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by Anika Vadlamani

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INTRODUCTION TO DEVELOPMENT STUDIES

REPORT ON

18

SCIENCE AND TECHNOLOGY DEVELOPMENT IN INDIA



SUBMITTED BY

2019A7PS0020U- DHRUV MAHESWARI

2018A7PS0051U- ANIKA VADLAMANI

2018A7PS0121U- SANJANA GUPTA

2018A9PS0900U- MEHNAAZ SAYED

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CONTENTS:

1. Executive Summary (Anika)	3
2. Introduction (Sanjana)	3
3. Historical Background (Anika)	4
4. Impact (Dhruv)	8
5. Major Issues and Challenges (Mehnaaz)	12
6. Conclusion (Sanjana)	15
7. Recommendations (Dhruv)	15
8. Learning Outcome (Mehnaaz)	16
9. References	17

Executive Summary

The tremendous growth of science and technology has played a major role in the development and growth of the country in majority of the sectors.⁵ The concept of sustainable development is coming across trending in today's world as it addresses the socio-economic development of every citizen of the country. India via its 4 policies so far has chosen a mixture of both imported and local technology. We always link development of any country to its advancement in science and technology. Countries that have been an active part of the industrial revolution has been termed more developed than the rest, as machines tend to deliver work faster and more efficiently than a man. Going beyond the sector of economy, Science and Technology has shown its great advances in the fields of space, medicine, justice, defense, banking etc. This expansion gives an uplift to compete with the more developed countries. This paper focuses on the evolution of development via science and technology post-independence in India, its impact in the current times and the major challenges and issues we face due to the same. Recognizing the issues and recommending its further solutions will also be encountered in this paper.

Keywords: Science, Technology, Innovation, Economy, Space, Healthcare, Banking, Agriculture, Defense, Law, Developed Countries

Introduction

Throughout the years, the role of science and technology has paved its way impressively in India. After its independence, Nehru promoted the benefits of development of science and technology in higher studies. This led to the establishment of the very first IIT (Indian Institute of Technology) in Kharagpur on 18th August 1951. This was followed by the opening of NITS (previously known as regional RECs). Continuing its progress in science and technology, India had also started its space program organization ISRO with the help of Soviet Union. Development in various fields and sectors helped India not only increase its GDP, but also minimize the gap its lacks from the other developed countries. Wherein sectors like economy, education, space, etc were easier to develop in, overcoming stereotypes in sectors like healthcare in most of the population has been one of the most excellent achievements. To grow organically, the country had to dive into the thresholds of science and technology [1].

With the launch of the department of Science and technology in 1971, there has been a constant lookout for newer fields to be developed via science and technology. It focused on its major responsibilities such as the making of newer policies to stay at par with the rest of the world, educating more organizations to and financing them to develop innovatively, etc [2].

The economy of India can only benefit if it kept up with technological changes. One of the changes required is to replace and upgrade the economic situation to a knowledge-based economy. It is a trend of being reliant on knowledge and records, which can be used by the business, government, and public sectors. However, we need to keep our cybersecurity on top

too. Without a constant update in the protection of our data, it would be extremely easy for any country or individual to hack into the system and steal important government information which could also lead us to World War 3 [3].

