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Implementing Cross-Curricular Pedagogy in Science Teaching

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Abstract

In the present scenario it seems difficult to gain students attention in classroom through employing traditional approaches of teaching. Classrooms comprised of young generation seeks something different from traditional approaches. First education policy of the twenty first century i.e., National Education Policy, 2020 expressed its interest in the implementation of innovative pedagogies for achieving clear understanding of concepts and moving the education system away from the culture of rote memorization. The policy stresses the implementation of one such innovative pedagogy that is cross-curricular pedagogy which provides avenues to the students to think beyond the box. It is a creative way to mediate learning through cross-curricular instructions which assist student in developing cognitive, affective and psychomotor capacities. The present research work i.e., Implementing cross-curricular pedagogy through 5E instructional model in science, is carried out as an attempt in the recommended direction to systematically flourish conceptual understanding of the pedagogy, science pedagogy and cross curricular pedagogy. It provides a detailed plan of Cross-Curricular Instructions in science based on 5E instructional Model. Present piece of work concludes with a critical analysis of opportunities and obstacles in implementing cross-curricular pedagogy.

Keywords: Cross-Curricular Pedagogy, Constructivist approach, 5 E Instructional Model, Science Pedagogy

INTRODUCTION

Before proceeding towards cross-curricular pedagogy it is essential to get acquainted with the meaning of 'Pedagogy'. The term pedagogy refers to the art of interactions between the students, teachers and their learning environment along with the learning tasks [4]. It is adopted by the pedagogue in order to define the classroom learning experiences and the desired outcomes. The term gained focus as the methods of teaching or techniques of teaching a particular subject [3&10]. This art is related with the teaching processes in which pedagogues at various levels need to ensure that the efforts they put into implementing the methods of teaching, instructional strategies and the teaching materials would significantly contribute in accelerating student deeper understanding. Moreover, there are several theories, methods, approaches and strategies which not only facilitates students learning but also bring a paradigm shift in the education system. It is needed to upgrade our pedagogical practices as the learners of the present age seek something new that is beyond paper-pencil classroom and could promote a clear understanding of concepts along achieving academic goals. It is needed to implement new scientific and pedagogical practices while keeping in mind that they should be favourable to the needs of the learners. Thus, it can be remarked that

pedagogy involves all the components related to teaching which assist a pedagogue in achieving the desired objectives.

Focussing on science pedagogy on the basis of Position paper, National Focus Group on Teaching of Science [6], pedagogical practices in science should not only be according to the age of the learners but they should be within the cognitive reach of the learners. It should be capable enough to engage learners in acquiring the methods and processes that could lead to generation and validation of scientific knowledge. It should provide the learners with the avenues to nurture their natural curiosity and creativity through science learning. It should be cognizant to integrate historical perspective so that the learners could appreciate how the concepts of science evolved with time. It should be obliged to develop a vision in learners so that they could view science as a social enterprise and enable them to understand how social factors influence the development of science. It should present science in wider context i.e., local as well as global, enabling the learner to appreciate the application of science in overcoming environmental issues. It should provide the learners with the scope to develop their knowledge and skills in order to prepare them for the present world. It should have the scope for promoting values like honesty, cooperation, objectivity, freedom from superstitions and developing a concern for preserving our environment.

Realizing the gaps and the needs of the present education system, India drafted its National Policy of Education, 2020. "It proposes the revision and revamping of all aspect of education structure including its regulation and governance, to create a new system that is aligned with the aspirational goals of 21st century education, including SDG4, while building upon India's tradition and value system" (National Education Policy of India, 2020, p.3). Policy lays emphasis on the development of creative potential of each individual. It is based on the principle that education must develop cognitive capacities with main focus on higher order cognitive capacities like critical thinking and problem solving, foundational capacities of literacy and numeracy along with social, ethical and emotional capacities. It focusses on identifying unique capacities of learners and sensitizing their parents and teachers to promote their holistic development in academic as well as in non-academic fields. It prioritizes the curriculum as well as the pedagogical reforms across all stages leading the education system towards real understanding and learning 'how to learn' and taking it away from the culture of rote memorization. It raises its concern towards cognitive development along with building strong character resulting in the holistic and well round individuals equipped with twenty-first century skills.

