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ARTICLE

Challenges in the Effective Utilization of Secondary Science Kits in Schools: Voices from the Field

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ABSTRACT

Learning science is not just about reading books. It works best when students explore, experiment, and stay involved. Science kits play a key role at the secondary level. They help students learn through activities and make concepts clear. This study, titled *"A Study of the Utility of NCERT Secondary Science Kits (SSK) for Classes 9 and 10 across the Country"*, was conducted by the Division of Educational Kits, NCERT in 2023–24. The research It examined the use of SSKs in 36 government schools across Haryana and Jharkhand through teacher interviews, classroom observations, and student interactions. The findings showed a mixed picture, although all the sample schools had the kits, their usage varied widely. Some teachers integrated them well into classroom teaching, but in many cases, kits were incomplete, non-functional, or underused. A lack of teacher training emerged as a key barrier to effective implementation.

Introduction

Learning science becomes more meaningful when students get an opportunity to do hands-on experiences instead of only reading from the textbook. Hands-on experiences make the concepts of science easier to understand and more interesting. This is the reason why science kits are considered important. This becomes even more important at the secondary stages when students are expected to develop some experimental skills in addition to the theoretical skills.

This paper is based on a research study titled "A Study of the Utility of NCERT Secondary Science Kits (SSK) for Classes

9 and 10 across the country". The research study was undertaken by the researchers of the Division of Educational Kits (DEK) in 2023-24.The study was focused on the use of NCERT Secondary Science Kits, which were designed and developed in the DEK, NCERT, and are being used in schools of different States and UTs.

In this study, researchers have investigated the challenges faced by teachers in the effective utilisation of these kits in the sample schools. The research team visited the selected 36 schools, 18 each from Haryana and Jharkhand.

The study highlights different important issues, such as the availability of the Kits, their working conditions, frequency of use, teachers' understanding of different items of the Kit and the need for orientation of teachers for effective utilisation of the Kits. We have followed a mixed-method approach in this study and identified the gaps in the effective utilisation of these Kits, which are, in general, considered and reported as very useful for providing hands-on experiences to children. The findings of the study showed both positive responses regarding the usefulness of the kits and also the challenges faced by the teachers in their effective utilisation.

Review of Literature

Over the years, many studies have highlighted the challenges faced by science teachers when they try to bring hands-on learning in their teaching-learning processes. For example, Koul and Verma (2018) pointed out that teachers often struggle with a lack of proper training, large class sizes, and even practical issues like maintaining items of the kit. More recently, Marshall, Forrester, and Tilsen (2024) emphasized another barrier; many schools simply don't have strong science leadership to guide and support teachers. Wee & Subramaniam (2001) highlighted that despite the challenges, there's been a global shift in how science is taught. As per NEP 2020, "Pedagogy must evolve to make education more experiential, holistic, integrated, inquiry-driven, discovery-oriented, learner-centred, discussion-based, flexible, and, of course, enjoyable." Flick (1993) reported that when the concepts of science are explained through hands-on methods it truly benefits students. Many studies have reported positive

benefits of hands-on approach for learning science. Kalogiannakis and Ampartzaki (2018) found that when children engaged in hands-on science activities, not only did their understanding of concepts improve, but they also began developing deeper knowledge. Similarly, Khan and Aajiz (2012) demonstrated that activity-based teaching helped secondary students strengthen their cognitive skills in physics. More recently, Srivastava and Jangir (2023) saw positive results of using NCERT's Middle Stage Science Kits in Government Schools of Delhi. The study reported improvement in the performance of students in science in all types of schools, such as Girls', boys', and co-ed schools. Based on these findings, the present study aims to study the utility of NCERT's Secondary Science Kits (SSKs), which are meant for carrying out activities of Grades 9^{th} and 10^{th}. The focus was kept on the two states of the country, i.e., Haryana and Jharkhand, as they both follow NCERT textbooks at the secondary stage (Grades 9 and 10), and both states have been among the largest two buyers of NCERT's Secondary Science Kits (SSKs). This made them a suitable choice for carrying out this study to know the utility of these kits in teaching-learning in classrooms. This research aims to explore not only how useful the kits are in practice, but also what challenges teachers and schools face while trying to integrate them. This becomes more important as the need for experiential learning is given a lot of emphasis in both the National Education Policy 2020 and the National Curriculum Framework 2023.

