ASSESSMENT OF SCIENCE LABORATORY EXPERIMENTS (PHYSICS, CHEMISTRY, AND BIOLOGY) IN INCULCATING SCIENCE PROCESS SKILLS AT THE HIGHER SECONDARY LEVEL.

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The present research aimed to study the significance of science laboratory experiments in inculcating science process skills at the higher secondary level. Science laboratories play a very vital role in understanding the concept of science to students. Coordination of theory with practical is significant for corroborating concepts and stimulating interest in students' minds. Moreover, when the students handle the equipment themselves, it gives a more profound understanding. The researcher used the survey method for the collection of data. The research tools, i.e., science process skill tests for each physics, chemistry, and biology, were designed and implemented to understand the ground reality. Each process skill in Science (physics, chemistry, and biology) for a particular experiment is assessed by a five-point scale. The process skills are assessed as (i) Beginning stage, (ii) Foundation stage, (iii) Developing stage, (iv)Accomplished stage, and (v) Proficient stage. The scores given for the stages are 1,2,3,4 and 5, respectively. The mean of the process skill test in biology, physics, and chemistry was 11.18. The standard deviation of the scores was 4.459.

Keywords: Science process skills, science laboratory, equipment, schools.

Introduction

Laboratory work can be categorised as a learning resource for science and technology as it runs on the principle of 'learning by doing' and a constructive approach. Performing experiments by themselves or observing the experiments being performed in front of them provides an upper hand experience to students. Laboratory work helps in the development of (i) understanding the nature of science, (ii) building a scientific attitude, (iii) cognitive abilities, and (iv) enhancement of science process skills. *Shahali et al. (2017)* argue that different teachers' knowledge of science process skills is different based on their teaching experiences. Laboratory work allows the teachers to inculcate science process skills, namely, observation and classification skills, inference skills, and communication skills. Lunetta, Hofstein and Clough (2007) explain that the natural sciences' knowledge is constructed to explain objects, phenomena, and their interactions in the natural world. With time, scientific ideas or concepts become connected by wider-ranging theories, and especially since the resurgence, new knowledge and understanding have developed through continual, dynamic interaction between scientific theories, research, and experimental data. Fraiser, McRobbie and Giddings, 1993, conclude that learning science requires many skills; the most crucial are problem-solving, keen observation, drawing, labelling, generation of ideas, and creativity. Higher secondary science education focuses on eliminating the abstractness of science built-in students who come from a junior level. Handling equipment and performing experiments individually also make the students sound in scientific concepts. Weinberg (1962) argues that the laboratory approaches can be inductive and deductive. In the inductive approach, first-hand experience is given priority, and then students get to learn the theoretical concept. In the deductive approach, the theoretical aspect is explained then the practical is performed.

Methodology

The research was intended to study the assessment of science laboratory experiments (physics, chemistry, and biology) in inculcating science process skills at the higher secondary level. Hence, the survey method was used to research the ground reality. A science process skill test was designed for each Physics, Chemistry, and Biology, and the related skills were scored. The study sample consisted of 11 higher secondary schools of Delhi NCR. The research intended to depict the science laboratory experiences of higher secondary school students and to analyse the difficulties faced by the teachers and students in using science laboratories in the higher secondary schools. In order to attain this objective, we have developed some tools that were discussed and prepared with the experts in a workshop conducted at NIE, New Delhi, from 30 July into 3 August 2018.

The tools used for the study are:

- A questionnaire for each—Physics, Chemistry, and Biology on utilisation of science in learning science (physics, chemistry, biology, respectively) in higher secondary schools of Delhi NCR.
- A classroom observation schedule to observe science laboratories for all the three laboratories— Physics, Chemistry, and Biology.
- A Science process skill test for Physics, Chemistry, and Biology each.

How do these tools help in achieving the objectives of this research?

(i) The questionnaires were prepared to know students' and teachers' difficulties using science laboratories.

(ii) A questionnaire was prepared on the utilisation of science laboratories in learning science.

