



Development of STEM Education in China

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Abstract. The purpose of the article is to explore the development of STEM education in China in a comprehensive manner. China has been focused on developing the STEM education system that defines the upgradation of learning methods to prioritize the science, technology, engineering, and mathematics subjects. This learning method has an impact on the society of the country along with the international community. Skill development, according to the 21st century, establishes a bridge between the gender gap, enhancing the management system along with economic benefits. The STEM education system has impacted the development of the future generation and the benefits in daily life. Besides this, the challenges faced by the education system create obstacles to adopting the educational system. The STEM education system also has to face some barriers, such as infrastructure challenges and awareness of the students. Some beneficial strategies have been discussed over here to resolve the challenges. The modification of the infrastructure, the development of the pedagogical approaches, and the promotion of the STEM education system enhance the student's interest in the STEM education system and can be implicated in developing STEM education learning methods. The study's conclusion has summarized the whole topic of the study with proper justification.

Keywords: STEM education · teacher · educational method · China · Skill development

1 Introduction

STEM education is essential for developing practical skills for students, which means education within specific systems and disciplines to teach correctly. This education was introduced in China in February 2017 by the Ministry of Education in China (Zenz, 2019). Government officials have taken this initiative for systematic and top-level teaching of students in China. The government of China is supportive and encourages this new style of education. The education system is introduced in tier-one cities along with a few second and third-tier cities of the country, with effective methodologies of STEM education. Important cities that have applied the new educational initiation are Shanghai, Beijing, Shenzhen, and Chengdu. The Ministry of Education has taken up this initiative with the in-depth promotion of the educational system in China. The government has proposed “Guidelines on the comprehensive and in-depth promotion of education

information during the 13th Five year plan period” (Zhou & Li, 2021). The Academy of Education sciences has followed this educational system for strategic support in developing scientific skills for students.

This STEM education is effective in the educational curriculum as this provides people with skills to make a great future. This educational system also makes a student employable and more innovative than meets the current demand of all organizations (Azmi, Kamin, Noordin & Nasir, 2018). This article is meant to describe the entire process of STEM education development in China in a comprehensive manner. Moreover, the study follows the challenges to effective development with STEM-based education in China and some more innovative strategies that eradicate issues related to this educational system. This system experienced the valuable contribution of a well-rounded educational system where the educational system is mainly given a good understanding of scientific knowledge and mathematical skills.

2 Concept of Stem Education

2.1 Overview of STEM Education

STEM is the innovative initiation of education, a unique approach to effective learning sessions. The STEM education system stands for science, technology, engineering, and mathematics (Saraç, 2018). This educational system has developed a better knowledge of mathematics, science, and technological ideas for usage in new trends and cultures. Stem education emphasizes technological integration with systematic ways that readily relate to students’ problem-solving. This educational system is to improve the skill of students and move those students to the future. Students’ performance is based on simple tests that are focused on the development of higher-level thinking skills. STEM education was first introduced in the United States and applied comprehensively and in a disciplinary manner. The United States has experimented with the overall development of the educational system since the 19th century and has introduced innovative ideas for the country’s educational system. The National Science Council of the country has published undergraduate science, mathematics, and technology skills for better future growth and development opportunities for students (Loyalka, Liu, Li, Kardanova, Chirikov, Hu., Yu, Ma, Guo, Beteille & Tognatta, 2021). This institution has proposed new implementations in the educational system that may develop the skill for technological knowledge. This initiative in the United States has also encouraged many state women to fulfill their primary desires. The systematic view of improving technological skills can effectively assist in getting a chance at NASA, which helps implement various new technologies for those organizations.

STEM is a responsible initiation for education that makes a realization for future built and capacity to implement new inventions for future generations. Traditional methods of teaching are not effective in improving the skill of technology; moreover, this is tougher to solve various problems (Coman, Țîru, Meseşan-Schmitz, Stanciu & Bularca, 2020). Apart from this, the STEM educational system emphasizes collaboration, developing research skills, solving research problems and communicating with others, and developing critical thinking. The universities of the USA provide OPT (Optional Practical Training), which leads to better workplace experience before applying for H1-B

