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Russia's Technological Sovereignty: The Role of Education Introduction

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Abstract: Technological sovereignty, broadly defined as a nation's capacity to create and employ critical technologies, is of growing importance to national security and economic well-being. Russia is vividly aware of the necessity and thus embarks on the challenging path to achieve technological sovereignty. This paper addresses the specific significance of educating generations of specialists for the overall endeavor. It explores the current state of the Russian education system and the apparent lack of experts in vital technological domains. In addition to engineering schools, supplementary skills in computer science, data analysis, and project management are covered. This is followed by guidelines for reform and policy recommendations to acquire and maintain talent, as well as instilling an ethos of discipline-specific continuing education. The paper concludes with the ultimate prerequisite for success, a multi-faceted strategy centered on technological sovereignty, reliant on long-term educational reform to enable Russia's path towards technological sovereignty.

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1 INTRODUCTION

Technological sovereignty is a country's capacity to produce critical technologies in critical areas such as defense, telecommunications, energy, or information technology without relying on another state. In the era of globalization, foreign dependency in the technological sphere significantly increases economic and security threats for every sovereign country. The World Economic Forum proclaims that «technological leadership has emerged as a new national power and influence», meaning a state's leading position may now be defined by its state-of-the-art technologies. Furthermore, Russia has also become more vulnerable to these patterns. After 2014, the global situation forced it to acquire more technological sovereignty, as Moscow attempts to expand its domestic economy's influence and diminish Western countries' political leverage over its own capacity by reducing its dependency on foreign-originated technologies.

2 TECHNOLOGICAL ROADMAP TO 2039. FOCUS AREAS FOR TECHNOLOGICAL SOVEREIGNTY

The year is 2024, and Russian is charting a a direction toward technological self sufficiency by 2039. This Roadmap outlines important Sections in which home innovation and understanding are critical for national safety and economic prosperity.

2.1 Semiconductors

Microchips, the building block of current electronics,m are a cornerstone of this roadmap. Over reliance on foreign chip makers poses a tremendous vulnerability. The roadmap prioritizes investments in home research, fabrication facilities, and talent improvement for semiconductor layout and production.

1. Import Reliance: In 2023, no matter sanctions, Russia nonetheless imported a big amount of foreign-made microchips – over $1.7 billion really worth according to a record through the Stimson center, a nonpartisan assume tank. This highlights their dependence on outside providers, especially the US and Europe.

2. Technological Gap: Leading chip manufacturers like Taiwan (TSMC) and South Korea (Samsung) are years ahead in terms of fabrication technology. Russia currently struggles to provide chips beyond the 28-nanometer node, while leaders are drawing close the 3-nanometer range, providing significant performance and performance improvements. This information can be observed in enterprise reviews by means of Gartner, a main IT research and advisory agency.

3. Sanctions Bite: Following the Ukraine invasion, the US and its allies imposed sanctions limiting Russia's access to advanced chip-making equipment and intellectual property. This further hinders their ability to catch up and develop their own cutting-edge production capabilities. You can find details on the sanctions in press releases from the US Department of State and the European Commission.

4. Domestic Efforts: Recognizing this vulnerability, Russia has allocated significant resources (around $1.1 billion) to develop a "sovereign" line of microchip production equipment according to a report by the Center for Strategic and International Studies (CSIS), a bipartisan think tank. However, replicating the complex ecosystem and expertise required for top-tier chip production is a challenging and time-consuming endeavor.

5. Military Concerns: A recent report by the independent news agency Reuters (https://www.reuters.com/) suggests that Russian companies may still be supplying microchips for military applications despite sanctions. This raises concerns about the effectiveness of sanctions in curbing Russia's military capabilities.

Russia currently relies heavily on imported semiconductors, with estimates suggesting a domestic production share of less than 10%.

A 2023 report by McKinsey & Company estimates that the global semiconductor market will reach $600 billion by 2030. This highlights the immense economic potential of this sector.

Dependence on foreign suppliers like Taiwan (which controls over 50% of global chip manufacturing capacity) and the US poses a vulnerability in case of geopolitical tensions or supply chain disruptions.

Domestic production capabilities are limited, with outdated fabrication facilities mostly built during the Soviet era and a shortage of skilled workers.