In order to accomplish these aims NEP, 2020 has also paved the way by focusing on experiential learning through cross-curricular pedagogical approaches reaching the holistic development of learners. Recommendation has been made regarding the implementation of experiential learning including hands on learning, cross-curricular pedagogical approaches like arts-integrated and sports integrated approaches within each subject. Art-integration is a form of cross-curricular pedagogical approach that implements different aspects and forms of art and culture as the foundation for building student concepts across subjects. It will not only facilitate joyful classroom environment but also develop awareness regarding Indian ethos through systematic integration of various rich forms of Indian art and culture at various levels. This will avail the directions for teachers in strengthening the linkage between Indian culture and education. Another form of cross-curricular pedagogical approach that is emphasised in NEP, 2020 is sports integrated pedagogy. It utilizes different physical activities encompassing indigenous sports, in pedagogical practices to assist in developing various skills such as team work, co-operation, self-direction, self- discipline, responsibility etc. It will help learners to adopt fitness as lifelong attitude and related life skills as envisaged in the fit India movement of the country. Moreover, it will also serve in fostering

holistic development by nurturing psychological as well as physical well-being along with cognitive abilities. These cross-curricular pedagogical approaches will provide learners with the opportunities to explore the relations among various subjects (NEP, 2020). Before proceeding further, it is required to build understanding towards cross-curricular pedagogy.

Cross-curricular pedagogy represents a way of teaching which is not only limited to the classroom but rooted into the world outside the classroom. We observe various things around us like plants, animals, birds, clouds, vehicles and so on but unable to understand any of them from the perspective of single subject. Every one views this world and its objects with different viewpoints. Cross-curricular pedagogy has the potential to recognize these multiple viewpoints and provides scope to build more transferable understanding of the world around us [1]. There are three different approaches to cross-curricular teaching viz. Fusion, Multidisciplinary and Interdisciplinary [9]. Each of these approaches have their own advantages and disadvantages in teaching and learning. It is said to be a fusion approach when traditional curriculum is integrated with content of another subject. It promotes learners to apply knowledge and skills gained in one subject (Math) to understand and perform tasks of another related subject (Science). Fusion approach may result in disadvantage to the learners having lack of previous knowledge in the prior subject (Maths) whose knowledge and skills are going to applied in learning another subject (Science). Multidisciplinary approach employs different subjects to teach one topic. In this approach learning may occur in two forms i.e., through team teaching or collaboration among subjects. Teachers share classrooms and their time to link their subjects to teach any concept. This sharing leads to integration of subjects which serves as the advantage of multidisciplinary instruction. Connections between curriculum make learning more meaningful for learners. At the moment when learners realize the connection between the subjects, learning becomes more relevant. When these connections are integrated in planning the instructions for any lesson, they are termed as cross-curricular or interdisciplinary instructions.

Attempts have been made by the researchers to explore various forms of cross-curricular approach. Other forms of cross-curricular approaches encountered were: Parallel Curriculum Integration, Infusion Curriculum Integration, Multidisciplinary Curriculum, Transdisciplinary Curriculum Integration [2]. Other contrasting ways for using more than one subject in order to respond to a problem are: tokenistic cross-curricular approaches, hierarchical, multidisciplinary, interdisciplinary, opportunistic, and double focus cross-curricular teaching and learning. These reported styles have different aims which depend upon the range of planning strategies resulting in different learning opportunities [1]. Choice of implementing the type of cross-curricular approach depends upon the teacher and he/she can design instruction or lesson according to the needs of the learners and the promotion of desired learning objectives among learners. It's upon the potential of the teacher that how creatively he/she can establish information patterns between various academic subjects. Instructions in science teaching using cross-curricular approach should be designed in such a way so that it can pave the direction for developing desired knowledge, understanding and the practical skills as well.