work in the same country. This country offers 400 STEM degree courses for enhancing technology and engineering (Roy, 2022).. These universities also give STEM degrees in other subjects like mathematics, soil microbiology, Architecture, information technology, and Animal sciences. More international students have applied for STEM degrees in the United Kingdom. This country is the preferred fruitful designation for international students as this country can provide high-quality education to all students. Brexit has changed immigration policy for a fairer and more accessible process for Indian students to apply for STEM education in the UK. There is a fair distribution of academic papers submitted in the UK-based STEM system for the companion of Science and Engineering (CaSE) (García-Holgado, Díaz & García-Peñalvo, 2019). This country mainly offers various subjects providing better degrees to the students, such as Civil engineering, Astronomy, Biochemistry, Biology, and more. This education system in Canada mainly offered lower fees than the UK and US.

2.2 STEM Education Development in China

China's STEM education development has entered a stage of vigorous development. The STEM educational system is recognized as an excellent educational system mainly proposed in various countries for developing educational strategies. STEM is an essential part of everyday life as it improves the level of ability, well-spoken power, and improving technological skill (Martín-Páez, Aguilera, Perales-Palacios & Vílchez-González, 2019). The Ministry of Education has declared STEM applications in every primary school section. The primary level of education improves the future development of every Chinese student. The Education Bureau commits that the school STEM education ensures a critical approach for young people in Hong Kong. Mathematical, scientific, and computer programming knowledge is the most important in every Multinational Firm. Therefore children should teach about all subjects.

The Ministry of Education in China has taken the initiative for the sake of students, and this introduces various new potentials in schools and colleges in China. There is a conference and release in China for the introduction of an educational white paper. The STEM system gives opportunities to all the teachers to take some training in this new education system, which provides a systematic teaching process (Barakabitze, William-Andey Lazaro, Ainea, Mkwizu, Maziku, Matofali, Iddi & Sanga, 2019). All the training schools and universities have collectively introduced this new teaching system, which has been introduced in 11 STEM Education Collaboration and innovative centers in China. China has introduced better educational strategies through the implementation of STEM education.

The Chinese tradition forms a manufacturing-based economy, but for further growth and development, it must focus on moving towards knowledge-based economies, mainly advancing technology and science. The technology-based economy is mainly based on improving organizational purposes, which can effectively improve economic development. In this concern, the Chinese institution should implement better and more systematic education for students. Chinese technology remarkably increased in the number of technology, science, mathematics, and engineering, for the effectiveness of STEM education. A recent survey was created for Chinese universities that observed that 17% of participants have responded to attending a tertiary degree at a higher educational level.

Data released by the Ministry of Education outlines that in 2015 Universities started majors in Artificial Intelligence (AI), 163 have set up majors for Robotics Engineering, and at least 132 have set up majors in Intelligent Science and Technology (Bal-Taştan, Davoudi, Masalimova, Bersanov, Kurbanov, Boiarchuk & Pavlushin, 2018).

Some specific challenges have been formed towards the top-level universities in China for better application of STEM. The survey has depicted a more effective percentage in this education system's governmental intervention and evaluation system. The overall educational system in China has followed significant development within higher levels of education. Chinese universities have mainly doubled the formation of this educational system for the betterment of students. Various top-level educational systems have developed an initiative to offer vocational or technological training for improvement at the educational level. Technological improvement at the educational level needs skillful teachers, which could be fruitful from effective training (Al-Ali, 2021). The Chinese government proposed a scientific paper that would increase the state level of educational institutions.

3 International View of Stem Education

Science, technology, engineering, and mathematics have effectively increased in all the educational institutions in developed and developing countries. The governments of all countries have effectively vowed to improve the education system. Top-level universities and schools worldwide have improved education through the STEM education system. This initiation has mainly improved students' technology and scientific knowledge. In this concern, the US has introduced this system in learning, mainly in universities. The top-level universities are mainly concerned about applying technological improvement that may develop the technology skills of present trends.

Various students are likely to apply for a graduate degree in STEM to understand advanced technology and innovations better. For example, the tertiary students in Oman and Tunisia prefer to perform and apply to graduate from STEM. The percentage of students doing that is between 43 and 46 that receive the most engineering degree, mathematical and technological degrees. However, regarding numbers, Indian students are mainly to receive a better share, with 2.7 million students graduating from the program (Freeman & Marginson, 2019). All this data has been published by UNESCO Institute for Statistics and provides a clear idea of STEM education development across the globe. The World Economic Forum (WEF) has highlighted the Chinese educational system that has guaranteed STEM education and better placement. This rate guarantee has exceeded the margin of India. Moreover, the National Foundation of Science also classified engineering and science fields and has shown better stability of the STEM educational system in various fields. Further, the US government has highlighted the data with 1.6 million guarantees of better scientific and technological education facilities.