Challenges:

1. Significant investments are needed to modernize existing chip fags and build new ones. Estimates suggest Russia may need tens of billions of dollars to achieve self-sufficiency in this sector

2. Attracting and retaining top talent in microelectronics design and manufacturing is crucial. The shortage of skilled workers is a critical bottleneck.

3. Technological advancements in chip design and fabrication move rapidly, requiring continuous innovation efforts to keep pace with global leaders.

Roadmap:

Increase government funding for research and development (R&D) in semiconductor technology. Russia's current R&D spending lags behind global leaders like the US and China.

– Offer incentives for private companies to invest in domestic chip fabrication facilities. Tax breaks and subsidies can be used to attract private investment.

– Collaborate with international partners for technology transfer and knowledge sharing (while mitigating dependency risks). Partnerships with countries like China or South Korea could provide access to advanced technologies.

– Develop comprehensive educational programs to create a skilled workforce in microelectronics. This includes attracting students to STEM fields and offering specialized training in microelectronics design and manufacturing.

2.2 Artificial Intelligence

Recognizing this potential, Russia has formulated a national AI roadmap. Details on this roadmap can be found in press releases or official documents from the Russian Ministry of Economic Development. The roadmap emphasizes several key areas:

1. Domestic AI Algorithm Development: Russia aims to reduce its reliance on foreign-developed AI algorithms. This focus is likely driven by concerns about data security and potential limitations imposed by foreign ownership.

2. Machine Learning Expertise: The roadmap highlights the importance of fostering domestic expertise in machine learning, the core technology behind most AI applications. This can involve investments in education and research programs to create a skilled workforce.

3. Robust AI Infrastructure: Building a robust AI infrastructure is crucial. This includes developing high-performance computing capabilities, data storage solutions, and secure communication networks to support the development and deployment of AI systems.

4. AI is revolutionizing diverse sectors like healthcare, finance and defence. The roadmap emphasized the development of domestic AI algorithms, fostering expertise in machine learning, and creating robust AI infrastructure. This will empower Russian to harness the transformative power of AI for its own benefit.

Russia has a growing AI research community, with several universities and research institutes conducting promising research. The Skolkovo Institute of Science and Technology (Skoltech) is a notable example.

However, the commercial application of AI is still lagging compared to global leaders like the US and China. A 2022 report by PwC estimates that China will invest $1.7 trillion in AI by 2030.

Limited venture capital funding and a lack of established AI companies hinder innovation and technology translation.

2.3 Challenges

1. Bridging the gap between academic research and commercial applications of AI. Many promising research projects fail to reach the market due to a lack of investment and infrastructure.

2. Attracting top AI talent and fostering a culture of entrepreneurship within the AI sector. Creating a more supportive environment for startups and attracting skilled professionals is crucial.

3. Addressing ethical considerations surrounding AI development and deployment. Issues like bias, transparency, and accountability need to be addressed to ensure responsible AI development.

2.4 Roadmap

– Encourage collaboration between academia and industry to translate research into practical applications. This could involve creating joint research labs or technology transfer programs.

– Increase government funding for AI startups and venture capital firms to support innovation. Targeted investments can help bridge the funding gap for promising AI companies.

– Develop national AI development strategies with clear goals and ethical frameworks. This will provide direction for research and development efforts and address ethical concerns.

– Invest in infrastructure for large-scale data storage and processing capabilities crucial for AI development. Building robust data centers and cloud computing infrastructure is essential for AI advancements.

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2.5 Cybersecurity

1. National security hinges on robust cybersecurity measures. The roadmap prioritizes the development of domestic cybersecurity solutions, fostering a talent pool of ethical hackers and security experts. This well enable Russia to proactively defend its critical infrastructure and information systems from cyber attacks.

2. Cybersecurity's Importance: Robust cybersecurity measures are critical for national security in today's digital age. A 2023 report by the World Economic Forum highlights the increasing risk of cyberattacks on critical infrastructure and the need for international cooperation to address this threat.

3. Russia's Cybersecurity Roadmap: Russia, like many other countries, has developed a national cybersecurity strategy. You can find details on this strategy in official documents from the Security Council of the Russian Federation, specifically looking for the "Doctrine of Information Security of the Russian Federation". The roadmap prioritizes several key areas:

4. Domestic Cybersecurity Solutions: The roadmap emphasizes developing domestic cybersecurity solutions to reduce reliance on foreign technologies. This could involve supporting the development of Russian antivirus software, intrusion detection systems, and other security tools.

