



SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS EDUCATION AS INDISPENSABLE ELEMENTS IN INDUSTRIAL AND ECONOMIC REVITALIZATION

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Abstract

The current global economic climate has rendered industrial and economic revitalization a pressing need for many nations and communities. This paper explored the role Science, Technology, Engineering, and Mathematics (STEM) can play in driving industrial and economic revitalization. It demonstrated how STEM-based products and processes are used as the basis for public and private investment in the revitalization of industry and commerce. The study considered the potential for technology-enabled solutions to drive productivity gains, with examples from successful real-world applications. Without Mathematics, there is no science, and without science technology, and engineering, society cannot exist. Application of mathematics to understanding economic trends, and how mathematical models were used to guide pivots in investments or production capabilities were considered. This paper provides evidence to demonstrate that investments in STEM-based products and processes, combined with technology-enabled solutions and mathematical models, can reduce costs and improve productivity, resulting in increased output and efficiency.

Keywords: economy revitalization, science, technology, engineering, and mathematics, industrial revitalization

Introduction

Science, Technology, Engineering, and Mathematics Education (STEM) is the pillar for the economic and industrial development of every Nation due to the significant role played in society. Mathematics forms the basis of science technology and engineering. Invariably, mathematical application is required to solve scientific problems. Technology and engineering cannot stand in isolation without Mathematics. Mathematics knowledge and application are so crucial in every setup due to their universal nature and applicability. Every facet of modern life is affected by science and technology (Akinoso, Agoro, Alabi, 2017); Akinoso, Agoro, Alabi, 2020); Akinoso & Awofala (2021); it is difficult to imagine any aspect of modern life that has not been affected by technology and science. However, most of the benefits and uses derived from science, technology, and engineering would not have been possible without the understanding and application of Mathematics.

Mathematics knowledge is required in society as the clue to solving problems either simple or complex (Akinoso, 2023). This might be the reason why mathematicians and Mathematics educators are referred to as problem solvers. No matter how tough or complex the problem is, the formula suitable for such will be developed, and applied and within a short period the solution is proffered. Technology is the product of Mathematics which is now what everyone in society



cannot do without (Akinoso, 2015). Technology has found its way of penetrating every affair in society, the application of which made life easier for individuals. Technology has taken over communication, shopping, finances, accounting, health, cooking, washing, and transportation. Technology aids learning especially Mathematics learning (Akinoso, 2018) due to its active nature and various activities which liberate learners from being passive but to contribute manipulating materials to develop more skills relevant to societal development. In teaching and learning, both educators and students benefit from technology since it has become a means of knowledge transmission in most nations. Society has seen that advancements in technology have altered how people think, work, and live. The learning would be relevant if a teacher with the necessary skills and expertise used technology.

Technology may be transformative in the hands of excellent instructors. Meanwhile, technology will never replace great teachers (Partner 2021), but technology in the hands of great teachers is transformational. To have effective teaching and learning, the teacher's methods for manipulating or transforming technology are crucial. Technology knowledge is required from every individual to perform effectively in the development of society (Simplilearn.com, 2023). It has become mandatory for all workers in society to have adequate knowledge of the use of technology being the medium of communicating vital information and ideas. Many firms in society encourage working at home which might not be realistic or be a bit difficult without adequate knowledge of technology use. An individual doesn't need to be physically present in a country before engaging as a worker in such a country. Training in society has taken a different dimension due to the use of technology. Different applications (apps) can be applied depending on such training. In society, training and different activities can be carried out virtually without the physical appearance of the participants through the use of technology and relevant tools. The main objective of this paper is to highlight the contribution of science, technology, engineering, and mathematics education to industrial and economic revitalization, and the benefits of revitalization of industries and the economy of any nation.

Industrial and Economic Revitalization

Revitalization is to renew or act of bringing something back to life. It involves the restoration, resuscitation, renewal, or revival of things that lack vitality. Revitalization is crucial for industries and a country's economy is to bring to life and ensure proper functioning. It is essential for the improvement and development of organizations. Industrial revitalization involves a capital investment in industrial facilities to replace or reconstruct buildings, equipment, machinery, and other essential personal property used in the operation of the facility, including the acquisition of any necessary real property. According to Han and Zhang, (2022), industrial heritage consists of the remains of the industrial culture with historical, technological, social, architectural, or scientific value. Industrial revitalization is necessary to acquire new knowledge and skills for new products and also to improve existing products. The industrial revitalization strategy does not mean abandoning traditional industries and promoting a service economy but rather transforming them into a new industrial production mode. This revitalization requires mathematical and scientific input.