Tunisia has shown better results within the STEM educational system when compared with other countries. Moreover, Russia also implemented a new initiative in education which led to a better educational system for the country. These countries have graduates making up 30% of the STEM educational system (Buchholz, 2020). On the other hand, the UK has graduates making up 26% to initiate better courses for students.

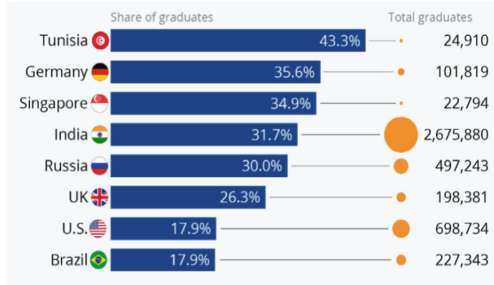


Fig. 1. Share of graduates and total graduates from STEM tertiary education program

Other countries provide STEM education with guaranteed better courses for developing technological knowledge (Fig. 1).

The United States has mainly developed better infrastructure for STEM initiation for education and offered mainly over 400 degrees for the students of this nation. Optional practical training is the specific training strategy the institute provides for betterment in organizational purposes (Hesbol, 2019). The United States has mainly effectively followed the special techniques for job facilities in legal firms. This training is more fruitful for the students in the nation, and this training process has provided better ideas that fulfill the requirement of modern trend organization. This is an optional system for the students, and there is no pressure to complete this system. This is why several students are applying to the curriculum of the US-based STEM education system.

The STEM technology of education has made intense initiation within business and management and in non-science subjects. However, this country has not made better guarantees within science and technology rather than other subjects. This country has awarded less than 500,000 degrees in technological and other sciences (Decker, 2019). On the other hand, the US has made a less effective percentage of getting awards in engineering. Apart from this, school students in both Singapore and Japan have better rates in national mathematics and science subjects. Singapore has the highest participation rate for science subjects; this is contained with high performance and better results in mathematics and science.

The government policy about “relaxed education policy” also being introduced for the necessary education has aimed at students in the nation. Japan has increasingly been applying a simultaneous process for the students of this nation (Decker, 2019). Moreover, technological development has already existed in Japanese organizations; this has made assurance of the STEM educational process. This country has introduced an enhancement of the educational process for motivating students in future aspects. The government of Japan has put some better opportunities for common students with the application of better strategies after the “PISA shock” in 2003. The initiation of STEM has given the student effective motivation for developing the future (Fig. 2).

The territory level of education has mainly focused on the attention to the Change of globalization. Globalization is a Change process of overall procedure on economic development that has mainly changed the process of business (Wu, Wei, Li & Yuan, 2018). Globalization led the change in all purposes along with the educational

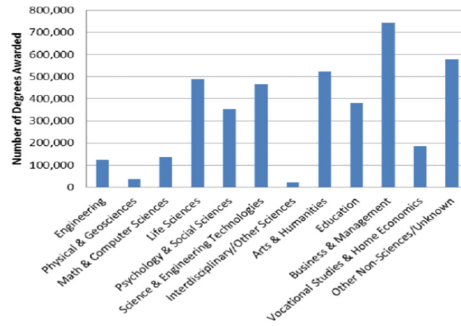


Fig. 2. STEM education in the United States

system; this has given rise to the STEM education system. The tertiary education trend is mainly based on STEM procedure education. Science and technology have mainly been encouraged within the modern age for organizational demand. A large amount of the women population is mainly admitted to the tertiary education sector rather than men. The STEM initiation has increased throughout all the countries, with the preoccupation of various students.

4 Impact of Stem Education on Society

4.1 Development of Skills for the 21st Century

STEM educational skills can emerge in the future education system and implement the students' skills. The STEM educational process provides better training and systematic learning (Papakostas, Troussas & Krouska, 2021). Thus, students can investigate, perform and solve the most challenging problems, allowing better economic development.