(iii) The current approach in science teaching is that science should be taught not as unalterable facts, theories, and principles but the teaching of various scientific methods, scientific thinking, and critical thinking to describe various science skills; these skills form the essential qualities of a good scientist, according to AAAS (American Association for the Advancement of Science). Hence we have prepared Classroom Observation Schedule based on science process skills which included (1) Observing skills, (2) Inferring skills, (3) Measuring skills, (4) Communicating skills, and (5) Classifying skills.

Science Process Skill Test

Science process skills are classified as basic skills and integrated skills. These skills can be accessed by applying them to a series of laboratory activities.

Observation means the action or process of closely observing or monitoring something or someone and using your senses to gather information about an object or event. It is a description of what was actually perceived. This information is considered qualitative data. This skill was tested in experiments like recording zero error signs and studying cardiac muscle characters. In these experiments, high observing power is required to observe cardiac muscle characteristics, and one should have excellent observation skills.

Measuring is using standard measures or estimations to describe specific dimensions of an object or event. This information is considered quantitative data. This skill was tested in experiments like determining the least count of measuring devices, recording measurements in proper units, time taken vs colour change (salivary amylase reaction). In these experiments, like in measuring most minor counts, one should have a reasonable estimation of measuring dimensions of the particular device. Hence, we can test measuring skills through these experiments.

Inferring is formulating assumptions or possible explanations based upon observations. This skill was tested in experiments like inferences drawn based on colour change of indicators, plotting graph between current and potential difference, and interpreting the graph. For example, in these experiments, like in the titrations, one should possess the skill to infer whether the given solution is acidic or basic. Hence we can test inferring skills through these experiments.

Classifying is grouping or ordering objects or events into categories based upon characteristics or defined criteria. This skill was tested in experiments like studying different types of epithelial/ muscle/ cartilage/ tissues and their distinguishing features, classifying anions and cations into various groups. In these experiments, one should be able to classify the given information correctly as NH4+ will come under zero group; similarly, other cations and anions can also be classified in their respective groups. Hence we can test classifying skills through these experiments.

Communicating is using words, symbols, or graphics to describe an object, action, or event. This skill was tested in experiments like computing the focal length of the convex mirror and interpreting the graph to determine the minimum angle of deviation. Chemicals and apparatus used in the experiment were appropriately listed. Students can perform these experiments by exhibiting good communicating skills.

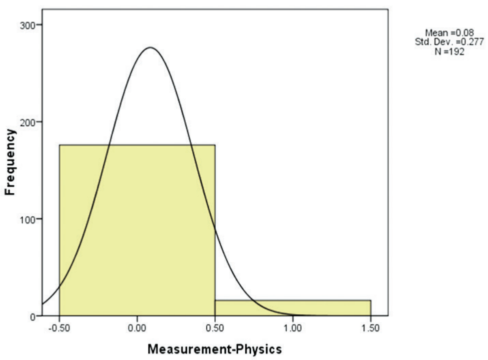
The process skills selected for assessment are:

(a) Observation
(b) Classification
(c) Communication
(d) Measurement
(e) Inference

Each process skill in science (Physics, Chemistry, and Biology) for a particular experiment is assessed by a five-point scale. The process skills are assessed as (i) Beginning stage, (ii) Foundation as stage, (iii) Developing stage, (iv) Accomplished stage, and (v) Proficient stage. The scores given for the stages are 1, 2, 3, 4, and 5, respectively.

Data Interpretation and Analysis

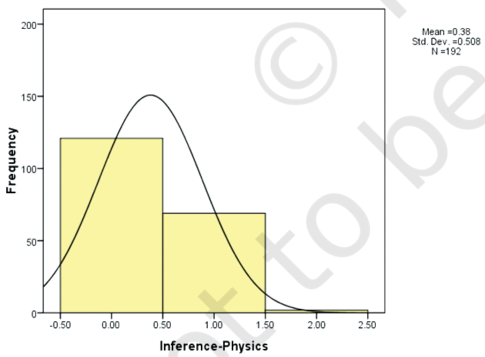
Measurement Skill of Students in Physics



Graph 1: Measurement Skill of Students in Physics

From Graph 1, it is clear that the mean of the process skill test in physics (process skill-measurement) is 0.08. The standard deviation of the scores is 0.277.

