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STEM Approach: Effect in Different Educational Levels and Role in Guiding the Future of Students

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Abstract: ***In the last few years, science and technology have played a very important role in the development of India. For some time now, the name STEM (Science, Technology, Engineering and Mathematics) has been very popular in the education system of India. Considering the importance of STEM approach, the Government of India has been continuously running programs at the government level for the last several years to promote it. This paper explains in detail the origins of STEM education. It also describes in detail the impact of the STEM approach on various educational levels, such as primary, secondary, and higher education. The paper also discusses the factors that influence the effectiveness of STEM education. This approach is crucial for shaping children's futures. It also explores how STEM education guides students' futures.***
Keywords: STEM, various educational level, effectiveness, interdisciplinary approach, innovation

I. INTRODUCTION

The modern era of the 21st century is the era of science and technology because science and technology have become a very important part of people's lives. One cannot even imagine living without them. In today's life, science and technology have revolutionized every sphere of life. We use many things in our daily life and all these things have been provided by science and technology. In the National Education Policy 2020, emphasis has been laid on promoting, blended models of learning, online assessments and examinations, experiential learning, researches and innovations.

II. STEM (SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS)

STEM Approach (Science, Technology, Engineering, Mathematics) is a teaching approach through which students are taught these four subjects together so that they can easily solve the problems that come in their life. In STEM, these four subjects are not taught separately in the traditional way, but are taught by integrating them in the form of STEM approach so that problem solving and innovation skills can be developed in children. According to National Science Teachers Association (NSTA), “An interdispinary approach to teaching Science, Technology, Engineering and Math, STEM integrates key concept between two or more STEM disciplines as students apply the practices of Science and Engineering to real word problems.”

STEM approach is very important for students because it develops the ‘FourCs’ in them, which include communication, collaboration, creativity, and critical thinking. In STEM approach, in Science, children are told about scientific principles and processes in detail. In Technology, they are taught to use various tools, machines and their techniques. Apart from this, in Engineering, they are told about how to solve problems using scientific knowledge. Along with this, in Mathematics, they are also taught to study various numbers and quantities. In STEM, students are made to work on projects in which the principles of these four subjects are applied.

According to (White D.W.,2014), Science, Technology, Mathematics, Engineering, Mathematics, all these subjects of STEM Education have been the main part of the academic career for the students which are described as follows:

1) *Science*: It includes experiments, measurements, physical, chemical phenomena, nature, the universe, and the formulation of laws to describe all these phenomena in general terms.
2) *Technology:* This branch deals with the creation and use of technical tools and their relationship with human life, society and the environment.
3) *Engineering:* It involves the practical application of knowledge of the physical or chemical sciences, such as the construction of bridges, engines, ships, mines, trains, and chemical devices.
4) *Mathematics:* A group of related sciences, including algebra, arithmetic, geometry, etc., that deals with the study of number, size, and space and their interrelationships using a special set of concepts.

III. ORIGIN OF STEM EDUCATION

STEM began to gain traction in the late 1990s, with many organizations and educators working on programs to integrate the four subjects: science, technology, engineering, and mathematics. The term SMET was used to describe the four subjects: science, technology, engineering, and mathematics. However, this term did not sound appealing. Therefore, in 2001, the term SMET was changed to STEM by Judith A. Ramaley, former director of education and human resources at the National Science Foundation (NSF), and the term STEM was formally adopted by the NSF.According to (Sanders,2008), The National Science Foundation understands the meaning of STEM well. For about two decades, the National Science Foundation has used STEM to refer to four different and distinct fields known as science, technology, engineering, and mathematics.

According to (Duggar, 2010), "STEM is an acronym for science, technology, engineering and mathematics. he had defined it as the integration of science technology engineering and mathematics in to a new cross disciplinary subject in schools." STEM establishes a close relationship between the four subjects of Science, Technology, Engineering, and Mathematics.(Bybee, 2010) stated that the term STEM education is being used extensively these days. In his opinion, "A true STEM education should increase students' understanding of how things work and improve their use of technology." Kennedy and Odell (2014) noted that STEM education has evolved into a diverse discipline. This integrated approach bridges the gap between these four subjects and focuses on innovation and problem-solving using current tools and technologies."STEM (Science, Technology, Engineering, Mathematics) education, it is an educational approach that many countries in the world have incorporated into their curriculum that allows to see the knowledge learned in science technology engineering and mathematics courses, with the aim of transforming theoretical knowledge into practical products and innovative inventions" according to (Yilmaz A. et al, 2018).