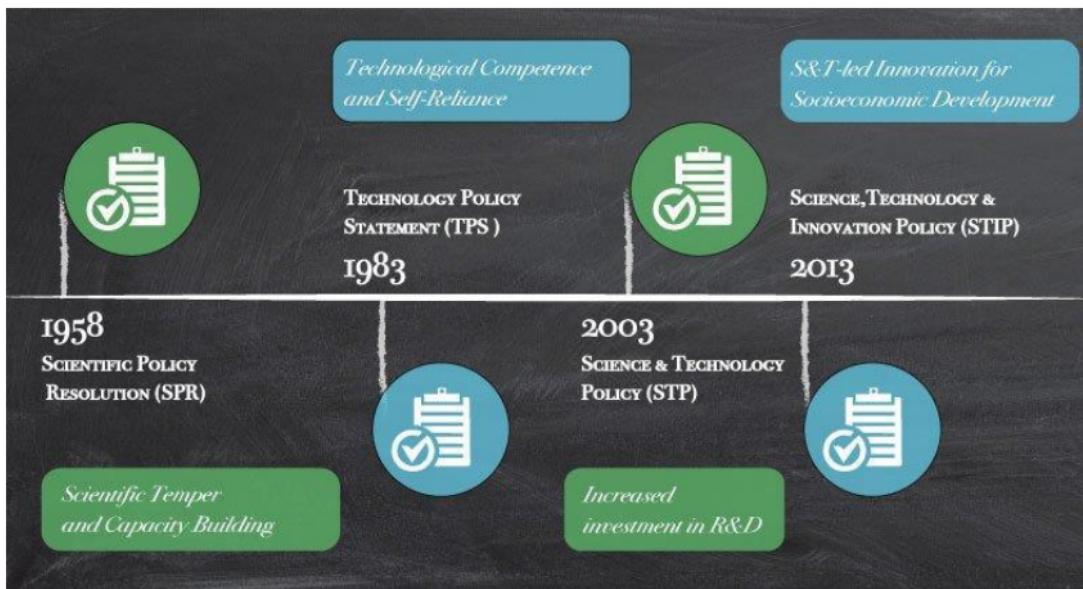
If we look at rural development in hand, science and technology can help overcome issues such as unemployment, protecting of their natural habitat and resources etc. There are constant efforts made to improve the living standard of people in rural areas as most of the country's population resides here. Facilities like shelter, food, clothing, education, employment are provided to the population. To meet all these demands, it is important to understand significance of science and technology [3].

Historical Background

After numerous years of resource and mankind exploitation, India decided to transform its condition and become a worthy competitor to the rest of the world in all the fields. As there was no prior background or knowledge of the Industrial Revolution, India decided to start from the beginning, educating the youth and promoting science and technology across the country. Leaders started giving more importance to technical and vocational training. Maulana Abul Kalam Azad and a committee of 22 members had collaboratively decided to inaugurate the very first IIT (Indian Institute of Technology) on 18th August 1951 [4].

By 1950, there were 5-year plans made by the planning commission wherein the budgets were divided among agricultural and industrial purposes. This plan had proved to be affected from between 1950-1962 where in there was an increase of the manufacturing of food items by 34 million metric tons and a boost of 94% in the industrial field. But due to the massive increase in the population, the overall profits were marginalized. But India had proved to be able to rise to one of the top positions in terms of scientific and technological development [1].

After Independence there were 4 main policies that were adapted by India, which were, Scientific Policy Resolution, which was made in 1958, Technology Policy Statement made in 1983, Science and Technology Policy initiated in 2003 and lastly Science, Technology & Innovation Policy in 2013 [5].



Scientific Policy Resolution (1958)

The very first policy among the four was drafted by then prime minister, Jawaharlal Nehru. This Policy had opened its doors to scientific innovations within the country. As the vision seen by Nehru for the country was to develop a welfare state and this could only happen if India progressed in science and technology [5].

The main aim of this policy was to be able to offer a fair and enough social, economic, and cultural facilities to every citizen of the country. The procedure intended to follow for these results to be obtained were industrialization and massive financing in the development of science and technology which was important as it would minimize the load off the usage of the capital and the raw materials. It would also implement to minimize the disparity among India and all the other developed countries. Hence this policy had made people realize the importance of science and technology for the development of the country and its economy [6].

But as it was one of the first policies to be introduced, SPR1958 had only focused on the scientific aspect of development. This was done to build a solid base of scientific knowledge before leaping into the technological execution of information. Hence the policies made after this focused on both the aspects. Huge investments were made in further projects and numerous numbers of organizations and laboratories were bought into action. This policy had formed a strong base in the department of Research and Development (R&D) [5].

