STEM Education and Interdisciplinary Learning in 21st Century

Dr. Shazia Mansoori*
Assistant Professor
Department of Education
Aligarh Muslim University, Aligarh

ABSTRACT

This research paper explores the importance of STEM education and interdisciplinary learning in today's rapidly evolving world. The paper examines the concept of STEM education, its benefits, and how it can be implemented in schools and higher educational institutions. The paper also discusses the role of interdisciplinary learning in STEM education, how it can be used to enhance student learning, and the benefits of integrating different disciplines. STEM education and interdisciplinary learning are closely related. STEM education provides the foundation for interdisciplinary learning by teaching students about science, technology, engineering, and mathematics. Interdisciplinary learning involves integrating knowledge from multiple subjects to solve real-world problems. Therefore, STEM education is essential for preparing students for interdisciplinary learning and helping them develop the skills necessary to solve complex problems. The paper also highlights the challenges of implementing interdisciplinary learning in STEM education and provides recommendations for overcoming these challenges. The author concludes that STEM education and interdisciplinary learning are essential for preparing students for the future and suggest that educators should focus on integrating these approaches into their teaching practices.

*Keywords***:** STEM education, Interdisciplinary approach, Integration of STEM in schools and higher education, 21st century teaching and learning process.

Email id: smansoori@myamu.ac.in
Contact No.: +91 9634922819

INTRODUCTION

In the modern world, the integration of STEM education (Science, Technology, Engineering, and Mathematics) and interdisciplinary learning has taken centre stage in education. The goal is to produce individuals who can tackle complex problems and challenges facing various sectors in society, from health and agriculture to business and security. STEM education has been recognized as a critical tool for economic growth and has been emphasized globally in educational policies. The integration of interdisciplinary learning and STEM education emphasizes the importance of linking STEM disciplines with other areas, including the social sciences, arts, and humanities. This paper explores the benefits of STEM education and interdisciplinary learning in the contemporary world.

STEM Education: The Concept

STEM stands for Science, Technology, Engineering and Mathematics. This field of learning is growing rapidly around the world in the education system. Globally, STEM education programs are widespread in schools as a unique approach to teaching and learning. The concept of STEM was introduced in 2001 by National Science Foundation (NSF) in United States. Initially the centre used the acronym SMET to refer to career fields in these disciplines. It incorporated a curriculum to integrate knowledge and skills from the fields of science, technology, engineering and mathematics. Later on, Judith Ramaley, an American biologist and Assistant Director of Education & Human resources at NSF changed SMET to STEM.

STEM education program is built on the concept that national growth, jobs, and innovations are all dependent on developments in science & technology. It is an interdisciplinary approach to education that focusses on integrating these four subjects into a cohesive learning paradigm. STEM education is designed to help students develop critical thinking, problem-solving, and analytical skills that are needed in today's world. It also emphasizes practical applications of these subjects in real-world situations. The STEM program is designed to encourage students to pursue careers in science, technology, engineering, and mathematics. It is based on the belief that these disciplines are interrelated and that a solid foundation in these fields can lead to a successful and fulfilling career.

STEM programs typically involve hands-on, project-based learning that encourages students to work collaboratively, think critically, and solve problems. They also often provide opportunities for real-world experiences, through internships, research projects, or other programs that allow students to apply what they've learned in the classroom to real-world situations. Overall, the STEM program aims to prepare students for the challenges of the future

by providing them with the skills and knowledge they need to succeed in a fast-paced, technology-driven world.

STEM EDUCATION IN INDIA

The inclusion of STEM education in schools and universities comes with several benefits, ranging from better career opportunities to increased innovation and economic growth. STEM education has gained significant traction in India in recent years with the government, private institutions, and educationists actively promoting and investing in this field. The aim of STEM education in India is to create a world where young people are encouraged to celebrate fun and excitement of science and technology, and inspire them to take science and technology-based career paths to become tomorrow's much needed technology leaders. Numerous initiatives have been taken by the Indian government to promote STEM education, including the establishment of schools and colleges dedicated to STEM subjects, initiating scholarships and fellowships for students pursuing STEM courses, and many more. One of the significant factors driving the growth of STEM education in India is the country's strong technological capabilities and the increasing demand for technology-driven jobs in the global market. The Indian government has also recognized the potential of STEM fields to drive economic growth and has been actively promoting entrepreneurship in these fields. The expansion of the Information Technology (IT) industry in India has played a significant role in the growth of STEM education. The demand for skilled IT professionals has been increasing in the country, with India being the world's second-largest supplier of IT services. This phenomenon has led to the creation of numerous STEM courses and programs that aim to increase the availability of skilled professionals in this field. Furthermore, several private institutions have also increased their focus on STEM education, providing a wide range of courses in Science, Technology, Engineering, and Mathematics. These include institutes such as Indian Institutes of Technology (IIT), Indian Institutes of Information Technology (IIIT), National Institutes of Technology (NIT), and many others.