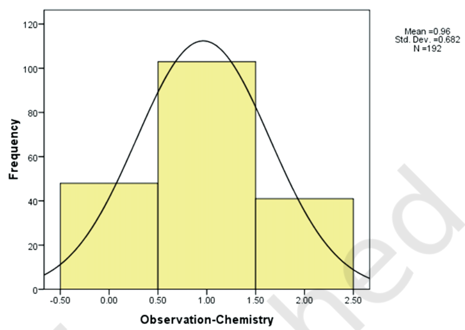
Inference Skill of Students in Physics



Graph 2: Inference Skill of Students in Physics

From Graph 2, it is clear that the mean of the process skill test in physics (process skill-inference) is 0.38. The standard deviation of the scores is 0.508.

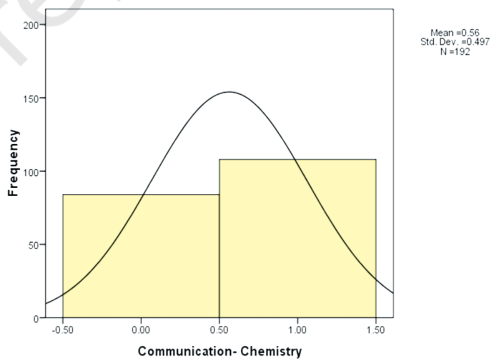
Observation Skill of Students in Chemistry



Graph 3: Observation Skill of Students in Chemistry

From Graph 3, it is clear that the mean of the process skill test in chemistry (process skill-observation) is 0.96. The standard deviation of the scores is 0.682.

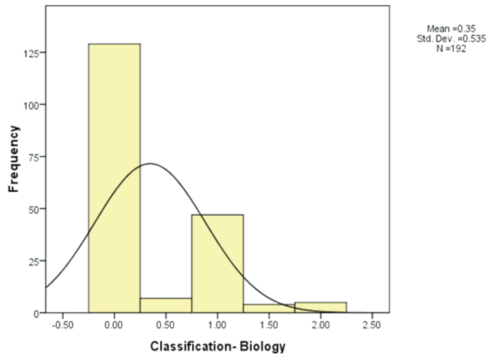
Communication Skill of Students in Chemistry



Graph4: Communication Skill of Students in Chemistry

From Graph 4, it is clear that the mean of the process skill test in chemistry (process skill-communication) is 0.56. The standard deviation of the scores is 0.497.

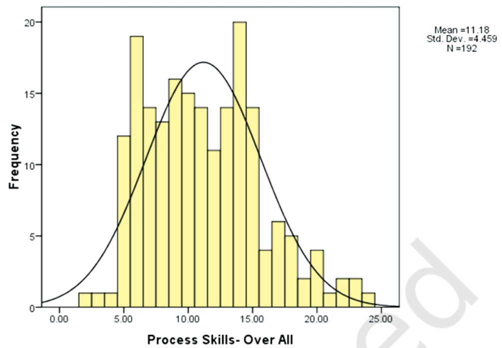
Classification Skill of Students in Biology



Graph 5: Classification Skill of Students in Biology

From the above graph, it is clear that the mean of the process skill test in Biology (process skill-classification) is 0.35. The standard deviation of the scores is 0.535.

Science Process Skill-Overall



Graph 6: Science Process Skill-Overall

From Graph 6, it is clear that the mean of the process skill test in Biology, Physics, and Chemistry is 11.18. The standard deviation of the scores is 4.459.

