

# Effectiveness of STEM Approach for Understanding Membrane Formation in Biology

Dr. Manisha Bajpai Gupta<sup>1\*</sup>, Medha Bajpai<sup>2</sup>

<sup>1\*</sup>Principal SAM College ,BU Bhopal, [Drmanisha.edu@gmail.com](mailto:Drmanisha.edu@gmail.com), 9425607373

<sup>2</sup>Lecturer, Govt Gyanodaya vidyalaya ,Bhopal, [purohit.medha@gmail.com](mailto:purohit.medha@gmail.com), 9425680356

**Abstract:** Research paper aims to explore the relevance and effectiveness of STEM approach through virtual learning for membrane formation in biology in the Indian context. In present scenario, it observed conventional approaches have very limitation for biology learning. Presently STEM approach give opportunity through virtual learning to promote collaborating and inquiry based learning. STEM is emerging as one of the most effective approach for learning. The present study was conducted to explore the effectiveness of STEM approach for understanding membrane formation in Biology. The main purpose of this study was to investigate the effectiveness of STEM approach for understanding of concepts of biology. The findings of the present study clearly revealed that student understand the concept of membrane formation through STEM approach in a better way as compared to conventional approach. This paper is a humble attempt to discuss position of STEM approach, initiatives of Government of India, and the impact it has on student learning and overall educational outcomes in India.

**Keyword:** STEM approach, Conventional Approach, Integrated Approach, Virtual Learning.

## 1. INTRODUCTION

### 1.1 Rationale

After the pandemic it realised that education system should be innovative and integrated to real life problems. UNESCO says that STEM education are considered an imperative part of competency – based curricula. The goal of STEM (science, Technology, Engineering, Mathematics) approach is to prepare students for the 21st-century workforce, which increasingly demands skills in these domains. The STEM approach in education refers to an interdisciplinary approach that integrates the subjects of Science, Technology, Engineering, and Mathematics. It aims to foster critical thinking, problem-solving, and creativity among students by connecting these subjects through project-based learning and real-world applications.

STEM is based on the belief that these subjects play a crucial role in our everyday lives and are interconnected. Through the STEM approach, students are encouraged to explore the natural connections between these disciplines and apply their knowledge in practical ways. By doing so, they develop not only a deeper understanding of the subjects but also the ability to transfer their learning into different contexts. The concept of STEM education has gained significant attention in recent years due to the growing need for a technologically skilled workforce. Many industries today require professionals who can apply scientific and mathematical principles to solve complex problems. The STEM approach in education aims to nurture the skills and competencies needed by future generations to thrive in these fields. One of the key aspects of the STEM approach is its emphasis on hands-on learning and inquiry-based activities. Students are encouraged to actively explore and investigate real-world problems, fostering a deep sense of curiosity and engagement. By engaging in projects and experiments, students learn to think critically, solve problems, and collaborate effectively, skills that are essential in STEM fields.

Additionally, the STEM approach emphasizes the integration of technology and engineering with science and mathematics. Technology plays a crucial role in our society, and students need to develop technological literacy and understand how to leverage technology as a tool for problem-solving. Similarly, engineering principles play a vital role in designing and building solutions to real-world problems. By integrating technology and engineering into the STEM curriculum, students gain a holistic understanding of the interplay between these disciplines.

Furthermore, the STEM approach underlines the importance of diversity and inclusion. STEM education seeks to create an inclusive learning environment where students from diverse backgrounds can collaborate

and contribute their unique insights . By fostering inclusivity in STEM education, we can encourage a broader participation in these fields and promote equity and diversity in STEM careers .