SCIENTIFIC POLICY RESOLUTION 1958

1958

MOTIVATION	SALIENT FEATURES	IMPACT
Nurturing scientific enterprise / scientific temper. S & T seen as an instrument of socio-economic transformation and nation building.	Cultivation of scientific enterprise in pure and applied science research and capacity building. Opportunities for scientific activity, discovery and dissemination of new knowledge.	Emergence of several scientific organizations and national laboratories. Strong foundation in R & D and higher education.

Technology Policy Statement (1983)

After the first policy was under action, India started working towards its second, Technology Policy Statement policy for the next three decades by developing scientific establishments. The country had formed a strong foundation in the industrial and agricultural fields by the first few years of the enactment of the technology policy statement. By this time majority of the youth had also been educated properly in the field. This policy had identified the need to support local technologies rather than import to increase the development of the country. Even if a foreign technology was taken into consideration, it should not harm the national interest. Technology that was outdated were taken into the picture and were modified or replaced with newer technologies that were keen to improve features like efficiency, quality etc, by utilizing only the least amount of money and resources [5].

The main aim for TSP1983 policy was to initiate technological autonomy via various methods. By adapting the local and inbred technology, it was aimed to minimize the liabilities in crucial areas and to also increase the usage of country made goods/labor [6].

TECHNOLOGY POLICY STATEMENT 1983

MOTIVATION	SALIENT FEATURES	IMPACT
Technology seen to influence lives and bolster societal expectations. Focus on meeting people's aspirations through technological development.	Maximize utilization of local (human and material) resources. Strengthen technological self-reliance in new sectors: information, electronics, and biotechnology	Establishment of Technology Development Fund (TDB) Establishment of Technology, Information Forecasting and Assessment Council (TIFAC)

1983

Science and Technology Policy (2003)

Once the 2000's had started, India had already developed a strong foundation and infrastructure in the field of science and technology. But there were still questions on how the science performed was practiced and the process of the development of technology etc. as technology had expanded to multiple sectors, it became necessary to form partnership with institutions and multinational collaboration. Heavy funding was needed by every sector exploring science and technology in the R&D department [5].

But with an exceptional increase in technology, there was also cybersecurity and ethics issues that was being faced by the companies. Hence to not fall prey for such issues and to still be in the competition with other countries, India released its new policy, STP2003 [5].

One of the most important characteristics of this new policy is the collection of inputs from scholars in the field by inaugurating procedures within the ministries and agencies. This policy also understood the need to upgrade the already existing infrastructure and building new facilities for upcoming research [6].

SCIENCE & TECHNOLOGY POLICY 2003		
MOTIVATION	SALIENT FEATURES	IMPACT
<p>Recognition that S & T enterprise is intertwined and inextricable.</p> <p>Unprecedented impact of growth in information technology and democratization of internet on socioeconomic growth and development.</p>	<p>Call to invest heavily into R & D.</p> <p>Goal to increase investments in R & D to 2% GDP.</p> <p>Modernize S & T infrastructure in academic institutions.</p> <p>Incentivize return of scientists and engineers trained abroad to contribute to the Indian R & D ecosystem.</p>	<p>Significant rise in R&D investment (0.7% GDP at the end of 10 yr period).</p> <p>Rise in India's publication ranking.</p> <p>Steady increase in institutional and human capacity (IISERs - 2006 onwards, New IITs - 2008 onwards).</p>

17 Science, Technology & Innovation Policy (2013)

Science and Technology was rising heavily by 2010. With the beginning of Artificial intelligence also, it was made obvious to upgrade the country's policies to more knowledge-based economy. The word "Innovation" had become an especially important and crucial term and hence was also included in the name of the policy. Bridges were starting to build which was going to connect science, technology, and innovation to socio- economic activities [5].