Objectives of the Study

The study was proposed for two states, i.e. Jharkhand and Haryana, with the following objectives:

- To study the availability and present condition of Secondary Stage Science Kits (SSKs) in schools.
- To assess the frequency of SSK usage in science teaching.
- To understand the challenges faced by teachers and students in utilizing the kits during their teaching-learning process.
- To collect suggestions for the improvement and future development of SSKs.

Methodology

Research Design

This research study followed a mixed-method approach for collecting both qualitative and quantitative data.

Sample and Sampling Technique

For choosing the sample for the study, the data related to the Kit distribution across the country was collected from the office of the Division of Educational Kits, NCERT. After comparing the five-year data related to Secondary Science Kit distribution in different states, it was found that during the last five years, the highest number of SSKs were supplied to the two states, Haryana and Jharkhand. The state of Haryana procured 3,261 kits, whereas the state of Jharkhand procured 2,683 kits till the time of the start of research. Therefore, these states were selected for carrying out the research. After the selection of the states, the team started working in coordination with the state authorities for the identification of the districts for the same purpose. Further, to identify the schools, a Google form was circulated among the science teachers, teaching science at grades 9 and 10 in both states. This Google form had questions to know the basic details with respect to the experience, subjects studied during their graduation and post-graduation, related to the training of the efficient use of the Secondary Science Kit, and the schools using these kits in their teaching-learning process.

More than 360 responses from Haryana and 240 from Jharkhand were received by the researchers. The data was analysed, and finally, three districts from each state were selected for the field visit. Further, six schools from each district were chosen in consultation with the district authorities of these districts. The schools were selected keeping in mind the following points: locality of the school; Urban or Rural, type of school in terms of gender; Girls, Boys, or Co-Ed schools, availability of the kit in the schools, and the accessibility of the schools.

A total of 36 schools were selected from the six districts of the two states. Collectively, the sample size of the study was 36 science teachers, one from each of these 36 schools. Though the

research team interacted with more than 60 teachers and lab assistants, however, response of only one teacher from each school was selected as it was filled by teacher in consultation with other teacher. For the sampling of the students, the team also planned to interact with 20 students on average from each grade, i.e., 9 and 10 of each school.

The number of students with whom the team interacted varied, and the team interacted with around 350 students.

Sampling Technique

Non-probability multistage sampling technique

First Stage: Purposive at the first stage for choosing states.

Second stage: Convenience sampling at the second stage for selecting the districts from these states, based on allocation and convenience.

Third stage: Criteria-based purposive sampling for selecting the schools.

Data Collection

To ensure systematic coverage and accuracy, the data collection process for this research was carried out in a phased manner. In the initial phase, the kit distribution data was collected from the office of the Division of Educational Kits, and primary data from responses of the teachers collected using the Google Form. This data helped in identifying and selecting the states and districts. Then, in consultation with experts, customised data collection tools were developed and validated in-house by the research team. The field visits to the selected schools were then conducted. The research team collected rich quantitative and qualitative data through the following sources:

- Interviews cum interactions with science teachers regarding kit utility, integration with the curriculum, and support systems such as training, user manuals, etc.
- Focus Group Discussions with selected students to assess

engagement and understanding.

- Direct classroom observations of SSK usage in some of the schools.

While ongoing examinations in some schools posed minor challenges, the team was able to carry out all planned interactions in the majority of schools, ensuring comprehensive and desired data.

The data related to the availability of kits, working conditions of kit items, challenges faced by teachers and students in utilizing the kit, and suggestions for improvement and future development of the Kits have been collected from the participants of the study.