Overall, the growth of STEM education in India is an essential factor in the country's development and a significant contributor to India's position as a leader in the global IT industry.

Robo Siksha Kendra

Robo Siksha Kendra is a CSR initiative by India STEM Foundation. This is an approach to help, and nurture the present generation who is enthusiastic to bring new developments and innovations in the field of STEM (Science, Technology, Engineering & Mathematics). It gives

children, access to Robotics and project based Hands-on learning activities for learning, develop a scientific temperament, foster innovation and creativity. The hands-on activity designed in-line with NCERT National Curriculum Framework and Approach is aligned with the mission of MHRD Rashtriya Avishkar Abhiyan, NITI Aayog Atal Tinkering Labs and PM Skill India projects. [1]

The Multi-dimensional I-STEM Web Portal [2]

Indian Science, Technology and Engineering facilities Map (I-STEM) is a dynamic and interactive national portal, which hosts various scientific programs, initiated by office of the Principal Scientific Adviser, Govt. of India. The main objective of having this portal (developed using public fund) is to provide support to needy researchers in different ways and strengthen the R&D ecosystem to fulfil the necessity of people of the country. The supports planned through these programs through this unique portal are designed in such a way that every researcher inculcate the concept of the Aatma Nirbhar Bharat in their mind, nature, and behaviour and work with full dedication to optimize the usage of the resources established across the country, using taxpayer's money i.e., public fund. With these concepts, the portal was launched and dedicated to the nation by the Honourable Prime Minister of India, Shri Narendra Modi, on Jan 03, 2020. It has now entered in Phase-II, w.e.f. Aug 2021. Some of the key highlights of this initiative are as follows:

- Provision of funds, equipment, support to national labs, establishment of research and development (R&D) infrastructure, collaboration between researchers and resources, technical assistance in operating their R&D equipment, following the guidelines set by I-STEM will be given.

- I-STEM also plans to assist industries and start-ups in reviewing the performance of indigenously manufactured equipment, standardizing them with imported alternatives available in labs, contributing to the "Local to Vocal" initiative.

- "Waste to wealth" program is an important initiative in I-STEM

- To create a collaborative network between institutions providing technical education (Polytechnic, ITI, etc.), linking academic institutions with established Science and Technology Clusters (City Knowledge and Innovation Clusters) in various cities, maintaining the I-STEM portal and cloud servers, ensuring the smooth running of applications hosted at the NIC in Delhi.

- To assist academic researchers, provision of platforms with software such as "COMSOL" for *class kit learning*, *theoretical modelling*, etc.

- I-STEM maintains a panel of experts from various domains to confidentially support researchers in their work.

- Lastly, the I-STEM portal allows academic institutions to advertise webinars, conferences, meetings, and experiments, providing a platform for organized online meetings using platforms such as WebEx.

How popular is STEM learning in India?
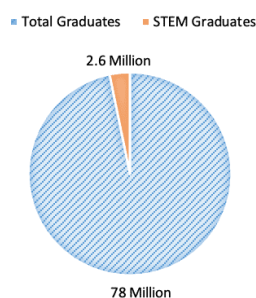
(Source: www.k8school.com, 2021)

Teaching and Learning with an Interdisciplinary Approach

Interdisciplinary learning is an approach to education that combines different fields of study to provide a more comprehensive and holistic understanding of a topic or issue. It involves breaking down traditional subject area boundaries and encourages students to work collaboratively to solve complex problems. Interdisciplinary learning is becoming increasingly popular in educational institutions because it promotes critical thinking, creativity, and problem-solving skills.

The concept of interdisciplinary learning is rooted in the belief that knowledge is interconnected and that learning should reflect this interconnectedness. Interdisciplinary learning involves the integration of multiple disciplines such as science, technology, engineering, math, humanities, and social sciences, to provide a more comprehensive understanding of a topic or issue. The goal of interdisciplinary learning is to equip students with the skills to approach problems from multiple perspectives and to develop creative solutions. By incorporating multiple disciplines, students are exposed to a wider range of ideas and approaches, which encourages them to think creatively and outside of the box. Interdisciplinary learning also promotes collaboration and teamwork, which are essential skills for success in the 21st century workplace. Another advantage of interdisciplinary learning is that it provides a more comprehensive understanding of a topic or issue. For example, if students were studying climate change, an interdisciplinary approach would involve incorporating science, geography, economics, and politics, enabling students to develop more

effective and sustainable solutions. There are many examples of interdisciplinary learning in educational institutions. For example, STEAM (Science, Technology, Engineering, Arts, and Mathematics) education is an interdisciplinary approach that combines the arts with traditional STEM subjects. This approach recognizes that art and design play an important role in innovation and problem-solving. Another example of interdisciplinary learning is project-based learning, which involves students working collaboratively on a project that integrates multiple disciplines.