The existence of this new policy was a step closer to bringing India in par with one of the most developed countries of the world. It bought nationwide attention to the importance of the growth

of science and technologies which in turn bought every sector's attention into the R&D ecosystem. The R&D ecosystem had now branched to other sectors such as, agriculture, education, banking, defense, healthcare, space, environment etc [7].

By the enactment of this policy, India was now participating in mega-science initiatives globally, such as the Laser Interferometer Gravitational-Wave Observatory (LIGO), the Large Hadron Collider(LHC- CERN), the International Thermonuclear Experimental Reactor (ITER), the Square Kilometer Array (SKA) etc. As we are still in the era of innovation, this policy stands strong to this date and leaves room for issues to be covered in the next policy [6].

SCIENCE, TECHNOLOGY AND INNOVATION POLICY 2013

MOTIVATION	SALIENT FEATURES	IMPACT
2010-20 announced as decade of innovation. Intent to synergize Science, Technology and Innovation (STI) to transition to a knowledge-based economy. Aim to position India among top 5 global scientific powers.	Innovation is the "key" to building Science and Technology (S&T) - lead innovation ecosystem. Attracting private sector into R&D. Linking STI to socio-economic priorities.	A step in the right direction towards building a robust national innovation ecosystem. India's leadership and participation in global megascience initiatives.



Throughout all these policies, India has seen both continuity and come changes. These changes could be considered such as the choice of policy instruments, priority fields etc. whereas continuity remained in features such as self-reliance and building of capacity. All their results are made clear by India's global ranking in publications and patents and other fields. With the Twelfth Five Year Plan on going, questions still remain such as how much should this country invest in the fields of science and technology and what is going to be the objective of the STIP2013 policy in the years to come? [7]

Impact

Education

With the shortage of skilled teachers, professors, and schools in many parts of the nation, educating the masses has always been a challenge. To overcome this, Government of India launched Aakash Tablets with an initiative to link 25,000 colleges and 400 universities in an e-

learning program in 2011. The aim was to provide education for all the people in remote areas with pre-recorded lectures as well as live lectures and promote creativity and holistic development of children [8].

With emergence of companies such as Byju's, Vedantu etc it is possible for students to understand the concepts better as they have a different approach from traditional blackboard teaching. They have digital animation videos which are more fun to learn and helps in retaining the concepts. Their online mentors are available round the clock to help students solve their doubts. With personalized learning, it is possible to learn at one's own pace. With mock tests, one can track his/her progress and improve upon [8].

Other platforms such as Udemy, Coursera, Eureka etc, offer courses which help them to enhance their skill set and knowledge base. Thus, it helps them to get better job opportunities [8].

Agriculture

With increase in global warming, pollution and change in normal weather cycles, it has become tough for farmers to predict the right time for sowing seeds. With satellite imagery, farmers can use weather forecasting apps to know the weather conditions and accordingly sow the type of crop that can give the maximum yield in that weather [9].

These systems help the farmer to understand which nutrient is deficient in the soil and can accordingly add manure/fertilizers for a good yield of crops [9].

AI applications can teach farmers about water management, crop rotation, type of crop that can be grown, optimum planting etc. With help of machine learning and imagery from drones, AI technologies scan for the presence of pests, insects or other factors that may be responsible for poor crop health. These early warning systems help farmers to take actions and save their crops [9]. Robots can do the job of manual labor even under the scorching heat of the sun. They can help the farmers in removing weeds, ploughing the soil, spraying pesticides etc. [9].

