

A Survey of the Practices, Procedures, and Techniques in Senior Secondary School Chemistry Teaching Laboratories

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ABSTRACT: A survey was conducted in various senior secondary schools of Rajasthan State that teach chemistry at senior secondary level and conducts chemistry practicals in laboratories in the India. The data include results from over 27 schools, describes the current practices, procedures and techniques used at these schools, and discusses the statistical results such as the adaptability of laboratories performed, the chemical techniques applied, the instrumentation/chemicals available, the laboratory equipment used, the chemistry practicals covered, the way they conducted and performed. The results provide a “snapshot” of the current state of the senior secondary school laboratory teaching chemistry practicals.

Keywords: Senior secondary, Chemistry laboratory, chemistry practicals procedures

INTRODUCTION

Education being one of the most important factors responsible to shape the personality of an individual and it has manifold functions. It is the potent source of material and human development. School Education is one of the important stages of education in the life of an individual. It comprises of pre-school, elementary, secondary and senior secondary level. The school curriculum from the pre-primary to senior secondary stages aims to construct for realizing the pedagogic potential of work as a pedagogic medium in knowledge acquisition, developing values and multiple-skills formation [1,2]. Science is an ever changing and evolving field of study. Not only do the theories and techniques of a particular scientific field to newer and more refined ones, but these changes must be reflected in the classrooms as well [3,4,5]. It has been described that chemistry is a branch of science concerned with properties, composition, and structure of substances and the changes they undergo when they combine or react under specified conditions [6,7]. Laboratories in the field of natural sciences are application areas for the learned theoretical knowledge and physical space where meaningful learning activities carried out [8,9,10] At middle and senior levels of schooling, note making should receive attention as a skill-development training exercise. This will go a long way in discouraging mechanical copying from the black board, textbooks and guides. Well-equipped laboratories have always been about as a part of science teaching at school level.

OBJECTIVES OF TEACHING CHEMISTRY

The study of chemistry as a science subject in senior secondary schools entails the exposure of learners to both theoretical and practical aspects of learning experiences. The chemistry curriculum is set to prepare students for the formulation of values and attitudes related to social, ethical, economic, and environmental aspects of chemistry, so that they may grow up to become responsible citizens.

REVIEW OF RELATED LITERATURE

For the purpose of conducting present research study, the investigator reviewed some of the studies

related to the present problem. The adequacy of laboratory facilities makes Chemistry teaching more concrete and stimulating, and laboratory facilities had a significant effect on the students' academic performance in Chemistry [11,12]. The adequacy of laboratory facilities had significant influence on students' academic performance in secondary school Chemistry teaching. A few studies have been reviewed to understand the status of laboratory uses and its implications the role of the teaching assistant (TA), or demonstrator, is often seen as pivotal to the student experience and the perceived importance of the different roles of the TA has been investigated from both TA and student perspectives [13,14].

NEED FOR THE LABORATORY

Laboratories are one of the characteristic features of education in the sciences at all levels. Laboratory work is an established part of courses in chemistry in school education at senior secondary level. Laboratory work here is used to explicate the practical exercises which students undertake using chemicals and equipment in a chemistry laboratory.

A considerable impact on school environment may be seen due to the availability of infrastructure facilities in the labs of school and it is one of the important indicators for assessing the learning environment in the schools. The government of India in last two decades has given a major emphasis on improving the school environment including infrastructure through RMSA, SSA and many other initiatives/flag ship program at different learning levels for the school systems. Adequacy of laboratory facilities and students' academic performance, play an important role in the teaching and learning experience and on the extent of adequacy of laboratory facilities in chemistry content and the teachers' effectiveness in the use of laboratory facilities with the aim of facilitating and providing meaningful learning experiences in the learners.

Laboratory experiences provide opportunities for team building, hands-on activities and inquiry-based learning and exposure to standard laboratory equipment and technology. The physical laboratory environment must be accessible to all students.

NEED OF THE STUDY

One of the most important factors, which prevent students' meaningful and permanent learning is, less importance given to laboratory training at senior secondary level. In recent years, research in science education has been focused on identifying and addressing students' problems related to laboratory aspects in teaching of science as general and chemistry in particular. The purpose of this research is to identify the shortcomings in procedural part, techniques, and practice followed in Laboratories while teaching Chemistry practicals in the selected sample schools of Rajasthan state.

OBJECTIVES OF THE STUDY

General Objective is to examine the laboratory practices used in chemistry at senior secondary level and availability of facilities in the chemistry labs, use of laboratories specifically; the present study was carried out with the following specific objectives:

- To study the practice adopted for conducting chemistry practicals in laboratories at senior secondary level.
- To identify difficulties faced by the teachers in conducting chemistry practicals.
- To study difficulties faced by the school authorities to conduct practicals in chemistry

Research questions

- What are the procedures and techniques adopted for conducting chemistry practicals at senior secondary level in laboratories?
- What are the difficulties faced by the teachers in conducting chemistry practicals?
- What are the practices adopted for conducting practicals in chemistry laboratories at senior secondary level?
- What are the difficulties faced by the school authorities to conduct practicals in chemistry at senior secondary level.

MATERIALS AND METHODS

Design of the study

The research study was carried out on laboratory procedures, techniques and practices used in Chemistry practicals at senior secondary level. The study was carried out in selected sample districts of Rajasthan viz. Banswara, Dungarpur, Pratapgarh, Udaipur, Jaipur and Ajmer. The details of the Sample are given in Table 1. The data were collected by visiting the abovementioned districts by the investigator faculty members of the Institute. Data were collected, analyzed and findings were compiled in the form of a report.

Sample of the study

The sample of the study was based on stratified random sampling. At the first stage, out of the 33 districts of Rajasthan, six districts namely Ajmer, Banswara, Dungarpur, Jaipur, Pratapgarh and Udaipur were selected in consultation with the State authorities of Rajasthan Education department. At the second stage, from each of the districts five Government Senior Secondary schools were selected. The details of schools selected are given in the Table below.

