

From Textbooks to Classroom Implementation: Experience Report of Middle School Science Teachers' Pedagogy for Activity-Based Learning

Zun Phoo MO*, Sunny Prakash PRAJAPATI, Sheeja VASUDEVAN & Sahana MURTHY

IDP in Educational Technology, IIT Bombay, India

**22d1078@iitb.ac.in*

Abstract: This paper provides an experience report of middle school science teachers' pedagogy for activity-based learning in Indian classrooms. For the study, four science teachers were interviewed having varied teaching experience in CBSE board schools. The transcripts of the interviews were analyzed using Thematic Analysis method, and the resulting themes were used to answer the research questions. Novel challenges related to culture and diversity were found, along with the findings reported in literature.

Keywords: Activity-based learning, science teaching, teacher challenges

1. Introduction

While teaching science in middle school classrooms, teachers often use activities as a part of their teaching strategies. These activities help engage students in the classroom that can support their understanding of the material. In the Indian context, textbooks from the National Council of Educational Research & Training (NCERT) ("NCERT." Accessed May 27, 2024. <https://ncert.nic.in/textbook.php>). are one of the most used in schools. These are equivalent to the federal textbooks used in other countries. Each chapter in the textbook contains a few activities, which are to be implemented by the instructors. However, instructors still face multiple challenges while implementing these activities in classrooms, due to various factors, such as large class size, classroom diversity, and so on.

Information and communications Technology (ICT) has impacted science teaching practices in some ways with the use of virtual laboratories, simulations, and other web-based platforms. For example, the use of AR in teaching a module on "Solar system" (ÄžimÄŸek & DirekÄŸi, 2023), similarly the use of animation in teaching abstract Biology concepts (Udin et al., 2020). Yet teachers struggle to design and implement activities. Through detailed interviews, this paper presents preliminary findings on how teachers implement science textbook activities in classrooms.

2. Literature Review

2.1 Activity-based learning in middle school

Activity-based learning is an important instructional method where the learner engages in a task by which their learning objectives are met. These activities are varied in nature and can vary from making a sketch or recording an observation to performing an experiment (Skulmowski, 2024). Learning through activities provide alternate means to engage students with scientific concepts, which are more satisfactory than the lecture-based teaching (Nwosu et al., 2022). They form an integral part of the science curriculum in schools and are facilitated by the instructor during class hours, and are centered around a single scientific concept.

Science textbooks play an important role in classroom teaching-learning, in addition to the curriculum content, they also provide activities, which need to be performed by the student in class or at home for the learning science concept. There are multiple studies that have been conducted to analyse science textbook activities (Aldahmash et al. 2016), and have concluded that these activities can impart science process skills in students, which include observing, collecting data and information, drawing conclusions, etc. (Özalp, 2023). NCERT textbooks, which are the government recommended textbooks, are also activity-based. These activities are integrated with the text in such a way that doing the activity will answer a question posed in the textbook (Kaur, 2019). Udin et al.'s systematic review highlights the use of 3D animation for teaching Biology concepts and in topics of Physics as well (Halim et al., 2021). Specifically for the Indian scenario, we see the application of AR technology in teaching concepts (Sarkar et al., 2020).

2.2 Teachers' challenges in activity-based learning

Science teachers face multiple challenges while implementing activities in classrooms. There are multiple factors that have been documented, such as, the need to foster conditions for students reasoning around the concepts, and higher demand on students in terms of participation, which can, at times, be overwhelming. Additionally, the instructor must determine the amount of guidance required for the students to be engaged (Harris & Rooks, 2010). Class discipline is one of the key aspects related to classroom management including mobilizing student enthusiasm, attention, and their sense of participation. Additionally, class duration was reported to be one of the most rigid constraints in implementing the tasks planned by the teachers, and hence, lesson plans are of limited help to them. Moreover, these challenges are faced even by experienced teachers, as reported by Aslam et al. where teachers' having 2-5 years of experience reported these challenges. The study also mentions the role of added responsibilities in contributing towards these challenges, such as, organizing students, time, space, and materials, etc. (Aslam, 2023). Looking at the challenges with technology, Riel et al.'s study had identified some of them, such as addressing emerging technological problems in class, usability of technology while doing activity, and technological fluency of teachers and students (Riel et al., 2016).