Findings and Discussion

The research team from the Division of Educational Kits collected data through interactions, focus group discussions, and classroom observations during the field visits and analysed the same. The findings related to the objectives of the study are reported under the following headings.

Profile of Sample Schools and Teachers

A total of 36 science teachers from 36 schools from 6 districts of the two states and about 350 students from the schools were involved in this study. The list of the districts and the number of schools involved from each district is given in Table 1.

Table 1: The list of sample States, Districts, and number of schools

State	Districts Visited	No. of Schools Visited
Haryana	Gurugram	6
	Faridabad	6
	Panchkula	6
Jharkhand	Ramgarh	6
	Khunti	6
	Ranchi	6

(i) Teaching Experience of Science Teachers

The details about the teaching experiences of the science teachers teaching at the secondary stage (grades 9 and 10) from both states are given in Table 2, and the same is represented graphically in Figure 1.

Table 2: Experience of teaching at the secondary stage, of the teachers from Haryana and Jharkhand

Total Teaching Experience in Teaching Science at the Secondary Stage	No. of Teachers	
	Haryana	Jharkhand
Less than 2 years	3	2
Between 2 and 5 years	5	8
Between 5 and 10 years	6	4
More than 10 years	4	4

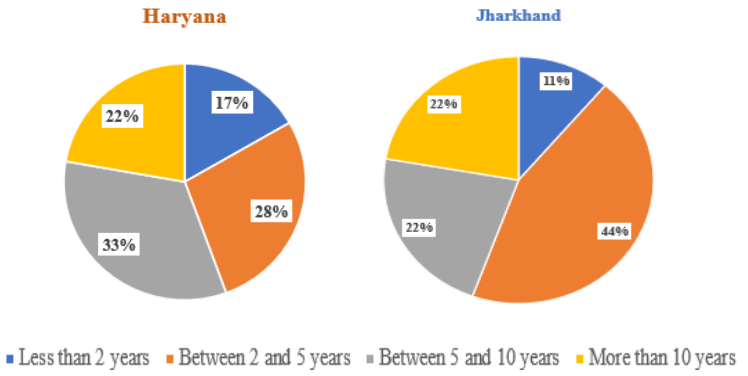

Figure 1: Experience of teaching at the secondary stage, of the teachers from Haryana and Jharkhand

It can be seen clearly from the same Figure1, that in both states, i.e., Haryana and Jharkhand, over 80% of teachers had at least two years of experience of teaching at the secondary stage. Also, it can be seen from Figure 1 that 55% science teachers from Haryana have teaching experience of more than 5 years, whereas the same is 44% in Jharkhand.

This may affect the efficient utilisation of the science kit in the teaching-learning process. Teachers having more experience may be more efficient in the usage of science kits.

(ii) Availability of the Secondary Science Kit

Significant disparities between the sample schools of the two states were found in the availability of the Secondary Science Kit. The data related to the availability have been presented in Table 3.

Table 3: The number of Secondary Science Kits in the sample schools of two states

School	No. of SSK Available in Schools of Haryana	No. of SSK Available in Schools of Jharkhand
School 1	8	1
School 2	3	1
School 3	8	1
School 4	4	1
School 5	14	1
School 6	2	1
School 7	2	1
School 8	5	1
School 9	5	1
School 10	3	1
School 11	10	1
School 12	5	1
School 13	2	1
School 14	2	1
School 15	10	1
School 16	8	1
School 17	8	1
School 18	3	1

The number of SSKs in the sample schools of Haryana varied from 2 to 14, whereas in each of the sample schools of Jharkhand, only 1 SSK was available, irrespective of the number of students or science teachers. Availability of more number of Kits in schools may affect the effective utilisation of the Kits. If the numbers are not sufficient, students may lack hands-on experiences, and the Kits may be used only for demonstration purposes.

(iii) Working Conditions of the Secondary Science Kit

It has been at least five years since the SSKs were procured by these states. Although the SSKs were available in all the sample schools of both states, but mere availability is not enough to ensure effective usage of the kit. It was found that the working conditions of the items of the kits in some of the schools were not good. Some of the items were found damaged due to wear and tear, whereas some of the consumable items were exhausted due to their use. The list of such items is given in Tables 4, 5, and 6.