Table 1. List of sample schools district wise

S.N.	Name of the School	District
1.	Govt. Senior Secondary School Saradhana Ajmer	Ajmer
2.	Govt. Senior Secondary School Ramgunj Ajmer	
3.	Govt. Girls Senior Secondary School Foy Sagar	
4.	Govt. Senior Secondary School Model Girls Purani Mandi Ajmer	
5.	Govt. Senior Secondary School Sundar Vilas Ajmer	
6.	Govt. Nutun Senior Secondary School Banswara	Banswara
7.	Govt. Senior Secondary School Garhi Banswara	
8.	Govt. Senior Secondary School Partapur Banswara	
9.	Govt. Senior Secondary School Thikariya Banswara	
10.	Govt. Senior Secondary School Khandu Colony Banswara	
11.	Govt. Senior Secondary School Chandrapol Gate Banswara	Jaipur
12.	Govt. Netaji Senior Secondary School Moti Katla Jaipur	
13.	Govt. Senior Secondary School Banipark Jaipur	
14.	Govt. Senior Secondary School Jhotwara Jaipur	
15.	Govt. Senior Secondary School Khatipura Jaipur	
16.	Govt. Senior Secondary School Gangauri Bazaar Jaipur	Pratapgarh
17.	Govt. Senior Secondary School Pratap Garh	
18.	Govt. Senior Secondary School Chotisadri Pratap Garh	Dungarpur
19.	Govt. Devendra Girls Senior Secondary School Dungarpur	
20.	Adarsh Govt. Maherwal Senior Secondary School Dungarpur	
21.	Govt. Senior Secondary School Bhiluda Dungarpur	
22.	Govt. Senior Secondary School Punarwas Colony Sagwara Dungarpur	
23.	Adarsh Mahipal Government Senior Secondary School Sagwara Dungarpur	Udaipur
24.	Government Senior Secondary School Mavli Udaipur	
25.	Government Senior Secondary School Dabok Udaipur	
26.	Govt. Senior Secondary School Fateh Nagar	
27.	Govt. Guru Govind Senior Secondary School Udaipur City	

RESEARCH APPROACH

The study employed basically the qualitative research approach. The data were collected from principal, chemistry teachers and students for laboratory facilities available in the school for chemistry practicals. The laboratory facilities were examined in terms of quantitative research approach, based on measurement of quantities of apparatus available, chemicals, teaching model, frequency of practical work, scores in chemistry practicals, total number of chemistry teachers, total number of students among others. The qualitative approach, on the other hand, has been used to collect principals, teachers' and

students opinions, and elaborate information on availability and use of laboratories, procedure of the practicals.

RESEARCH DESIGN

This research is a descriptive survey study. Descriptive research design was adopted by the researcher to be able to describe the phenomenon as it is on the ground. By using this method the current study tried to find out the adopted techniques and aspects between techniques, procedures and practices in chemistry practicals.

Tools used in the study

Five tools in the form of Questionnaires and one achievement test were developed in the Institute by the Faculty members from the institute well as from outside institutes during a five day work shop and same has been tried out. Descriptions of each of the tool in detail are given in the following paragraphs.

Questionnaire for school description

This Questionnaire contained 19 questions which were open ended and mainly related to general aspects of the school with special reference to chemistry point of view viz number of students, availability of chemistry teacher and availability of laboratory. Provision in the Time Table for chemistry practical work, source of finance for academic work / lab work, provision for inclusive education and suggestions for improving the present status of lab facility.

Questionnaire for principal

This Questionnaire contained 23 items that were both closed and open ended related to general information about the number of chemistry teacher, availability and access to laboratory, textbook and time Table for conducting chemistry laboratory work, performing of activities- venue, nature, involvement of students and guidelines, special arrangement for children with special needs, difficulties faced while conducting the activities, availability and mode of conduct of lab work, source of finance, infrastructure, lab materials available and suggestions for improving the facilities in chemistry Lab.

Questionnaire for description of chemistry laboratory

This Questionnaire/information Schedule consisted of two parts A & B and comprises various questions pertaining to the facilities/ infrastructure available in the laboratory. The information was collected about physical infrastructure, availability of glassware's, equipment, water facilities for experiments, experiment wise availability of chemicals/ reagents through open ended questions.

Questionnaire for subject teacher

This questionnaire consist of 29 items to know about the experience of teaching chemistry and conducting practicals in the chemistry laboratory, availability of separate chemistry laboratory in the school, its utilization, and provision for practical in the Time Table, number of classes allotted for chemistry theory and practicals separately, process of conduct of experiments, practice of fine etc. This questionnaire was developed to know more about chemistry teaching; procedure adopted for the practicals, practices followed for chemistry experiments in the laboratory and consumed time for each type of experiment. In the questionnaire full freedom has been given to elaborate about number of classes used for each of the experiments, yearly planning of practicals, students understanding about the experiments, availability of chemicals/glassware's for the students, maintenance of equipments/material breakage of equipments and guidelines for conduct of the experiments and safety in the lab.

Questionnaire for students

This questionnaire consist of 17 open ended items for students, to know more about the procedure, practices involved during chemistry experiments. The questions were mainly on allotment of theory and practical classes, conducting of experiments, procedure adopted for experiments, use of lab coat, chemicals, glassware's, steps followed by the subject teacher during conducting experiment, use of chemicals and glassware's in different experiments, writing of experiments in the practicals record and evaluation of record by the teacher, role of lab assistant. The questions were also asked about safety measures in the laboratory, cleanliness of the laboratory, suggestions were also asked for improvement of the laboratory work.

An achievement test consisting of 20 objective type items on qualitative inorganic analysis, titration and functional group were prepared for students and administered.