Mathematics and Industrial Development

Mathematics plays a crucial role in industrial and economic development, whether it's in planning industry affairs or managing activities for optimization. One aspect of Mathematics that directly addresses industrial issues is Operations Research (OR). OR involves constructing mathematical models to solve problems related to decision-making in organizational management. These problems are broken down into basic components and solved step by step using mathematical analysis. This demonstrates the importance of Mathematics in every organization. There are several steps to follow in using OR to solve industrial problems. First, the problem should be identified, then a model should be constructed, followed by applying the model to solve the problem, testing each solution on the model, analyzing the success, and finally implementing the solution. This approach is used to efficiently utilize minimal resources to maximize profits. Mathematics also provides the foundation for various analytical and problem-solving techniques, playing a significant role in industrial development (Jain, 2023). Some of the roles of Mathematics in industry include the following:

- 1 **Optimization:** Mathematics, particularly in the field of Operations Research, helps industries optimize their processes and make informed decisions. Mathematical models and algorithms are used to solve complex optimization problems, such as production planning, resource allocation, scheduling, inventory management, and logistics. By optimizing these processes, industries can maximize efficiency, reduce costs, and improve overall productivity.
- 2 **Analysis:** Industrial development often involves analysing large amounts of data to understand patterns, trends, and correlations. Statistical techniques, such as regression analysis, hypothesis testing, and design of experiments, are applied to make data-driven decisions and improve quality control. By using Mathematics to analyse data, industries can identify areas for improvement, troubleshoot issues, and make evidence-based decisions.
- 3 **Quality Control:** Mathematics plays a crucial role in ensuring product quality and reliability in industrial settings. Statistical process control methods, such as control charts and acceptance sampling plans, are used to monitor and control variations in production processes.
- 4 **Supply Chain Management:** Mathematics is essential in optimizing supply chain operations, including demand forecasting, inventory management, production planning, and distribution. Effective supply chain management facilitated by Mathematics can lead to streamlined operations, reduced lead times, and improved customer satisfaction (Chen, & Hammad, 2023).
- 5 **Simulation and Modelling:** Mathematical modelling and simulation techniques are used to analyse and predict the behaviour of complex industrial systems. These models allow industries to test different scenarios, evaluate the impact of potential changes, and optimize system performance. By simulating various conditions, industries can make informed decisions, mitigate risks, and improve the efficiency of their operations (Chen, & Hammad, 2023).



- 6 **Process Control and Automation:** Mathematics plays a critical role in control theory, which is applied in industrial settings to regulate and optimize processes. Control systems use mathematical algorithms to monitor and adjust process variables in real-time, ensuring that production operates within desired specifications which leads to improved process stability, reduced variability, and increased productivity.
- 7 **Research and Development:** Mathematical concepts and methods are used in research and development activities across various disciplines, including engineering, materials science, computer science, and data analysis. Mathematical modelling, simulations, and numerical analysis enable industries to design new products, improve existing technologies, and explore novel solutions.
- 8 **Industrial Automation and Artificial Intelligence:** The rise of industrial automation and artificial intelligence heavily relies on mathematical foundations. Machine learning algorithms, neural networks, and deep learning techniques are based on mathematical principles and statistical methods. These technologies enable industries to automate processes, make predictions, and perform complex tasks with high accuracy, leading to increased efficiency and productivity (Qiyao 2021).
- 9 **Risk Analysis:** Mathematics, particularly in the field of probability theory and stochastic modelling, is used to analyse and manage risks in industrial settings. The risks include financial risks, project risks, safety risks, and environmental risks.
- 10 **Data Analytics:** With the advent of big data, Mathematics plays a crucial role in extracting valuable insights from large datasets. Mathematical techniques such as data mining, machine learning, and pattern recognition are used to analyse and interpret data, identify trends, and make data-driven decisions. Industries can use these insights to optimize processes, improve customer experiences, and identify new business opportunities.
- 11 **Forecasting and Demand Planning:** Mathematics is used in forecasting future demand for products and services, which is crucial for effective production planning and inventory management. Time series analysis, regression analysis, and other statistical methods are employed to analyse historical data and predict future trends. Accurate demand forecasting helps industries optimize production levels, reduce inventory costs, and meet customer expectations (Lima, Firmino, & Rocha, 2023).
- 12 **Engineering Design and Optimization:** In engineering fields, Mathematics is utilized in design optimization, where mathematical models and algorithms are employed to find the optimal solution that meets design constraints.
- 13 **Energy Optimization:** Mathematics is employed in optimizing energy consumption and energy efficiency in industrial processes. Mathematical models and algorithms are used to analyse energy consumption patterns, identify areas of improvement, and optimize energy usage. This helps industries reduce energy costs, minimize environmental impact, and achieve sustainable practices (Lima, Firmino, & Rocha, 2023).



