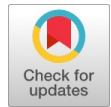# Evaluating the Role of STEM Education in Empowering Secondary School Students

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Abstract: In recent years, the global emphasis on STEM (Science, Technology Engineering, and Mathematics) education in secondary schools has grown significantly, driven by the recognition of its pivotal role in preparing students for the complexities of the 21st-century workforce. STEM education transcends traditional disciplinary boundaries, emphasizing critical thinking, problem- solving, and innovation—the cornerstones of technological advancement and economic competitiveness. The present study delves into the relevance of STEM education in secondary schools, exploring its impact on students' academic development, career readiness, and the broader societal implications. By examining current research, trends, challenges, and future prospects, this investigation aims to provide a comprehensive understanding of how STEM education equips students with essential skills and knowledge to navigate and contribute meaningfully to our increasingly STEM-oriented world. This study was conducted using the survey method with 50 secondary school teachers as the study samples. The data were collected using opinionnnaire and analyzed using quantitative descriptive analysis. The study results revealed that STEM education implemented at secondary school level helped in the development of the higher cognitive abilities of the learners, such as problem solving, critical thinking, creative thinking etc.

Keywords: STEM Education, Secondary School Level

I. INTRODUCTION

The advancement of science and technology has brought about a great deal of change in the education sector. Modern teaching techniques that make learning simpler and more engaging have been introduced as a result. One such strategy is STEM education. Science, Technology, Engineering, and Mathematics education is referred to as STEM education. It is a novel method of instruction that combines mathematical, science, technological, and engineering knowledge with student engagement. STEM education takes particular traits into consideration and focuses on the interests and learning styles of each student. This implies that every student might benefit from STEM education.

STEM education connects the subject areas according to the principle of interrelation, which makes both the teaching and learning processes smooth and meaningful and thereby develops a meaningful learning environment.

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This is in contrast to traditional education systems, which aim to organise subject areas. STEM education provides students with an engaging learning environment while enabling teachers in effectively imparting material. STEM is intended to foster creativity, critical thinking, and problem-solving while enhancing students' practical knowledge and teamwork. STEME ducational so serve sasan important pedagogical approach by in culcating in the learners entrepreneurship skills and thereby making them a productive member of the society and can lead to economic welfare of the country making the learners an asset. Hence, STEM Education prepares the students for a real-world situation. At the level of the learner, STEM Education provides room for independent exploration of the subject matter and helps in discovery learning, since a constructive classroom environment is generated in STEM classrooms. The teacher talking time is reduced here and the learner engagement and productivity is ensured. Also STEM Education expands the curiosity of the learners and elevates them to the level of curious and accountable learners. The academic performance will gradually improve when the students are exposed to a STEM learning environment. Apart from the academic aspects, STEM Education also helps to meet the current and future needs of labour market as it develops entrepreneurship skills in the learners. Students use the concepts they learn in class to solve real-world problems by brainstorming ideas and coming up with suitable solutions. This helps them strengthen their decision-making abilities, which in turn helps them acquire life skills. In a nutshell, the STEM classrooms lead to the all-round development of the learners. The importance of STEM education in India for young learners is clearly evident from the fact that the Government of India has launched the Atal Innovation Mission (AIM) at NITI Aayog. STEM education has a profound impact on developing nations by driving economic growth, technological advancement, and societal well-being. By investing in STEM education, countries can create a skilled work force, foster innovation. The nature of STEM programme includes applying real-world scenarios to bring students out of the classroom and show how they can use subjects in real life. This kind of lesson helps students understand the importance of the subject matter to better appreciate what they are learning and feel more invested in their education. The present study explores the idea of STEM Education and its importance in secondary education and how far STEM Education is successful in improving the academic and non-academic abilities of the learners. The study aimed to understand the the implementation of STEM Education in secondary schools of Kerala.

II. NEED AND SIGNIFICANCE OF THE STUDY

All of the skills required to ensure a holistic development can be nurtured by the learners through employing the particular techniques and methodologies. STEM education offers opportunities for students in order to advance their science, technology, engineering, and math skills. Through learner-centered classrooms and the development of 21st century abilities in students, STEM education broadens their cognitive and emotive domains.