RESULTS AND DISCUSSION**Sample schools profile**

Total 27 schools have been selected randomly as sample, out of which 20 are located in the urban area while 07 are located in the rural area. Out of 27 schools 23 are being run for classes one to twelve while others schools classes running from 9 to 12 and 6 to 12. In all the schools the post of chemistry teachers is filled and the team could not find a vacancy in chemistry in any of the schools. This can be considered as good and positive point as the authorities are very much serious about the faculty in the subjects. Out the sample in more than 50 % of the schools one chemistry teacher is available to teach chemistry classes, while the remaining sample schools are having more than one chemistry teacher to teach chemistry because of enrolment of large number of students in the school in science stream. Out of the sample 81.48% schools having a separate chemistry laboratory but rest of the schools although runs science stream both in physical and biological group but no separate laboratory for Physics, Chemistry and Biology is available. It means the state authorities run the science stream without adequate facilities of the laboratory.

Availability of laboratory staff in the school

Availability of laboratory staff is one of essential conditions in all the schools and their assistance is required for proper maintenance of laboratory facilities and equipment and also to assist in the preparation for practical experiments. The study was to find out the availability of lab assistant and laboratory boy in the schools as well as in the chemistry laboratory because this will give an idea about the functioning of the laboratory.

Table 2. Status of availability of laboratory staff in the school and in the chemistry lab.

Availability of Laboratory Staff	Percentage of availability of laboratory staff in the school			
	Not available	One	Two	Three
Availability of Lab Assistant in Schools	18.52	37.04	18.52	25.93
Availability of Lab Assistant in Chemistry Laboratory	25.93	74.07	0.0	0.0
Availability of Lab Boy in school	40.74	29.63	18.52	11.11
Availability of Lab Boy in Chemistry laboratory	59.26	40.74	0.0	0.0

As revealed in the Table 2. although in 81.48% schools there is a laboratory assistant but out of this only in 74% chemistry laboratory the post is filled. As far lab boy is concerned only in the 59.26% schools it is available out of which more than 68% chemistry laboratory runs without lab boy. This is very critical condition of the chemistry laboratory because lot of laboratory work suffers without the laboratory staff. Students worked in very pathetic situation without the laboratory staff. The lack of supporting staff may also affect the delivery of curriculum, preparation for practical work or even the ability to do practical work. It

can be considered a single most important factor for lack of interest of practicals among students. Non availability of laboratory staff implies inadequacy of Human resources in the chemistry laboratory. The authorities of the state should take immediate action to ensure for the betterment of Chemistry Laboratory.

Planning and execution of chemistry practicals

There is a provision for the chemistry teachers to organize the practicals in batches having of 20-25 students per batch for regular practices. Teacher should plan and organize the practical according to the capacity of lab.

In the present study mostly the number of batch was restricted to two up to 75 students in the classes, but in some cases it goes to more than two when the number increases up to 175. In some of the schools, number of enrolment of students in science is more than 300 at senior secondary classes. The school having single Chemistry laboratory and a large number of students (300 or more) therefore, it is very difficult to conduct the practicals for all the students on regular basis.

As far as Board of Secondary Education, Rajasthan is concerned the laboratory capacity (number of students can work at a time) for each of the school were provided which is given in the Table3 and it goes to maximum 20. Although while observing it was found that practicals was conducted in the school in a much jumbled manner. The number of students in batches not kept ideally as per the guidelines for organizing the chemistry practicals. In most of the schools the students clearly mentioned that they are not getting enough space for performing chemistry practicals. In this way they learn the things wrongly and not understand the systematization of the experiments and do not understand properly the depth of the entire exercise.

Table 3. Status of enrolled students in science and capacity of chemistry laboratory

S.N.	School Code	Total number of students in Classes		Total	Capacity of Chemistry Laboratory
		XI	XII		
1.	SARADHANA	119	111	230	15
2.	RAMGANJ	22	19	41	20
3.	FOY SAGAR	14	21	35	10
4.	PURANI MANDI	109	131	240	20
5.	SUNDARVILAS	14	12	26	8
6.	NUTUN	290	317	607	15
7.	GARHI	98	131	229	16
8.	PARTAPUR	164	169	333	10
9.	THIKARIYA	26	18	44	10
10.	KHANDU COLONY	43	47	90	10
11.	CHANDRPOL GATE	41	21	62	20
12.	MOTI KATLA	33	23	56	10
13.	BANIPARK	44	46	90	15
14.	JHOTWARA	39	33	72	10
15.	KHATIPURA	0	31	31	16
16.	GANGAURI BAZAR	13	11	24	10
17.	PRATAPGARH	118	113	231	20
18.	CHOTISADRI	39	59	98	10
19.	DUNGARPURDEVENDRA	21	18	39	10
20.	DUNGARPURMAHERWAL	50	56	106	20
21.	BHILUDA	23	26	49	8
22.	PUNARWAS COLONY	274	176	450	20

23.	SAGWARA	119	210	329	8
24.	MAVLI	150	148	298	16
25.	DABOK	8	4	12	0
26.	FATEH NAGAR	118	71	189	12
27.	UDAIPUR	116	110	226	20

It can be concluded that due to inadequacy of laboratory space the learning environment of the laboratory affects and some time the poor performance of the students is reflected in chemistry.

The school principals must be aware about the laboratory capacity and number of students enrolled in science stream. The subject teacher must well plan for practicals and proper documentation should be workout for execution of plan. If possible an extra time may be provided to complete all the exercise related to practicals to cover the entire students registered in the stream. The authorities must envisage the importance of laboratory work and its importance. Prime importance must be given to the laboratory work at this level.

Status of physical infrastructure in chemistry laboratory

For effective chemistry experiments practice, all senior secondary schools laboratory are supposed to have adequate facilities in the laboratory such as, physical resources including well equipped laboratories, functional equipments, proper ventilation, lightening, space, demonstration Table and workbenches.

The data were also collected to know about the physical facilities, like facilities of water supply, pollution prevention, safety measures in the laboratory and available equipments, chemicals and glassware's.

Table 4. Status of physical facilities in chemistry laboratory.