A. Indian Government's initiatives to promote STEM Education

For the past few years, the Government of India has been running several government schemes to promote STEM education, such as Atal Tinkering Labs (ATL), Robo Shiksha Kendra, STEM Champ Program, National Digital Library, Virtual Labs, Swayam Prabha, Prime Minister Research Fellows Scheme, Swayam, etc. The main objective of these schemes is to make students self-learners and disciplined, so that they can be well prepared for their future life and can develop the country by becoming better citizens. The main objective of all these schemes is to increase the quality of education in the country and to provide students with opportunities to learn by doing, freeing them from bookish knowledge.

IV. BENEFITS OF STEM EDUCATION

Through this, various skills are developed in children because STEM education emphasizes learning by doing, in which students do things themselves through hands -on-learning, problem solving, and projects and after understanding them, they solve the problems arising in their studies. STEM education opens the doors of the future for children. Through STEM approach, students are being prepared for their better future.

In this, the subjects which children find difficult, including mathematics, science, technology, etc., they now learn easily through play and clear their concepts. Al Hamad, et al. (2024),shared their view of STEM education is that it introduces students to the interrelationships of scientific principles, technological applications, engineering processes, and mathematical thinking through the integration of various disciplines. This holistic approach reflects the collaborative nature of real-world problem solving.

STEM education is emerging as a significant revolution in the Indian education system because it shifts its emphasis from rote learning to experiential learning, preparing students for their future. The STEM approach has seen many changes in education systems across the world, and its impact is being seen in India as well. In today's rapidly changing world, STEM (science, technology, engineering, mathematics) education is playing a crucial and central role in shaping students' bright futures. The STEM approach is not limited to just four subjects; it is developing a mindset that is crucial for career success in any individual. STEM education is no less than a boon for children because they enjoy it a lot, due to which their academic achievement also increases significantly.

The schemes run by the Government of India to promote education are having a profound impact on the children of the country. Through this, creative thinking, creativity and critical thinking are being developed in children. Through this, children are prepared to solve problems faced in the real world and they are also given knowledge of various skills. STEM education has a profound impact on India's education system, leading to the country's social and economic development.The impact of STEM education is visible in every field of education from primary level to higher level. However, the implementation of STEM education at each level is different, hence the impact at each level is different.

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V. STEM APPROACH EFFECT ON PRIMARY EDUCATION LEVEL

At the primary level, children are very young. Therefore, the primary objective of STEM education is to foster curiosity and creativity in children. At this level, children are encouraged to learn through play, activity-based learning, and develop a tendency to learn by doing.STEM education is having a positive impact on children at the primary level, leading to the development of the following qualities:

A. EncouragingCuriosity

At the primary level, students are very curious and want to know more and more about everything. In STEM activities, the emphasis is not on scientific principles but on play-based activities and practical knowledge, which satisfy children's curiosity and help them understand things better by doing them themselves.For this, activities like making simple models, observing things closely, getting children to role play, etc. are conducted in STEM education.

B. DevelopingProblem-Solving Skills

At this educational level, children are prepared to face small challenges so that they can find solutions to the challenges given to them themselves. Such a mindset is developed in them which inculcates problem solving tendency in them. In STEM activities, knowledge is imparted about making a structure using blocks, completing a simple project, making a simple circuit, etc.

C. Developmentof Observational Skills

At the primary level, children are very young. Therefore, various activities are conducted to enhance their observational skills. These activities are so effective that they provide children with an opportunity to understand and observe things in a better way. This is an important part of children's development through which various skills are taught. Under this, various types of question-answer sessions are held with children and they are made to do interactive activities through which they learn to observe things deeply.

D. FosteringInnovation

STEM activities create an environment for children where they can openly ask questions about what, why, and how. They have a very curious nature and are encouraged to experiment with various methods to satisfy their curiosity. The process of learning is made interesting for children through various types of STEM activities, which move away from traditional methods. This helps students not to get distracted from studies but prepares them for new experiments, which increases their tendency to innovate. They face new challenges and learn by doing by repeated efforts, which as a result develops a sense of innovation in them.

*E. Understanding*Basic Scientific and Mathematical Concepts

In STEM, science, technology, engineering and mathematics are taught together and the concepts of subjects that children find difficult, such as science and math, are cleared. As a result, they get rid of the fear they have about these subjects and they start understanding the concepts well. These activities are so interesting that children do not even realize that they have acquired a lot of knowledge while playing.