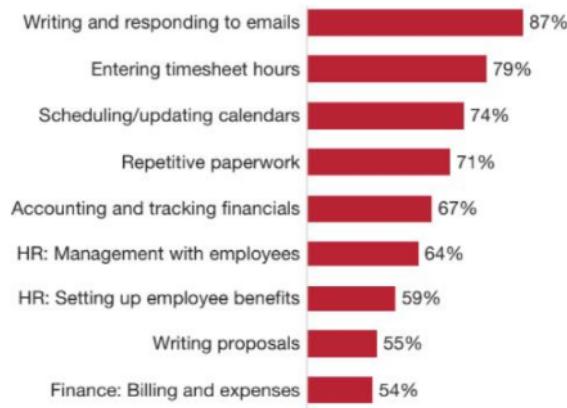
Governance sector

The government of Andhra Pradesh has collaborated with Microsoft to develop Kaizala App for enhancing citizen-government interface. The feedback coming from the citizens is directed to appropriate department for evaluation of performance of public services. For example, under the leadership of National Informatics Center, AI is used to track the progress and condition of public toilets in India [10].

Business

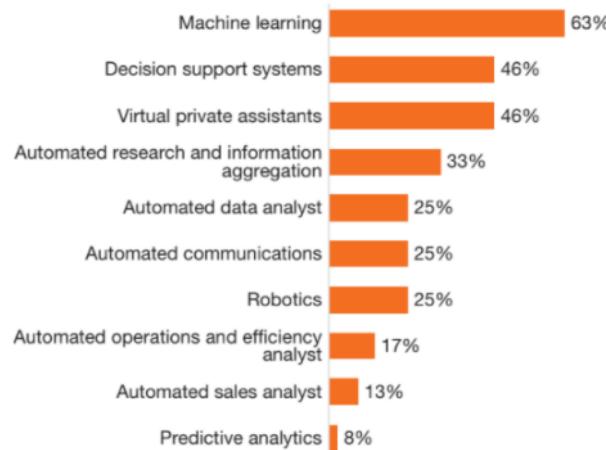
Now a days, every corporate company employs the functionalities of AI as mentioned in the figure. This helps them to reduce the manual work and at the same time AI ensures that there is 100% accuracy [10].

Job elements that can be outsourced to digital assistants



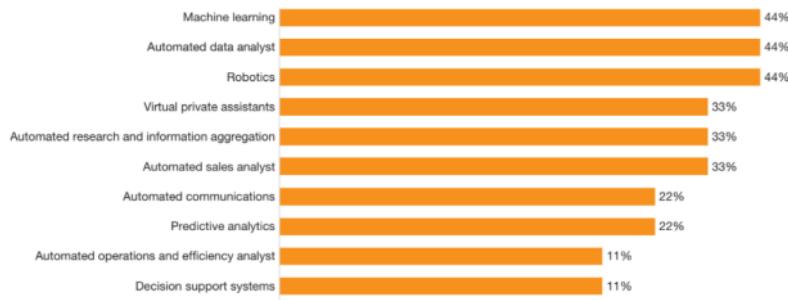
It is believed that Machine learning will help to do away with activities which require repetitive manual jobs [10].

IT/ITES – percentage of decision makers indicating that AI-powered solutions are highly impactful



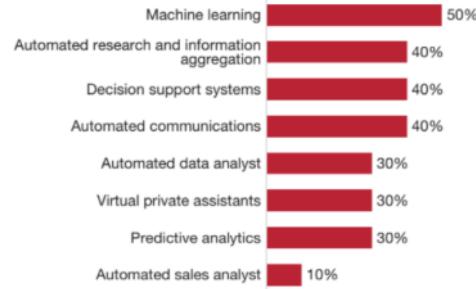
It is predicted that with the solutions offered by AI, it would lead to automation of processes, better customer support (by providing Chatbots) and better back-office operations. It would also lead to better analysis of market situation as AI can process more data than what a human being is capable of. Would also help in giving more security to online transactions and would be able to predict the defaulters based on their past records [10].