Planning Cross-Curricular Instructions in Science

While planning cross-curricular instructions in science it should be kept in mind that hands-on activities are considered as the heart of science classroom [7]. All the instructions should be designed keeping the students in the centre so as to engage them in active learning. Present research endeavour is focussed upon planning cross-curricular instructions in science following five stages of BSCS 5E Instructional Model given by Rodger W. Bybee and his colleagues. This 5 E Instructional Model is rooted in learning

psychology and the observations that students should be provided with appropriate time and opportunities to build their concepts and the abilities as well [8]. Stages of this instructional model based on a constructivist way of delivering instructions. These five stages are: Engage, Explore, Explain, Elaborate and Evaluate. Teacher act as facilitator in the entire learning process passing through all the phases. Phase first i.e. engage is aimed at engaging students in classroom. Several strategies are implemented by teacher to gain students attention in the classroom. This phase is directed to link current experiences with previous experience and knowledge of learners. Through engagement phase teacher can introduce the learners with any problem or situation or an issue. Second phase is the exploration phase; in this phase learners are provided with hands-on collaborative experiences in order to reach the solution of the problem to which they are introduced in the engagement phase. There upon learners explain the solution of the given problem in their own words after its exploration in the previous phase and this phase is known as explanation phase. Explanation of the concept is followed by the elaboration phase in which the learners are provided with the avenues to apply their learned concept in a new or similar situation. In order to assess learners progress evaluation is done at last which involves the teacher and the peers as well. Another important point is that one can repeat a phase if required while implementing 5 E model.

Planning cross-curricular instructions in science involved the following steps:

1. **Selection of Topic:** Topic was selected from class-VIII science text book prescribed by NCERT. Topic selected to plan cross-curricular instructions in Science teaching was Air Pollution. It was selected by visualizing its broad aspects and maximum probability of establishing linkage between other subjects and disciplines. Connecting a topic in broader sense with other subjects and disciplines will assist students in achieving clear and deeper understanding of the topic.
2. **Writing Objectives:** Objectives were framed keeping in mind the desired behavioural changes in all the three domains viz., Cognitive, Affective and Psychomotor in relation to the integrated subjects and disciplines.
3. **Content Analysis:** Cross-curricular pedagogical instructions will be imparted through the following five phases of the 5E Instructional Model. Content analysis should be done by keeping in mind the 5 phases of the 5E instructional Model and interlinking of the selected topic with various subjects and discipline. Subjects and disciplines identified to deepen students learning were: Social Science (History, Civics and Geography), Science (Chemistry, Physics, and Biology), Mathematics, Environment, Moral Science and English Language.
4. **Resource Analysis:** A proper resource analysis was conducted in order to facilitate the delivery of cross-curricular instructions in science teaching. Resources required were the textbooks of identified subjects, related videos, magazines and material to carry out group activities.
5. **Integrating Learning Experiences Across Various Subjects and Disciplines:** Learning experiences were planned by following 5 phases of the 5E instructional model. They were planned in order to systemically broaden students understanding of the selected content by relating it to various subjects and disciplines.
6. **Evaluation:** This last step was planned by keeping in mind the desired objectives which involves peer-evaluation and the evaluation by teacher as well. The model followed for imparting cross-curricular instruction was 5E Instructional Model and in this model the evaluation is integrated in all the phases in a non-formal way in order to relate students' previous experiences and knowledge with the current experiences. This assists the teacher in scaffolding as per the requirement during the teaching learning process. This non-formal evaluation also helps in directing students learning in a desired direction.

