MIZORAM UNIVERSITY JOURNAL OF HUMANITIES & SOCIAL SCIENCES
A Refereed Bi-annual Journal
ISSN(P): 2395-7352
eISSN: 2581-6780
Vol. IX, Issue 2 (December 2023) http://www.mzuhssjournal.in/

Competence of High School Science Teachers on Teaching of Science Process Skills

Lalthaduha*
Nitu Kaur†

Abstract

Science is more of a process than product. Science process skills are fundamental in fostering scientific inquiry and critical thinking among students, yet their effective integration into classroom instruction remains a significant challenge. This study delves into the effectiveness of high school science teachers in teaching science process skills across five distinct districts in Mizoram. The research encompasses a total sample of 32 teachers and involves the development of a tool to identify Basic and Integrated Science Process Skills. Additionally, it evaluates the teachers' comprehension of these skills and examines their instructional practices, drawing insights from prior studies in this field. The analysis also explores the contextual factors influencing the teachers' approaches to teaching science process skills. This study also suggests areas for improvement in teaching science process skills by identifying some fundamental needs.

Keywords*: Competence, Science Process Skills, Teaching, High School Science Teacher.*

Introduction

In the realm of science education, the acquisition and application of Science Process Skills (SPS) play a pivotal role in fostering scientific literacy and critical thinking among students. As educators strive to equip the next generation with the necessary tools to thrive in an increasingly complex world, the cultivation of these skills takes precedence. Developing students' skills in scientific thinking and scientific methods is one of the main goals of education in the modern day. In their science curricula, many countries have recently prioritized scientific thinking and scientific process skills from elementary school through university. Science process skills should be taught to all students since they are the cornerstone of fostering critical and creative thinking in children (Houtz, 2008). As a result,

*Research Assistant, ICSSR Major Project 2023-25, Department of Education, Mizoram University, Aizawl, Mizoram, India.
†Assistant Professor, Project Director, ICSSR Major Project 2023-25, Department of Education, Mizoram University, Aizawl, Mizoram, India. Email: nitukaurmzu@mzu.edu.in

educators especially those who teach science need to inform students and evaluate their understanding of these scientific skills.

Students develop science process skills as they do scientific investigations, hence these skills must be included in the learning assessment as well. Science Process Skills refer to cognitive processes or thinking processes pupils need to develop in order to learn science. They are a reflection of the methods used by scientists in producing comprehensive information about science such as product, attitude, process, and application dimensions (Rosana et al., 2020). The products of science learning are produced through the application of process skills in learning either classroom or laboratory. Process skills that are more often used and emphasized by students in studying science and scientists in problem-solving are called process skills in science. Components of scientific attitudes are grown in process skill-science based learning, including responsibility, curiosity, honesty, openness, objective, creativity, tolerance, work accuracy, self-confidence, and so on, related to scientific attitudes. The component that is taught in learning is the scientific method in experimenting or investigating as scientists in the field of science. Science-A Process Approach, SAPA (AAAS, 1971) classifies science process skills into two groups; first, Basic Science Process Skills consists of observing, inferring, measuring, communicating, classifying, and predicting. Second, integrated science process skills consist of controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Bell, 2008; Sheeba, 2013; Sermsirikarnjana et al., 2017). Basic process abilities include the capacity to lay the foundation for learning and mastering integrated science process skills.

Effective teaching of science process skills not only facilitates deeper understanding of scientific concepts but also empowers students to actively engage in the scientific process. By incorporating hands-on activities, inquiry-based learning approaches, and real-world applications, high school science teachers in Mizoram can create dynamic learning experiences that resonate with students' experiences and cultural backgrounds. Furthermore, the integration of science process skills aligns with contemporary educational frameworks that emphasize student-cantered and experiential learning. Through authentic experiences in scientific inquiry, students develop not only disciplinary knowledge but also crucial transferable skills such as critical thinking, collaboration, and information literacy.