F. Build Collaboration Skills

In STEM education, children are often taught to create group projects, conduct group experiments, etc. in effective ways, which helps them listen to each other's ideas, share their own, take responsibility, respect others' perspectives, and work in a team spirit. STEM activities create an environment in which children easily learn to collaborate, which helps them avoid any difficulties in team-oriented work in the future.

G. EncouragingCreativity

STEM-based activities also develop a sense of curiosity in children, allowing them to think 'outside the box' and look at things from a different perspective.To foster creativity in children at this stage, they should be given the opportunity to play independently. Encourage them to learn independently through imaginative play through a variety of activities that will generate creative ideas and prepare them to take creative risks. STEM activities take all these factors into account, leading to the development of creativity in children at this stage.

VI. STEM APPROACH EFFECT ON SECONDARY EDUCATION LEVEL

A. Tackling Real-World Problems

Under this, children first identify the problem, then prepare various designs for its solution, in which they face the challenges, after that they observe the problem deeply and find its solution, thus inculcating the tendency of problem solving in children.STEM projects can involve many real-world problems, including how to prevent soil erosion, how to keep the environment clean, finding ways to purify water, where and how to use solar energy, etc.

B. Promoting Project-Based Learning

At the secondary level, children are made to work on different projects in STEM activities. While doing the projects, children find solutions to the problems they face on their own and understand and clear their concepts well. Through this, the knowledge acquired by the children becomes durable and they also develop a sense of working with each other.

C. Introduction to the Digital World

At the secondary educational level, children are introduced to different technologies in STEM activities, which use robotics, coding, decoding, programming etc. Apart from this, robotic labs etc. are also run in schools, which provide children the opportunity to learn and do things digitally, by doing it themselves.This is very important for children because becoming familiar with the term digital will help them a lot in their future research and connecting with the digital world helps them in easily accessing various learning materials. It gives children the opportunity to explore and create their own identity in the digital world.

D. Developing Critical Thinking

STEM activities encourage children at this stage to analyze things, ask questions, and solve problems, thereby rapidly developing critical thinking. STEM involves specific activities designed to challenge their minds and push their cognitive boundaries, allowing them to analyze things better and develop critical thinking skills.

E. Developing Deep Understanding and Analytical Skills

STEM-based activities teach students to study things in depth, teaching them various skills, such as how to recognize patterns, how to evaluate data, and how to conclude things effectively. Activities use evidence-based reasoning and prepare them for analytical skills.

F. Preparing for Higher Studies

STEM activities at the secondary level include activities that strengthen children's foundations. They are given opportunities for research experiences, science fairs, and advanced courses that prepare them for future challenges. These activities also include numerous collaborative projects, allowing children to become self-guided. They are also encouraged to engage in extracurricular activities alongside their studies, which ultimately eliminates their fear of higher classes.

G. To Encourage Confidence and Leadership Quality

STEM activities at this stage involve children in a variety of activities, projects, and experiments, which build their confidence and develop leadership qualities.STEM activities involve tasks that develop leadership skills. Students learn to work in teams, present their ideas, and develop a sense of listening to, understanding, and respecting the ideas of others.

VII.STEM APPROACH EFFECT ON HIGHER EDUCATION LEVEL

A. Encourage Research

At higher levels, students are encouraged to pursue research through STEM activities. They are motivated through hands-on projects, innovation competitions, and skills that enable them to conduct research effectively. Essential guidance is provided to them from time to time, enabling them to explore new possibilities. This helps build confidence. The Government of India provides various scholarships to students for research, including Prime Minister's Research Fellowships, CSIR-UGC Fellowships, and scholarships from various institutions to provide financial assistance to students for higher education and research.

B. Prepare for Careers

The main objective of STEM Education is to prepare children for their future at a higher level so that they can make their career and be successful in it. STEM education provides job opportunities to children in all fields like Science, Technology, Engineering, Mathematics etc. and gives children a strong foundation so that they can move ahead in their future life and develop their country because for a developed nation, the life of all citizens should be happy and successful.To help students with higher education pursue a career, the government, through initiatives like Startup India, encourages technical graduates to start their own companies, enabling them to stand on their own feet and contribute to nation building.

C. Enhance Competitive Spirit

At higher levels, various programs are run to increase the spirit of competition among students, which creates a positive environment for children. Keep your objectives clear about what they want to do in the future. Apart from this, self-improvement is also encouraged in children. Such a mindset is developed in them that they take failure with equal ease and learn from it. To develop the spirit of competition in children, they are encouraged for teamwork. Through these activities, collaborative problem solving and self-confidence building is developed in children. Students are made to do attractive activities, so that they see failures as learning opportunities and develop their mental development, which awakens the spirit of healthy competition in them.