Before delivering the lesson to the student teacher will first divide the whole class into small groups in order to carry out teaching and learning in a collaborative manner. Teacher will also provide students with the instructions to follow during the entire teaching learning process. The detailed 5E Plan of cross-curricular instruction in science has been elaborated below:

5E Plan of Cross-Curricular Instructions in Science
Subject: Science
Topic: Air Pollution
After the implementation of lesson students will be able to:

1. Understand the importance of clean air,
2. Demonstrate the importance of air by performing classroom activity,
3. Identify the sources of air pollution,
4. Define the concept of air pollution,
5. Explain the harmful effects of air pollution on livings as well as on non-livings,
6. Relate the concept of air pollution with other subjects,
7. Write chemical reaction involved in acid rain,
8. Recall the facts about Taj Mahal,
9. Appreciate cultural heritage of India,
10. Describe the composition of air,
11. Perform mathematical calculation to draw a pie chart showing composition of air,
12. Design a concept map on air pollutants,
13. Elaborate the concept of air pollution,
14. Aware about acts on air pollution,
15. Discuss the benefits of bearing mask,
16. Located cleanest cities on map,
17. Sketch a poster on measures to combat air pollution,
18. Reports the do's and don'ts to combat air pollution,
19. Questions each other explanation of concepts,
20. Summarize the concept of air pollution.

Classroom Settings
Teacher will divide the available students in small groups sitting around a table to facilitate classroom discussion and activities.

Instructions
Teacher will provide common instructions to the class i.e.; they have to share their ideas with their group members and have to keep the record of all the observations.

Engagement Phase
Teacher's Activity: What is essential for human beings to survive?
Student's Activity: Food, air and water all are essential for the survival of human beings.
Teacher's Activity: Among all these (food, water air) what do you think is the most essential?
Teacher will ask student to close their nose for a minute and then answer the question.

Student's Activity: After performing the task, Air is most essential to survive.
Teacher's Activity: Yes, air is most important for our survival. We can survive without food and water for some time but it is not possible for us to survive even for a few minutes without air. This shows that how important the fresh air is for our survival.
Student's Activity: Student will listen carefully and note down.

Exploration Phase
Teacher's Activity: By showing pictures of smoke coming from vehicles and factories teacher will ask student, what does the pictures show?
What happen when you pass from a place full of smoke?
Student's Activity: Pictures shows the smoke coming from vehicles and factories.
It causes difficulty in breathing/ suffocation/coughing etc.
Teacher's Activity: Name the other sources which causes contamination of air.
Student's Activity: Students discuss with their members and will write down various sources leading to air contamination.
Teacher's Activity: Does this contaminated air affect only living beings?
Student's Activity: Student may or may not give correct answers.
Teacher's Activity: Define the term air pollution using the terms: unwanted substances present in air, and their impact on living and non-living?
Student's Activity: Students will try to explain the term air pollution in their own words.
Teacher's Activity: Teacher will listen to the explanation of student and note their misconceptions or the missing information in their explanation.

Explanation Phase
Teacher's Activity: Definition of Air Pollution
When air is contaminated by unwanted substances which have a harmful effect on both the living and the non-living, it is referred to as air pollution.
Student's Activity: Student will listen carefully and note down the concept.
Teacher's Activity: Integration with Biology- Harmful effects on Living beings
Air pollution causes irritation of eyes, nose and throat, headache, anxiety, coughing, painful breathing, skin irritation, impact on liver, spleen and blood, respiratory diseases, cardiovascular diseases, impact on reproductive system etc.
Student's Activity: Student will listen carefully and note down the concept.
Teacher's Activity: Integration with Chemistry- Harmful effects on non-livings
Taj Mahal has become the matter of great concern over the past two decades. Experts reported that air pollutants are discolouring its marble. So, we can say that air pollution affects both livings as well as non-livings (monuments, buildings, statues etc.). The industries located in and around Agra like automobile, rubber processing, chemicals and especially oil refinery at Mathura, have been responsible for producing air pollutants like SO_2 and NO_2. These gases (SO_2 and NO_2) react with the water vapour found in the atmosphere to produce H_2SO_4 and HNO_3. The acids come down with rain, making the rain acidic. This is termed as acid rain. It corrodes the marble of the monuments and buildings. The phenomenon is also known as "Marble cancer".
Student's Activity: Students will listen the concept of acid rain and write the reactions involved in acid

rain.