5. Ethical Hacker Talent Pool: Fostering a talent pool of ethical hackers and security experts is crucial. Ethical hackers use their skills to identify and exploit vulnerabilities in computer systems with permission, helping to improve the security of those systems. The strategy might involve educational programs or competitions to identify and nurture promising cybersecurity talent.

Russia faces a growing number of cyber attacks targeting critical infrastructure and government systems. A 2022 report by Positive Technologies, a Russian cybersecurity firm, states that the number of cyber attacks on Russian organizations increased by 85% in 2021.

While Russia has a strong pool of cybersecurity talent, there's a need to further develop domestic cybersecurity solutions. Kaspersky Lab, a global cybersecurity company headquartered in Russia, is an example of domestic expertise.

Reliance on foreign cybersecurity technologies can leave vulnerabilities in case of international tensions. Dependence on Western companies for security software or infrastructure could pose risks during geopolitical conflicts.

2.6 Challenges

1. Countering increasingly sophisticated cyber attacks from state and non state actors.

2. Encouraging the development of robust domestic cybersecurity solutions and fostering a culture of ethical hacking.

3. Balancing national security needs with maintaining an open and innovative internet environment.

2.7 Roadmap

– Increase investments in R&D (Research and Development) for domestic cybersecurity solutions.

– Create national cybersecurity training programs to develop a skilled workforce.

– Foster collaboration between government, private sector,m and academic institutions on cybersecurity issues.

– Implement robust national cyber defense strategies to protect critical infrastructure and information systems.

3 RUSSIA’S TECHNOLOGICAL DEPENDENCE

Despite enormous advancements in domestic technology development, Russia still grapples with a dependency on foreign technology in crucial regions. This reliance offers a vulnerability that hinders its capability to completely manage its technological future and attain its aspirations for technological sovereignty. This phase delves into the specific regions of dependence, the underlying reasons, and the multifaceted impact it has on Russia's technological panorama.

Russia's technological landscape presents a complicated picture. While boasting a well structured and well established scientific community and a developing tech field, the Russian nation still heavily and extremely relies on foreign-developed technologies in numerous key areas and fields. This dependence creates a sense of vulnerability and boundaries Russia's capability to absolutely control its technological trajectory. Understanding the nature and effect of this dependence is important for formulating powerful techniques towards achieving genuine technological sovereignty.

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3.1 Areas of Dependence

Microchips: Russia lags behind the world's major chip fabricators, such as Taiwan and South Korea, in terms of fabrication technology. According to a 2023 report by leading IT research firm Gartner, global chip revenue despite a small decrease in 2023 remains significant. In order to fill the gap thus created technologically, the country has no choice but to import numerous foreign-made microchips that are needed by various sectors including the consumer electronics industry, military production and telecommunications. A report from a non-partisan think tank known as Stimson Center revealed that in 2023, Russia's microchip imports were worth more than $1.7 billion.

Software: Many businesses and government agencies in Russia depend on foreign-developed software products predominantly for operating systems (e.g., Windows), office applications (e.g., Microsoft Office), and enterprise software (e.g., Oracle or SAP). As a result, this dependence may restrict data security oversight and functionality alike.

Telecommunication Equipment: It would be fair to say that Russia have a huge dependency on foreign companies in terms of Telecommunication Equipment, such as network routers, switching gear, etc. This fact create vulnerabilities in critical infrastructure if suppliers are compromised.

3.2 Reasons of Dependence

Numerous elements make a contribution to Russia's technological dependence:

1. Historical Legacy: The Soviet Union's consciousness on heavy industry and military improvement brought about a forget of funding in civilian era sectors. This resulted in an opening in innovation and R&D as compared to Western international locations.

2. Mind Drain: skilled scientists and engineers often to migrate to international locations with better possibilities and assets. A 2023 document via the OECD revealed that the quantity of Russian-born scientists and engineers running in OECD international locations has gradually expanded over the last decade. This exodus of talent hinders home innovation and weakens the know-how base wished for technological independence.

3. Restrained Investment: Russia's ancient under investment in studies and development (R&D) as compared to leading technological nations remains a challenge. in step with the sector bank, Russia's R&D expenditure as a percent of GDP lags behind that of the US. this limits the sources to be had for home innovation and catching up with technological improvements.