Teachers often prioritize students' learning outcomes, particularly in the cognitive domain, over their experiential processes. The prevailing assumption is that when more students achieve high learning outcomes, they have succeeded and comprehended the material well. However, it's crucial to acknowledge that learning success isn't solely determined by the results attained but also by the processes involved. Therefore, teachers must understand these skills to effectively teach them to students. By raising awareness among high school science teachers about students' process skills, comprehensive evaluation can be conducted, leading to valuable suggestions for students' future improvement. With this aim in mind, the researcher took up this study.

Statement of the Problem

According to the Nationally Identified Desired Learning Outcome at the Secondary Stage by NCERT, 2019, “Science is being taken as one of the core subjects in the secondary school curriculum.” The document emphasize on a set of learning outcome that reiterates the emphasis on the process part of science more than the product orientated science learning. Also, the emphasis is to be targeted to all the three domains of sciences i.e., the content, processes and attitude, targeting the cognitive, conative (psycho-motor) and affective domain equally. Science can't be learned until students infuse their thought and action.

In the context of high school science education in Mizoram, there exists a significant oversight regarding the assessment and awareness of science process skills among both teachers and students. Unlike other essential educational components, the explicit measurement and incorporation of these skills into the curriculum have been lacking. The current state of affairs underscores the need for a comprehensive examination of the level of competence among high school science teachers regarding science process skills. By gaining insights into teachers' understanding and perceptions of these skills, it becomes possible to identify areas of deficiency or misconception that may impede their integration into instructional practices.

Objectives of the Study

a) To find out the competence level of high school science teachers in teaching of science process skills in terms its identification and working knowledge.
b) To find out the relation between competencies in identification of science process skills and working knowledge of science process skills amongst the high school science teachers.

Delimitations of the Study

The present study has following delimitations:

a) Due to limited time, the present study has been delimited to five Districts of Mizoram i.e., Aizawl, Khawzawl, Siaha, Serchhip & Kolasib from where high school science teachers were sampled.
b) High school teachers working in state government and private unaided school only formed the sample of the present study.

Method of Study

The present study employed “Descriptive Survey Method”. The study is mainly of quantitative nature.

Population and Sample

The population of present study comprises of all the high school (IX-X) science teachers teaching in Mizoram. According to Annual Publication (2017-18) data from the Department of School Education Mizoram there are 324 high school science teachers in Government and Private High Schools. The sample comprises of 32 high school science teachers from the five districts i.e., Aizawl, Khawzawl, Siaha, Serchhip & Kolasib selected from the west, east, central, south and north of Mizoram respectively.

Sampling Technique

Stratified random sampling was employed for the purpose of data collection with government and private school being the two strata of the population.

Tool for Data Collection

For Collection of Data no suitable tool to find out the competency of high school science teachers on teaching of Science Process Skills (SPS) was found. Hence the researcher decided to self-construct a tool. For this purpose, a tool for identification of Basic and Integrated Science Process Skills and assessment of working knowledge of science process skills was made, taking idea from some studies conducted in this area. Based on the review of related literature both abilities to identify basic and integrated process skills and ability to apply them while teaching science has been taken as the two dimensions to determine the competency level of science teachers. The first draft of tool comprised of 20 items under both identification and working knowledge. The test was validated through five experts from the field of Higher Education Sciences (Physical and Life Sciences) using the expert construct validity. The final validated draft of the tool comprised of 14 items and 20 items respectively for identification and working knowledge sub sections of the tool, thus comprising of 34 items altogether. The Coefficient of Cronbach's alpha was calculated at this stage of tool construction to measure the internal consistency of the constructed items, which is best measure for MCQ type test items. The Cronbach's alpha was calculated separately for the two sub sections of the tool. The Cronbach's alpha for the SPS Identification items SPS working knowledge items was found to be 0.59 and 0.76, both of which are very acceptable measures to call the tool internally consistent and reliable. Further on being subjected to item analysis 3 items were discarded from the working knowledge sub sectionof the tool on the basis of difficulty value and discriminatory indices, thus making a total of 31 items. Table 1 and Table 2 lists out the item difficulty and discriminatory indices of the two sub-sections. The sampled teachers were grouped into three groups comprising of top 27% of high scorers as upper group (9 teachers) and 27% of bottom scorers as lower group (9 teachers) and remaining middle 46% (14 teachers) comprised of middle group.