Table 4:Items of the SSK kit that have been exhausted

Name of the item	Haryana	Jharkhand
Blotting paper	6	5
Copper wire	5	6
Dispensing Bottle	1	2
Filter Paper	12	9
Glass Slide	4	5
Iron Filings	8	4
Litmus Paper	15	12
Muslin Cloth	11	8
Nichrome wire	3	4
pH Paper	16	10
Rubber cork	2	7
Sand paper	9	9
Vials	1	2
Wire Gauze	1	4

This kit involves both consumable and non-consumable items. In every school, some of the items were reported as exhausted. In the majority of the sample schools from both states, Litmus paper, pH paper, filter paper, etc, were found exhausted. Some of the other items that have been exhausted are also listed in Table 4.

In addition to the exhausted consumable items in some of the schools, some non-consumable items, such as dissecting microscope, circuit board, microscope, and digital stop clock were found non-functional. The details of the non-functional items are given in Table 5.

Table 5: Items of the SSK that are not working properly (non-functional)

Name of the Item	Haryana	Jharkhand
Circuit Board	3	8
Compound Microscope	6	6
Connecting Wire with Banana Plug	1	3
Crocodile Clips	1	3
Digital Stop Clock	4	4
Dissecting Microscope	9	3
Magnetic Compass	5	5
Magnifying Glass	3	5
Multimeter	1	1
Permanent slide	4	5
Ray-streak box	2	1
Set of four resistors	4	5
Spring Balance	6	4

Table 6: Items of the SSK that have been broken

Name of the Item	Haryana	Jharkhand
Glassware items of the SSK		
Beaker (50 mL)	4	6
Boiling Tube with cork	2	1
Capillary Tube	7	6
Concave Mirror	2	4
Conical flask	4	2
Convex Mirror	1	4
Cover Slips	6	3
Glass Rod	6	6
Glass Slide	3	4
Glass tube	6	6
Laboratory Thermometer	7	4
Magnetic Compass	3	4
Magnifying Glass	1	2
Measuring Flask	4	4
Micro Beaker (10 mL)	6	4
Micro Test Tube 2 mL	2	3
Permanent slide	5	4
Plain mirror strip and stand	2	5
Plane mirror	5	5
Plano concave lens	3	1
Test Tube 20ml	3	3
Torch bulb with holder	3	5
Triangular Glass Prism	5	5
U-tube (glass/plastic)	4	6
Watch glass	2	1
W-tube	7	6

Non-Glassware items of the SSK		
Double convex lens (Perpex)	2	4
Laboratory Stand	1	2
Magnetic Compass	1	3
Slinky	5	3
U-Clips/ Paper clips	1	1
Raystreak box	3	0
Torch bulb with holder	7	5

In some of the sample schools, glassware items, including capillary tubes**,** glass rods, and glass slides, were found broken. In addition to the glassware, some other items, such as Slinky, Raystreak box, etc., were also found broken in some of the schools. The details are given in Table 6.

All the items of the Kit, either consumable or non-consumable, are essential for conducting one or the other classroom activity given in the textbook; therefore, their unavailability affects the transaction of different concepts in a hands-on manner.

While interacting with the teachers of the sample schools, it was brought to notice that many of the schools do not have a proper storage facility for keeping the items properly, and also, the glasswares were not provided in any sturdy cases; therefore, many times, fragile items break while taking them out of the Kit box. Some of the teachers also said that there should be guidelines for handling different sophisticated items of the Kit. Teachers also wanted some mechanism through which the broken/exhausted / non-working / lost items may be replaced in the Kit.

(iv) Frequency of use of Secondary Science Kit (SSK)

The data regarding the use of the SSK in the teaching-learning process was also collected from the science teachers of all the sample schools. As indicated in Table 7 and Figure 2, more than 85% of science teachers use the kit items once a week in their classroom teaching.