## 1.2 Why STEM Approach?

We are in a period in which education system realise to change all education system developing stamp approach that are relevant and futuristic . education cannot occur in space every discipline has their unique feature but they will understand and grasp buy the interlinking of concepts and principles of other discipline . The integrated approach of STEM approach in education involves connecting the concepts and principles from science, technology, engineering, and mathematics to enhance students' understanding of biology . Rather than teaching these disciplines in isolation, the integrated approach seeks to demonstrate the interconnectedness and real-world application of STEM subjects . In the context of biology, the integrated approach encourages students to explore concepts through interdisciplinary projects and activities that incorporate elements from various STEM fields . For example, students may investigate the impact of environmental factors on plant growth by collecting and analyzing data (science), designing and testing prototypes for a controlled environment system (engineering), using technology tools for data visualization and analysis (technology), and applying mathematical models to understand the growth patterns (mathematics) . Similarly, if students are acquiring knowledge of function of human eye, they might aware the function of lance (Physics), calculation of power of eye (Mathematics), using technology for identification of defective eye . This parallel approach will encourage critical, logical thinking, decision making and collaboration, and communication skills . They can see how concepts and principles from different STEM fields are interconnected and how they work together to provide a holistic understanding of biological phenomena . These skills provide the foundation of success in students' life .

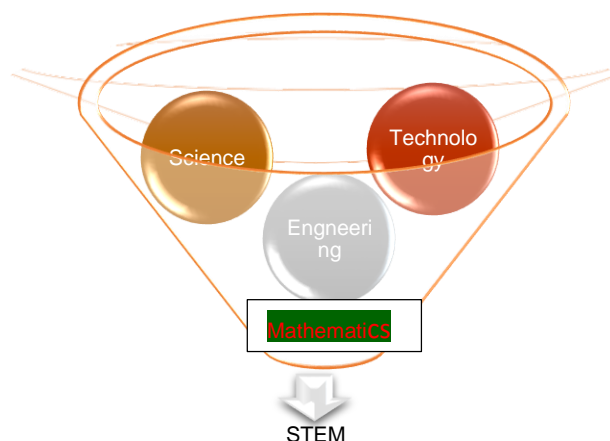


Figure -1.1

### STEM Approach

## 1.3 STEM Approach in India

“Bharat” has been the centre of learning since ancient period . In Bharat STEM is not a new approach in education . If we analyse, the basic principles of STEM we find that these subjects are taught in a such a way that student learn to apply the concept in real life situation . we can also say that transdisciplinary approach which based on integrated approach of 4Cs, that is creativity, critical thinking, collaboration, and communication . In ancient education system in Bharat they all are incorporated in terms of *64 Kalas and 14 Vidhyas* ie known as skills and vocational education . Students could adopt these Kalas and Vidhyas according to their capabilities, interest and attitude which is now days known as CBCS (Choice Based Credit System) . The education model of was largely student centric with focus on multidisciplinary education including the study of ancient scriptures, law, medicine, astronomy, military science and the *eighteen silpas or arts (20)* . The

Upanishads provides enough evidences of Gurukul traditions of teaching learning methodologies of ancient times, seemingly providing basis for many of the teaching learning concepts of contemporary times .

Now in present era NEP–2020 (National Education Policy 2020, Government of India ) emphasis on the holistic development of learner and multidisciplinary approach in education . The fundamental principles of NEP–2020 India, correlate well with the concept of STEM . the Government of India accelerate constructivist approach in education system spending major part of its research budget on stamp program for school student . However, in order to collinear image, STEM has grown to represent a unique approach of teaching and learning that promotes transdisciplinary approach in education. Initiatives taken by Government of India (GOI) by collaboration with IBM to improve STEM opportunities for girls in October 2020 . Vigyan Jyoti, Vigyan Prasar, Atal Tinkering Lab are very innovative initiative taken by GOI .

#### **1.4 What Researches say about effectiveness of STEM through virtual Learning?**

Research studies have indicated that visualization of phenomena through computer simulations can contribute to student' s understanding of physics concepts at the molecular level by attaching mental images to these concepts (Cadmus, 1990) .

In this way, students contribute not only to learning but also to the economic development of countries by understanding how to use this information (Gonzalez & Kuenzi, 2012) . Furthermore, STEM education aims to raise a productive, scientifically literate society by adopting rapidly developing technological, and scientific changes (Bray, 2010) . In other hand the effect of STEM education on students' academic success was statistically higher in the random–effects model . (İbrahim Yaşar 2021) . Oner and Capraro (2021) suggested that STEM education should collaborate four subjects according to their application context . Similarly , Delen &Uzun (2018) emphasise that STEM is strongly correlated to applied aspects of engineering context . In other hand, some studies also focussed on well–designed interrogation of content (Moore et al. , 2020) , Guzey et al. (2020) . On other hand review the studies (Cotabish et al. , 2014; Çetin, 2019; Dedetürk, 2018; Ercan, 2014; Gülen, 2016; Irkıçatal, 2016; İnce et al. , 2018; İzgi, 2020; Olivarez,) explore that STEM approach enhance academic success .