By adopting the specific strategies and methods, it is possible to develop in the learners all the skills necessary to ensure a holistic development. STEM Education provides room for developing the skills of the learners in Science, Technology, Engineering and Mathematics. STEM education develops in the learner the 21st century skills and offers learner-centred classrooms , expanding the cognitive domain as well as the affective domain of the learners.

The collaborative learning environment generated in a STEM classroom develops team spirit in the learners. Since it employs project-based learning technique it helps in inculcating research attitude and organizational skills in the learners. As a result of this an experiential learning atmosphere is generated, this prevents the learner from rote memorization and improves retention of concepts in learners. The student's active participation and involvement is ensured in the STEM classrooms and therefore the student takes the ownership of their own learning. The integration of technology in education has transformed the education system all over the world , here comes the need for STEM education to meet the ever-changing demands of the education system. Hence the present study is significant in this contemporary educational scenario.

III. STATEMENT OF THE PROBLEM

STEM Education is a cross-disciplinary approach to education which interrelates disciplines of various fields such as Science, Technology, Engineering, and Mathematics. The present study analaised the necessity of STEM Education at secondary school level and the topic of investigation was thus entitled "**Evaluating the Role of STEM Education in Empowering Secondary School Students**".

Definition of Keyterms

STEM Education

STEM Education stands for Science, Technology, Engineering, and Mathematics   Education, which is a multi-disciplinary pedagogical approach integrating Science, Technology, Engineering and Mathematics skills in the learners.

Secondary School Level

Secondary school level includes standard VIII, IX and X in recognized schools of
Kerala.

HYPOTHESIS

STEM education contributes to the all-round development of the students.

OBJECTIVES OF THE STUDY

Following are the objectives of the study

1.   To understand the need for STEM Education at Secondary school level.

2.   To identify the various dimensions of STEM Education and its implementation at secondary school level.

IV. METHODOLOGY

A.   Method

For this study, the survey method is used. In order to collect information about the performance of secondary school students and the degree of implementation of various aspects of STEM education, a survey was administered to the teachers of the selected secondary schools [16][17].

B.   Sample

The sample selected for the present study includes 50 Secondary school teachers who are teaching students in standard VIII, IX and X. The study was conducted to understand how far STEM education is implemented at secondary school level and the impact of STEM education on the performance of the learners [18][19][20]. The survey conducted among the teachers helped to understand the effect and effectiveness of STEM education on the all-round development of the learners.

C.   Tool

The tool used for the present study is opinionnnaire. An opinionnnaire with forty items was used to gather information regarding the opinion of secondary school teachers about STEM Education. It comprised a list of various statements that the respondent is asked to endorse or reject. It is used by the researcher to collect the opinions of the selected sample on certain facts or factors of the problem under investigation. These opinions on different factors of STEM Education are further quantified, analyzed and interpreted.

D.   Measures Adopted for Calculation of Data

The present study has adopted percentage analysis for the required calculation. Percentages are one of the most commonly used methods in statistics.

E.   Procedure for Data Collection

Data collection is the process of collecting and measuring information in a systematic and coherent manner. In the present study the investigator has prepared an opinionnnaire consisting of 40 items where,"yes", and "no"were given as options. The statements were formed on the basis of the objectives of the study. After the preparation of the tool, the investigator has distributed it among the sample selected for the survey-teachers in secondary schools. The investigator has recorded the responses of 50 teachers. Later, the collected data underwent data analysis and interpretation. The data collected was computed by calculating the percentage analysis to understand the need of implementing STEM education at secondary school level.

V. ANALYSIS AND INTERPRETATION

The relevant data collected from the sample were analysed as follows:

All the sample teachers agreed that they have an idea about the concept of STEM Education. 92% of the teachers were of the opinion that STEM education implemented in Secondary schools help in the development of higher cognitive abilities of the learners, but 8% of the secondary school teachers responded negatively. of the total responses, 86% of the secondary school teachers opined that STEM education influences the affective domain of the learners. Majority of the secondary school teachers (98%) agreed that learners exposed to STEM education develop entrepreneurship skills but 2% of the teachers were against this. Most of the secondary school teachers (90%) were of the opinion that STEM education serves as an important pedagogical approach to teachers for easy content transaction.