D. Develop Entrepreneurial Spirit

To promote this, schools focus on STEM curriculum and offer dedicated courses that help children develop understanding of market analysis, business planning, finance, and marketing. Guest speakers are invited from time to time to inspire students with their success stories and inside experiences of their entrepreneurial journeys. During these activities, various competitions are posted for children to build a supportive mindset and encourage a questioning mindset. In addition, in place of traditional coursework, a system is developed that allows children to connect with real-world problems and take practical steps to solve them.

E. Inspire Innovation

At higher levels, students are involved in the self-reflection process. Through this, children understand their strengths and see the opportunities in the area they are interested in and try to pursue them. Apart from this, a flexible learning environment is created in which children are taught on the basis of new learning strategies and research-based fields, which is different from the traditional teaching method. Through all these activities, children develop independent thoughts. They learn one-to-one learning, have hands-on experience, and have group conversations, as a result of which new ideas are awakened in them and they move forward to innovate. In STEM activities, along with the children, teachers also continue to teach children with passion and they provide proper planning and content delivery to the children in the creative learning process.

VIII. BARRIERS TO EFFECTIVENESS STEM EDUCATION

The STEM approach has tremendous potential to transform the Indian education system. Its impact on children at every educational level can be easily observed. However, there are still many areas in the country where it is not being properly implemented, resulting in children not seeing its benefits. At the primary level, many schools still lack electricity, computers, and internet access. Science kits are missing, and STEM-related resources are missing. Furthermore, STEM education requires effective teachers, but these schools lack trained teachers. Consequently, these subjects cannot be taught in an integrated and engaging manner. Furthermore, the Indian education system places a heavy emphasis on completing the curriculum, which needs to be changed.

Children are focused solely on achieving good grades, not on instilling in them the attitudethat will enable them to stand on their own two feet and become successful citizens.At the higher level, it is often seen that many talented people of India migrate out of the country in search of jobs because they feel that there is no opportunity for progress and good growth in their own country. For this, the government should pay attention to this thing so that the migration of talented people can be stopped. This is the challenge which is preventing the STEM approach from becoming effective.

Educational institutions at every level in the country need to modernize their infrastructure, laboratories, and research facilities. Furthermore, many areas in India are deprived and rural, where providing quality STEM education to children is a major challenge. To address these challenges and strengthen effective STEM education, the Government of India, educational institutions, and all individuals need to work together, as only with everyone's cooperation can these barriers be overcome. Every student can benefit from it, and the country can be taken forward.

IX. ROLE IN GUIDING THE FUTURE OF STUDENTS

In India, the STEM approach is playing a crucial role in shaping students' futures by equipping them with diverse skills. This approach isn't limited to simply studying four subjects (science, technology, engineering, and mathematics) simultaneously; it also fosters a mindset that is essential for life and career success. STEM education is crucial for preparing students for their future careers. There's a growing demand for employment opportunities in fields such as artificial intelligence (AI), data analysis, biotechnology, computer science, robotics, and more, all of which are based on the STEM approach. This education prepares students to excel in all of these fields. Furthermore, it's not just providing jobs in technically skilled fields. Traditional departments like medicine, engineering, finance, and healthcare are also seeing demand for STEM students.

A. STEM Carrier Options for Students in ScienceField

There are various job opportunities in the field of science for students graduating from STEM subjects, including golden opportunities to become data scientists, research scientists, software technology, forensic scientists, biologists, chemists, physicists, microbiologists, geologists, etc.

B. STEM Carrier Options for Students in Technology Field

The field of technology offers various opportunities to students, in which there is a high demand for skilled people in all these fields like Artificial Intelligence specialist, game developer, cyber security analyst,software developer, biomedical engineer, robotics, web developer, Cloud architect etc.

C. STEM Carrier Options for Students in Engineering Field

There are various career options available for STEM graduates in the field of engineering which offer high salaries and growth opportunities to the students. They can make their career by becoming robotics engineer, automotive engineer, civil engineer, computer engineer, mechanical engineer, aerospace engineer etc.

D. STEMCarrier Options for Students in Mathematics Field

There are various options for STEM students who want to pursue a career in mathematics. They can make their career by becoming mathematician, statistician, quantitative analyst, data analyst, cryptographer, algorithm engineer etc.