2.3 Teaching practices for accommodating culture and diversity

An urban classroom in India has a diverse socio-cultural student population, which belong to different regions, religions, economic classes, and speak different languages (Koul, 2019). Teachers adapt their teaching practices in a variety of ways to accommodate this diversity, such as explaining concepts and translating certain words in the native language, simplifying activities and explanations to include low performing students, and so on. Additionally, encouraging students to share their lived experiences, and sharing personal experiences with students has also shown to be effective (Vyas, 2023). Other reported practices include encouraging student reflections and class participation at different times, and developing empathy towards students (Tan, 2010), group work during class activity, and discussions with peers and teachers (Koul, 2019).

3. Method

This pilot study is a part of broader research which aims to support science teachers in designing and implementing science inquiry activities while engaging with diverse classrooms in India. The research questions for this study are: What are the challenges middle school science teachers face when implementing activities prescribed in the textbook? *And* what are the teaching practices for implementing science textbook activities in the classroom? A) How do teachers ensure student engagement and active participation during activities? B) How do teachers accommodate the diverse learning needs and cultural backgrounds of their students?

3.1 Participants

Four teachers were contacted for the interviews for this study who are teaching science in grades 6-9 in urban areas in India. All of them were teaching in CBSE board and have access to ICT tools and technologies, and the textbook they referred for teaching science was published by NCERT, which is the state recommended textbooks for schools. Convenience sampling method was used for the recruitment of the teachers, out of the four teachers two were male and two were females, and all of them have at least 3 years of teaching experience, with max 17 years teaching experience.

3.2 Data collection

Four teachers were interviewed in online mode by the researchers, and the conversations were recorded using a screen-recording software. Consent for the data collection was taken beforehand from all the teachers. The interviews were conducted in the semi-structured format, and were finalised after conducting a pilot interview with one teacher. Interview questions were broadly related to challenges faced while conducting activity, support sought, culture and diversity in the classroom, and so on. The length of each interview session ranged from 30 to 45 minutes, and the conversation happened in English and Hindi. The recorded interviews were transcribed and translated using cockatoo.ai software tool, and the translation of the segments in Hindi were checked by a researcher who had Hindi language proficiency. The resulting transcripts were then analysed using the Reflexive Thematic Analysis process.

4. Analysis and Findings

The interview transcripts were coded using an inductive coding process where, in the first step the segments from the transcripts were coded with descriptive codes, which were then combined to form themes. In total seven themes emerged from the data; these are 1. Support required by teachers, 2. Culture and diversity in classrooms, 3. Use of technology, 4. Issues with implementing activities, 5. Teaching practices, 6. Student engagement, 7. Teacher's perception of textbook activities. The research questions were answered using these themes.

4.1 Teacher challenges in implementing activities

Teacher challenges in implementing activities arise from multiple areas, which are issues with the classroom environment, resources, large class size, diversity of students and activity design. One teacher stated that *"Large size of classroom. at least 70 students right now in each class. So, it is very difficult to perform,"* while was another said *"Number of students is the first obstacle we face doing activities or experiments in the class"* and in such cases giving feedback also becomes a challenge as one teacher said *"Checking 65 kids' notebooks in a day or giving feedback to them is not that easy"*. Sometimes the teachers also face students' resistance to participation in the activities, as one teacher narrated *"Children do not listen to instructions sometimes, if the other group's result is not good then it has to be done again"*, and another said, *"The best way is to keep the kids in the class. Because sometimes the kids run away"*.