During the interaction with the teachers, it came to notice that the teachers of the sample schools were using certain items of the kit more frequently, whereas some of the items were still unused or rarely used in their science grades. The most used items are those with which they are most familiar and comfortable using.

Table 7: Frequency of using SSK in the teaching-learning process

Frequency of use of SSK	No. of schools: Haryana	No. of schools: Jharkhand	Total no. of schools
Once a week	14	17	31
More than once a week	4	0	4
Once in a month	0	1	1

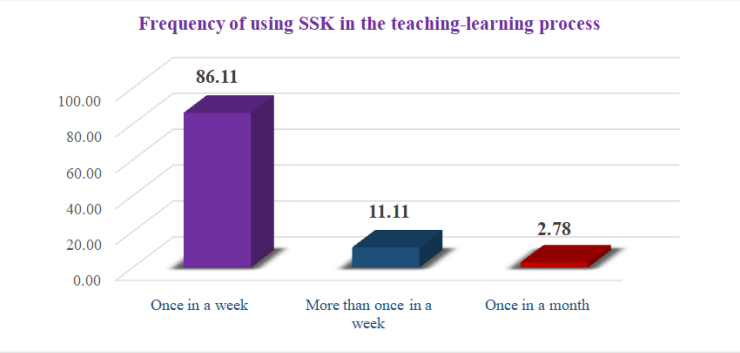

Figure 2: Frequency of using SSK in the teaching-learning process.

(v) Perceived Usefulness of the Kit

The data related to the usefulness of the items in teachers' opinions was also collected. For this the items of the Kit were broadly categorised into three main groups; **Group A**: Comprising of the items related to activities from the Theme, *Moving Things, People, and Ideas; Natural Phenomena*, **Group B**: Comprising the items related to activities from the *Materials; Natural Resources; How Things Work*, and **Group C**: Comprising the items related to activities from the Theme, *Food; The World of the Living.* The data related to this is given in Table 8.

Table 8: The rating of the items of SSK related to different themes as per perceived usefulness

States	Usefulness of the items of SSK in performing activities related to (Out of 10)		
	Group A	**Group B**	**Group C**
Haryana	8.4	7.2	7.4
Jharkhand	5.9	6.7	6.9
Average	**7.2**	**7.0**	**7.1**

The perceived usefulness in the case of Haryana is higher than in Jharkhand, and the reasons for this may be the involvement of PGTs of the three subjects, viz. Physics, Chemistry, and Biology in teaching Science in Grades 9th and 10th, whereas the same was taught by TGT Science in Jharkhand.

It can also be seen from Table 8 that the minimum rating in Jharkhand was for Group A items, which is related to Physical Sciences. The reason for this may be the subject background of the teachers teaching science. It was found that the majority of the TGT Science of the sample schools of Jharkhand were from the Biological Sciences.

(vi) Familiarity with Kit Items

The kit contains over 160 specific and general-purpose items. While interacting with science teachers, it was observed that most of the teachers of the sample schools were familiar with almost all of the items of the Kit; however, when it comes to the specific uses of the items, some of the teachers expressed their unfamiliarity. The list of some of these items, which were not familiar to teachers, is given in Table 9.

Table 9: List of some of the items of the SSK with which the teachers were not familiar

Haryana		Jharkhand	
Name of the item	**No. of teachers**	**Name of the item**	**No. of teachers**
Bar Magnet	14	Bar Magnet	12
pH Paper	13	Double Convex lens	11
Concave Mirror	12	Double convex lens	11
Convex Mirror	12	pH Paper	11
Cylindrical Magnet	12	Compound Microscope	10
Copper wire	12	Beaker (50mL)	9
U-Shape Magnet	12	Concave Mirror	9
Slinky	12	Litmus Paper	9
Iron Nails	11	Parts of flower	9
Glass tube	11	Test tube holder	9
Tuning Fork and rubber pad	10	U-Shape Magnet	9
Micro Test Tube 2 mL	10	Permanent slide	8
U-tube (glass/plastic)	9	Test Tube Stand	8
Test Tube Brush	9	Blotting paper	7
Raystreak box	7	Calorimeter	7

(vii) Challenges in Using the Kit

The data related to challenges faced by science teachers is a very important part of this study. Despite having general familiarity with the kit items, teachers from both states faced some common challenges while using the kit items in their teaching-learning process. Some of the reasons were unclear instructions, less number of Kits, less time, etc. The data related to different reasons for the challenges is given in Table 10 and presented graphically in Figure 3.