4.2 Create the Bridge Within the Gender Gap

There is a considerable gender gap within large companies' workforce that only prioritize the male group. The STEM education system has provided better educational skills for developing modern business activity (Malik, 2018). However, there is a lack of opportunities for women worldwide. The gap can be reduced through proper educational systems in the nation. Technology innovation and implementation in the educational system may connect employees and organizations. In this concern, women can get some opportunities by getting a chance in the organizational sector. The STEM educational system provides better disciples that can be effective in the organizational system and also provide awareness of the importance of girls in management.

4.3 Enhancement of Management System

The STEM educational system is a systematic procedure that prioritizes better strategy within the technological innovation of the learning process. The modern learning process

acquires the necessary knowledge to improve skills in present trends to achieve specific goals (Hannola, Richter, Richter & Stocker, 2018). The educational goal can be fruitful for applying to a better firm in future development. Effective technological innovation knowledge can produce new inventions, resulting in a profitable return from outcomes. The overall management process has mainly emerged through technological innovation and recent trends in digital marketing. This can be trained through the systematic approach of STEM education. Moreover, students with effective skills can quickly get a higher level of job as that person has gained the ability to manage the present business trend.

4.4 Economic Impact of STEM Education

The STEM education system impacts society by creating jobs based on the STEM system. The students who engage with this STEM education have the scope of getting a job in today's market driven by technology (Li, Wang, Xiao & Froyd, 2020). Engineering jobs will be offered to the students of STEM education as the students get more preference in engineering job sectors due to the developed skill of the students. On the other hand, the country's GDP rate can be positively increased depending on the benefits of jobs and the development of the country in technological aspects. The revenue of the developing business in the country increases by the skilled employees belongs to the STEM education system of the organization.

4.5 Development of the Future Generation of the Country

STEM education encourages students to experiment and innovate new things using the advanced technology of STEM. This learning system also motivated the students to work in a team and enhanced their creative ability and critical thinking development. The students have learned the value of advanced technology through STEM education with practical experiences. STEM education provides great opportunities for the future to build a solid and successful career (Maab, Geiger, Ariza & Goos, 2019).. Communication skills also have been developed by the students of STEM education, which helps the students communicate with society and resolve the problems with the societal development.

4.6 Positive Effect in Everyday Life

The STEM education system also helps to develop life skills such as budgeting and proper use of money. Mathematical integration has been developed by the students in STEM education that can be applied in the daily life of society (Simamora & Saragih, 2019). The problem-solving attitude has been developed in the STEM education system that helps the students and society to face the challenges or problems of society and solves the problem using critical thinking ability. Team workings and communication build-up are all positive ways to develop the society inherited by the STEM education system and used in everyday life.

5 Challenges Faced by China for Stem Education

Stem education is mostly approaching educational service in the modern era. However, some barriers are faced with China's STEM education development program. The primary and most crucial problem in developing STEM education is the lack of skilled teachers for STEM education. On the other hand, poor STEM education infrastructure leads to losing interest among students. Teachers are not interested in teaching as teaching honorarium is not up to the mark. STEM education also faces pedagogical challenges, curriculum challenges, structural challenges, lack of awareness between students and the assessment, and teaching support problems.

5.1 Special Needs Challenges

The special needs challenges also affected STEM education as the students have trouble understanding the current level of learning of science and mathematics due to their age. Teamwork is not acceptable to a few students as class noise distracts them from focusing on their studies. The satisfaction of the students by providing the proper knowledge and comfort level to them becomes rigid due to the needs of the student (Vennix, den Brok & Taconic, 2018). Besides this, the concentration level of learning varies among students. Therefore, the learning ability differs, leading to a loss of interest in students who cannot cope with the study techniques. China also has faced this challenge of students having trouble with the techniques of STEM education.

5.2 Pedagogical Challenges

The pedagogical learning process is the procedure of resolving the problems of the real world with contextual learning and teaching, including STEM education. Pedagogical learning has five effective approaches such as constructive, collaborative, integrative, reflective, and inquiry-based learning. However, the pedagogical learning method of STEM education has to face the challenges such as inappropriate teaching methods and lack of equipment for teaching procedures (Papadakis, Vaiopoulou, Sifaki, Stamovlasis, Kalogiannakis & Vassilakis, 2021). Unskilled teachers lead to the loss of students' interest, and teaching support has depreciated for STEM education. Due to the under-qualified teachers, the assessment procedure is hampered, leading to the deterioration of STEM education. China is trying to establish a vital STEM education in all educational institutes; however, the pedagogical challenges create barriers to the Chinese STEM educational system.