BFSI – percentage of decision makers indicating AI-powered solution to be highly impactful



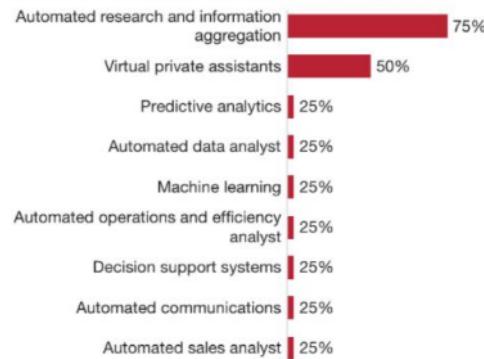
Coupled with Machine learning and Decision support systems, it would be possible for the suppliers to take decisions as to what the consumers want and how much of it should be supplied. AI would be able to guess the appropriate market for a particular product, this would help in increasing the sales and in turn the profit [10].

Manufacturing – percentage of decision makers indicating that AI-powered solutions are highly impactful



People think that Automated research and Information aggregation (75%) would help them to efficiently run their systems.

Administration – percentage of decision makers indicating that AI-powered solutions are highly impactful



Defense

The Indian Army has started using unmanned vehicles and drone to detect any kind of enemy threat in the Indian territory. The revenge of Uri Attack was successful due to great intelligence inputs from these drones. The Army was prepared and exactly knew the hiding places of the terrorists. DRDO has tested Rustom-2 and robot called Daksh to diffuse explosives and make it safer for foot soldiers to carry out their operations [8].

Law Enforcement

Under the Crime and Criminal Tracking Network and Systems, introduced in India in 2013, with funding under the National e-Governance plan, the Telangana police set up 30,000 CCTVs camera across the state. Many more states have followed the footsteps of Telangana. The concept behind putting CCTV surveillance at public places is to create a national database log which will be integrating approximately 15,000 police stations, district and state police headquarters and automated services. The request for integrating CCTV and social media applications to carry out predictive policing processes. Facial and speech recognition through CCTV cameras with the database of criminals would help the police capture the criminals on the flee [11].

With shortage of manpower and battling extreme weather conditions, robo-cops can be deployed to maintain law and order, enhance traffic management at busy intersections. Can be deployed at sensitive places such as airports round the clock. With predictive analysis, it is more likely that a Robo-Cop would be able to nab a law offender than a human being. The first state to post a robo-cop(KP-Bot) is Kerala [11].

Health

As India is a developing country with more than 70% of our population living in villages and remote places, it is difficult for everyone to get access to quality health care services. According to reports, there is only 1 doctor per 1457 person. There are two reasons for this poor ratio. Firstly, India is highly populated. Secondly, very few people volunteer to go and serve in the backward areas [12]. With the capabilities of AI, robots, and science, it is possible to augment the potential of a trained doctor and to offset the absence of regular lab facilities [12].

In the recent pandemic, if we would have the help of robots, it would have been easier for the already overburdened doctors to handle the patients. They would have acted as helping hands and more lives could have been saved, both doctors as well as the patients. Airports, malls, and other public places have infrared sensors installed which are able to detect patients with high temperatures and the concerned authority is informed. This helps in containing the virus [12].