Even though there are so many meta – analysis study in the literature demonstrate that (Angelo et al. , 2014; Ayverdi & Öz–Aydın, 2020; Becker & Park, 2011; Belland et al. , 2017; Saraç, 2018; Yücelyiğit & Toker, 2021) , there is not a comprehensive international meta–analysis for the period 2014–2021 (İbrahim Yaşar & Yalcin 2021) .

Therefore, no conclusions can be arrived at on the basis of previous researches hence some more researches are needed in Indian context . The present study was conducted with this aim in mind . The main purpose of this study is to investigate the effectiveness of STEM approach for understanding of membrane formation in biology .

##### **1.4.1 Objectives of the Study**

1. To identify and design virtual activity from the available resources (online) for STEM approach .
2. To Study the effectiveness of STEM approach for understanding of science concepts .

#### **1.5 Research Design of the Study**

The present study employed pre– post experimental design . This experimental design enables the manipulations of the variables to be observed under the control of the researcher in order to investigate cause and effect relations . The variables under study are :

- Dependent Variable: Achievement Gains

- Independent Variable : Virtual activity on STEM
- Intervening Variable : Previous achievement in Science

### 1.5.1 Teaching Pedagogy and Procedures

#### a. Virtual Learning

There are various ways of defining virtual learning. A virtual learning is particularly useful when some physical constrain are involve between learning and teaching. Experiments may involve hazardous chemicals and risky equipment. Virtual learning also, is used in the system aiming to replace physical machine with virtual machines on one host server. They eliminate the limitation of physical appearance so that students are able to complete security exercises on the local operating system with their own time and space. In this there are certain advantage– It is very easy to learn how to use them, the leaning objectives is more clearly defined.

In this study, virtual learning environment was created to examine effectiveness of STEM Approach. NetLOGO 6.0.3 virtual setup were taken as an activity for experimental group learning. 10<sup>th</sup> grade biology topic membrane formation was taken for activity of STEM. The researcher of the present study has gone through this website and found a virtual activity on membrane formation fitting in to the purpose of the study and therefore, decided to employ the same. This virtual activity allows students to control inputs such as percentage, concentration, and reactions, and it allows them to receive immediate feedback on the results of changes to the experimental set-up. With proper guidance, students can use the simulation to construct a mental model of the activity. The, NetLOGO virtual setup shown in Fig. 1.2, is downloaded from the NetLOGO website.

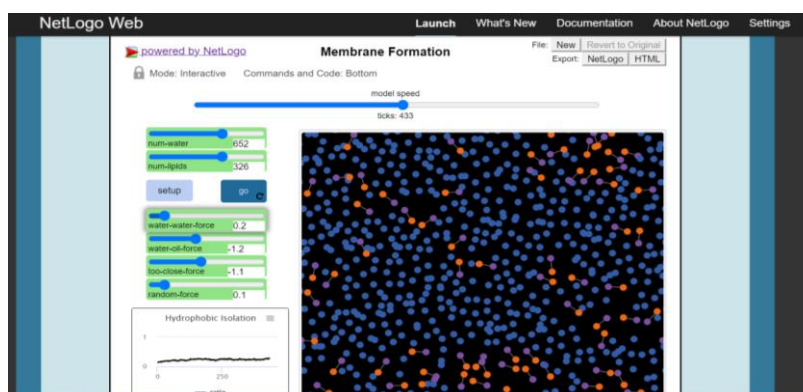


Figure 1.2

#### Screen Capture of NetLOGO virtual setup

This virtual activity also allows students to interactively construct the graphs commonly found in textbooks and students are able to see the relationship between the graphs and the experiment more clearly than they see when viewing static and dynamic images. For this activity, individual and group assessment tools are prepared by researchers. In other hand, detailed guideline was provided to explain how and what they used STEM approach in problem solving.