5.3 Infrastructure Challenges

The infrastructure of STEM education has fewer budgets to improvise with advanced technologies. STEM education has the mission of low-cost budget STEM learning and developing the future generation with proficient knowledge about science, technology, engineering, and mathematics. The maintenance of this mission of low honorarium for the teachers creates less interest for the teacher to do this teaching. Unskilled and

unqualified teachers are appointed for STEM education due to the low budget, leading to inappropriate teaching methods (Suebsing & Nuangchalerm, 2021). Besides this, the lack of essential learning tools leads to incomplete teaching procedures. China also has the mission of low-budget STEM education that hampers the learning method of the students. Students become impatient along with dissatisfaction with the learning procedure. The practical experience of learning, especially in STEM education, is essential, and the lack of infrastructure in Chinese STEM education fails to reach the development goal of STEM education.

5.4 Awareness of Students

Students are still unaware of the importance of STEM education, and all the students have not accepted the upgradation of the learning method. The students believe in traditional learning and have trouble understanding the benefits of STEM education. Science and mathematics are measured as tough subjects, and technology, along with engineering learning, helps to grow a student for future application in the professional field (Lyailya, Nurziya, Dariya, Saule, Assel & Bulbul, 2021). This vision has motivated.

China has to develop STEM education in educational institutes to equip students for learning improvement. However, the lack of knowledge about the STEM education system in students has created an obstacle to developing and spreading the STEM education system (Thibaut, Ceuppens, De Loof, De Meester, Goovaerts, Struyf, Boeve-de Pauw, Dehaene, Deprez, De Cock & Hellinckx, 2018). Students are unwilling to accept the learning method, and the results reflect the discontinuation of the students from STEM learning education.

The student's concentration is also hampered by the improper teaching methods that grow the loss of interest in the students. Furthermore, the advanced technological learning procedure makes it difficult for the students to cope with and understand the learning, leading to a loss of interest in the students.

5.5 Curriculum Challenges

STEM education differs from traditional learning education as STEM education focuses on Particular subjects of Science, technology, engineering, and mathematics. The students do not accept this changed pattern from the parents of the students (Yanez, Thumlert, De Castell & Jenson, 2019). China has followed the Chinese national curriculum, which includes comprehensive learning. The sudden change of learning method creates difficulties for the student to cope with the new learning method. The Chinese education syllabus focuses on all students with different merits. STEM education has an advanced learning system that all students of different merits may not understand.

This barrier creates a loss of interest in the students, and the student's preference in choosing subjects differs from other students. For example, some students like science subjects; on the other hand, some students like to learn literature subjects. According to the student's preferences, STEM education cannot be generalized in all educational institutes in China. This challenge has generated a barrier to developing STEM education in China. The students of China are accustomed to the traditional learning procedure and not so comfortable with accepting the changes through the STEM education system.

6 Strategies to Mitigate the Challenges Faced by China for Stem Education

6.1 Promoting the Importance of STEM Education to the Students with the Support of Management

Understanding the importance of STEM education can increase the student's interest in the STEM learning system. Authentic learning activities can influence the students to adopt this learning method that should be provided by the management of the education system (Vennix, den Brok & Taconis, 2018). Establish a connection between science and students' daily lives to create the query in students' minds and attract them to the STEM education system. This approach helps to modify the pedagogical approaches. The particular campaigning program based on the STEM education system can be conducted by the management of the STEM education that helps to promote the education system.

The management can organize seminars and references associated with this particular education system for developing the STEM educational system. Mock classes can also be implicated free of cost to promote the educational system. The advantages of the STEM education system have to be explored by using different and unique techniques that help to grow the interest of students along with their parents (Uğur, Duygu, ŞEN & Kirindi, 2020). The need to upgrade the learning procedure in recent days helps to develop the knowledge of society about the STEM education system. The future prospectus of the STEM education procedure has to be promoted to change the mindset from traditional learning to STEM learning.

