company can be seen in terms of sciences leading to materials, materials getting converted into components by technologies, and then getting engineered through facilities into products. This is a cycle.

In this cycle, three things happen. One, nothing happens standalone, like if you want to extract novel materials in a novel fashion, you need extraction equipment. So engineering is involved, technology is involved. Similarly, if you want to design a product, you need materials to be measured by material sciences, measuring sciences. So, it is all interrelated. So, interdependence is one important thing. Then synergy of domains, nanotechnology is nothing but synergy with physics, chemistry and other material science domains.

Then we should also look at new opportunities arising out of this kind of interdependence as well as synergy of various domains. So, when we look at this kind of virtual collaborative framework, we will have new education, new start-up opportunities coming in. They in turn create new industries, new opportunities. Then we have new ecosystems and new opportunities. So, the list only grows wider and larger as we look at the potential technology has got in enhancing the growth of industries through enterprise.

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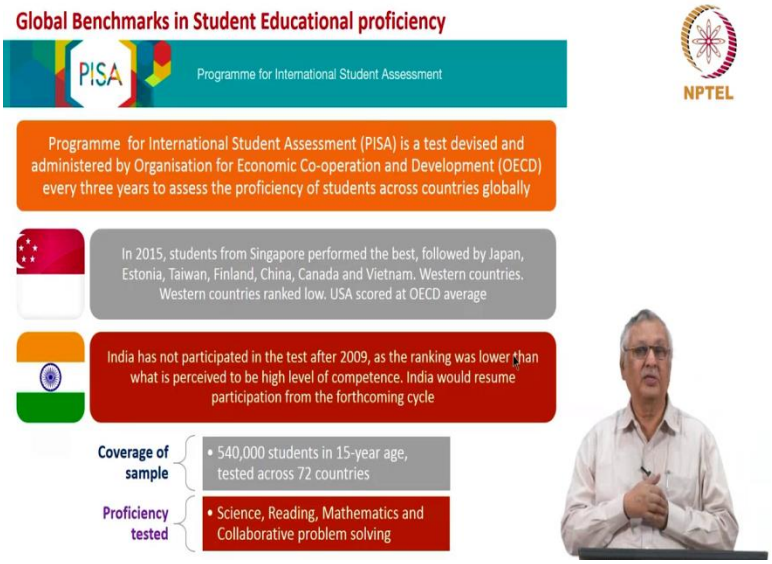

Now, let us also look at we have talked about higher education. We can also look at what happens at the school level. Because what we learn at school level that is pre-college level is extremely important to see how we rank ourselves in the higher education system. So let us shift gears from higher education to school education, because what we achieve in higher education is a function of what we achieve in school education, and the foundations of school education, primary school as well as high as secondary school, secondary school they should be pretty robust if we want to turn out high caliber, higher education products.

Now when we look at global benchmarks in student educational proficiency, how do we do? We have a program run by OECD which is called PISA, Program for International Student Assessment is a test devised and administered by Organization for Economic Co-operation and Development, acronym OECD, every three years to assess the proficiency of students across countries globally.

In 2015, the results of which were published in 2018, students from Singapore performed the best, followed by Japan, Estonia, Taiwan, Finland, China, Canada and Vietnam. Western countries ranked low. USA scored at OECD average. India has not participated in this test after 2019 as ranking was lower than what was perceived to be high level of competence that exists in India in these domains. India would resume participation from the forthcoming cycle.

It is a fairly extensive and expansive sample we have, 540,000 students in 15-year age group are tested across 72 countries and the proficiency tested covers three basic verticals, one is science, second is reading, third is mathematics. It also measures collaborative problem solving of students.

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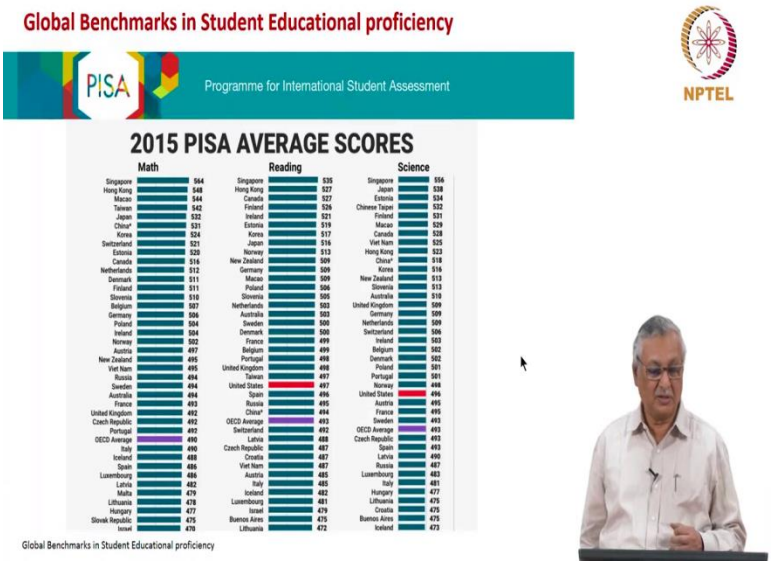

So, what we have here are the 2015 PISA average scores. If you look at Math, you will find Singapore, Hong Kong, Macao, again part of China, Taiwan, Japan, China, Korea, Switzerland, amongst the top countries. In reading as well, we have similar kind of ranking. And so does science indicate similar kind of ranking.