Teachers also modify activities due to issues with equipment, such as outdated equipment, shortage of resources, or poor quality of materials. One teacher said, *"Sometimes the chemical is not up to mark. It doesn't give results. The preferred color, preferred gas which we need, it doesn't come out."* Another issue is with the design of the textbook activities itself where most of the time there is no clarity in guidelines and procedure, and no verification of the results. Two teachers narrated *"I think there should be at least at the end, it should be given what kind of results we would see if we proceed"*, *"When you see the activity of "NCERT", I think QR code is not given. If QR code is given We should know how to do the activity"*.

Another set of challenges in implementation is related to cultural background or social context in the textbook activities, which can be due to differences in regional knowledge. One

teacher said *"There was an activity in which One of the flowers is called Sehjan. So the vegetable made from the flowers of Sehjan It is mostly grown in Bihar or UP. So the kids from Delhi, they gave the answer to the question that the flower of Sehjan is grown from that and the kids from other places where there was no such thing in their culture they were not able to answer"*, while other teacher also mentioned *"Some cultural aspect and geographical aspect is also there. And students living in one particular area find it very difficult to understand the things in the other area"*. Also, one teacher also narrated diversity in culture specific food and dietary practices *" There is a colloidal solution. And the example is the egg albumin. If we mix the whole egg in a beaker, it will be like an example of colloidal solution. Some students don't eat egg. They don't like it, using it or touching it or the smell of the egg."*, and diversity in mother tongue of the learners. Other interesting challenge is that all four teachers are faced with different types of diversity of students, such as due to geography, language, physical appearance like height, academic performance and due to special ability as one teacher mentioned *"Diversity is there in every way in terms of language, yes in terms of state."*

4.2 Teaching practices for implementing science textbook activities in classrooms

Teachers choose activities based on availability of science kits, chemicals, apparatus, duration of time, students' interest, students' level of understanding and connectivity with the topic. All four teachers mentioned *"that are interesting to students, less in time to do, the level of the children and how they can understand the activity quickly, on the resources, which material is easily available to me from the FSA kit"*, *"We have science kits"*, *"the feasibility, the availability of all the apparatuses ,how much it is related to the topic"*. They also make preparations such as sharing experiences in science teacher groups, discussion with seniors, and doing rehearsal before actual experiments in class for successful implementation of activities. One teacher said *"to know if chemicals are properly reacting or not, I perform myself first"*, and other two teachers also mentioned *"We share our experience and resources in our science groups"*, *"If there is a particular activity, if the result is not obtained and I take help of my senior. He told me another method"*. While implementing activities, teachers use strategies such as connecting real life examples to activities, making activity interesting for students, monitoring class engagement, observing their actions and asking questions during demonstration, assigning group leaders to make sure that all group members engage in activities for student engagement and active participation.

All teachers have reported motivating students to participate in different ways, such as through group leaders, motivating to ask questions, etc. They constantly monitor the class engagement during activities. One teacher revealed, *"I take help from the monitor of the class and few, two or three students help me, assist me so that every student is engaged in the activity"*. Teachers also provide necessary support so that students can engage in an activity properly. As science concepts are connected from grade to grade, they remind students of the related concept(s) from the previous grade or chapter so that students can get a clearer picture of scientific phenomena as mentioned by a teacher, *"We have to repeat concepts again and again. So that they will remember the things from time to time"*. When students do not understand the guidelines of an activity or if they are stuck during an activity, teachers repeat the demonstration, making the steps simpler for the students, changing their ways of teaching, using technology, and modification of activity. Three teachers mentioned *"If students might not have understood, I explain full demonstration again"*, *"change my way of teaching as student don't need only one method to understand"*, *"For optic band, we perform the activity with the help of optic bands, but that is not easy for students to understand.so, we use some candles and mobile phones to show this kind of activity"*.