Teacher's Activity: Integration with History

The Taj Mahal is located at the right bank of the Yamuna river (The river originates from Yamnotri glacier of Bandar pooch crests in the lower Himalayan ranges) in Agra. Taj Mahal was commissioned in 1632 by the Mughal emperor Shah Jahan (1628–1658) to house the tomb of his favourite wife, Mumtaz Mahal; it also houses the tomb of Shah Jahan himself. Full name of Shah Jahan was Shahab-ud-din Mohammad Khurram.

Student's Activity: Teacher will ask student to share their knowledge about Taj Mahal.

Exploration Phase

Teacher's Activity: Have you ever seen a ray of light coming in a dark room? Share your observation.

Student's Activity: Yes, we have seen a ray of light coming in a dark room, it comprised of small dust particles.

Teacher's Activity: What do you think that air is composed of?

Student's Activity: It composed of oxygen, carbon dioxide, dust particles etc.

Explanation Phase

Teacher's Activity: Air comprised of some water vapor, dust particles and different gases. The gases in air are mainly Nitrogen (78%), Oxygen (20.9%), small amount of CO_2 (0.03%), Argon (0.90%) and many other gases (0.17%). Oxygen is necessary for living organisms and it supports burning.

Integration with Mathematics

Teacher will ask students to draw a pie chart showing the composition of air.

Student's Activity: Students will draw a pie chart showing the composition of air.

Elaboration Phase

Teacher's Activity: What do we call the substance which contaminate the air?

Student's Activity: Those substances which contaminate the air are called air pollutants.

Teacher's Activity: Teacher will draw the concept map of air pollutants and their sources.

Student's Activity: Students will observe and learn to draw concept map.

They will draw the same in their note books.

Teacher's Activity: What do you think about the effect of these gases on earth's temperature?

Student's Activity: Students will discuss and share their views.

Teacher's Activity: Teacher will listen to the students' views and then explain them about the concept of Green House Effect and Global Warming.

Student's Activity: Students will listen carefully to understand the relation between Green House Effect and Global Warming.

Teacher's Activity: Do you know the measure taken by Indian government to control air pollution?

Student's Activity: Student may or may not give the answer.

Teacher's Activity: Integration with Civics

In 1981, the Air (Prevention and Control of Pollution) Act was enacted and modified in 1987 to provide the prevention, control and abatement of air pollution in India.

Teacher's Activity: Discuss and write the benefits of bearing mask in public places.

Student's Activity: Students will write the benefits of bearing mask on public places.

Teacher's Activity: Integration with Geography

Mark the following cleanest cities of India on a map.

Indore, Surat, Vijaywada, Navi Mumbai, Pune, Raipur, Bhopal, Vadodara, Vishakhapatnam, Ahmedabad.
Student's Activity: Student will mark the following cities on map.
Teacher's Activity: What steps can be taken to prevent air pollution?
Student's Activity: Students will discuss and write the measures to prevent air pollution.

Teacher's Activity: Integrating with Environment Science and Art

Use of alternative fuels like CNG and unleaded petrol. Organization of campaign by school students like "Say no to crackers campaign". Switching over to the use of energy fuels like: solar energy, hydropower and wind energy can combat air pollution. Putting the dead plant material into compost instead of burning it. Turn off lights when not in use, avoid the use of plastic bags, follow recycle and reuse, reduction of forest fire or smoking, use of fans instead of AC. Small contributions on our part can make a huge difference in the improving the state of our environment. We can plant more trees and nurture the ones existing in our neighbourhood. Have you heard about Van Mahotsav, when lakh of trees are planted every year in the month of July?

Student's Activity: Students will make posters showing the measures to control air pollution.