S.N.	Physical facilities about	% YES	% No
1	Cross Ventilation in the Laboratory	88.89	11.11
2	Proper Lightening in the laboratory	85.18	14.82
3	Board in the Laboratory	92.59	7.40
4	Fire extinguisher in the Laboratory	3.70	96.29
5	First Aid box in the Laboratory	37.03	62.97
6	Exhaust fan in the Laboratory	11.11	88.89
7	Demonstration Table in the Laboratory	44.44	55.56
8	Table with facilities of Sink, Gas pipe & Water supply	25.92	74.08
9	Facilities for ejection of Waster Water	74.08	25.92
10	Use of Distilled Water for Experiments	11.11	88.89

As the data revealed in the Table 4, most of the schools have well ventilated chemistry laboratory as well as proper lightening. Fire extinguisher is not available in more than 96% of the sample schools which is a very serious matter of concerns. First aid box is available only in 37% of the sample and the data for availability of fire extinguisher and first aid box clearly indicates that the authorities are not much serious about the safety measures. The data also revealed that in nearly 41% of the sample water tap is not available hence buckets are used as source for obtaining water. Furthermore, the exhaust fans are not found in more than 88% of the sample schools, laboratory rooms have standard windows but the floors recommended are not available in all schools. Facilities such as fume chambers are absent in all sampled schools. Laboratory safety is an important aspect while doing/demonstration of an experiment.

Subject teacher as well as authorities must pay focused attention towards availability of safety equipments in the laboratory as well in the schools. Students must be enabled to develop an understanding of the principles of chemical safety, first aid box and to enable them to apply these concepts when working in a laboratory. At the state level policy related to providing first aid box and fire extinguisher should be framed for the entire schools of the state. A demonstration is to be made for basics of first aid procedures for common minor laboratory accidents.

The demonstration Table for teachers is available only in around 44% of the sample. As far as Table with facilities of Sink, Gas pipe & Water supply is concerned, it is available only in 25.92 % of the sample, although the water ejection facility for waste water is available in 74.08% of the sample. A well-equipped laboratory will not be the one just having the demonstration Table but also Tables with Gas pipes, sinks and Water supply facilities. Having a view of the experiment is one thing but doing it ourselves correctly is all the more important. Gas pipes, sinks and water supply facilities serve the purpose and are must for a chemistry laboratory.

An important finding regarding the use of distilled water in chemistry laboratory that only 11.11% sample schools were having this facility (distilled water). The data clearly indicates about the quality concerns while performing the experiments in chemistry laboratory. At senior secondary level in the curriculum the experiments such as titration, qualitative inorganic analysis, functional group identification, preparation of sols have been given and it is mandatory to use of distilled water while preparation of reagents, analysis, dilution or any other experimental work to be carried out in the chemistry laboratory. In the sample schools it was also observed that preparation room planned but its use was not practiced adequately, in some of the sample schools small sink is available but there is not any space for gas cylinder.

Many of the reagents used in chemistry are in the form of solutions which need to be purchased or prepared well in advance using distilled water. It is also mentioned in the book such as Vogel's and other well-known contributors to use distilled water for cleaning, rinsing of glassware's, preparation of laboratory reagents/solutions in any laboratory. To maintain the quality, authenticity of the experiment use of distilled water is mandatory conditions. All the students, teachers and school principals must be made aware about significance of distilled water its procurement, and availability of distillation assembly in the schools.

Status of availability of apparatus in chemistry laboratory

Availability of kip apparatus, volumetric flask, gas burner, and other common use apparatus were also find out in the sample schools through the laboratory description tool.

Table 5. Status of availability of apparatus in chemistry laboratory

S.N.	Physical facilities about	% YES	% No
1.	Availability of Spirit Lamp	37.03	62.96
2.	Availability of Gas Burner	25.92	74.07
3.	Availability of gas stove	51.85	48.15
4.	Availability of kerosene stove	07.41	92.59
5.	Availability of Volumetric flask	22.22	77.78
6.	Availability of Ignition tube	25.92	74.07
7.	Availability of Boiling tube	25.92	74.07
8.	Availability of capillary tube	51.85	48.14
9.	Availability of Measuring cylinder	85.19	14.81
10.	Availability of tripod stand	25.92	74.07
11.	Availability of Wire gauze	48.14	51.85
12.	Availability of Burette stand with clamp	74.07	25.92
13.	Availability of Kip Apparatus	100.00	0.0
14.	Availability of glass dropper	44.44	55.56
15.	Availability of plastic dropper	33.33	66.66
16.	Availability of Balance	22.22	77.77
17.	Availability of Glass rod	22.22	77.77
18.	Availability of Funnel	100.00	-

The findings revealed in the Table indicate that some apparatus like spirit lamp is found only in 37% of the sample while gas burner is found to be 25.92%. These data indicates that the basic things needed to the laboratory have not been procured. Other basic and an important apparatus volumetric flask are found only in 22.22% of the sample schools. In 85.19 % of the sample schools even measuring cylinder was not available, although kip apparatus is found in all the sample schools. Further observation revealed that glass dropper, plastic dropper although available in 44.44% and 33.33% respectively but their use is

doubtful. As indicated in the syllabus, in case the commercial teaching and learning resources are not available, the teacher should work with the students to collect or improvise alternative resources available in their environment. The availability of ignition tube only is 25.92% of the sample that show the importance of experiment using ignition tube. In the chemistry or any other practicals accuracy of results is very important hence a balance either digital/electronic should be available but unfortunately in 22.22% of the sample it was available. The data indicates that schools have poor laboratory facilities hence the data may affect to adequacy of teaching learning environment in the laboratory. Adequacy of laboratory facilities would certainly enhance the quality of learning in the laboratory and also interest towards the subject.

Laboratory provides a sufficient space for learners to work safely, with access to the full range of desired resources such as spirit lamp, gas burner, tripod stand, wire gauze, droppers and ignition tube but will also include the necessary services. State authorities and officials at all level of education department must ensure about the availability of adequate basic resources of the laboratory in the schools and also the subject teacher and principal of the school timely checked, complete the requirement process at the beginning of the session.