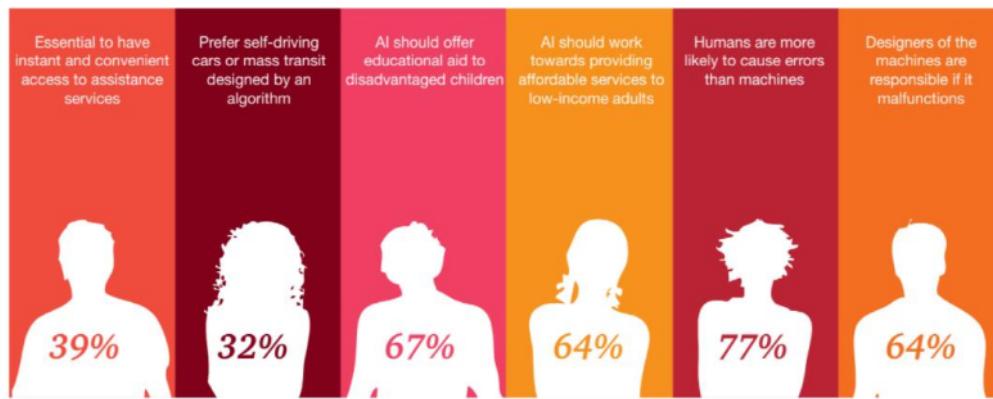
Energy

As India is a developing nation, it has a huge demand for energy. With India's large population and area, it is difficult to provide uninterrupted energy supply to all. AI algorithms can reduce energy consumption by automatically going into sleep mode or turning off appliances when not in

use. This would avoid wastage of power, save on bills and direct resources for alternative uses [13].

Society

The picture shows how AI can help in different day to day activities and how AI is beneficial.



Although people might lose their jobs, but many more jobs would be created. With the vast population in India, AI would offer job opportunities to many.

- i. Hybrid team: If we combine the potential of AI and humans, it will help in making better business models. It may also give suggestions as it has the potential to predict possible outcomes based on previous data fed into it.
- ii. Maintenance jobs: As machines must be looked after to ensure smooth functioning of the programmes, it'll demand for skilled people for the upkeep.
- iii. As the profits of company grows by analysing the sales pattern, demand for a product in a particular region, the company would expand itself, thus creating more job profiles.
- iv. AI in robotics is growing at a fast pace. People would be required to supervise the functioning of unmanned drones, robots etc particularly in the defence sector.
- v. In the financial and banking sector, companies look for programmers who can fix bugs to reduce frauds and make transactions more secure [14].

Space

ISRO had launched its first interplanetary mission, Mangalyaan also known as the MARS Orbiter Mission on 5th November 2013. This put India in many charts such as the 4th country to reach mars, the 1st Asian country to reach mars and the 1st country to reach mars in its first attempt [15].

When the moon impact probe was released at a height of 100 km from its mother ship, Chandrayaan-1 on 18th November 2008, it was captured that there was signs of water on moon during its 25 minutes descent [15].

Major Issues and Challenges

Indian science and technology has the potential to reach different heights and accomplish and address those challenges that could take world development to the next level because Indians have the brains for it but lack the combined effort of exploration and assets. We should seriously and cautiously focus on the future of innovation in science and technology, focus on the new hurdles and opportunities and keep in mind the risks that lie ahead. Sadly, despite being the birthplace of some of the most brilliant scientists India as a country only contributes less than even 3% of the global research output and out of that also just half of its peer-reviewed publications are received from 40 Indian institutions [16].

Our country faces many challenges when it comes to S&T development and one of the main issues is brain drain. Every year more than 13,000 Indian students go to the US to get a science and engineering degree and this mainly happens because of the lack of good quality education in our country. Continuing the topic of education, another challenge we face is that not everyone receives appropriate amount of education because of one's social standing and a welfare model in terms of education cannot be reached until India decides to accelerate and develop technology to meet that end [16].

Rajiv Gupta the head of technology advancement practice, BCG India also brought light to the lack of a modernized legal framework which will keep up with the rapidly growing technological standards [16].

Another issue that comes into play is the lack of financial inclusion of people living in the rural area. As Dr. Hemant Joshi, Partner, Deloitte Haskins & Sells LLP pointed out that the only way to target eradication of poverty, improving literacy and agriculture and healthcare is by using technology to focus on financial inclusion of these people but sadly no focus is being given to this because for India to excel in S&T it not only has to achieve the status of a 'Developed Nation' as fast as it can but also has to compete with the best technologies already out there in the world so that it could be counted among the best techno-economic leaders [16].