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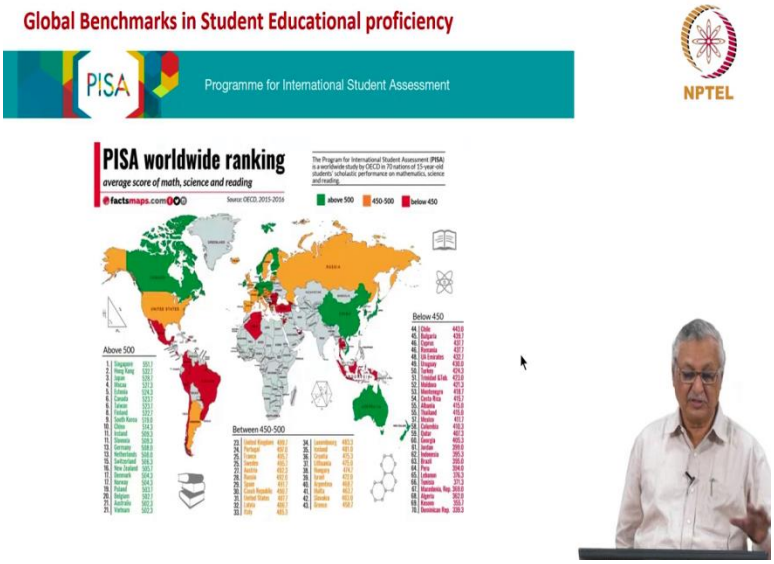

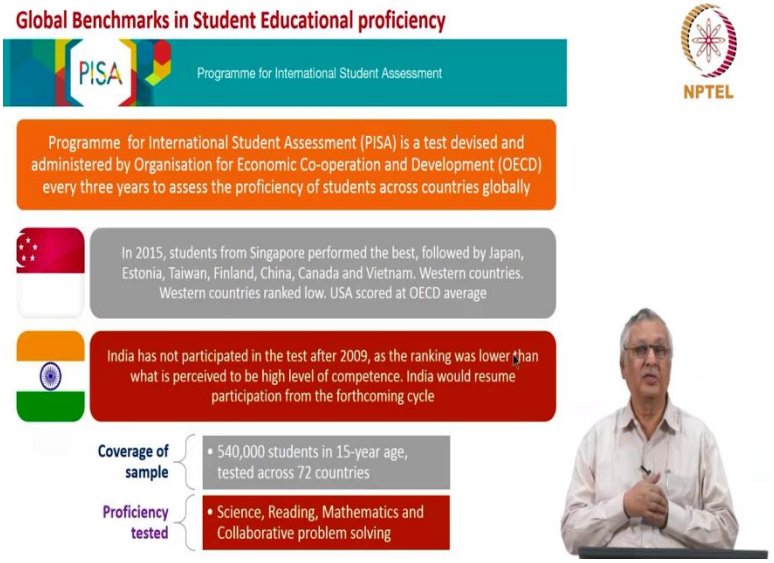

So, if you look at the heat map of this ranking, you will see that the average score of math, science and reading. The green countries are the ones which are having high score of above 500. Between 450 and 500, we have got the brown color countries. And below 450, we have got countries in brick red. So, we have got this heat map of countries participating in the score. And one would believe that India would be in the green territory as and when the country participates in this ranking.

What it does indicate? Going back to what we have seen earlier, science, mathematics and the ability to read and comprehend and express and the ability to collaboratively network and solve

problems these are extremely important at the school level to generate the kind of capability in terms of educational proficiency. So educational proficiency is measured not only in terms of marks you secured against the subjects which you study, but also is assessed in terms of your overall competencies of communication, as well as in collaboration.

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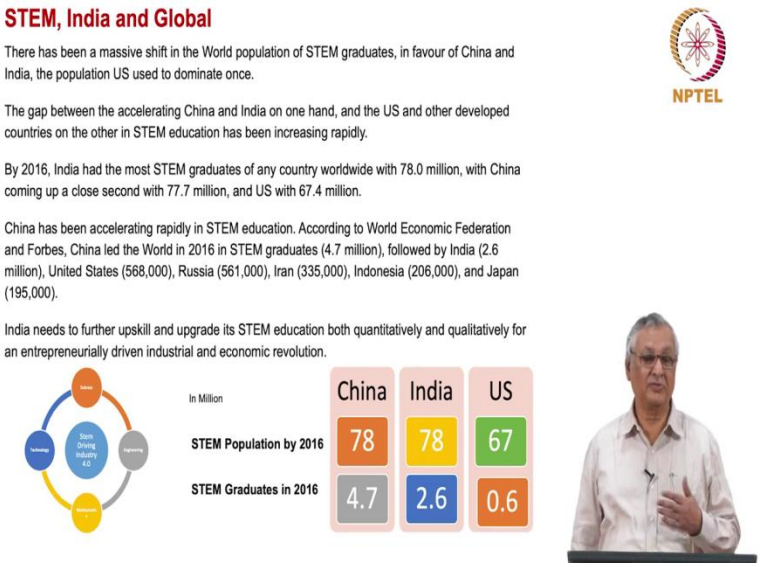

In this slide, we have certain data related to the STEM student population in India and global. There has been a massive shift in the world population of STEM graduates in favor of China and India over the last few years. The gap is occurring between China and India on one hand and the U.S., because China and India are accelerating in terms of STEM population, whereas U.S. and other developed countries have been decelerating in terms of additions to these STEM graduates.