Status of availability of glassware's chemicals in chemistry laboratory

Practical exercises are normally conducted in a laboratory using of apparatus and chemical reagents, if a laboratory has sufficient chemicals and glassware's it creates a healthy atmosphere in the practical work, while performing experiments chemical theories can be re-interpreted or even replaced in light of new evidence and develop scientific interest among students. In the present study using the laboratory description tool investigator tried to find out the actual availability of chemicals and glassware's which is given in Table 6.

Table 6. Status of availability of chemicals in the laboratory

Quantity of chemicals present	
Sufficient as per the need	In sufficient
Ammonia Chloride	Ammonium Hydroxide
Benedict solution	Benzoic Acid
Barium Chloride	Bromine Water
Calcium chloride	Chloroform
Calcium Oxide	Calcium Carbonate
Copper Chloride	Calcium Hydroxide
Copper Nitrate	Ferric Chloride (Iron III Chloride)
Copper Sulphate	Iodine Crystals
Ferrous ammonium Sulphate	Iron Sulfide
Ferrous Sulphate (Iron II Sulphate)	Nickel Salts
Hydrochloric acid (concentrated)	Magnesium Carbonate
Lead Carbonate	Magnesium Ribbon
Lead Nitrate	Magnesium Sulphate
Litmus paper (blue & red)	Methylene orange
Manganese Dioxide	Oxalic acid
Nitric acid (concentrated)	Phenol
Potassium Permanganate	Phenolphthalein
Sodium Hydroxide	Potassium ferrocyanide
Sodium chloride	Salicylic acid
Sulfuric acid (concentrated)	Sodium Carbonate (anhydrous)
Zinc carbonate	Sodium Nitroprusside
Zinc Sulphate	Zinc Nitrate

As revealed from Table 6, some of the chemicals/reagent are available adequately. However, the important chemicals are found to be inadequate. In the present investigation it was also found that mostly in sample schools only those chemicals are found to be in adequate amounts which are generally used in qualitative inorganic analysis, titration and functional group identification. Mostly the solution is prepared in the laboratory as and when required. Students use them accordingly but lack of stock solution is observed. Chemicals/reagents used in the laboratory were stored either on top of the Table or in the Almirah. Some of the chemical/ reagent are available in the school laboratory but due to large number students' enrolment teaching resources including laboratories, equipment and chemicals are maintained inadequately. Some of the chemicals/reagents/ are not available in the laboratory as the chemistry teachers are very specific about conducting of some of the experiments only, while excluding other experiments. Almost in all the sample schools it was found that very selective practicals were chosen from the available syllabus at senior secondary level and only these practicals are being performed/ practiced by all the students. Authorities of state Government may provide sufficient chemicals to schools to strengthen experimental work leading to fruitful learning of the students. There may be separate fund allocation for the laboratory expenditure. Chemistry teacher may prepare a list of needed chemicals well in advance at the beginning of the session and ensure about availability of chemicals in time.

Number of periods for practicals and distribution of students

The data related to the number of batches and distributions of students in each batch were also taken by the project team and it indicates that the number of students in a batch varies to a large extent. The students were distributed in accordance to the total number of students enrolled for the class. Although preference have been given to class XII students for practicing the experiments. Mostly in all the sampled schools same kind of practicals were practiced but the number of practice session were different. Information pertaining to the number of periods allotted for the each practical was tried to obtain but the team could not succeed. In some of the observations teacher conducted 20 exercises for titration but in other case it was different. Class XI students were ignored while taking practicals classes. A group of students have informed to the team that they are not able to understand properly the concept/theory related to the practicals due to lack of time with regards to practicals.

Chemicals/glassware's access to the students

After visiting the labs of sample schools it was found that chemicals are easily accessible to the students while performing the experiments. 44.44% of the students reported that although they have facilities to access the chemicals, however, proper instruction regarding the use of chemicals and handling of glass wares is missing. A group of students also reported that there is a need of proper guidance and method of utilization of chemicals and it must be briefed in the laboratory for better proper understanding of the concepts related to the experiments.

ARRANGEMENT, CONDUCTING AND PLANNING OF PRACTICAL WORK DURING REGULAR CLASSES

Teacher perceptions

On asking, how the teacher explains the practical, it was found that 87.09% teachers simply explain the practical on blackboard, even the ones which are to be demonstrated. The data also revealed that all the experiments are carried out in groups, and the group members appreciated this, but at the same time they also expressed the need for individual attention in experiments like in qualitative inorganic analysis. The team had also enquired about timely completion of the experiments in the scheduled period of Time Table. 77.41% of the sample reported experiments related to titration, functional group identification completed timely but in case of radicals extra time is required. In the qualitative inorganic analysis two anions and two cations are identified in the given mixture of salt. The time duration for each of the period is 35 minutes means 70 minutes for the whole process of qualitative inorganic analysis. The students generally complete the identification of anions only; cations are identified in the next scheduled period on other day. Teaching methods that allow students to use hands, eyes, ears and mind in studying chemistry subject enhance

effective learning and students' achieve more than the teacher centered methods.

Students' Perceptions

The data was also collected from 405 students to know more about the conduction, arrangement and planning of the practical work. The size of the group is too large therefore; other students are not able to pay attention to the task. Furthermore, findings revealed that when teacher demonstration was done in the overcrowded class, due to small laboratory space, students who sit in front desks near the teacher's Table benefited much while those at the back got problems in observing and understanding the procedures and hence fail to comprehend the concepts and topic in general. 74.13% of the students indicated that although they have gone through the practicals, they are not confident enough in doing them because of the time management during conduction of practicals. A group of students also reported that most of the instruction of the concerned practicals given by the teacher only at once before commencement of the practicals. There is need to synthesis each aspect of the practical during the practical work so that they can understand the theoretical as well as practical concepts in linked way. All the students of these schools do not have any lab apron while performing the practicals in chemistry laboratory. With regard to the pre and post lab discussion, the data indicates that the entire group of students do not verify the results from the teacher for all the experiments performed by them. These data reflects a serious issue in conduction of the practicals. With regard to naming the chemicals, most of the students write only the names of pipette, burette and chemicals used in the titration. Neither for qualitative Inorganic analysis nor for detection of functional group almost all the students do not have any name in their mind.