About 94% of the secondary school teachers were of the opinion that STEM education is an important base for developing basic skills needed in 21stcentury, but a small number of teachers(6%)wereagainstthis.Mostoftheteachers(86%)wereoftheopinionthatSTEM education prepares the students for a real-world situation, but 14% of the teachers disagreed to this view.88% of the secondary school teachers were of the opinion that STEM education contributes to student's ability to think creatively in daily life problems using science and mathematics, but 12% of the teachers didn't agree with this.90% of the secondary school teachers were of the opinion that STEM literacy contribute to the increasing of professional interest of students at Secondary school level but 10% of the teachers were completely against this. 98% of the secondary school teachers were of the opinion that teacher centered classrooms are replaced by student centered classrooms in STEM education, but 2% of the teachers responded negatively. Of total responses,78% of the teachers agreed that the psycho social system created by STEM education takes into consideration the individual differences of the learners, and 22% disagreed with this.

80% of the total respondents opined that STEM education arouses the interest of students in learning. Most of the teachers (82%) opined that STEM education makes the students digitally skilled, but18% of the teachers were against this.78% of the teachers were of the opinion that STEM education is time consuming, but 22%of them disagreed to this. Mostof the teachers (84%) believed that STEM education acts as an advance organizer by connecting previous knowledge with new knowledge, but 16% of the teachers were against this.

76% of the secondary school teachers opined that STEM education uses teaching methods by integrating different disciplines rather than compartmentalizing it, but 24% of the total respondents disagreed with the same.82% of the teachers were of the opinion that synergic method used in STEM education improves the performance of students in learning, but 18% of the teachers were against this. Of the total respondents, 84% believed that lack of infrastructure hinders the successful implementation of STEM education at schools, but 16% of the teachers responded negatively.82% of the total teachers responded that trained manpower is a prerequisite for the successful implementation of STEM education, but 18% of the teachers were against this.86 % of the total respondents opined that

the rate of learning and learning outcomes increases with STEM education, but 14% of teachers disagreed with this. 92% of the secondary school teachers are of the opinion that STEM education prevents rote memorization, but 8% of the teachers responded negatively.

Most of the teachers (78%) responded that STEM education develops a constructive classroom imparting meaningful learning, but 22% of the respondents were against this. 86% of the total teachers responded by saying that STEM educands are exposed to an experiential classroom but 14% of the teachers were against it.80% of the total respondent teachers believed that project-based learning environments in STEM classrooms encourage divergent thinking in learners, but 20% of them disagreed with this. Majority of the secondary school teachers (90%) opined that introduction of STEM education can reduce the rate of dropouts in secondary schools, but about 10% of the teachers disagreed with this. Around 92% of the respondents agreed that STEM education can easily prepare the students for higher education, but 8% of the responses were negative.80% of the responses said that STEM education develops investigative spirit in the learners, but 20% of the teachers responded against this.

Most of the secondary schoolteachers (76%) opined that STEM education encourages action based learning where learners take active role in learning, but 24% of the teachers were against this.74% of the total teachers believed that integration of STEM teaching strategy in classrooms improve the retention of concepts in learners but 26% of the teachers were against this.78% of the teachers were of the opinion that STEM system of education provides room for individual and team work.82% of the total respondents opined that project-based learning in STEM system develops research attitude and organizational skills in learners, but 18% of them didn't agree with this. Around 88% of the respondents believed that integration of STEM education creates a stronger workforce in all fields of Science, Technology, Engineering, but 12% of the teachers were against this.

82% of the teachers agreed with the point that STEM education system encourages independent exploration of subject matter, elevating learners to the level of discovery learners, but 18% of the teachers were against this point. Around 76% of the secondary school teachers were of the opinion that the collaborative learning environment generated in STEM class inculcates team spirit and group accountability in learners, but 24% of the teachers disagreed to this.