By 2016, India had the most STEM graduates of any country worldwide with 78 million, while China came up a close second with 77.7 million and U.S. was a rather distant third with 67.4 million. However, we have to note that China has been accelerating very rapidly in STEM education.

According to World Economic Federation and Forbes in their joint study, China led the world in 2016 in terms of STEM graduates 4.7 million in a year, followed by India at 2.6 million and United States at 568,000, Russia at 561,000, Iran at 335,000, Indonesia at 206,000, and Japan 195,000. So there has been a greater emphasis in U.S. on STEM education as a result of that.

The increased influx of people experts into U.S. is attributed to the proficiency which India and China and a few other countries have in STEM education, but India needs to keep this STEM competence at high level, not merely for enabling people to migrate to U.S. or other developed countries, but STEM capabilities help India achieve greater level of industrialization, higher level of business expansion and also greater competitiveness globally. So, we need to further upskill and upgrade our STEM education both quantitatively and qualitatively, so that we can be an entrepreneurially driven industrial and economic system.

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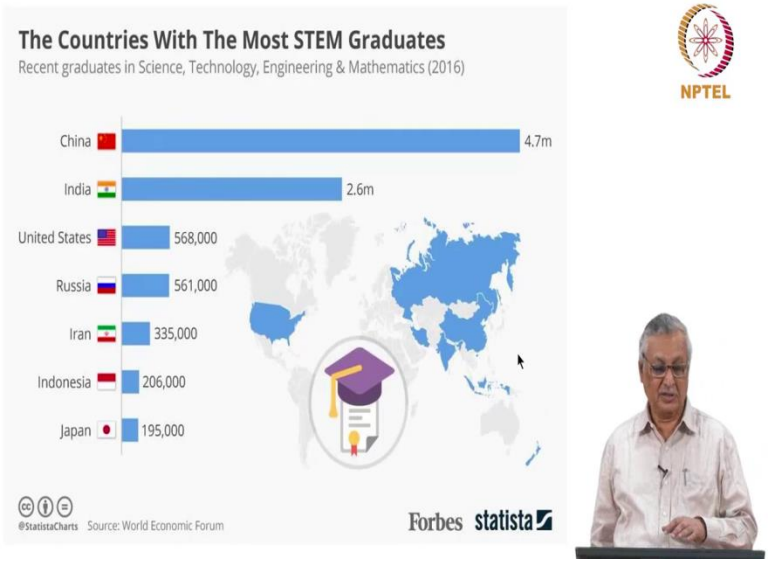

So, this represents what we have discussed in earlier that India has 2.6 million STEM graduates each year, while China has a much larger number of 4.7 million and U.S. has 568,000. The sources are acknowledged at the bottom.

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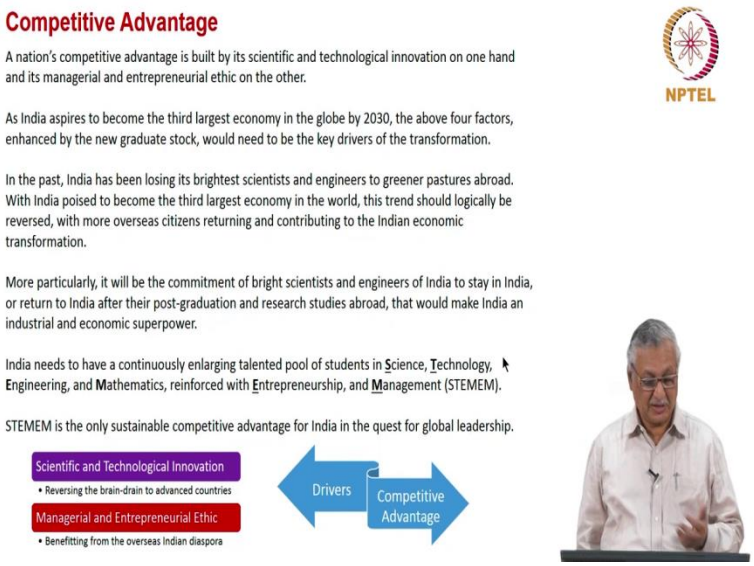

Now, scientific and technological innovation, managerial and entrepreneurial ethic, these are the two aspects which will provide us competitive advantage. What does scientific and technological innovation do? If scientific and technological innovation is concentrated only at the apex of our higher educational system that is only in, let us say, a few of the IITs, and within the IITs amongst people who are willing to move on to the developed world, we will actually experience brain drain we have experienced in the past.