- 14 **Financial Modelling and Analysis:** Mathematical concepts such as discounted cash flow analysis, risk assessment, and portfolio optimization are employed to evaluate investment opportunities, assess financial viability, and manage financial risks.
- 15 **Quality Assurance:** Mathematics is utilized in statistical quality control techniques, such as Six Sigma, to monitor and improve product quality. Statistical process control charts, capability analysis, and quality metrics are employed to ensure that products meet defined quality standards. Mathematical principle assists industries to reduce defects, improve customer satisfaction, and enhance their reputation.
- 16 **Process Simulation:** Mathematical modelling and simulation techniques are used to simulate industrial processes and systems. This allows industries to analyze and optimize process parameters, identify bottlenecks, and improve overall system performance.
- 17 **Resource Allocation:** Mathematics is employed in optimizing the allocation of resources, including manpower, materials, and equipment. Mathematical models, such as linear programming and integer programming, are used to allocate resources efficiently, minimize costs, and optimize productivity.
- 18 **Supply Chain Optimization:** Mathematical models and algorithms are used to optimize inventory levels, transportation routes, and distribution networks. By employing mathematical optimization techniques, industries can reduce costs, shorten lead times, and improve supply chain efficiency.
- 19 **Process Control and Robotics:** Mathematics is utilized in control theory and robotics to design and implement control systems for industrial processes and automated systems. Mathematical models and algorithms are employed to regulate and optimize process variables, ensuring stability and desired performance.
- 20 **Innovation and Research:** Mathematical theories and methods enable industries to explore new concepts, develop new technologies, and advance scientific understanding.

Science, Technology, Engineering, and Mathematics in Industrial and Economic Development

The fields of Mathematics, Science, Technology, and Engineering are all crucial for industrial and economic development. Mathematics serves as the foundation for science, technology, and engineering, and none of them can thrive independently of Mathematics (Akinoso, 2017). Science and Technology play significant roles in societal development. Technology is essential for creating wealth, improving quality of life, fostering economic growth, and driving social transformation. Mathematics provides the necessary tools and techniques for industrial development. By utilizing mathematical concepts, models, and analytical methods, industries can optimize processes, enhance quality control, improve supply chain management, foster innovation, and achieve sustainable growth. Mathematics is a pivotal factor in enabling industries to remain competitive in the global market and adapt to the ever-changing economic and technological landscapes.

The fields of engineering, industrial revitalization, and economic development are interconnected and crucial for driving growth, innovation, and job creation. By using engineering principles and



strategies, countries and regions can revitalize their industrial sectors, improve productivity, and promote economic advancement. The key concepts and strategies related to engineering, industrial revitalization, and economic development include; implementing advanced manufacturing technologies such as automation, robotics, and additive manufacturing (3D printing) to enhance productivity, reduce costs, and enable rapid innovation (Nof, 2019). According to Lee and Bagheri (2015), leveraging Industrial Internet of Things (IIoT) technologies can improve operational efficiency, enable predictive maintenance, and facilitate data-driven decision-making in industrial processes. Additionally, Azapagic, Perdan, and Clift (2019) emphasized that sustainable practices in industrial processes can reduce environmental impact, enhance resource efficiency, and contribute to long-term economic viability. Furthermore, adopting digital technologies, including big data analytics, artificial intelligence, and cyber-physical systems, can transform traditional industries and enable the creation of new business models (Wang, Vonortas, & Ruan, 2018).