Majority of the secondary school teachers (80%) agreed that simulation tools supported in STEM learning brings a virtual reality to learners which brings easy grasping of ideas, but 20 % of teachers disagreed this statement. About 82% of teachers were of the opinion that instructional tools like gaming used in STEM classrooms facilitate critical thinking in learners, at the same time 18% of teachers were against this.

VI. DISCUSSION OF RESULTS

The results of the study indicated that STEM education serves as an important pedagogical approach to teachers for easy content transaction. Majority of the teachers opined that STEM education implemented at secondary school level help in the development of higher cognitive abilities of the learners. This view is supported by the study conducted by (Firdaus and Rahayu ,2019) [1]. The teachers agreed unanimously that STEM education is the need of the hour, since it leads to the all-round development of the learners.

But there are some areas which the school should improve, like the infrastructure it provides inside the classrooms like the white board facilities, some teachers also experience difficulty in incorporating STEM education techniques in classrooms. Also, the teachers agreed that STEM education influences all the domains of the learners, not only the cognitive, but also the affective and psycho-motor domains by inculcating in the learners social and emotional learning skills and other life skills(CH. and YM,2022) [3][4][5]. The learners exposed to STEM education develops entrepreneurship skills also. The collaborative learning environments generated at STEM classrooms develop a sense of oneness and belongingness among the learners [14][15].

Moreover, the school does not give simulation effects in the classroom, which prevents students from experiencing virtual reality. STEM education puts students at the center of the teaching and learning process through action-oriented learning (Kennedy and Odell, 2014) [2][6][7]. A successful implementation of STEM education also requires educated workforce, yet some teachers are reluctant to employ this technology because they lack digital literacy. The paper by Ugras (2018) addressed the idea of providing instructors with skill-building training [13].

STEM education has enhanced the performance rate of the learners and brought about drastic change in the learning outcomes of the learners because unlike the traditional system of education it prevents rote memorization in the learners and makes them active constructors of knowledge (Ardianti et.al.,2020,) [11][12] From the analysis of the results, it is clear that STEM education helps in meaningful learning and thereby bringing about maximum retention of the concepts in the learners. It is also understood that STEM classrooms prepare the learner for future and makes them an asset for the nation. The study done by Jyoti and Prasad (2018) also reflected the same idea of economic progress that STEM education brings to the nation [8][9]. Also, the learners develop a sense of research attitude through STEM Education and they find new ways of addressing the problems and hence it expands the creative outlook of the learners [10].

The analysis also identified the areas of improvement, such as the lack of training for teachers to use changing technology, lack of infrastructural development, difficulty in including simulation effects in classrooms. The study, 'Moving STEM Beyond Schools: Students' Perceptions About an Out-of-School STEM Education Program' conducted by Evrim Baran puts forth the suggestions for improving the existing STEM setup. Hence, there is a need to develop the infrastructure of the school, to make the teachers digitally skilled, provide training programmes for teachers, because STEM education is the much-needed revolution in the education industry since it has the potential to reshape the child's future. It can be understood from the analysis that STEM education will be useful in combating the real-life problems.

VII. MAJOR FINDINGS OF THE STUDY

STEM education implemented at secondary school level helped in the development of the higher cognitive abilities of the learners, such as problem solving, critical thinking, creative thinking etc. STEM education served as an important pedagogical approach for the teachers for easy content transaction. STEM centric classrooms are learner-centric which involved active participation of the learners .STEM education saved the time and labour of the teachers, and acted as an advance organizer for the teachers by connecting previous knowledge with the present knowledge, and the teachers integrated various disciplines rather than compartmentalizing the disciplines. STEM educands are exposed to experiential classrooms, where the learners get a first-hand learning experience and hands-on learning. Project-based learning environments generated in STEM classrooms encouraged the divergent thinking of the learners. STEM education prepared the learners very easily for higher education by developing in the learners an investigative spirit and research attitude by taking responsibilities of their own learning, and it also brings in the learners' organizational skills.