Table 1: Science Process Skill Test Result

Science Process Skill Test Result					
		Process Skills in Chemistry	Process Skills in Physics	Process Skills in Biology	Process Skills- Over All
N	Valid	192	192	192	192
	Missing	0	0	0	0
Mean		4.44	4.22	3.78	11.18
Std. Deviation		2.02	1.72	1.69	4.46
Variance		4.09	2.95	2.86	19.88
Skewness		-.05	-.02	1.14	.49
Std. Error of Skewness		.18	.18	.175	.18
Kurtosis		-.22	-.60	1.83	-.18
Std. Error of Kurtosis		.35	.35	.35	.35

From the above table, it is evident that the mean scores of 100 students in the process skill test in Chemistry, Physics, and Biology are 4.44, 4.22, and 3.78, respectively, while the standard deviation of the scores is 2.02, 1.72, and 1.69. The skewness of the three scores is -.05, -.02, and 1.14, respectively, which shows that the scores form a normal curve. The kurtosis values of the scores are -.22, -.60, and 1.83, which also proves that the curve is almost normal. The table also shows that the mean score of 100 students in the process skill test, when all the three subjects taken together is 11.18, and the standard deviation is 4.46. The skewness is 0.49, and kurtosis is -.18, which shows that the scores almost follow a normal curve.

Result and Discussion

Regarding the science process skills in Biology, 59.7 per cent of students belonged to the average category, 8.9 students scored low, and 31.4 high. In case of Physics, 76.4 percent of students belonged to the average category, 15.2 students scored low in science process skills, and 8.4 in the high category. In Chemistry, 83.2 percent of students belonged to the average category, 5.8 percent scored low, and 11 percent in the high category.

As the current study was based on the significance of science laboratories in the execution of science process skills at the higher secondary level, it has been established that coordination of theory with practicals is significant for validating concepts and stimulating interest in students' minds. When the students handle the equipment themselves, it gives a deeper understanding. Therefore, there should be proper coordination between theory and practical. When they run parallel to each other, it is helpful in better understanding of the science concepts.

Inference

From the results obtained, we infer the following:

- First, it is observed that nearly all the schools have adequate infrastructure to carry out Physics, Chemistry, and Biology experiments in their laboratories. They had judicious working space, flooring, water supply, ventilation, provision of waste disposal, and electrical connectivity.
- It can be concluded that nearly all the schools under study provided sufficient safety measures for carrying out the experiments in their Physics, Chemistry, and Biology laboratories.
- The study showed that for teaching and dissemination, all the schools under study relied upon blackboard, books, and manuals as teaching aids, and more than half of the schools used e-resources for demonstrating the experiments. Also, more than one-third of the teachers demonstrated the experiments before the practical.
- A limited number of schools made efforts to educate the students about the signs and symbols related to laboratory safety of chemical bottles or any other place.
- Teachers faced difficulty demonstrating biology experiments such as DNA extraction and Salivary Amylase activity due to lack of apparatus. In addition, untrained laboratory staff was also appointed in some schools, and the majority of the staff were not proficient in using the available e-resources.

- Students faced difficulty in performing practicals such as drawing the characteristic curve of the Zener diode and determining its reverse breakdown voltage, finding the focal length of a convex lens by plotting graphs between u and v or between 1/u and 1/v, etc.

Suggestions for teachers and educational planners:

- Information and Communications Technology (ICT) tools should be present in the laboratories. Lack of ICT tools was observed in the schools due to which the teachers were not able to use audio-video materials during practical sessions.
- The laboratory assistants should be given yearly in-service courses to update themselves according to the new techniques in the laboratory.
- There should be proper coordination between theory and practical. When they run parallel to each other, it is helpful in better understanding the science concepts.
- As observed in schools, the equipment was not sufficient for each student to perform the practicals individually, and it is indispensable to have sufficient apparatus and chemicals in providing first-hand experience to the students.
- Schools should have facilities for children with special needs (CWSN) to get good laboratory experiences, ensure better learning of science concepts, and develop science process skills among the students.

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