The difficulty value (DV) is percentage of sample in the high and low performing group who answered the item correctly. Popular consensus suggests that the best approach is to aim for a mix of difficulties. That is, a few very difficult, some difficult, some moderately difficult, and a few easy. However, the level of difficulty should be consistent with the degree of difficulty of the concepts being assessed (Tobin).

The criteria for classification of the DV are as follows: DV<30 (too difficult items), DV between 30- 70% (acceptable/average items), DV>70% (too easy items) and DV between 50-60% (excellent/ideal items) (Kumar et al., 2021). On the other hand, the discriminatory power/index (DI) is the ability of an item to differentiate between groups of higher and lower abilities and ranges between 0 and 1. Generally DI ≤ 0.20 is considered poor, between 0.21–0.24acceptable, between 0.25–0.34 (good) and DI ≥ 0.35 is excellent (Date et al., 2019).

The formula used to find difficulty level is DL= Ru+Rl/Nu+Nl and that of discriminatory powerRu-Rl/Nu(or)Nl, where,Ru = The number sample in the upper group who responded correctly, Rl = The number sample in the lower group who responded correctly, Nu= Number of sample in the upper group, Nl= Number of sample in the lower group.

Items comprising of difficulty value between 0.2-0.8 and discriminatory power above 0.2 were retained. For the purpose of scoring each item followed up with 4 options to choose from, where 3 are incorrect and 1 is correct. The respondents were given 2 marks for each correct answer. The total possible score on the tool is thus 62 and minimum score is 0. On the sub-section of SPS identification tool with 14 items the maximum score is of 28 and minimum score is of 0. Similarly on the sub-section of SPS working knowledge tool with 17 items the maximum score is of 34 and minimum score is of 0.

Table 1: Difficulty Value and Discriminatory Power of Items
SPS Identification Sub-Section

Item No.	Mean	SD	Difficulty Level	Discriminatory Power	Status of Item
1	0.5	0.51	0.39	0.56	Retained
2	0.41	0.49	0.28	0.33	Retained
3	0.31	0.47	0.44	0.67	Retained
4	0.66	0.48	0.72	0.33	Retained
5	0.37	0.49	0.33	0.67	Retained
6	0.28	0.46	0.33	0.22	Retained
7	0.34	0.48	0.38	0.33	Retained
8	0.66	0.48	0.61	0.22	Retained
9	0.25	0.44	0.38	0.33	Retained
10	0.5	0.51	0.38	0.78	Retained
11	0.75	0.44	0.77	0.44	Retained
12	0.68	0.47	0.72	0.56	Retained
13	0.31	0.47	0.39	0.56	Retained
14	0.59	0.49	0.61	0.56	Retained

Table 2: Difficulty Value and Discriminatory Power of Items
SPS Working Knowledge Sub-Section

Item No.	Mean	SD	Difficulty Level	Discriminatory Power	Status of Item
1	0.47	0.51	0.44	0.44	Retained
2	0.78	0.42	0.72	0.56	Retained
3	0.63	0.49	0.56	0.89	Retained
4	0.19	0.39	0.22	0.22	Retained

Item No.	Mean	SD	Difficulty Level	Discriminatory Power	Status of Item
5	0.56	0.50	0.5	0.56	Retained
6	0.47	0.51	0.39	0.56	Retained
7	0.41	0.49	0.33	0.22	Retained
8	0.31	0.47	0.44	0.22	Retained
9	0.47	0.51	0.56	0	*Rejected*
10	0.44	0.50	0.56	0.67	Retained
11	0.38	0.49	0.39	0.78	Retained
12	0.34	0.48	0.33	0.44	Retained
13	0.56	0.50	0.72	0.56	Retained
14	0.31	0.47	0.39	0.56	Retained
15	0.59	0.49	0.56	0.67	Retained
16	0.41	0.49	0.44	0.44	Retained
17	0.38	0.49	0.44	0.22	Retained
18	0.25	0.44	0.22	0	*Rejected*
19	0.06	0.25	0.05	-0.11	*Rejected*
20	0.31	0.47	0.28	0.33	Retained