**b. Sample of the study** – Looking in to the nature of the study, Purposive sample was selected. The participants of the study were 50, students of 10<sup>th</sup> grade ranging in age from 14 to 16 in Bhopal city India of 2021–2022 academic year. Pre and post achievement test on the above topic through an Achievement Test”. For both groups were allowed to learn the same concept of science.

c. **Procedure** – The step by step procedure of the followed in the present study can briefly be described as below :

1. 50 students of 10<sup>th</sup> grade studying were divided in two groups based on their previous achievement marks in previous exams and their achievement was evaluated by administered Pre-test through an Achievement Test". For both groups were allowed to develop same concept of Biology .

2. Participants in the First group, designated as control group, were allowed to conduct face to face class . This group were taught by conventional approach .

3. Participants in the second group, designated as experimental group were provided the facilities of virtual activity for conceptual understanding of membrane formation . These participants used virtual setup of Net Logo 6.0.3 on a personal accessible mode with STEM approach .

4. After completing the activity in both the situations, students of both the groups was administered Post "Achievement Test" to evaluate the conceptual understanding of membrane concept and achievement gain was calculated .

## 1.6. Statistical Analysis of Data

To study the effectiveness of virtual lab, the independent samples t- test, were used for testing the data obtained in the study. The SPSS 11.00 (Statistical Package for Social Sciences) statistical program was used to evaluate all the data collected from pre-and post-tests. Findings Statistical results about the comparison of pre-test and post-test scores of the experimental and the control group students. Students in experimental group who learned the concept of membrane formation through STEM approach gained more compared to control group, who learned the same through conventional approach. Independent t-test was employed to investigate further whether this difference in achievement gains between two groups is really significant. Independent t-test results, clearly shows that there is a significant difference between groups, scores of the achievement gain ( $t=1.3$ ) is in favour of experimental group. Therefore, it can safely be concluded that student learned concepts of biology through STEM approach in a better way compared to conventional approach.

**1.6.1 Findings and Discussions:** The present study found that student learned concepts of membrane formation through STEM approach in a better way compared to convention approach. The findings of the study corroborate with the findings of earlier studies (Moore et al., 2020), Guzey et al. (2020, (Cotabish et al., 2014; Çetin, 2019; Dedetürk, 2018; Ercan, 2014; Gülen, 2016; Irkıçatal, 2016; İnce et al., 2018; İzgi, 2020; Olivarez,) The contradictions in findings of such as (Gonzalez & Kuenzi, 2012), Bary2010, these studies with the present one may be due the nature of concept to be learned, approach of STEM, control of intervening variable, different design of the study and statistical analysis etc. Therefore, some more such researches are needed to arrive at valid generalization.

Findings of this study also revealed that to integrate STEM approach with biology teaching, teachers should focus on the formation process and the application of the core concepts of life sciences. Teachers can promote their students to use inquiry based methods to solve real life problems, and develop their social and moral responsibility.

## REFERENCES

- [1]. Ancient Education System of India. <https://ncert.nic.in/textbook/pdf/hei111.pdf> Accessed on 2022
- [2]. Bedau M. A., Buchanan A., Gazzola G., Hanczyc M., Maeke T., McCaskill J. S., Poli I. and Packard N. H. (2005). Evolutionary design of a DDPD model of ligation. In Proceedings of the 7th International Conference on Artificial Evolution EA'05. Lecture Notes in Computer Science 3871, 201–212, Springer Verlag
- [3]. Bozan, M. A., & Anagün, S. Ş. (2019). STEM focused professional development process of elementary school teachers: an action research. *Anadolu Journal of Educational Sciences International*, 9(1), 279–313. <https://doi.org/10.18039/ajesi.520851>