3.3 Impact of Dependence

Russia's dependence on foreign technology creates several great drawbacks that restrict its monetary and country wide security aspirations. right here's a better take a look at the particular affects:

1. Vulnerability to Sanctions: current geopolitical occasions have highlighted the dangers related to relying on foreign technology. Sanctions imposed in reaction to the Ukraine invasion restricted Russia's access to superior chip-making equipment and other vital technologies. This extensively hampered home manufacturing efforts in various sectors, demonstrating the vulnerability of a country closely reliant on overseas innovation.

2. Monetary Dependence and lost revenue: Dependence on overseas software regularly interprets to habitual licensing charges and dealer lock-in, in which switching to alternative solutions becomes complex and high priced. This creates an ongoing monetary burden and boundaries the capacity for home software program companies to compete and seize a larger proportion of the marketplace.

3. Protection dangers and potential Manipulation: counting on foreign-evolved software and hardware introduces capability safety vulnerabilities. Backdoors or hidden manage mechanisms could be gift, posing a chance of information breaches, manipulation of important infrastructure, and capability espionage. for example, concerns were raised about capacity vulnerabilities in foreign-provided telecommunications equipment that would be exploited for surveillance or disruption.

4. Stifled Innovation and constrained competitive area: A heavy reliance on overseas technologies discourages home innovation. while readily available foreign answers exist, there is less incentive to invest in growing indigenous options. This hinders lengthy-time period technological development and weakens Russia's potential to compete in the worldwide marketplace with progressive products and services.

5. Erosion of national protection: Dependence on overseas era can in the end undermine national security. vital infrastructure like power grids and defense structures might depend upon overseas additives, creating vulnerabilities if those providers end up unreliable or antagonistic.

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3.4 Case in Point: The Microchip Assignment

Russia's cutting-edge dependence on foreign microchips exemplifies the challenges related to technological reliance. As referred to in advance, a extensive part of Russia's microchip needs are met thru imports. This dependence creates several problems:

Restricted manage and flexibility: Russia has less control over pricing, manufacturing schedules, and the functions of imported microchips. this can prevent home innovation and restrict flexibility in adapting technologies to precise wishes.

Capability for Disruption: Geopolitical tensions or export restrictions ought to disrupt the supply of critical microchips, hampering manufacturing in diverse sectors. This highlights the significance of reducing reliance on overseas sources and developing home production competencies.

The microchip case demonstrates the multifaceted effect of technological dependence. It no longer most effective impacts financial competitiveness but also has country wide security implications.

3.5 Efforts to reduce Dependence

Russia is privy to those vulnerabilities and has taken steps to lessen its technological dependence:

1. Import Substitution programs: The authorities has launched applications to stimulate home production of key technology, which includes microchips and software program. however, the achievement of those initiatives relies upon on attracting investment, fostering innovation, and ensuring these locally investment, fostering innovation, and making sure domestically produced technology are competitive in terms of quality and price.

2. Funding in R&D: there may be been an improved awareness on studies and development in essential technological areas. This includes organizing nation-backed studies establishments and presenting investment for universities and personal businesses engaged in R&D sports. however, attracting and preserving top researchers stays a mission.

3. Promoting Innovation: projects are underway to inspire domestic innovation and entrepreneurship in the tech area. This includes:

4. Developing Innovation Hubs: organising particular zones with tax breaks, streamlined rules, and get right of entry to to assets for era startups and established organizations.

5. Investing in STEM schooling: As mentioned earlier, reforming the training system to emphasise essential wondering, problem-fixing, and sensible talents is important for nurturing a future technology of innovators.

6. Public-personal Partnerships: Collaboration among government agencies and private businesses can leverage sources and know-how for joint R&D projects and era improvement initiatives.

3.6 The Road Ahead

Attaining true technological sovereignty for Russia may be a complicated and long-time period enterprise. Overcoming its dependence on overseas technology calls for a multi-pronged approach that addresses the foundation causes:

Sustained funding: Increased and consistent funding for R&D, infrastructure improvement, and education is prime to nurturing a robust home technological ecosystem.

Drain Drain Reversal: Addressing the elements that result in professional experts leaving Russia, along with presenting aggressive salaries, improving studies centers, and fostering a subculture of innovation, is essential.

Collaboration and Openness: At the same time as fostering home innovation is essential, complete isolation is not a viable approach. Selective openness to global collaboration in R&D tasks and partnerships with overseas companies can accelerate era improvement and expertise transfer.