Table 10: The reasons for facing challenges by the science teachers of both states in using the items of SSK

The Reasons for Facing Challenges	Haryana	Jharkhand	Both States
	No. of teachers	No. of teachers	No. of teachers
Instructions for the use of items is/are not clear	3	2	5
The purpose of certain items is/are not clear	5	4	9
A smaller number of SSK / its items in the school	6	5	11
Because no training has been given for the use of the kit	10	9	19
Having less time to carry out activities during teaching	4	3	7

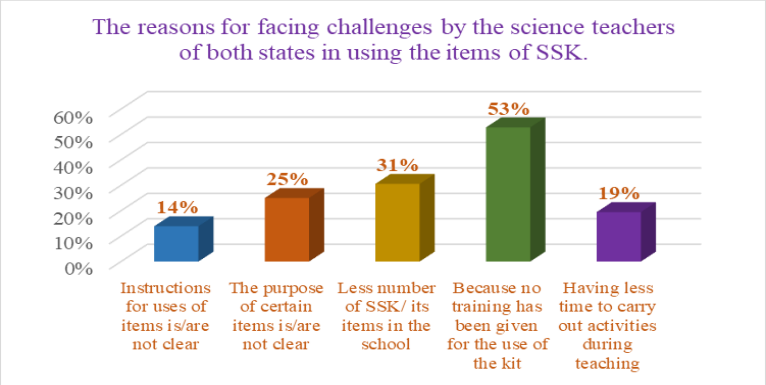

Figure 3: The reasons for facing challenges by the science teachers of both states in using the items of SSK.

- ***Lack of Training***

The most frequently reported challenge science teachers face is due to the absence of adequate training on how to use the kit items. This concern was reported in both states, and a total of

53% teachers reported that they had received no formal training on kit usage (Table 10, Figure 3).

Even in Haryana, where kit availability was better compared to Jharkhand, teachers expressed the need for hands-on workshops to build confidence and explore the full potential of the Secondary Stage Science kit in their teaching-learning process.

- ***Unclear Purpose of Certain Items***

About 25% of the science teachers reported that there is no clarity on the purpose of certain items and no clarity on the instructions for using these items.

This may be because the kit manual provided with the kit was in English only, and the language of instructions in both states was Hindi. Therefore, the non-availability of the Hindi version of the manual along with the Kit might have enhanced the difficulty in understanding the specific use of the kit items and the exact procedure to use them effectively.

- ***Inadequate Kit Availability***

Science teachers from more than 30% sample schools in both states reported that the school does not have a sufficient number of kits in comparison to the number of students in grades 9 and 10 in these schools.

However, schools in Haryana were better equipped with the kits, but a lack of proper maintenance and wear and tear limited the usable items. This may have impacted the opportunity for hands-on experiences to the large number of students.

- ***Time Constraints***

Around 20% of science teachers from the sample schools reported that more time is required to provide hands-on experiences to students and explain the concepts of science using the Kit items. The tight academic schedule provides less scope for explaining the concepts through Kit items. This was particularly more relevant for teachers handling multiple subjects or large class sizes, where activity-based instructions required extra efforts and planning.

(viii)General Findings: Focus Group Discussion and Classroom Observation

During the classroom observations and focus group discussions with students, it was observed that students were excited about learning through the use of Kit items. It was also observed that during the demonstration of activities using Kit items, most of the students were listening to the explanation actively and also took part in the activities. Teachers preferred to use only those items for demonstrations in which they were more comfortable to use, such as demonstrations using magnesium ribbon, iron nails, spring balance, etc.