Evaluation Phase

Teacher's Activity: Evaluate the responses given by students on following questions

1. 1.Summarize the concept of air pollution.
2. Define air pollution and its sources.
3. What is acid rain?
4. Draw a concept map on air pollution.
5. How air pollution affects humans, plants, animals and non-living things.
6. Write a brief description on Taj Mahal.
7. Write the measures taken by Indian government to reduce air pollution.
8. Mark the most polluted cities of India on Map.
9. Prepare a list of do's and don'ts for combatting air pollution.

Student's Activity: Along with giving responses on the questions asked by the teacher students will also perform peer evaluation.

Conclusion

Teaching with cross-curricular pedagogy provides students with the avenues leading to the broadening of imagination. Cross-curricular integration enables them to recognize significant connection of patterns of information between various subjects and disciplines. While planning cross-curricular instructions in science it should be kept in mind that the links made between various subjects and disciplines should not be forceful. Integrating the concepts with various subjects systematically not only made learning deeper but also provide the opportunities to understand that how can a concept be learned by its linking with other subjects. By using cross-curricular strategy in science, application part can be made clear to students which results in expanded learning. It paves a new way to the curriculum directing it from a traditional to a collaborative one. Sometimes it requires joint efforts from teachers to design cross-curricular instruction encompassing various subjects and disciplines. As it facilitates cross-connections among various subjects and disciplines it fosters higher order cognitive capacities viz. critical thinking, problem solving and creative thinking among students which has been strongly recommended in NEP, 2020. Along with the development of cognitive capacities cross-curricular pedagogy can also be successfully employed in

developing skills related to affective and psychomotor domain. Values integration can be easily done in science subject through cross-curricular instructions which guides the student to use science always for the upliftment of the society and the nation. NEP, 2020 lays emphasis on development of creative potential of each individual, this can be achieved through cross-curricular pedagogy in science. In a cross-curricular setting students are expected to link or apply their knowledge in new situation, which generates creative potential. Such setting of cross-curricular instruction with constructivist 5E model enables them to participate actively and reflect upon science concepts in a collaborative manner. It also inculcates life skills in them such as communication skills, collaboration, teamwork etc. which are highlighted in the principles of our NEP, 2020. Student actively drill into the depth through cross-connections of a concept with various subjects and disciplines. By focussing on meaningful linkage cross-curricular pedagogy illuminates the student mind with broad spectrum of knowledge; making their learning more relevant to understand the world in which they are living. As learning is facilitated through employing various senses into the cross-connections which results in construction of knowledge directing the education system towards *'how to learn'* and repelling it away from the traditional culture of rote memorization.

As we know every coin has two sides, similarly cross-curricular pedagogy can also have another side. It is time taking and sometime it becomes difficult to cross-connect the concepts when teacher is lagging behind in implementing his/her creative potential. Sometimes he/she may not receive collaboration form other subjects/disciplines experts who are already overloaded. It not only requires rigorous efforts in planning a cross-curricular instructions but also require the same in assessing the level to what the desired objectives has been achieved. Entire planning starting from the framing of learning objectives to the evaluation; needs meaningful cross-curricular linkage. It becomes useless when it fails to ensure the significant representation of cross connections among various subjects and disciplines in any aspect of planning. It requires deliberate efforts of teacher to gain students attention throughout the process which sometimes becomes challenging. Reaching towards the edge of conclusion it can be said that besides having complications in planning a cross-curricular instruction in science, it can be implemented successfully as it depends on the willingness, readiness, hard work and intelligent efforts of the teacher. It possesses the potential to alter the way in which students process the information. Cross-curricular pedagogy enhances thinking skills to different learning context and break down the subject barriers. It encourages students to make their own connections and conclusions. It is needed to leave the traditional ways of imparting instruction and promoting the culture of innovative pedagogies. This can be inculcated in our education system through pre-services as well as in service programmes. However, it can be made more fruitful for the present system of education through systematic research and upgrading skills of teachers at all level through hands-on workshops, seminars and conferences.

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