But if we make our scientific and technological education and innovation very broad based any movement to the other countries would not impact the overall level of scientific and technological innovation. Therefore, it is a kind of virtual system which would exist in India and if people are able to perceive that India has got laboratory infrastructure and also innovation infrastructure, which is on par with the world, you will find that people would be willing to return. Therefore, we will be able to reverse the brain drain to advanced countries with scientific and technological innovation.

And having Indian experts and professionals working abroad and creating new technology is not necessarily a negative for India, because if the Indian diaspora abroad is economically prosperous and technologically competitive in today's globalized world, they can create newer centers of excellence in India.

As Chairman Emeritus of Cisco observed, India is becoming a satellite center of start-ups, for the start-ups which have been established in Silicon Valley. So, the more start-ups, let us say, our Indian experts and professionals established in the world system, the more start-ups could also be established in India by the same start-ups back home. Therefore, there could be a kind of networked start-up ecosystem that could happen with the increase in the scientifically and technologically empowered Indians who migrate to other countries.

And of course, as we have many more people working in India, it is possible that we have got start-ups ecosystems which are intertwined with each other. So, it will be the commitment of bright scientists and engineers of India is to stay in India or return to India after their post-graduation and research studies abroad. Obviously, it would make a good boost to the Indian quest for economic superpower, but that also need not be a deterrent if they would be abroad. They can help India become a start-up power even by being there.

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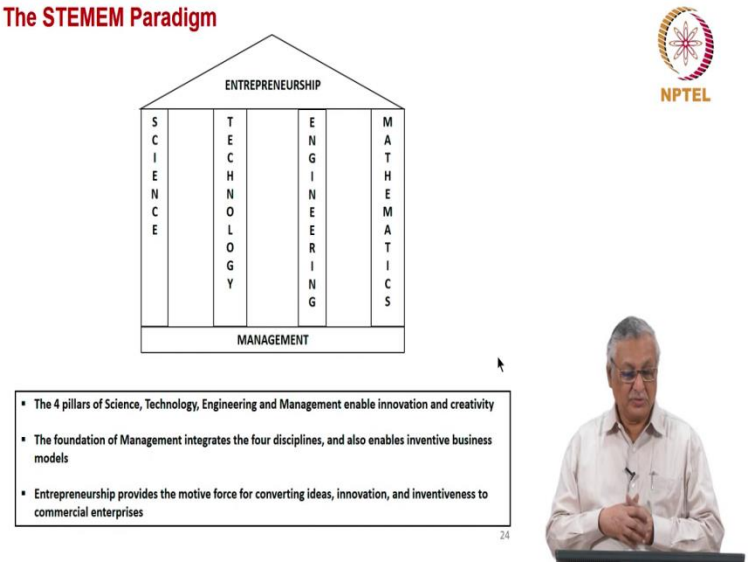

So, when we have management at the bottom, we have science, technology, engineering and mathematics as the four pillars entrepreneurship takes place. They provide, these four pillars provide innovation and creativity. The foundation of management integrates these four disciplines, enables inventive business models. And an entrepreneurship provides the motive force to convert the products into deliverable results for the customers.

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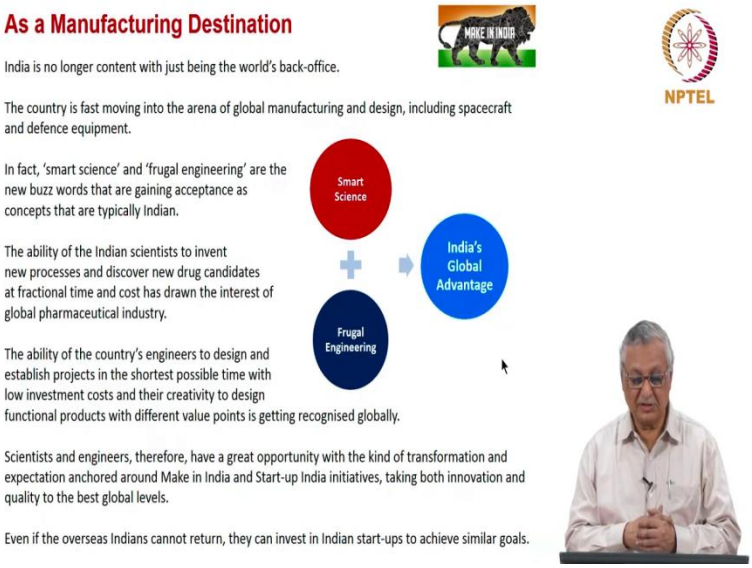

So, how does India's global advantage come? There are two ways in which Make in India can happen in reality. One, we need smart science and we need frugal engineering. What is smart science? Smart science is the ability do with the technologies available natural preservation. The moment you discover new process and discover new drug candidates faster than others, India has become a global destination for medicinal chemistry research.

Most of the work in clinical research is done in India, not only because the patient population is very diversified and the disease parameters are quite diverse, it is also because we have an ability to conduct the clinical trials at a scalable level in productive timeframe. So, clinical research is a smart science that is deployed in India.