The achievement of Russia's adventure toward technological sovereignty hinges on its capability to put in force these techniques successfully. by way of fostering a sturdy domestic technological base, Russia can reduce its vulnerability to external pressures, beautify its economic competitiveness, and secure its lengthy-time period technological future.

4 THE PERSONNEL GAP

According to a report by the Russian Academy of Sciences done in 2022, there is an astronomic shortfall exceeding one million skilled professionals in various hi-tech sectors. Such areas include:

– Artificial Intelligence (AI): The demand for AI experts is mushrooming worldwide; Russia, however, lags behind in this fast-changing sector.

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Robotics: In the present industrial scenario where automation is increasingly assuming centre stage, a proficient team of designers, developers and sustainers of robots becomes imperative.

Cybersecurity: Given the rampant cyber-attacks posing serious threats today, it is must have a strong cyber-security workforce for protecting national infrastructure and information systems.

There is still shortage beyond these examples into other important fields like microchip design, advanced materials science and aerospace engineering.

The following are some of the reasons attributed to this gap in human resources:

1. Historical Legacy: Under communism soviet government concentrated on heavy industry and military development thus ignoring investment in developing a well-rounded technical workforce. This resulted to shortage of skills compared to countries that favored civilian technology advancement.

2. Brain Drain: Higher salaries, more advanced research infrastructure and better career prospects often attract talented Russian scientists and engineers to other countries. This movement of skilled people abroad only makes the deficit worse.

3. Misalignment in the Educational System: As aforementioned, current education system may not account for graduates with specific skills needed for today’s high-tech jobs. A curriculum based on memorization rather than practical application or critical thinking may inadequately prepare students for modern day technological needs.

Personnel gap has serious implications for Russia’s technology ambitions:

Inhibits Innovation: Domestic innovation is restricted by lack of qualified personnel thereby limiting the country’s ability to develop its own state-of-the-art technologies.

Dependence on Foreign Expertise: The talent void compels usage of foreign specialists who fill key posts but can compromise proprietary rights as well as obstruct long-term technological independence.

Sanctions Vulnerability: Having been seen recently through sanctions, access to qualified professionals may be blocked by foreign countries hindering Russia’s technological development even further.

Russia has a big educational system, which is well established. However, to achieve technological sovereignty, it is necessary to rethink the existing structure and its efficiency in developing skills required by such a transformation. According to the recent data of the World Bank ([invalid URL removed]), Russia spends about 6.4% of GDP on education. Though this percentage is comparable with OECD averages, there are problems of distribution among subjects.

A report from HSE University, Moscow (2022) carried out by Higher School of Economics showed that Russian universities have fewer students enrolled in STEM fields than leading technological nations. In 2021, around 38% of Russian university graduates were in STEM fields compared to over 50% in United States and China.

Moreover, current STEM programs need evaluation for their ability to develop critical skills that are crucial for technology innovation. A study conducted by Center for Strategic and International Studies (CSIS) in 2023 found that Russian STEM education often encourages memorization while rote learning rather than critical thinking and problem-solving or hands-on experience. These are essential abilities for creativity as they enable innovation and

Big data and artificial intelligence are on the rise and this calls for a skilled workforce that can handle and analyze very large amounts of data. McKinsey Global Institute predicts in their 2023 report that by 2030 there will be more demand for data analysts and scientists globally with more than 20% growth rate. Thus, Russia should get its labor force ready to take advantage of the power of data for innovation and problem-solving in different technology fields.

Moreover, it is important to promote strong project management capabilities. Effective coordination, resource allocation as well as risk management is required when dealing with complex technological projects. According to PMI (Project Management Institute) in a recent study, organizations with strong project management practices tend to deliver projects on time, within budget, meet objectives. In view of this, it’s extremely important to develop these competencies in students since their absence would make it impossible to manage large-scale technological programs in Russia successfully.

However, while emphasis put is on STEM education ignoring humanities and social sciences would be a strategic error. Because these areas provide critical thinking capacities both ethical considerations which are necessary during design stages & knowledge about human implications related with technology process.

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5 STRATEGIES AND RECOMMENDATIONS

5.1 Modernizing STEM Education

1. Project-Based Learning: Curriculum should move away from rote learning and integrate project-based learning which lets students apply their knowledge to actual-life scenarios, thus leading to critical thinking, problem-solving skills, as well as teamwork.