Explanation of the distribution of periods for experiments

The team inquired about the number of periods consumed for each type of experiments and the responses are found to mix in the sense that no particular time has been allotted to each kind of the experiments. Most of the teacher reported that they neither have any time frame to complete the particular kind of experiment nor it was required. Proper schedule for the number of periods allotted to a particular type of experiment is not maintained by most of the teachers of the sample schools. In whole study of the collection of data it was also found that for each type of experiment, all the sample teachers mentioned number of required periods differently.

Involvement of students in practical work

A question was asked about the students' involvement in performing different experiments in the laboratory and the response of the students is given in Table 7, reflected in Figure 1.

Table 7. Skills obtained during performing experiments

S.N	Obtained Skills by the Students'	Percentage for different experiments		
		Titration	Mixture analysis	Detection of functional group
1	Abilities of observation	58.06	45.16	45.16
2	Abilities of communications	51.61	61.29	51.61
3	Writing of practicals in records	58.06	67.74	64.51
4	Abilities to classify	58.06	54.83	45.16
5	Abilities of measurement	61.29	48.38	41.93

The data revealed that ability of observation is 58.06% in titration experiment is more as compared to mixture analysis and detection of functional group. The ability of communication skills was found to be 61.29% this indicates predominance in case of mixture analysis. The data also reflects about writing skills of practicals in record for mixture analysis for about 67.74% hence number of students is basically just tries to complete the record irrespective of doing the experiment. The data also indicates that 58.06% of students are having much ability to classify the results of titration only.

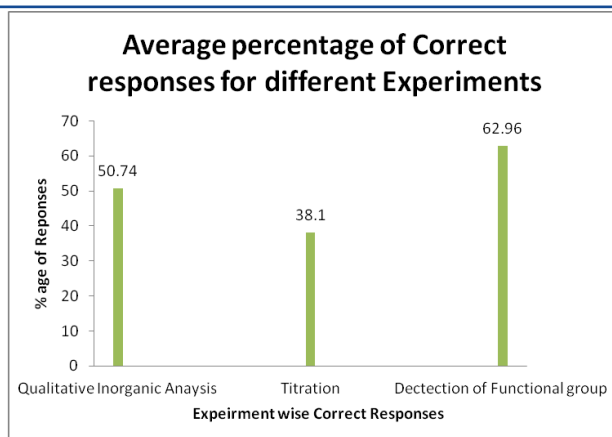


Figure 1. Showing average percentage of correct responses for different

The ability of measurement was found to be 61.29% which more in case of titration. Observing all the data we can infer that more emphasis was given for the titration experiments this indicates the negligence towards other important experiments. In view of the experiments conducted at this level the mixture analysis needs more observation skill. All the skills should be incorporated while conducting of the practicals and adequate emphasis should be provided for each kind of practicals.

Checking of practical records

The data was also collected to know about the regular checking of practical records of each student. Although around 80.64% of the teachers reported that usually they check the practical record of the students before commencement of the next practicals but neither students nor teacher mentioned any date on experiment or during signing for the same. It reflects that there should be closely monitoring is required from the Head of the school 60.34% of the students reported that during the practical classes generally teacher used to conduct theoretical lectures and practicals classes mostly engaged from the month of October to December while 39.64% students reported that they have practicals in guidance of lab staff.

Frequency of the laboratory visits

The data was also collected about the visits of students to the chemistry laboratory for regular practices of practicals. While 40.88% of the students reported that they visit the chemistry lab for two times in week while 27.09% students reported it for one time. These two contradictory statements of students create lot of confusion regarding visit for conduction of practicals.

Achievement test results

To know more about the procedural part adopted by the schools of Rajasthan state an achievement test was also conducted comprises the basic syllabi from senior secondary level Qualitative Inorganic analysis, Titration and detection of functional group in given organic compounds. Total number of 20 objective questions was framed from all the three areas keeping all the aspects of practicals. The students' responses were recorded and tabulated and analyzed as shown in Figure 2.

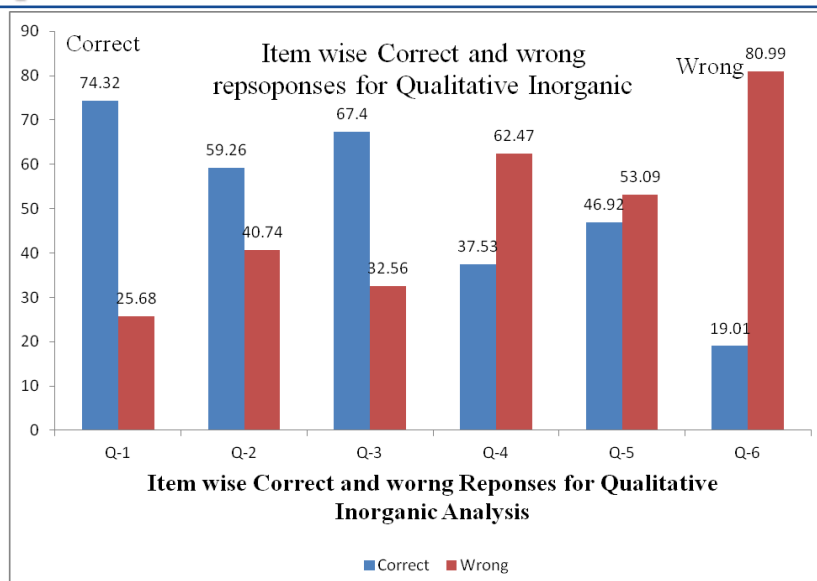


Figure 2. Item wise responses for qualitative inorganic analysis.

Qualitative inorganic analysis

The syllabus prescribed by the Board of Secondary Education, Rajasthan at senior secondary level includes in Qualitative Inorganic analysis is identification of two cations and two anions from a given salt mixture. Conducting of qualitative inorganic analysis experiments at senior secondary level allow students to have implicit knowledge or the phenomena, handling of reagents & apparatus and to build up evidence of the phenomena. Students can apply what they have learnt by planning, executing and evaluating experiments to identify unknown samples. Although in syllabus following radicals/ cations and anions are given.