We also have smart science, as I said, in creating novel compound which have got medical efficacy. We also have the ability to test these models in in-vitro models. We also have got the ability to develop a number of clinical isolates from our vast disease patterns in the hospitals and then test the new drug candidates in-house. Therefore, there is the ability of Indian scientists to invent new platforms which can attract global pharma companies to do smart science in India with the ability.

Similarly, many of the automobile companies are supported by Indian companies in terms of development centers, not much is known about those development centers in public domain, but thousands of engineers are working for various established multinational automobile companies

to design and establish the new vehicle paradigms. We have considered in one of the earlier sessions that KWID which is developed by Reno engineers in India has been Indian activity from ground zero and it has also been supporting conversion into an electric vehicle based on Indian inputs. Therefore, scientists and engineers have got great effect.

How is frugal engineering important in this effort? Frugal engineering is important because you are able to establish facilities at a smaller proportion of what developed world takes to establish those facilities and we are able to conceptualize engineer and construct those facilities in shorter timeframes. So, when we have smart science combined with frugal engineering, we have a global advantage. When we have a global advantage, make in India becomes a reality.

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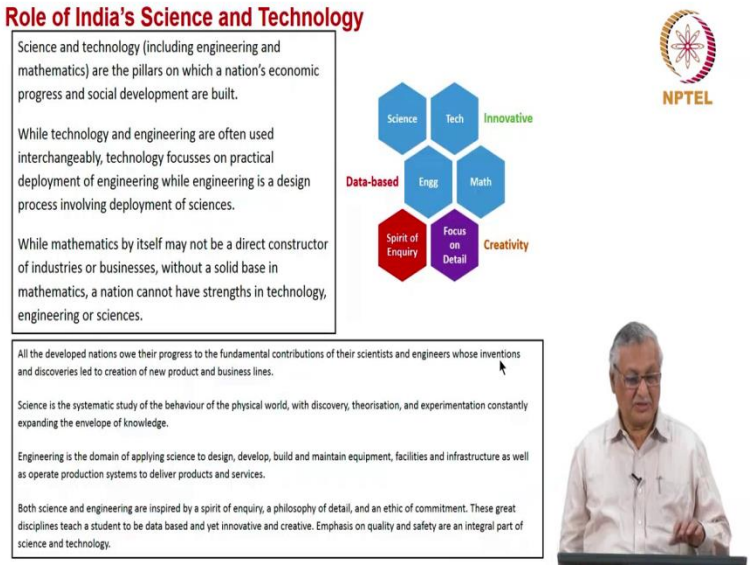

So, the role of science and technology in this is that we create new products which can be developed for the world, which can be manufactured for world and also be sold in India as well as abroad. While technology and engineering are often used interchangeably, technology focuses on practical deployment of engineering, whereas engineering is a design process which is involved in the deployment of sciences. So, sciences are deployed in designs and in construction of products through engineering principles, whereas technology focuses on practical deployment of engineering. Therefore, there is a subtle difference between engineering and technology.

While mathematics by itself may not create products or may not create businesses, mathematical principles are the very foundation of both science as well as technology. Mathematical

principles, for example, are the key aspects of digital technologies, whether it is encryption, whether it is data analytics, or statistical analysis, mathematics is the core.

All the developed nations owe their progress to the fundamental contributions of their scientists and engineers whose inventions and discoveries led to creation of new product and business lines. So, science is the study of the physical world, whereas engineering and technology are the creations of new physical worlds. Science studies whatever is available and sees the uses for that, whereas engineering takes on from where science ends up as results and creates new products, new services, new systems for human beings to benefit from.

So, to be very accurate in how we express, science is the systematic study of the behavior of the physical world with discovery, theorization, and experimentation constantly expanding the envelope of knowledge. I mean discovery of a molecule and thereafter the discovery of atom and thereafter the discovery of electrons, protons, and then looking at the rare particles. These are all the pushing of the envelope of knowledge through scientific examination.

So, it is a systematic study to expand the knowledge. Whereas engineering is the domain of applying science to design, develop, build and maintain equipment, facilities, and infrastructure, as well as to operate production systems to deliver products and services. Both science and engineering have got one common feature that is the spirit of inquiry.

They are also spurred by the philosophy of detail and they also have ethic of rationality and commitment. These great disciplines teach a student to be data based and yet innovative and creative. Emphasis on quality and safety are an integral part of science and technology, which is the reason why science and technology are considered essential for a logical rational society to develop.

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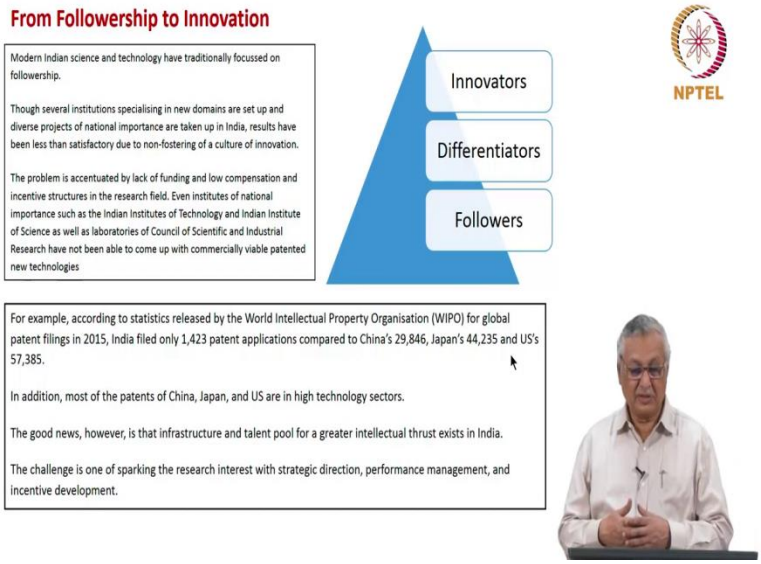