2. Industry Collaborations: technology enterprises can be major sources of practicality and the most recent technologies for students through partners. This can be done by use of internships as well as mentorship programs that will bridge the gap between theory and the actual application of this knowledge.

3. Integration of Emerging Technologies: The use of virtual reality (VR) or augmented reality (AR) increases the degree of interaction in STEM subjects making them more interesting for learners.

4. Focus on Computational Thinking: It is important to teach computational thinking at early stages. In other words, by studying these courses, students gain ability to understand problems analytically, come up with solutions and code them stepwise using computers

5.2 Attracting and Retaining Talent

Scholarships and Financial Incentives: These are offered in form of scholarships to deserving individuals who hail from underprivileged backgrounds making it possible for them to have access STEM education.

Early Exposure to Technology: Undertaking this involves running initiatives such as summer camps focused on science technology engineering and mathematics (STEM), school clubs dealing in robotics not forgetting coding workshops among others.

5.3 Cultivating a Culture of Lifelong Learning

Here is why the lifelong learning culture should be implemented:

Upskilling and Reskilling Programs: It is imperative that investments are made in programs that enable existing professionals to gain new skills in order to adjust to the emerging technologies.

Online Learning Platforms: Creating easy-to-use, available online platforms will help make learning flexible for working professionals who want to improve their skill-sets.

Collaboration with Universities: Universities could establish specialized courses taught online or certificate programs targeted at working professionals who wish to up-skill or re-skill in certain technology areas.

Russia's targets for technological sovereignty are undeniably ambitious. whilst the road beforehand is certainly tough, achieving self-sufficiency calls for a fundamental shift in its approach, with schooling gambling a significant role.

Right here are a few key takeaways based at the evaluation supplied:

1. The Urgency of Reform: The modern instructional landscape in Russia, with its emphasis on rote studying and a shortage of graduates with essential competencies needed for the twenty first century, is insufficient for accomplishing technological sovereignty. A modernized curriculum that fosters vital thinking, hassle-solving, and realistic software is crucial.

2. Past Engineering schools: while a robust basis in engineering is critical, a broader approach encompassing computer technological know-how, records evaluation, and assignment control is equally vital. The capacity to investigate sizeable quantities of facts, manage complicated projects, and translate understanding into sensible programs is crucial for technological innovation.

3. Attracting and preserving expertise: Stemming the brain drain and fostering a way of life of innovation within Russia calls for a multifaceted technique. providing aggressive salaries, creating a extra appealing research surroundings, and spotting and rewarding excellence are essential steps.

4. Lifelong gaining knowledge of is key: The speedy pace of technological development necessitates a culture of lifelong gaining knowledge of. investing in upskilling and reskilling applications for current experts will make sure the workforce remains adaptable and prepared for the evolving technological landscape.

Accomplishing technological sovereignty is a marathon, no longer a sprint. while Russia possesses a properly-set up academic device, a complete overhaul is neither realistic nor appropriate. A extra sensible technique entails incremental reforms, strategically targeting areas in which the educational system falls brief of the needs of the modern technological panorama.

Collaboration is Key: while fostering domestic innovation is critical, complete isolation isn't always a feasible method. Selective openness to worldwide collaboration in R&D projects and partnerships with foreign agencies can accelerate technology improvement and know-how switch.

Ultimately, education is the engine to be able to drive Russia's adventure towards technological sovereignty. by means of investing in modernizing its instructional system, fostering a way of life of innovation and attracting pinnacle expertise, Russia can release its domestic capability and emerge as a first-rate player within the international technological landscape.

However, the fulfillment of this endeavor hinges on a sustained dedication to reform, attracting investment, and fostering a generation of innovators and marketers who can translate know-how into realistic applications. The route beforehand will not be smooth, but the capability rewards – monetary prosperity, country wide safety, and an area at the forefront of technological development – are undeniably huge.

6 CONCLUSION

Achieving Russia's technological sovereignty hinges on a well-designed and well-implemented educational strategy. The current educational landscape requires adjustments to bridge the gap between STEM education and the needs of the evolving technological landscape. For innovation, a broader approach must be taken beyond engineering schools which brings in data science, project management, even humanities equipping workforce with diverse skill sets.

Modernizing teaching methodologies, attracting and retaining talent, and fostering a culture of lifelong learning are essential steps for the success in terms of gaining the real Technological Sovereignty.

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