During the Focus Group Discussion(FGD), some of the students expressed their desire to have a larger number of kits in the school so that they can get more opportunities to explore the Kit items and their uses. When the students were asked about the items during the FGD, it was found that they were only aware of the names and uses of items that were commonly used by their teachers during the teaching-learning process, such as magnesium ribbon, microscope, etc.

Conclusion:

The purpose of this research study was to determine whether the NCERT's SSKs are available and utilized by science teachers, and also to identify the challenges faced by science teachers during the teaching-learning process.

The study finds that the SSKs are available in all the sample schools of both states, and these kits are generally being used by science teachers in the teaching-learning process. Most of the teachers are familiar with the uses of most of the items. The students from these schools were found to be excited to explore the uses of kit items. The teachers in both states acknowledged the usefulness of the kits. However, there are some concerns related to the SSK that came out through this study;

For example, the sample schools in Haryana are better equipped in terms of the number of kits, whereas the sample schools of Jharkhand have limited availability of the kits, with only one kit per school, irrespective of the number of students in grades 9th and 10th in those schools.

The science teachers from both the states have never received any training in kit usage. This emerged as a central barrier to effective integration of hands-on activities in science classrooms.

Some teachers were not familiar with specific items, and their purposes were also not clear to them. Mostly, these were the items which were not related to their academic specialisation subjects in graduation. And this problem was exaggerated with the unavailability of the Kit manual in the language of instructions in the classrooms.

Most of the items were in good and usable condition, but some of the items were found non-functional, broken, or exhausted across the sample schools from both the states.

Mostly the teachers were using the kit items for demonstration purposes, as there were not sufficient numbers of functional kits in most of the schools, and the number of students in each grade was very large.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

- Training or Orientation programmes to train a large number of science teachers in government schools for the effective use of the Secondary Stage Science Kit in their teaching-learning process. The training may also include how to utilise locally available items for carrying out the activities or demonstrations. These programmes may be organised by Samagra Shiksha, NCERT, SCERTs, and similar agencies. These training sessions should be done in a cascade model where the trained teachers further train other teachers of the same school or nearby schools.
- Glassware items of the Secondary Science Kit should be packed securely to prevent damage during transportation and handling. The secure packaging may include protective materials such as bubble wrap, foam padding, and boxes to ensure that fragile items, particularly glassware, can reach schools in good condition and also can be kept securely after use.

- There must be a mechanism to replenish the items that have been consumed, broken, or non-functional, as the absence of these items hampers hands-on learning.
- To ensure ease of use, the kit manual for the Secondary Science Kit must be provided in the language of instruction used in the State/UT, for example Hindi version of the manual should be provided along with the Kit in the states in which Hindi is used as the language of instruction in the classrooms. This will help teachers better understand the uses of the items in the kit.
- For ease of transporting the Kit to the classrooms, it will be good if the boxes have wheels and handles like trolley bags.
- For providing better hands-on experiences to students, it is suggested to have at least five functional kits in each school. And also, the number/ quantity of some of the items which are not very costly may be increased in the kit, such as pH paper, litmus paper, glass slides, iron filings, etc. The number of some of the items should be increased so that more activities or more students can be engaged simultaneously.
- To make the kit items more user-friendly, demonstration videos on their usage should be prepared. These videos can be included as part of the kit and also be uploaded on the NCERT website for wider access.

Delimitations of the Study

- This study was conducted in only two states, i.e., Haryana and Jharkhand of India. Therefore, the findings may not fully represent the diverse contexts and practices that are being followed across all the states in the country.
- Out of 18 schools from each state, we could only interact with the students from 12 schools in Haryana, and only 6 schools in Jharkhand.
- During the school visits, the research team planned to interact 20 randomly selected students from each grade i.e. 9 and 10 from each school, but due to administrative constraints, such as the ongoing internal

examinations for grade 9 in some of the schools, and the engagement of the students in the final examinations, the team, could interact with only about 350 students from selected schools.

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