Interdisciplinary instruction

Bransford et al. (2000) drawing on scientific research findings from the fields of neuroscience, cognitive science, social psychology, and human development asserts that interdisciplinary forms of instruction are very beneficial for students learning.[3]

- Integrate conflicting insights from alternative disciplines
- Interdisciplinary instruction helps students understand why conflicts commonly arise over; the causes and consequences of an issue and, the ideal way for policy to address the issue of concern. When learning is confined to a single disciplinary perspective ambiguity is often considered either a shortcoming of the analytical framework or evidence that assumptions need to be adopted to provide a clear prediction.
- Interdisciplinary Teaching Helps Students Appreciate Ethical Dimensions of Concerns
- Interdisciplinary Teaching promotes significant learning
- Promote student engagement in the learning process and greater learning occurs.

Repko (2009) asserts that interdisciplinary instruction fosters advances in cognitive ability. As a result, given that students are heterogeneous in their learning styles and have diverse backgrounds, interests, experiences, talents, and values, he believes that drawing on a broad array of frameworks and methodologies will enhance student engagement, and thus learning.[3]

STEM Education as a key to Interdisciplinary learning

STEM education promotes interdisciplinary learning by focusing on the interrelatedness of Science, Technology, Engineering, and Mathematics. In STEM education, students learn to apply knowledge across multiple disciplines, developing a holistic understanding of real-world applications. For example, in a science class, students learn about concepts such as force,

motion, and energy. In a math class, students learn about equations and how to solve them. However, in an interdisciplinary STEM project, students may use both sets of skills to design and build a bridge. They may need to use their knowledge of physics to calculate the force required to support the bridge, their knowledge of mathematics to calculate the length of the crossing, and their engineering abilities to design the structure of the bridge.

STEM education draws from a variety of different fields, including social sciences, economics, and sustainability, to incorporate multiple perspectives into the problem-solving process. This helps to promote interdisciplinary learning by incorporating multiple viewpoints and approaches to problem-solving. Interdisciplinary STEM projects challenge students to think critically and creatively, developing problem-solving skills that can be applied across multiple disciplines. Overall, STEM education promotes interdisciplinary learning by providing students with the tools and skills they need to solve complex, real-world problems that require a multifaceted, interdisciplinary approach.

STEM education focuses on teaching students about science, technology, engineering, and mathematics through an interdisciplinary approach. By incorporating multiple disciplines, STEM education can improve interdisciplinary teaching and learning in several ways:

1. Encouraging collaboration: STEM education emphasizes teamwork and collaboration among students with different backgrounds and skill sets. This encourages students to work together, share ideas, and learn from one another, which can improve interdisciplinary teaching and learning.

2. Providing real-world context: STEM education often involves real-world problems and challenges that require interdisciplinary solutions. By working on these problems, students can see how different fields of study are interconnected and how interdisciplinary approaches can solve complex problems.

3. Developing critical thinking skills: STEM education encourages students to think critically, analyse data, and solve problems using a variety of methods and tools. This type of thinking is essential for interdisciplinary teaching and learning, as it allows students to approach problems from multiple perspectives and develop creative solutions.

4. Integrating technology: STEM education often involves the use of technology, which can facilitate interdisciplinary teaching and learning. Technology can be used to gather and analyse data, create simulations, and design solutions to complex problems.

Overall, STEM education can improve interdisciplinary teaching and learning by encouraging collaboration, providing real-world context, developing critical thinking skills, and integrating

technology. By incorporating multiple disciplines, students can develop a broader understanding of how different fields of study are interconnected and how interdisciplinary approaches can lead to innovative solutions.

STEM in Schools and Higher Education Institutions

In the classroom settings, teachers can help the students by introducing STEM in a number of ways. The STEM lesson needs to be developed in such a way that it helps both the teachers and students to understand the concept. For example, developing a video lesson on relevance of STEM education. The students can work collaboratively to develop STEM lessons in the form of projects or activities. It will also help in analyzing how to implement STEM education successfully in the education system. The key feature of STEM education and research is collaboration. The students should work together for better understanding and activities. Teaching aids can be used by teachers to help the students understand the various concepts such as charts, posters, video aids, activities, etc. Hand-made projects of science, mathematics, geography, etc. can be used as aids to teaching which are linked to STEM fields. Students designing their own working models, 3-D models, or even robots will be an application of students understanding, creativity, and interest. There are many different ways to incorporate STEM education in educational institutions for interdisciplinary learning. Here are some example activities:

1. Robotics: Robotics is an excellent way to incorporate STEM education into interdisciplinary learning. Students can learn engineering, coding, and electronics skills to build and program robots. They can also incorporate art and design to create visually appealing, functional robots.