Teachers also frequently assess students' understanding of concepts while they demonstrate activities in class through questions, which are often short questions with one word answer. One teacher narrated, *"We ask some small questions, one-word questions or objective type questions to check whether they have understood that or not yet"*, the other teachers asks orally in class, *"Mainly orally First of all..."* and questions connect with the real world *"If I have given one example of displacement reaction activity and if they are able to understand the other example with the help of that and are able to answer that as well then*

that means they have understood the things". Additionally, they also evaluate students' understanding through homework assignments, which allows them to assess every student in their class. One teacher mentioned *"When I have written the questions and the activities because I may not be able to connect with all the students. So for that I give homework questions and assignments"*. Teachers have reported use of technology in a few ways, they specially used videos and learning from YouTube for the activities that cannot be performed in the classroom. And videos are especially helpful for teaching biology as it can be used for easy visualisation and there are very few materials to show internal organelles of organisms. As one teacher narrated, *"I have to search videos in which the diagrams are shown"*. Also, teachers use different technological platforms for searching some additional activities that are new and may be of interest to the students, *"now there are many experiments on YouTube"*.

Ensuring engagement of all students in class is not an easy task for teachers. All teachers acknowledged that some forms of diversity are present in their classrooms. As we have discussed in the challenges section, they also face challenges that relate to different types of diversity due to which the learning needs of the students may vary. Teachers use a variety of techniques to meet the learning needs of their students, such as modifying activities so that the learners can relate to the concepts in the textbooks with the context with which they are aware. One teacher said, *"For example, I would take the example with which they are familiar in their daily life. I try to find any such example where they have come through that situation. In this way I modify the situation and awareness of students' background"*. For the students with special needs, teachers use a special arrangement of classroom settings, taking help from special educators so that they can also participate in the activity. Two teachers mentioned, *"if there is a specially-abled child in my class I am modifying my activity for that"*, *"Most of the time I give opportunity to them if there are such students in my class. Later on, the other students. I always try to involve them in my class"*.

5. Discussion and Conclusion

The research reports a preliminary study of middle school teachers' experience of how they teach science concepts using activities. For this, four teachers with varied years of experience were interviewed, and the data were analysed using the thematic analysis approach. Some of the challenges in the findings, such as that with the shortage of resources, high classroom strength, and with classroom environment were also reported by other researchers in the context of activity-based learning (Aslam, 2023, Changtong, 2020). However, the challenges related to the cultural background and social context that emerged were novel, such as students' in-ability to relate to the activity's context highlighted by teacher's class observation, and large differences in students' competencies. Looking at the teaching practices, strategies such as giving real life examples and contextualising activities according to learners are in line with the literature, such as in the studies by Vyas et al. and Tan et al. (Tan & Barton, 2010, Vyas & Dalvi, 2023). Some teachers have also reported revising the concepts present in the previous grades for better understanding. Also, all teachers acknowledge diversity, they try to accommodate this issue by modification of activities based on students' needs and their background, taking help from special educators, use of technology and making arrangements so that every student can perform in activities without any barriers. Based on the findings from study, we find that teachers are facing difficulties and they need more activities for teaching some of the scientific concepts, and want specific guidelines to implement activities. They also highlighted the need for a communication platform, like a website, so that they can share their unique experiences of how they implemented new activities in their context. This can serve as a learning resource for other teachers of the same grade across the country.

Understanding the practical challenges that teachers face in their classroom will help us in future to design a technology-enabled environment wherein the teachers can interact with each other, create, and share their work thereby forming a community. This is essential as some of the teachers during the interview mentioned "Teachers should have a platform where they can discuss and share their activities with their students, NCERT should also have a platform where they can change the curriculum within 2-3 years". The technological platform will facilitate interactions amongst teachers wherein they can share the activities that they

have designed themselves, share their thoughts and experiences etc. They can also use it for understanding /developing the instructions in the activity and check the verification of results from these activities. The study here presents a preliminary analysis of various aspects of implementing textbook activities in classrooms. It provides a limited account of teachers' experience in implementing activity-based learning in classrooms. Teachers did mention technology use and challenges which were routine and standard but challenges regarding the diversity and culture were novel. For future work, we will address these challenges effectively using technology.

Acknowledgements

The authors would like to thank Ms. Priti Ingle for assisting with the audio transcription, Ms. Ishika for assisting with contacting and scheduling the interviews with teachers, and Mr. Alekh V for providing feedback on the manuscript.