X. CONCLUSION

The STEM approach not only teaches children by combining subjects like science, technology, engineering and mathematics, but also equips them with qualities like problem solvers, pioneers, etc. This approach is crucial for transforming traditional education and revolutionizing the country's education system. STEM develops skills in children, enabling them to perform every task with attentiveness and skill. It produces highly skilled professionals. STEM education is crucial for improving the future of the new generation and increasing their versatility. It also helps promote equality in education system. STEM education courses at all educational levels are designed in such a way that students are curious to learn more and more. They try to find answers to questions like what, why, how, etc. STEM education should be taught to children from the primary level itself so that they can live a better life in the future, can diagnose their problems themselves and can contribute to the building of the nation by becoming successful citizens.

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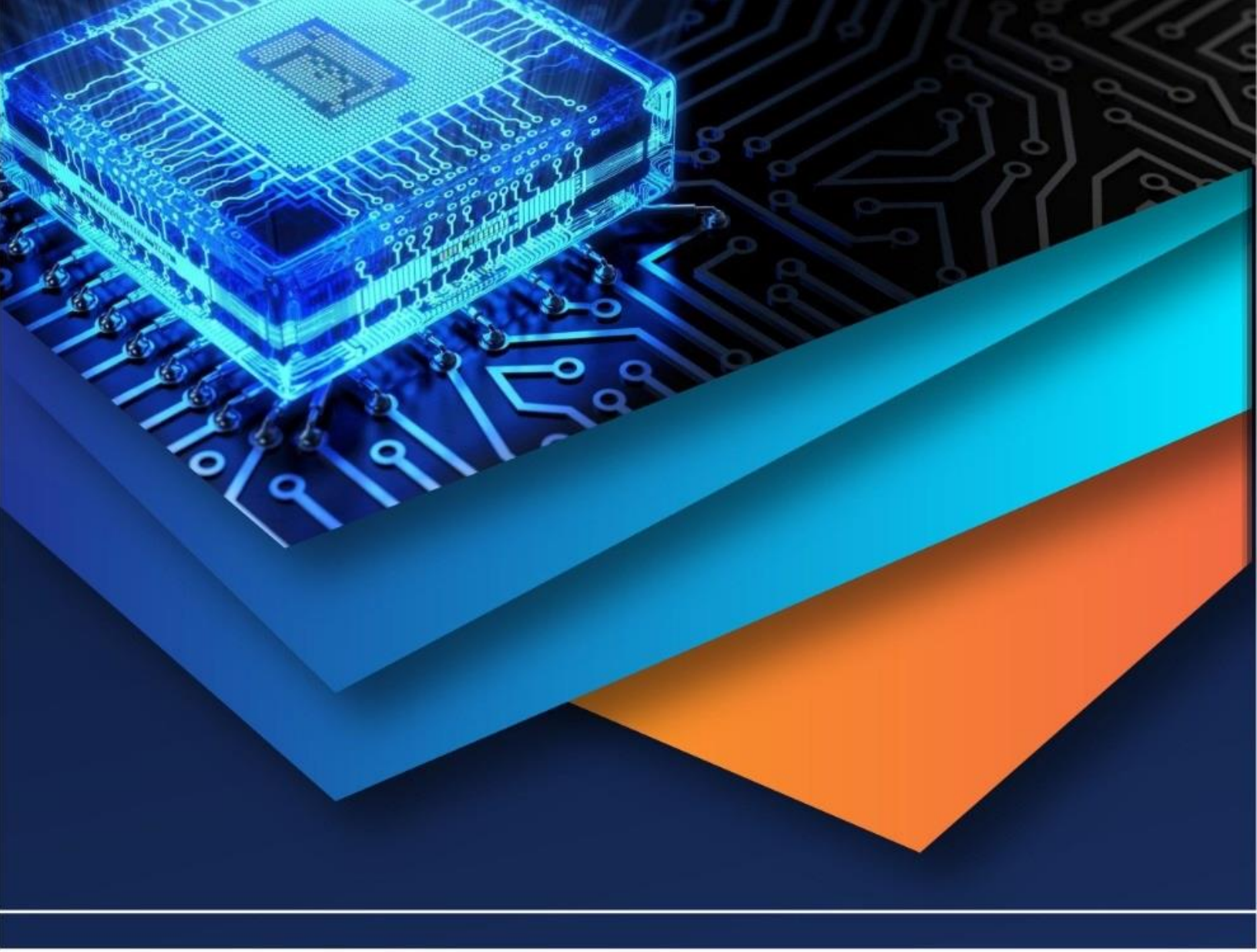

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