Themes Chosen for Construction of Tool

For the purpose of understanding the identification of science process skills and working knowledge of science process skills the items of the tool were constructed from Class X MBSE Science textbook from the selected chapters from three subjects of high school science, namely Light, Reflection and Refraction; Electricity from Physics, Chemical Reactions and Equations from Chemistry and Life Processes from Biology.

Process Skills Identified for Tool Construction

The basic process skills of Observing, Classifying, Measuring, Inferring, Predicting, Communicating and the integrated process skills of Defining operationally, Formulating Hypothesis, Hypothesis testing, Experimenting, Acquiring & Interpreting data, Formulating Models and Procedural Knowledge were selected for construction of items for the construction of tools.

Procedure of Data Collection

Investigator went to the field to collect the data with the help of constructed tool. By interacting with the high school principal/headmaster and taking the permission, the required data was gathered sampling the high school science teachers available on the day of visiting the high schools. For some science teachers Google form Test was also constructed owing to their non-availability.

A. Descriptive Analysis

Objective 1: To find out the competence level of high school science teachers in teaching of science process skills in terms its identification and working knowledge.

For the analysis of the above objective the description of the overall scores obtained by high school science teachers was done in order to understand their competence level to teach science process skills. This has been measured by taking their obtained scores on identification of science process skills and working knowledge of science process skills applied during teaching science subject. Table 3 shows the important descriptive statistics values based on their total scores.

Further, the description of the scores on identification and working knowledge on science process skills by high school science teachers were separately obtained in order to understand their competence level in identification of science process skillsand working knowledge of science process skills applied during while teaching science lessons. Table 4 and Table 5shows the important descriptive statistics values based on their scores respectively for identification and working knowledge of science process skills.

Table 3: Descriptive Statistics on the Competency of Science Process Skills (SPS) in the High School Science Teachers

Mean	Median	Mode	Standard Deviation	SEM	Minimum	Maximum
28.5	27	16	11.3365	2.004028	10	48

Interpretation: On the basis of descriptive analysis of the scores obtained for Competency of Science Process Skills (SPS) in the High School Science Teachers depicted in Table 3, it can be said that a mean score of approximately '28.5' is indicative of slightly below average competency of science process skills (score of 31 is 50% of the total score). The range of the score is of 38 with maximum score of 48 and minimum of 10. The standard deviation for the sample is high with a value of 11.33 and a standard error of mean of 2.0.

Table 4: Descriptive Statistics on Identification of Science Process Skills (SPS) in the High School Science Teachers

Mean	Median	Mode	Standard Deviation	SEM	Minimum	Maximum
13.25	13	8	5.98	1.06	2	24

Interpretation: On the basis of descriptive analysis of the scores obtained on Identification of Science Process Skills (SPS) in the High School Science Teachers depicted in Table 4it can be said that a mean score of approximately '13' is indicative of slightly below average competency in identification of science process skills (score of 14 is 50% of the total score). The range of the score is of 22 with maximum score of 24 and minimum of 2. The standard deviation for the sample is high with a value of 5.98 and a standard error of mean of 1.06.This is indicative that there is a high variation in the obtained scores on competency of science process skills identification amongst the high school science teachers.