Acidic radical:

CO_3^{2-} , CH_3COO^- , NO_2^- , S^{2-} , SO_3^{2-} , Cl^- , Br^- , I^- , NO_3^- , $\text{C}_2\text{O}_4^{2-}$, SO_4^{2-} , PO_4^{3-}

Basic radical:

Ag^+ , Pb^{2+} , Bi^{2+} , Cd^{2+} , Cu^{2+} , Sb^{2+} , As^{3+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Co^{2+} , Mn^{2+} , Zn^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+} , NH_4^+

Although there is provision for teacher to include all the variety of salt. The details of the practical syllabi for classes XI and XII are given in Tables 8 and 9.

Table 8. Details of chemistry syllabi practical prescribed by the board for class XI.

S.N.	Name of the Experiments	Allotted marks
1.	Experiments based on pH	02
2.	Qualitative Estimation	04
3.	Quantitative Estimation	06
4.	Element detection in Organic Compounds	03
5.	Project work	04
6.	Characterization and purification of Chemicals	03
7.	Purity of edibles	02
8.	Record	04
9.	Viva	02
	Total	30

Table 9. Details of chemistry syllabi practical prescribed by the board for class XII.

S.N.	Name of the Experiment	Allotted marks
1.	Volumetric Titration	11
2.	Inorganic salt mixture: qualitative Analysis (Two cations and Two anions)	08
3.	Detection of functional group or preparation of Inorganic/organic compounds or Identification of Carbohydrates, fats and protein in Food products	04
4.	Subject based questions	03
5.	Record	02
6.	Viva-Voce	02
Total		30

In the achievement test total 06 questions were framed for Qualitative inorganic analysis. Out of 20 items and results were analyzed. Table 10 and Figure 3 gives the details.

Table 10. Items wise responses of students for qualitative inorganic analysis.

S.N.	Item	Percentage Responses	
		Correct	Wrong
1	When a small amount of a salt is heated with a few drops of ethanol and a concentration of Conc.H ₂ SO ₄ and added to water, a fruit-like aroma is obtained, which indicates the presence of which of the following ions? a) acetate b) carbonate c) sulphate d) nitrate	74.32	25.67
2	In the qualitative test of nitrate ion (NO ₃ ⁻), aqueous solutions of nitrate salts and equal volumes of ferrous sulphate are mixed and then a small amount of concentrated sulfuric acid is carefully poured across the wall of the test tube. The name of this test is: a) Chromyl chloride test b) Nessler test c) brown ring test d) diphenylamine test	59.25	40.74
3	Which of the following are zero group cations? a) NH ₄ ⁺ b) Al ³⁺ c) Pb ²⁺ d) Mg ²⁺	67.40	32.59
4	In ash test, the color of C or C salts is blue. This blue color is due to the formation of: a) double oxides of Al or Co, b) oxides of Al or Co, c) nitrates of Al or Co d) hydrides of Al or Co	37.53	62.46
5	The cation of IV group in qualitative analysis is- a) Pb ²⁺ b) Al ³⁺ c) Zn ²⁺ d) Ba ²⁺	46.91	53.08
6	What is the color of the flame of salt containing barium? a) red like brick b) green like apple c) crimson red d) yellow	19.01	80.98
Average		50.74	49.25

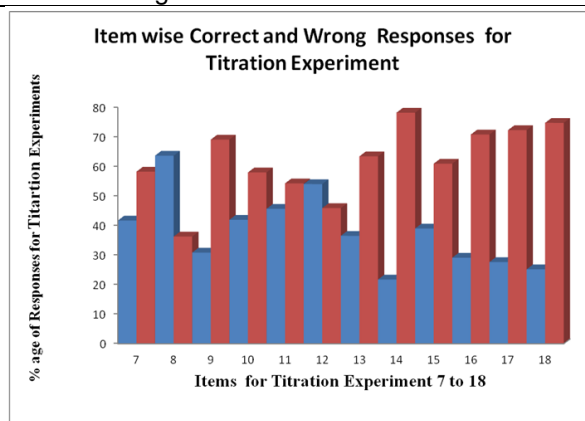


Figure 3. Item wise correct and and wrong responses for titration.

In the qualitative inorganic analysis as mentioned in the Table 10 questions were asked. The data in the Table 10 reflects that the average percentage of correct responses was 50.74 %. Moreover students are not much familiar about the actual procedure involved for analysis of salt mixture. The students also raised the issue related to the lack of understanding of use of suitable reagent for the right choice. Many students did not realize that the procedures and the reagents used could indicate which gases might be evolved during the process. Hence, they randomly tested for the gases specified in the syllabus. A group of students also informed that they were not aware about the linkage between procedure and problems in making inferences from their results. The students had already learned the reactions involved in Qualitative Analysis in the chapters of theory paper in the portion related to "Reactivity of Metals" and "Periodicity," but it seemed that they were unable to link what they were doing in the Qualitative Analysis practical work with the theory that they were taught in the classroom.

Titration

Considering all the important aspect of the chemistry the questions were also asked about the concept of titration. The discussion with the teachers indicates that most of the time of chemistry practical classes devoted to titration. In class XI mainly the experiment includes to determine the molarity of a solution of unknown concentration by combining it with a reactant of known molarity while in class XII mainly redox titrations have been discussed. Total 12 questions were designed in the questionnaire and the items wise details of correct and wrong responses are given in the Table 11.