So, when we look at the technology pyramid or the scientific pyramid, you will find that there are three classes. At the top of the pyramid, we have innovators, who discovered the scientific product or technological product for the first time. Then we have differentiators, who follow the pioneer, but also differentiate the product in a completely different way. Then we have got lots of followers, who mimic the innovators and differentiators in terms of their ability to create similar products.

But this level of innovation and differentiation is benchmarked by the number of patents we are able to file and the intellectual property we are able to protect. So according to the World Intellectual Property Organization, out of the global patent filings in 2015, India filed only 1,423 patent applications compared to China's 29,846, Japan's 44,235, and U.S. 57,385. We have seen that we have got second largest STEM graduates, China has obviously the highest STEM graduates, and the U.S. has only one fifth of the capacity, STEM capacity as let us say India and even less compared to China.

However, we see that in terms of the patent application, we are only 1,423, whereas U.S. is at 57,385. Therefore, converting our knowledge science, technology, engineering and mathematics to intellectual property and then protecting the intellectual property, there is a vast difference in terms of the potential as well as actual result. That is one thing which we need to do.

Similarly, the other point to note is that in terms of the patents, most of the patents of China, Japan and U.S. are in high technology sectors, whereas most of the Indian patents were either in terms of process patents or in terms of patents which were non-infringing patents. That is, there is a patent which is already existing and then you have found out a new way of doing that product or service.

So, there is need for moving India from followership to innovation and for that there is a great infrastructure and talent pool for bigger infrastructural thrust in India. The good news, however, is that infrastructure and talent pool for a greater intellectual trust do exist in India and we need to make use of that.

The challenge is one of sparking the research interest. We have seen earlier that the PhD registrations are but miniscule part of the entire higher educational system. That is because everybody would like to be employed in a firm and then earn a salary rather than working on the research proposals.

There are ways and means by which the government of India is trying to mitigate this queue by offering good research scholarships, but corporations also can participate by which they advance employ the research scholars partly on their roles or partly in terms of funded projects and ensure that there is a sparkling research interest in the higher educational system.

Therefore, we have got, if we have a good strategic direction for the research environment, we have got good ways of performance management and also incentive development. There is no reason why we will not be able to move from the current predominantly follower situation to differentiator and innovator situation in the research area.

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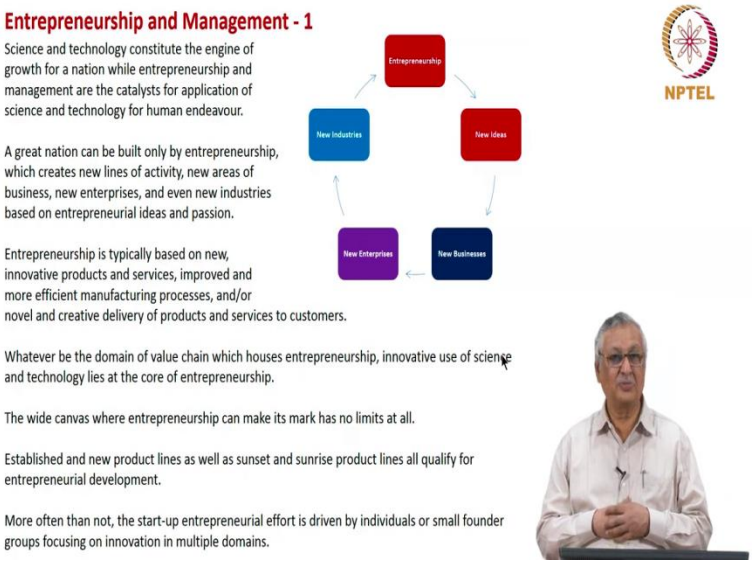

Now, how entrepreneurship and management help us. They help us in many ways. First, an entrepreneurship leads to new ideas and the new ideas lead to new businesses, new businesses lead to new enterprises and new enterprises lead to new industries. This is the cycle. Entrepreneurship is essentially based on new ideas, not follower ideas, because you take a risk, you take a risk on new products rather than a product which is already established. Therefore, there is advantage of pursuing entrepreneurship for industrial development.