Table 5: Descriptive Statistics on Working Knowledge of Science Process Skills (SPS) in the High School Science Teachers

Mean	Median	Mode	Standard Deviation	SEM	Minimum	Maximum
15.25	16	8	7.58	1.34	4	30

Interpretation: On the basis of descriptive analysis of the scores obtained on Working Knowledge of Science Process Skills (SPS) in the High School Science Teachers depicted in Table 5, it can be said that a mean score of approximately 15.25 is indicative of a below average competency in working knowledge of science process skills (score of 17 is 50% of the total score). The range of the score is of 26 with maximum score of 30 and minimum of 4. The standard deviation for the sample is very high with a value of 7.58 and a standard error of mean of 1.34. This is indicative that there is very great variation in the obtained scores of working knowledge of science process skills amongst the high school science teachers. This is indicative that there is a slight variation in the obtained scores on identification of science process skills amongst the high school science teachers.

B. Inferential Analysis

Objective 2: To find out the relation between competencies in identification of science process skills and working knowledge of science process skills amongst the high school science teachers.

For the analysis of the above objective the Pearson product moment correlation was obtained to depict the strength and direction of relationship between competency of science process skill identification and science process skills working knowledge amongst high school science teachers. For this objective a research hypothesis was formulated on the basis of positive complementary relationship between science process skills identification abilities and science process skills working knowledge applications. The research hypothesis guided by review of related literature thus states:

H:-There exists a positive relationship between competency of science process skill identification and science process skills working knowledge amongst high school science teachers.

In order to statistically test the research hypothesis, it was converted to null form which is

Ho: There exists no relationship between competency of science process skill identification and science process skills working knowledge amongst high school science teachers.
Ho: r12=0 where r= Correlation Coefficient for variables 1 & 2 (1=Identification of SPS & 2 = Working Knowledge of SPS).

Table 6 depicts the result of Pearson's Product Moment correlational analysis

Table 6: Relationship between Identification of Science Process Skills (SPS) and the Working Knowledge of Science Process Skills (SPS) in the High School Science Teachers

Variables	N	Df (N-2)	Pearson's Correlation Coefficient	Significance Level
Identification of SPS	32	30	0.436	S*
Working Knowledge of SPS	32	30		

** Significant at 0.02 level*

Interpretation: A reference to Table 6, it is found that there is a positive significant (0.420) relationship between the competency of science process skill identification and science process skills working knowledge amongst high school science teachers as the obtained value of r (0.436) > than critical value of r (0.409) at 0.02 level of significance. Hence the null hypothesis (Ho) is rejected and the research hypothesis is accepted.

Findings of the Study

i) According to a descriptive analysis of the results for the High School Science Teachers' Competency of Science Process Skills, the mean score for both identification and working knowledge is somewhat around average for the entire sample that was studied.

ii) The competency of science process skill identification and science working knowledge are found to have a positive significant (0.436) association among high school science teachers in accordance to Pearson product moment correlation.

Discussion

It is observed and found that there exists a gap between the ideal science processes to be taught to high school students and ways of teaching science in reality. Particularly concerning is the apparent dearth of understanding among high school science teachers regarding the significance and implementation of science process skills within their instructional practices. This gap in awareness poses several challenges. Firstly, without formal mechanisms for assessing science process skills, educators are unable to accurately gauge students' proficiency in areas crucial for scientific literacy and critical thinking. Additionally, the lack of teacher awareness regarding these skills inhibits their ability to effectively integrate them into classroom instruction, thus limiting students' opportunities for meaningful engagement with scientific inquiry and problem-solving. It seems that many teachers are not adequately trained or informed about the importance of science process skills in student learning. Furthermore, the challenges mentioned by teachers, such as the lack of facilities such as infrastructural requirement, science laboratories and resources are very much visible. Teachers face difficulty in relating science process skills in terms of poor supply of adequate resources and instructional support system. In spite of many obstacles many young high school science teachers are very much willing to implement the process based teaching approach into their classrooms. The biggest hurdle is the financial constrains within the education system. Without proper resources and support, it becomes challenging for teachers to effectively teach and integrate science process skills into their curriculum.