6.2 Developing the Pedagogical Learning System

Proper teacher training has to be introduced by the STEM education system for the development of teaching techniques. Lack of teaching support has led to a critical situation for developing the STEM education system. Maintaining the low budget, a fruitful training program has to be given by STEM to skilled teachers with proper teaching methods (Srikoom, Faikhanta & Hanuscin, 2018). The basic needs of STEM education have also followed the recruitment of teachers. A qualified teacher can adopt the skills of the STEM education method and adequately conduct the teaching procedure that benefits the students. The low budget should be prepared considering the proper honorarium of the teacher that helps in developing the STEM education system. Therefore, China should start a robust and skillful training program for teachers to develop the pedagogical learning system of STEM education.

6.3 Well-Equipped Infrastructure of the STEM Education

Modification of the infrastructure of STEM education is needed to develop the STEM education system and attract students by implanting advanced technology in the educational procedure. Enough accessibility to educational tools and resources helps build a concrete STEM education system infrastructure (Feinstein & Mach, 2020). Besides this, the inter-discipline section has to be vital to maintain the sustainability of the STEM education system. The instruction provided by the STEM education system management

authority has to be followed to maintain the balance of teachers' and students' activities that enhances the chances of development of the STEM educational procedure. China has to use this strategy to strengthen the infrastructure of STEM education. The classroom's ambiance must be prepared according to the STEM education system that inspires the students and gives them a comfort zone.

6.4 Increasing Student Engagement in STEM Education

The students are the main focus of STEM education; therefore, the system needs more student engagement in this educational system. The independence of learning or the self-directing learning opportunity helps to motivate the student to engage in this educational system (Mosalanejad, Razeghi & Ifard, 2018). Students are influenced by the independent learning experience that enhances their problem-solving capability. Practical experience is the best way to teach a lesson; hence the on hand opportunity of experiments attracts students more effectively. Information about the importance of STEM education for building a solid career in the future and the value of advanced technology has to be spread among the students.

The education system has to give a reason with justification to accept the STEM education procedure broadly, which can get more attention along with students' engagement. As in China, the students who are losing interest in STEM education can use this strategy to encourage more students to adapt to the STEM education system. The real-life connection with the STEM education system also enhances students' interest and helps to adapt the educational system (Huang, Erduran, Zhang, Luo & Li, 2022). Using different techniques for learning, such as games, teamwork, and giving challenges to complete the task in a limited time helps to grow the interest among the students. In addition, creating communication between students and teachers helps the students cope with the learning methods.

Special attention given by teachers to the students who have trouble understanding the learning methods can motivate the students to give more effort to cope with the learning system. Furthermore, maintaining the class's discipline helps the students concentrate on their studies without any distractions.

6.5 Acceptance of Curriculum Changes

All countries have their traditional learning methods; therefore, accepting new learning methods is tricky. The country's future depends on the educational structure of the country and the students (Shaturaev, 2021). The self-conflict about the success of the new learning method has been created in society, and it becomes afraid to adopt it. The STEM education system has to clarify the fear of accepting these learning methods in society along with justifying the advantages of the STEM education learning method to adopt by society.

7 Conclusion

The entire study has been focused on the development of STEM education in China. Stem education defines the science, technology, engineering, and mathematics learning

method. China is effortlessly trying to establish this learning method in all educational institutes of the country, considering the advantages of the STEM education system. Internationally the STEM education system has been accepted broadly, and China has been influenced by the impact of the STEM education system. The STEM education development program focuses on understanding the importance of STEM education along with the origin of STEM education. This development program also upgraded with current circumstances to develop students' science, technology, engineering, and mathematics skills.

The benefits of STEM education are creating critical thinkers for the country's development and increasing scientific literacy in society. Innovative ideas have been generated by the students in technological aspects that can help to develop the country in the future. Different students have different needs; some prefer individual learning instead of team learning. The mission and vision of STEM education are the students and development of the country. Therefore, the main focus of STEM education is to motivate students to adopt the STEM learning method and inherit technological innovation capability. This inventory of the students helps to develop the economic growth of the country. The up gradation of learning methods has positively impacted China, and the development of the STEM education system has been successfully enhanced with the implication of the strategies by China.

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