STEM education provided a base for creating a stronger workforce in the country in the fields of Science, Technology, Engineering and Mathematics and thereby making the learners more productive and an asset for the nation. Apart from affecting the academic domain of the learners, STEM education developed the social- emotional skills of the learners through collaborative learning and group work. STEM education also imparted life skills in the learners. The present education system must incorporate whiteboards and interactive displays in classes, as they encourage students to gather around an area and collaborate. For the successful running of STEM system of education, proper implementation of a STEM classroom design that supports the   curriculum and activities is necessary. The classroom must be conducive to learning, cooperation, and creativity. A STEM classroom typically isn't a traditional classroom with columns and rows of desks arranged in regimented manner. STEM classroom layouts should be flexible like, it should combine a conference table arrangement with a wide floor space for doing projects unlike the traditional   classroom set up in India.

STEM-related educational initiatives should be the first step in shaping today's kids to be tomorrow's innovators and creators. Children nowadays require not just a solid academic foundation but also practical knowledge and essential life skills such as critical thinking, problem-solving, decision-making, and many more.

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This is basically the goal of STEM education for the developing mind, as it equips students with the knowledge and abilities needed to solve problems independently.

VIII. TENABILITY OF THE HYPOTHESIS

Based on the main findings, the acceptability of the hypotheses developed for the study was determined. The hypothesis states that, STEM Education contributes to all round development of students. It is accepted on the basis of the opinion of teachers that STEM education contributes to all types of development in the learners.

A. Suggestions

1. Teachers should switch on to STEM instructional strategy rather than following conventional methods of teaching, by ensuring a learner - centered classroom environment.
2. In STEM classrooms teachers should take initiative to continuously evaluate the performance of the students through formative assessment techniques.
3. Teachers should encourage creativity, teamwork and leadership of the students for promoting a STEM based classroom, a teacher's role is to spark curiosity in the students.
4. Teachers should take effort to integrate technology with content to be transacted to ensure maximum engagement of the learners, as it improves the retention of the concepts in the learners.
5. Teachers must provide group works for learners for cooperative learning.
6. It is the responsibility of teachers to make sure that all the students are on the same level of STEM education and should understand individual differences of learners.
7. .It is the responsibility of parents and teachers to motivate and spread awareness
About STEM education in India so that many young minds will benefit from
STEM education.
8. The school authorities must make sure that the learners are exposed to STEM
classroom with all the necessary equipments including the laboratory and technical devices.
9. The STEM learning area at home must be a quiet place where the child can focus and
concentrate on the experiential learning process, which the parents should take care of.
10. The curriculum planners must take necessary steps for the proper implementation and evaluation of STEM based curriculum.

IX. CONCLUSION

Innovation is a key component of STEM education since it enables students to identify different approaches for handling problems. Collaborating in STEM educational activities fosters a sense of a sense of brotherhood among students. The study emphasized how STEM knowledge acquired in the classroom assisted students in resolving problems and barriers that arose in the real world. Developing countries enable its people to propel economic progress and make valuable contributions to the global marketplace by allocating resources towards STEM education. Given that India is home to more engineers and scientists than any other nation in the globe, STEM education needs to be a core component of the curriculum in all Indian schools. STEM education is the road to a better future, not just for the students but for the entire society. STEM learning activities help students develop critical thinking abilities, problem-solving skills, and a high creativity quotient. In simple words STEM learning is based on the idea of teaching meaningful skills to the young innovators in the four main domains of – Science, Technology, Engineering, and Mathematics. STEM education in India is all about learning by doing. The present study revealed that STEM education makes use of a framework that promotes learning by doing in learners. While many subjects rely on lecture-based lessons, STEM can provide a break in that learning style and provide hands-on activities. From the study it is clear that STEM activities and topics use many different skills, like problem-solving and critical thinking, that work better when students can interact with the subject material themselves.

In summary, the study concluded that it makes sense to begin imparting STEM subjects to pupils at a young age in view of increasing demand for STEM abilities across a variety of areas globally.

DECLARATION STATEMENT

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