Table 11. Items wise responses of students for qualitative inorganic analysis

S.N.	Item	Percentage Responses	
		Correct	Wrong
1.	The formula for calculating the equivalent mass of an acid is: Equivalent mass = molar mass/basicity The equivalent mass of H ₂ SO ₄ will be? a) 98 b) 49 c) 1 d) 196	41.72	58.27
2.	What do you understand by standard solution? a) the solution prepared by the teacher b) a solution of known concentration c) Solutions in which maximum dissolved substance is dissolved. d) A solution in which at least the dissolved substance is dissolved.	63.70	36.29
3.	What will be the color of phenolphthalein in acidic medium? a) pink b) colorless c) orange d) brick red	30.86	69.13
4.	Which solution is usually taken in burette in acid-base titration? a) acid) b) alkali) c) acid with indicator d) base with indicator	41.97	58.02
5.	The chemical formula of Peacock salt is- a) (NH ₄) ₂ Fe (SO ₄) ₂ .6H ₂ O b) (NH ₄) ₂ Fe (SO ₄) ₂ .12H ₂ O c) (NH ₄) ₂ Fe (SO ₄) ₂ .18H ₂ O d) (NH ₄) ₂ Fe (SO ₄) ₂ .24H ₂ O	45.67	54.32
6.	Which indicator is commonly used in permanganometric titration? a) methyl orange b) phenolphthalein c) methyl orange or phenolphthalein d) itself	54.07	45.93
7.	Which indicator is commonly used in the titration of weak acids and strong bases.	36.55	63.45

	a) phenol red b) phenolphthalein c) methyl orange d) litmus solution		
8.	The correct way is to take the reading of colored solutions in the burette while performing the titration. a) looking at the upper meniscus b) seeing the lower meniscus c) Average of upper and lower meniscus d) None of the above	21.73	78.27
9.	The relevant reading in the titration is considered to be: a) Average value of concordant reading b) any two equal values of the readings taken c) two consecutive identical values in the readings taken d) Out of the concordant reading	39.02	60.98
10	What do you understand, in principle, by the end point (the quadratic) in a titration? A) The reaction is completed at this point. B) The color change takes place at this point. c) the completion of the reaction	29.14	70.86
11	20 N of the solution at 0.5 g is added to 100mL of water in a standard flask. What is the normality of the solution in a standard flask? a) 1 g b) 2 g c) 0.1 g) 0.5 g	27.65	72.35
12	The amount of volume is needed to make 100 mL of 0.1 g of volume will be: a) 0.4g b) 40g) 0.04g) 4g	25.19	74.81
Average		38.10	61.90

The data revealed that although much of time was spent in the titration but the average comes out to be 38.10% which is very low as far as importance is concerned. The main basis in process of titration is to prepare a known concentration solution either in Normality or Molarity but the data indicates that only 41.72% of the sample students know about Equivalent weight concept correctly.

Indicators play an important role in the titration but only 30.86% of the sample having knowledge about the color change of Phenolphthalein and shows different color in acid and base. There is meaning of upper and lower meniscus in the observing the reading from Burette. Surprisingly only 21.73% of sample students clearly know about meaning of meniscus in case of color and colorless solutions. A group of students also informed to team, although they have used Burette and Pipette in the lab, why a particular solution has been taken through Pipette and other one from Burette they have no idea. This is an important point to be noted.

The detection of end point in any titration having meaning surprisingly only 29.14% students are able to answer the meaning of end point. While, 27.65% of the students know about the preparation and use of standardize solution in the titration, a group of students report that they have idea about titration experiments but could not understand in details about accurate calculations of volumes of solutions. All the findings about the titration show a negative judgment about the procedural part of the titration in the chemistry laboratory of senior secondary sample schools. Although while conducting the experiment much time was spent during the session but results indicates the lack of knowledge about the experiment. Most of the time the results in the form of value have not been verified and tally with peer groups. Teachers and students both are having an impression that once they read the value and write the calculations their work gets over for the experiments. The data obtained were not discussed in details in the light of experiments. The data also indicates that teachers and students are not much serious about the experimental part of titration and simultaneously the students are not acquiring the skills of weighing, solubility, accuracy and standardization. Procedural understanding about the experiments and concepts of laboratory practices develops perceptions about the laboratory work and creates temporal constraints amongst students' behavior.

Detection of functional group

In the class XII detection of functional group or preparation of Inorganic/organic compounds or Identification of Carbohydrates, fats and protein in Food products was also included for four marks. Although different experiments have been suggested in most of the schools only detection of functional group have been practiced. Detection of functional group experiment develops skills of observation, solubility, and nature of organic compounds and detection of extra elements present in the given organic

compound. The data is given in Table 12.

Table 12. Item wise responses for detection of functional group

S.N.	Item	Percentage Responses	
		Correct	Wrong
1.	You have been given an organic substance, which smells like fish. What are your initial guesses about this substance? a) The substance may be carboxylic acid b) The substance can be an ester. c) The substance can be an amine. d) The substance may be alcohol.	53.33	46.66
2.	-COOH is a functional group a) ester b) carboxylic acid c) aldehyde d) ketone	72.59	27.4

The data reveal that it is quite good percentage as compared to other experiments. About 53% of the students were able to identify the smell of given compound and more than 72% of the students clearly able to identify the representation of carboxylic acid functional group. This is a significant indication about the learning of functional group chemistry however, not much time was spent on these exercises.

CONCLUSION

Based on the discussion of the results on the use of the survey of the chemistry laboratory in selected schools we observed that chemistry labs should be supported with Human resources such as Lab staff, Lab boy and the school principals must be aware about the laboratory capacity and number of students enrolled in the science stream. The subject teacher must plan for practicals in advance and proper documentation should be workout for execution of laboratory practice. The authorities must take care about availability of safety equipments in the laboratory as well in school. Students must be enabled to develop an understanding of the principles of chemical safety, first aid box and to enable them to apply these concepts when working in the laboratory. The use of distilled water should be a common and mandatory condition for all the laboratory work. State authorities and officials at all level of education department must ensure about the availability of adequate basic needs and resources of the laboratory in the schools and also the subject teacher and principal of the school needs timely to check to complete the requirement process at the beginning of the session. State authorities should plan in-service training program periodically for teachers including, all aspects of teachers' professional development incorporating the need based practical work. Teachers should also go through the innovativeness way of learning and need to keep themselves updated.

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