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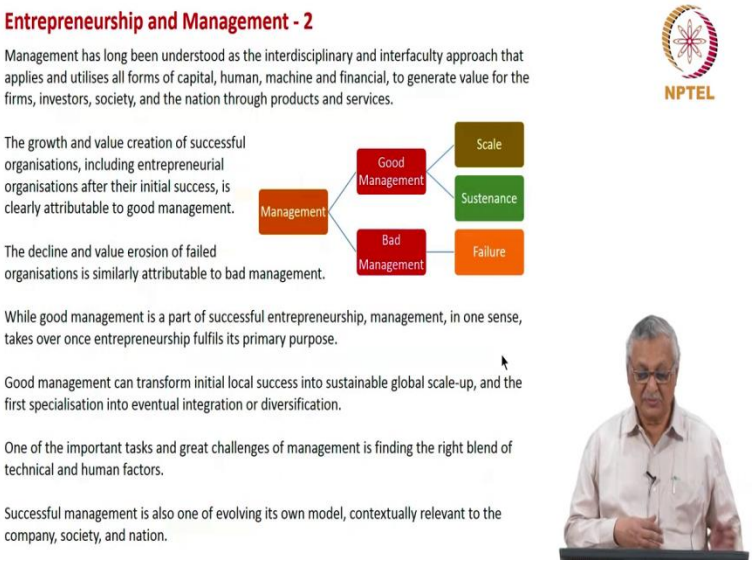

Similarly, management has got a good input in this. Management can be classified into two categories; one is a good management; another is bad management. What is good management? We can have several definition of it, but a good management practice is one which provides scale and which provides sustenance. And a bad management is one which has failure or lack of profitability, lack of viability.

Good management is part of successful entrepreneurship, but good management also takes over by the time entrepreneurship fulfills its primary purpose. You can be kind of maverick, you can be a little chaotic in the way you organize your entrepreneurial journey. The way in which you can bring out a product you need not necessarily follow all the principles of good management, but once a product is developed and brought to a pre-commercialization stage, it is important that good management takes over so that the product is commercialized in an effective way and also both scale and sustenance are provided for the product.

So, good management can transform initial local success into sustainable global scale-up, and the first specialization into eventual integration or diversification. So, how do we really blend good technical aspects of entrepreneurship and good human factors of good management that is a challenge for good management. So, to see technology science, they help very much in terms of creating new products, creating new businesses, but for these new businesses become enterprises and then become industries, you do need good management, which can achieve scale as well as sustenance for entrepreneurship.

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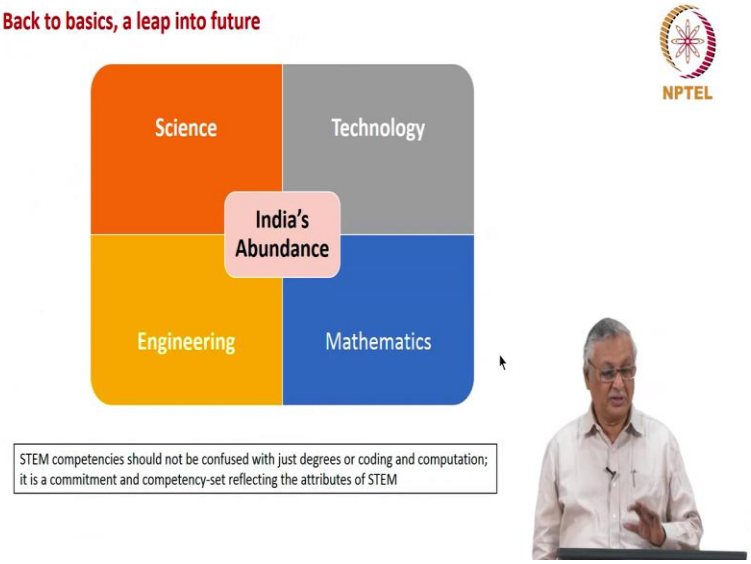

So, India's abundance, we have seen in a great detail that we have science, technology, engineering, mathematics, and these competencies should not be confused with just degrees or coding capability or computation capability. It is a holistic commitment and competency-set reflecting the attributes of STEM which we discussed earlier that creativity, innovation and enterprise etc.

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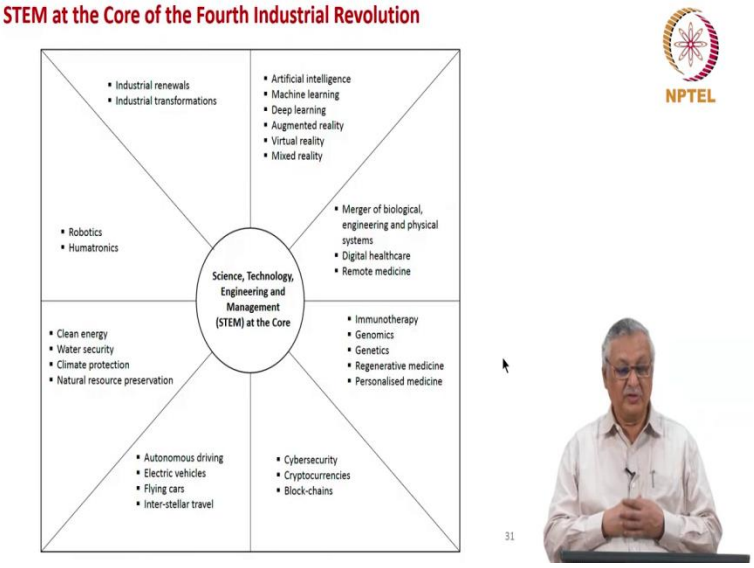

So where do these STEM capabilities help? We often talk about the fourth industrial revolutions, the revolution that is going to occur. There are four aspects of this industrial revolution as we

say. One which is related to science, the other which is related to technology, the third which is related to engineering and the fourth, which is related to management. But the beauty of this is that they are often overlapping. And therefore, there are as many as 8 segments we can look at as collaborative endeavors of this STEM impact.