- [4]. Brophy, J. (2010). Motivating students in classrooms. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (pp. 624–630). Elsevier. <https://doi.org/10.1016/B978-0-08-044894-7.00613-8>
- [5]. Büyükbastırmacı, Z. (2019). The effect of STEM applications used in power and energy unit in 7th grades on success, attitudes and motivation [Unpublished master's thesis]. Necmettin Erbakan University, Konya.
- [6]. Bybee, R. W. (2010). Advancing STEM education: a 2020 vision. *Technology and Engineering Teacher*, 70 (1), 30–35. <https://doi.org/10.1126/science.1194998>
- [7]. Capobianco, B. M., DeLisi, J., & Radloff, J. (2018). Characterizing elementary teachers' enactment of highleverage practices through engineering design-based science instruction. *Science Education*, 102 (2), 342–376. <https://doi.org/10.1002/sce.21325>
- [8]. Cavas, P. (2011). Factors affecting the motivation of Turkish primary students for science learning. *Science Education International*, 22 (1), 31–42.
- [9]. Clough, M. P., & Olson, J. K. (2016). Final commentary: Connecting science and engineering practices: a cautionary perspective. In L. A. Annetta & J. Minogue (Eds.), *Connecting science and engineering education practices in meaningful ways: Building bridges* (pp. 373–385). Springer.
- [10]. Corbett, K. S., & Coriell, J. M. (2014, June 15). STEM explore, discover, apply – a middle school elective (curriculum exchange) [Paper presentation]. 2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana.
- [11]. Cotabish, A., Dailey, D., Robinson, A., & Hughes, G. (2013). The effects of a STEM intervention on elementary students' science knowledge and skills. *School Science and Mathematics*, 113 (5), 215–226. <https://doi.org/10.1111/ssm.12023>
- [12]. Çoban, M., Akçay, N. O., & Çelik, İ. (2022). Using virtual reality technologies in STEM education: ICT pre-service teachers' perceptions. *Knowledge Management & E-Learning*, 14 (3), 269–285. <https://doi.org/10.34105/j.kmel.2022.14.015>
- [13]. Çorlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. *Educational and Science*, 39 (171), 74–85. D' Angelo, C., Rutstein, D., Harris, C., Bernard, R., Borokhovski, E., & Haertel, G. (2014). *Simulations for STEM learning: systematic review, and meta-analysis*. Menlo Park, CA: SRI International.
- [14]. Dedetürk, A. (2018). Developing, implementing, and investigation of achievement in the 6th-grade sound subject teaching activities by STEM approach. Unpublished Master thesis, Erciyes University, Graduate School of Educational Sciences, Kayseri.
- [15]. Gazzola, G., Buchanan, A., Packard, N., & Bedeau, M. (2007). Catalysis by Self-Assembled Structures in Emergent Reaction Networks. In M. Capcarrere, A.A. Freitas, P.J. Bentley, Johnson, C.G. Johnson, & J. Timmmis (Eds). *Advances in Artificial Life. Lecture Notes in Computer Science. Vol. 4648*, pp. 876–885. Springer Verlag. [https://link.springer.com/chapter/10.1007/978-3-540-74913-4\\_88#page-1](https://link.springer.com/chapter/10.1007/978-3-540-74913-4_88#page-1)
- [16]. Head, B. and Wilensky, U. (2013). NetLogo Membrane Formation model. [http://ccl.northwestern.edu/netlogo/models/Membrane Formation](http://ccl.northwestern.edu/netlogo/models/Membrane%20Formation). Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston,
- [17]. <https://content.inflibnet.ac.in/data-server/eacharya-documents>
- [18]. [https://www.education.gov.in/sites/upload\\_files/mhrd/files/NEP\\_Final\\_English\\_0.pdf](https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf)
- [19]. Şahin, A., Ayar, M. C., & Adıgüzel, T. (2014). STEM related after-school program activities, and associated outcomes on student learning. *Educational Sciences: Theory & Practice*, 14 (1), 13–26. <https://doi.org/10.12738/estp.2014.1.1876>
- [20]. Şahin, B. (2020). The effects of STEM based outdoor activities on the prospective science teachers' academic achievement about the plants, and the opinions about the outdoor activities. Unpublished Master thesis. Sıtkı Koçman University, Department of Elementary Education, Muğla.
- [21]. William, P. J. (2011). STEM education: proceed with caution. *Design, and Technology Education: An International Journal*, 16 (1), 26–35
- [22]. Wilensky, U. (1999). NetLogo. <http://ccl.northwestern.edu/netlogo/>. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

DOI: <https://doi.org/10.15379/ijmst.v10i2.3122>

This is an open access article licensed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>), which permits unrestricted, non-commercial use, distribution and reproduction in any medium, provided the work is properly cited.