To address these issues, there is a need for comprehensive teacher training programs that focus on educating teachers about the importance of science process skills and providing them with the necessary tools and resources to effectively teach these skills in the classroom. Additionally, policymakers and education stakeholders should work towards improving infrastructure and providing access to resources that facilitate the integration of science process skills into science education. Major science curriculum reforms should be introduced that assess the students' level on Science Process Skills on annual basis as they are moving ahead in middle and high school years, those year being the fertile year for grooming the important basic and integrated science process skills. The changing world and the reform efforts in science instruction require new assessments (Rezba et al., 1995) and current status of the assessment practices of students are very outdated, limited only to the body of knowledge and not on processes of science. Students need someone to guide them through the process of learning about science as they do science (Bell, 2008) and teachers need to meet the standards of creating the 'doing science' experiences in classroom.

Conclusion

To have creative, dynamic, and innovative effects on high school science education, teaching requires to be rescaled and revamped. Teachers are encouraged to implement innovative teaching strategies as aspiring teachers. In keeping with that, this research was carried out to determine a science teacher's competency in teaching science and its process skills as well as to find out how teachers are realising the need for students to exercise their creative thinking by creating textbooks for science process skills using a problem-based learning model. The knowledge of science process skills among teachers is assessed using a descriptive quantitative research methodology for both a basic and integrated level, and the present studies can unmistakably confirm from the statistical analysis that the teachers at the high school level are slightly below than average on their competence of science process skills although the study is limited to a small sample of thirty two teachers only which cannot be generalized for whole population. Also, the intent of study was construction of a valid tool to assess the high school science teachers' competence in teaching of Science Process Skill which is the mandate of secondary school curriculum (Learning Outcomes for Secondary Stage, NCERT, 2019). It seems the training of teachers in teacher training institutions is not meeting the desired expectation and mandate of state, where more skilled science teachers are need of the hour.

****

References

AAAS (1971). *Science A Process Approach: developed by The American Association for the Advancement of Science*, U.S. Department of Health, Education, and Welfare.

Annual Publication (2017-18) Department of School Education, Statistical Cell, Directorate of School Education, Government of Mizoram.

Bell, R. L. (2008). *Teaching the nature of science through process skills. Activities for Grades 3-8* Pearson; Allyn & Bacon, Boston.

Date, A. P., Borkar, A. S., Badwaik, R. T., Siddiqui, R. A., Shende, T. R., & Dashputra, A. V. (2019). Item analysis as tool to validate multiple choice question bank in pharmacology. *International Journal of Basic & Clinical Pharmacology*, *8*(9), 1999-2003.

Houtz, B (2008). *Teaching science today: Professional development for successful classroom.* Shell Education.

Kumar, D., Jaipurkar, R., Shekhar, A., Sikri, G., & Srinivas, V. (2021). Item analysis of multiple choice questions: A quality assurance test for an assessment tool. *Medical Journal Armed Forces India*, *77*, S85-S89.

NCERT (2019). *Learning Outcomes at the Secondary Stage*. New Delhi, India: Author.

Rezba, R. J., Sprague, C., & Fiel, R. (1995). *Learning and assessing science process skills.* Third Ed. Kendall Hunt, Iowa.

Rosana, D., Widodo, E., Setianingsih, W., &Setyawarno, D. (2020). Developing assessment instruments of PISA model to measure students' problem-solving skills and scientific literacy in junior high schools. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *8*(2), 292-305.

Sermsirikarnjana, P., Kiddee, K., & Pupat, P. (2017, December). An integrated science process skills needs assessment analysis for Thai vocational students and teachers. In *Asia-Pacific Forum on Science Learning & Teaching, 18*(2), 25.

Sheeba, M. N. (2013). An anatomy of science process skills in the light of the challenges to realize science instruction leading to global excellence in education. *Educationia Confab*, *2*(4), 108-123.

Tobin, M. A. (n.d.). *Guide to Item Analysis.* Institute for Teaching Excellence The Pennsylvania State University. Retrieved from GuideToItemAnalysis.pdf (psu.edu) on 19th Feb., 2024.