2. Environmental science: Environmental science is a great way to incorporate STEM education into interdisciplinary learning. Students can learn about ecosystems, climate change, and renewable energy sources. They can also incorporate math skills to analyse data and create models to predict future environmental changes.

3. Biotechnology: Biotechnology is another excellent way to incorporate STEM education into interdisciplinary learning. Students can learn about genetics, microbiology, and biochemistry to understand how living organisms work. They can also incorporate engineering and computer science to develop new technologies for healthcare and agriculture.

4. Architecture and design: Architecture and design can be used to incorporate STEM education into interdisciplinary learning. Students can learn about math and physics to understand the principles of construction and design. They can also incorporate art and history to create buildings that reflect cultural values and aesthetics.

5. Space exploration: Space exploration is another great way to incorporate STEM education into interdisciplinary learning. Students can learn about astronomy, astrophysics, and space technology to understand how humans explore and study space. They can also incorporate history and social sciences to understand the impact of space exploration on society.

Some specific activities that can be done to incorporate STEM education into interdisciplinary learning are:

- Build a solar-powered car or device to learn about renewable energy and engineering principles.

- Design and build a sustainable garden to learn about environmental science and biology.

- Create a computer game that teaches math concepts to learn about coding and game design.

- Design and build a scale model of a building or bridge to learn about architecture and engineering principles.

- Create a space exploration mission to learn about astronomy, astrophysics, and space technology, and the impact of space exploration on society.

These are just a few examples of how STEM education can be incorporated into interdisciplinary learning. The possibilities are endless, and the key is to combine multiple disciplines to create meaningful and engaging learning experiences for students.

CHALLENGES

Integrating STEM education for interdisciplinary learning can be challenging due to several factors. These challenges include:

1. Lack of Professional Development: Integrating interdisciplinary learning into STEM education requires teachers to have a deeper understanding of different subjects. However, many teachers may not have the necessary training or professional development to teach interdisciplinary content effectively.

2. Insufficient Funding: Integrating interdisciplinary learning into STEM education requires resources such as technology, equipment, and materials. However, many schools may not have enough funding to provide these resources, making it challenging to implement interdisciplinary learning.

3. Limited Time: Teachers may face time constraints in covering all the STEM subjects and integrating interdisciplinary learning into their curriculum. The lack of time may prevent teachers from exploring and integrating interdisciplinary learning into their lessons.

4. Need for a Paradigm Shift in Education Systems: Integrating interdisciplinary learning into STEM education requires a shift in the education system's traditional approach to teaching.

This shift may require significant changes in curriculum, teaching methodologies, and assessment practices.

5. Resistance to Change: Integrating interdisciplinary learning into STEM education may face resistance from educators who are comfortable with the traditional approach to teaching. This resistance may hinder the adoption of interdisciplinary learning in STEM education.

In conclusion, integrating STEM education for interdisciplinary learning faces several challenges that require significant changes in the education system. Overcoming these challenges requires collaboration between educators, policymakers, and stakeholders to provide the necessary training, resources, and support to implement interdisciplinary learning effectively.

Discussion

STEM education has emerged as a critical tool for promoting interdisciplinary learning. This research paper has explored the concept of STEM education and its importance in preparing students for the rapidly changing world. The study has found that STEM education is a holistic approach that integrates science, technology, engineering, and mathematics, and encourages problem-solving, critical thinking, and creativity. It has been shown that STEM education can help students develop the skills and knowledge necessary to succeed in the 21st century. Moreover, the study has also discussed the role of interdisciplinary learning in STEM education. Interdisciplinary learning can also help students develop empathy, collaboration, and communication skills, which are essential for working in diverse teams. The integration of different disciplines such as art, social sciences, and humanities can help students connect the dots between different subjects and develop a cross-functional understanding of the world.

However, the study has also identified some challenges in implementing interdisciplinary learning in STEM education. These challenges include the lack of professional development for educators, insufficient funding, and the need for a paradigm shift in education systems. To overcome these challenges, the study recommends that educators should focus on integrating interdisciplinary learning into their teaching practices and collaborate with other educators to share best practices. In conclusion, STEM education and interdisciplinary learning are essential for preparing students for the future. STEM education provides students with the necessary skills and knowledge to succeed in the 21st century, while interdisciplinary learning helps students connect different subjects and develop cross-functional understanding and skills. Although there are challenges in implementing interdisciplinary learning in STEM education, educators can overcome these challenges by integrating interdisciplinary learning into their

teaching practices and collaborating with other educators. Therefore, it is recommended that educators focus on promoting STEM education and interdisciplinary learning to prepare students for the challenges of the future.

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