References

- Aldahmash, A. H., Mansour, N. S., Alshamrani, S. M., & Almohi, S. (2016). An analysis of activities in Saudi Arabian middle school science textbooks and workbooks for the inclusion of essential features of inquiry. *Research in Science Education*, 46, 879–900.
- Aslam, S., Alghamdi, A. A., Abid, N., & Kumar, T. (2023). Challenges in Implementing STEM Education Insights from Novice STEM Teachers in Developing Countries. *Sustainability*, 15(19), 14455.
- ÅžimÅŸek, B., & DirekÅŸi, B. (2023). The effects of augmented reality storybooks on student's reading comprehension. *British Journal of Educational Technology*, 54(3), 754–772.
- Changtong, N., Maneejak, N., & Yasri, P. (2020). Approaches for Implementing STEM (Science, Technology, Engineering & Mathematics) Activities among Middle School Students in Thailand. *International Journal of Educational Methodology*, 6(1), 185–198.
- Halim, A., Farhan, Ahyuni, A., Susanna, Andriani, W., & Irwandi. (2021). The impact of PhET virtual lab worksheets on student learning outcomes on sound wave materials. *Journal of Physics Conference Series*, 1806(1), 012033. <https://doi.org/10.1088/1742-6596/1806/1/012033>
- Harris, C. J., & Rooks, D. L. (2010). Managing inquiry-based science Challenges in enacting complex science instruction in elementary and middle school classrooms. *Journal of Science Teacher Education*, 21, 227–240.
- Kaur, G. (2019). Textual Texture of School Science. In R. Koul, G. Verma, & V. Nargund-Joshi (Eds.), *Science Education in India Philosophical, Historical, and Contemporary Conversations* (pp. 49–66). Springer Singapore. https://doi.org/10.1007/978-981-13-9593-2_3
- Koul, R. (2019). Addressing Diversity in Indian Science Classrooms. In R. Koul, G. Verma, & V. Nargund-Joshi (Eds.), *Science Education in India Philosophical, Historical, and Contemporary Conversations* (pp. 129–142). Springer. https://doi.org/10.1007/978-981-13-9593-2_7
- Nwosu, S. N., Etiubon, R. U., & Ofem, I. B. (2022). Effect of the activity-based learning on basic science and technology students' non-cognitive skills in south-south Nigeria. *European Journal of Education and Pedagogy*, 3(5), 67–74.
- Özalp, D. (2023). Science Curriculum Requirements Science Process Skills in Textbook Activities. *Journal of Educational Research and Practice*, 13(1), 123–141.
- Riel, J., Lawless, K. A., & Brown, S. W. (2016). Listening to the Teachers Using Weekly Online Teacher Logs for ROPD to Identify Teachers' Persistent Challenges When Implementing a Blended Learning Curriculum. *Journal of Online Learning Research*, 2(2), 169–200.
- Sarkar, P., Kadam, K., & Pillai, J. S. (2020). Learners' approaches, motivation and patterns of problem-solving on lines and angles in geometry using augmented reality. *Smart Learning Environments*, 7(1), 17. <https://doi.org/10.1186/s40561-020-00124-9>
- Skulmowski, A. (2024). Learning by Doing or Doing Without Learning? The Potentials and Challenges of Activity-Based Learning. *Educational Psychology Review*, 36(1), 28. <https://doi.org/10.1007/s10648-024-09869-y>
- Tan, E., & Barton, A. C. (2010). Transforming science learning and student participation in sixth grade science A case study of a low-income, urban, racial minority classroom. *Equity & Excellence in Education*, 43(1), 38–55.
- Udin, W. N., Ramli, M., & Muzzazinah. (2020). Virtual laboratory for enhancing students' understanding on abstract biology concepts and laboratory skills A systematic review. *Journal of Physics Conference Series*, 1521(4), 042025. <https://doi.org/10.1088/1742-6596/1521/4/042025>
- Vyas, T., & Dalvi, G. (2023). *Environmental Education Through Activities Teacher Practices of Including Students' Lived Experiences*. 261–266.