As a country our goal should be to achieve a correct mix of traditional and modern science and technology knowledge for rural India and hence, we need to focus on innovative agriculture for a country like ours whose major economy is agriculture based. As Mr. Guru Ganesan, MD of ARM India has said that innovative agriculture could be a game changer for a country like ours. Use and introduction of technologies such as vertical farming, drip irrigation and soil solarization could not only benefit farmers but

also maximize the profits hence shooting up our economy. But sadly, this isn't enough as we will also have to fine tune the technology and implement such methods that could give optimization to our already existing technological strengths so as to create the latest strengths in critical and enabling technologies [16].

For technology and science to develop in our country we first need to fix the problem of inconsistent power supply as consumers face extreme difficulty when operating machinery that requires steady and consistent power supply and because of this the companies themselves must decide to overcome this problem hence demotivating them as this is expensive. Instead, this issue should be tackled by the government and they could do so by investing in technologies for power generation and building the infrastructure for industries to flourish but sadly no efforts are being made and even if they are most of the money goes in the pockets of hungry corrupt politicians which ultimately causes a major hindrance to our countries S&T development [16].

Conclusion

India has come across a long way since its independence, in the field of science and development. With its first step being educating the country on the importance of S&T in the development of the country. The infrastructure left back by the British was being modernized and used by organizations. India set out policies keeping in mind the current scenario of its own country and the rest of the world. From its first policy in 1958, India has realized major issues in each step of the way and have tackled it with the release of the next policy. Science and technology have affected almost all the sectors of India. With the greater deeds done by Artificial Technology's existence in collaboration with S&T, there has been many wonderful outcomes and results of it. But with every great technology, there must be negative factors linked to it. Some of the major reasons for the lack of complete potential of India's development are Brain drain, Lack of funds, Corruption, Lack of resources, Lack of Consistent power supply, Lack of accessible technology etc. These issues can be handled with a better form of working bodies and a better education among all of population.

Recommendation

AI has vast potential that can help everyone lead a better lifestyle. Few things that may help in realizing this are:

1. More programs on AI, machine learning, deep learning etc should be made a part of central programs such as Skill India, Digital India. This would not only help people learn but would also give increased earnings and would also help to solve the problem of unemployment.
2. Efforts should be made to connect each village and backward area with internet connectivity. The benefits of AI should reach to all the citizens.

3. Dedicated course in schools for AI would help children develop a mindset to solve real life problems with the help of AI.
4. The concept of AI is only used in private sectors. It is high time that these resources are also used in public sector to increase efficiency.
5. As AI has positive uses, it has negative uses as well. Strict laws should be made to prevent any kind of cyber-crime. Strict laws should be made to protect 'Right to Privacy' as many big tech companies snoop on private data. For eg India can learn from European Union's General Data Protection Regulation (GDPR) guidelines, which have been enforced in May 2018, which ask developers to make less-privacy invasive systems.

10

Learning Outcome from the Exercise

Science is a dynamic, growing collection of information, covering new areas of encounters. It is a human undertaking to comprehend the world by building - up reasonable models based on perceptions and along these lines showing up at hypotheses, laws, and standards. In a reformist society, science can play a freeing job, assisting individuals with getting away from the endless loop of neediness, obliviousness, and strange notion. Individuals today are confronted with an inexorably quick - changing existence where the main abilities are adaptability, development, and imagination. These various objectives must be remembered in molding science instruction. Great science schooling is consistent with the youngster, consistent with life and consistent with the order.

As steady with the phase of intellectual turn of events, science is being taken as center subject in the educational plan at upper essential stage. At this stage, it is a progressive change from ecological investigations of the essential stage to the components of science. It is essential to grow the skyline of kid bit by bit and start with things that are inside the immediate encounters of youngster. The youngster ought to be occupied with learning the standards of science through recognizable encounters, working with hands to plan basic mechanical units and models, and proceeding to study the climate and wellbeing, including conceptional and sexual wellbeing. Logical ideas are to be shown up at essentially from exercises, trials, and reviews. Gathering exercises, conversations with friends and educators, studies, association of information and their presentation through displays, and so forth, in schools and the area ought to be significant segments of teaching method.

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