The fields of Science, Technology, Engineering, and Mathematics (STEM) education are indispensable elements in the process of industrial and economic revitalization. STEM education equips individuals with the knowledge and skills necessary to thrive in the modern industrial and economic landscape. It fosters critical thinking, problem-solving abilities, creativity, and innovation – all highly valued qualities in industries that drive economic growth. Technological advancements, science, and technology are major drivers of industrial and economic growth. STEM education provides individuals with a strong foundation in scientific principles, technological literacy, and the ability to apply mathematical concepts in practical scenarios.

In terms of productivity and efficiency, STEM education facilitates the adoption and implementation of technology-enabled solutions that enhance productivity and efficiency in industries. Knowledge of science, technology, and mathematics enables individuals to identify opportunities for process improvements, automation, and optimization. Additionally, STEM education fosters a culture of innovation and entrepreneurship, which are crucial for industrial and economic revitalization. It nurtures creativity, problem-solving skills, and an entrepreneurial mindset. STEM education plays a vital role in driving research and development (R&D) activities, which are essential for industrial innovation and economic revitalization.

STEM education promotes economic diversification by enabling individuals to explore new industries and sectors. It equips them with transferable skills that can be applied across various fields, allowing for flexibility and adaptability in the rapidly changing economic landscape. Global Competitiveness is another STEM contribution. It is essential for maintaining global competitiveness in the industrial and economic spheres. Countries that prioritize STEM education produce a skilled workforce capable of driving innovation and technological advancements (Akinoso, Agoro, & Alabi, 2017). Such countries are better positioned to attract investments, foster industrial collaborations, and participate in the global knowledge economy.



Benefits of STEM in Industrial and Economic Revitalization

In today's globalized and technologically advanced world, industries and economies rely heavily on advancements in STEM fields (Akinoso, Agoro, & Alabi, 2017). The significance of STEM education in industrial and economic development is as follows.

- 1 **Technological Innovation:** STEM education fosters technological innovation, which is a key driver of industrial revitalization. By equipping individuals with a solid foundation in science and technology, STEM education enables them to develop new products, processes, and services that can revolutionize industries. Technological advancements lead to increased efficiency, productivity, and competitiveness, which are vital for economic growth.
- 2 **Workforce Development:** A strong STEM education system produces a skilled workforce that can meet the demands of modern industries. STEM skills are highly sought after by employers across various sectors, including manufacturing, information technology, healthcare, and energy. By promoting STEM education, countries can cultivate a pool of talented individuals equipped with the knowledge and skills.
- 3 **Entrepreneurship:** STEM education encourages an entrepreneurial mindset and provides individuals with the skills to create and develop innovative start-ups. Promoting STEM education can foster a culture of entrepreneurship, leading to the establishment of new businesses and industries, which in turn drives economic growth.
- 4 **Increased Productivity and Efficiency:** STEM-based products, processes, and technologies are known for their ability to enhance productivity and efficiency in industries. Automation, data analytics, artificial intelligence, and robotics are examples of STEM-enabled solutions that can streamline operations, reduce costs, and optimize resource utilization.
- 5 **Economic Diversification:** STEM education contributes to economic diversification by enabling the development of new industries and sectors.

Conclusion

Science, technology, engineering, and mathematics (STEM) education is an indispensable element in industrial and economic revitalization. By nurturing STEM talent, promoting technological innovation, and leveraging Mathematics and technology-enabled solutions, countries can drive industrial growth, improve productivity, and foster economic development. Investing in STEM education and cultivating a skilled STEM workforce is crucial for nations and communities aiming to revitalize their industries and achieve long-term economic prosperity. STEM contributed to industrial and economic revitalization through technological innovation, workforce development, entrepreneurship, increased productivity and efficiency, economic diversification, and data-driven decision-making. Mathematical models, such as linear programming, network optimization, and simulation, are used to optimize the flow of materials, minimize costs, and improve responsiveness. In conclusion, science, technology, engineering, and Mathematics contribute immensely to industrial and economic revitalization.



Recommendation

It is therefore recommended that emphasis should be placed on Mathematics learning due to its contribution to STEM education. Also, STEM education should be prioritized to produce a skilled workforce capable of driving innovation and technological advancements for industrial and economic revitalization.

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