One, digital economy can renew or transform every industry. We are seeing that when automobile industry is transforming into an electrical vehicle industry, it is an industrial transformation. When the energy sector is getting transformed with the rural, with the renewable energy, it is an industrial transformation. When rare earths are being recovered through newer material technologies, it is an industrial transformation. When we want to look at circulating economy, it is an industrial transformation.

Then we have got a whole set of technologies and products and services which help us in terms of improved efficiency and better way of doing things, reduce bias in our thinking, reduce variability in our thinking, artificial intelligence, machine learning, deep learning, augmented reality, virtual reality, mixed reality these are areas by which we do the improved productivity aspects.

For example, if you look at a pizza, you do it based on certain time parameters which are established based on the experience that if you break it for this minutes, you will get the right kind of pizza. But then pizza making machine which is powered by artificial intelligence would see the ingredients in terms of their characteristics, would assess the level of development of pizza based on the specifications that have been established and then say that this particular level of specifications is attained at this particular customized time given the kind of ingredients.

So, it is the same pizza making, but when you have powered the pizza making by artificial intelligence, sensor technologies and also computational technologies, you are bringing in a whole new way of doing things. So, these are improvements to how things do. Human innovation cannot be replicated, but human biases, human variability, human distractions they will be eliminated when you have artificial intelligence, machine learning and tools like that.

Then we have got the other one which is mergers of biological engineering and physical systems. When you create nanotechnology particles, when you have prosthetics which are lightweight, one prosthetic was demonstrated in the recent Center for Innovation event by IIT Madras, so

when you have those kinds of mergers of biological engineering and physical systems or when we have, da vinci surgical robot, these are the ways in which you can improve how the delivery of healthcare or how the well being of individuals can be enhanced.

Then we have a totally different set of capabilities that are happening with the immunotherapy, genomics, genetics, regenerative medicine, and personalized medicine taking the center stage as we go through the future. Again, block-chains, cryptocurrencies, cyber security these are another segment of the application of STEM.

We talked about autonomous driving, electric vehicles, even flying cars could be there, and inter-stellar travel is likely. Then clean energy, water security, climate protection, natural resource presentation, and ultimately humatronics, that is combination of human capabilities and robotic capabilities in one system. So, these are the areas by which STEM could be at the center of fourth industrial revolution. Obviously, all of these things offer great opportunities.

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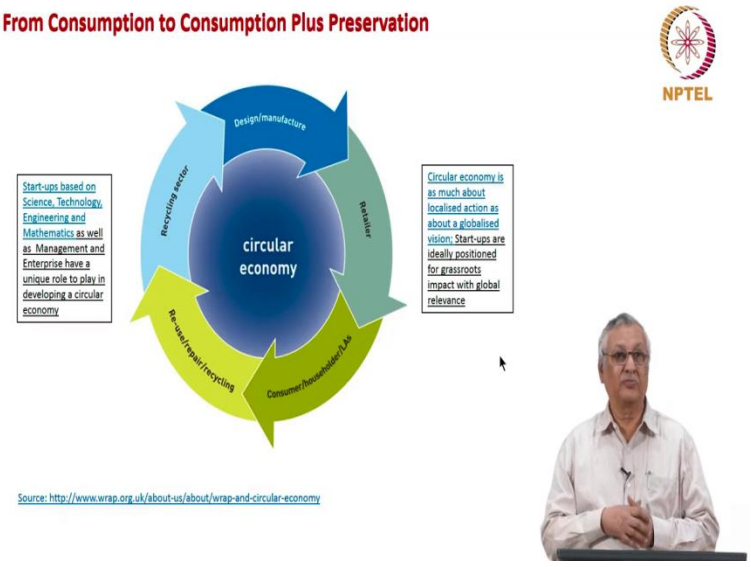

Now the latest buzzword is circular economy. We have experienced that excessive use of any item leads to de-conservation or diminishing of earth's natural resources, not only that it creates burden on the economy, burden on the planet. So, the idea is how do we really create a circular economy? We can create through design, manufacture. We can create through retailer. We can create through consumer, householder, re-use, repair, recycling and through the recycling sector itself.

Again, to have a zero waste economy or a circular economy, we need start-ups which are based on STEM. It is not about doing a product in a different way. It is a overall system by which localized action helps us achieve a globalized vision of having less number of products, but doing more. Start-ups are by and large grassroots activities.

So, start-ups are best positioned to create grassroots impact which will have global relevance. So, from consumption, we are going to move to a situation of consumption plus preservation and that requires circular economy and circular economy requires lot of start-up effort as we look at it.