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TEACHERS' PERCEPTIONS OF USING DIAGRAMMATIC REPRESENTATIONS TO TEACH SCIENCE IN PRIMARY CLASSROOMS

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ABSTRACT

Teachers use diagrammatic representations in classrooms to enhance students' understanding of science concepts. This study explores how primary science teachers in public sector schools use, manipulate, and interpret diagrams to simplify science lessons. Guided by the research question, "How do teachers use, manipulate, and interpret diagrammatic representations to enhance science learning?", the study employed a qualitative design using semi-structured interviews with ten purposively selected teachers. Data were analyzed using the constant comparative method within a grounded theory framework. Findings revealed that while teachers acknowledged the effectiveness of diagrams in improving student understanding, they rarely used or fully understood how to manipulate and interpret them effectively. Most had not received formal training in this area. The study highlights the urgent need for professional development to build teachers' competencies in using diagrammatic representations to support science teaching.

Keywords: *Diagrammatical Representations, Constant Comparative Method, Primary Science Teaching, Students' Educational Achievement (SEA).*

INTRODUCTION

A bulk strength of students is attending the science subject at every level of education system, especially school level in Pakistan. At the primary level, science is a mandatory subject. There are 165.9 thousands primary schools with 430.9 thousands teachers teaching 20.2 million students in Pakistan (Govt. of Pakistan, 2016). There are 36870 primary schools with 109759 teachers teaching 4032750 students at primary level in public sector schools of the province of Punjab (http://schoolportal.punjab.gov.pk). The Govt. of Punjab has specifically appointed teachers at primary schools (e.g. ESE Science) for teaching the science subjects to impart the science literacy among students. The National Curriculum of Science (2006) constitutes the goals of science education as to engage learner in inquiry, problem solving and decision- making situations and contexts that give meaning and relevance through adopting the scientific method (Govt. of Pakistan, 2006). This goal shows that there is a dire need to adopt the pedagogy that encourage students' own experiences and interests by using the learning activities, hand on experiences, teaching aids for promoting critical sense for wonder and curiosity about scientific endeavors among students in the science classroom. For this purpose, the significantly important teaching strategy is the diagrams representations in the classroom to enhance students' science

lessons, conceptual understanding and knowledge acquisition (Bui, & McDaniel, 2015; Cromley, Snyder-Hogan & Luciw-Dubas, 2010; Hall & Virrantaus, 2016; Murica, 2013; Zeipel, 2015). Thus, the manipulation of diagrammatical representations in teaching science at primary level is very effective for enhancing students' understanding of science lesson and concepts. There are many styles of learning, such as learning by reading, learning by hearing and learning visual experiences, and the students who have an aptitude for dealing with information visually prefer pictures and diagrams (Ornstein & Hunkins, 2014). Students' learning of science needs diagrammatical representations and conventions because they develop students' conceptual understandings. Diagrams are a supportive mode of learning and afford specific advantages over the textual media (Skamp, 2015). They are universal for science literacy because they illustrate the processes, structures, relationships, comparisons, and cause and effect of scientific phenomena in order to support the learning and reasoning (Novick, 2006). Using, manipulating and interpreting with the help of a variety of diagrammatical representations of science phenomenon makes teaching and learning process easy.

Diagrams are the most widely used tool by human being to depict the ordinary life communication, for brainstorming of complex problems and sketching the complete structure and process of talks and papers (Moktefi & Shin, 2012). A diagram is defined as a graphic representation that shows how something works or makes something easier and facilitate the understanding (Nakatsu, 2010). It also defines as the basic representation, presenting the system, organization, or functioning of some concepts as drawing. Diagrams increase understanding and integrate the ideas of science. When students' learns through creating graphical representations, it produces enormous positive effect on their academics (Marzano, 1998). It is also very useful for science students that they can explain the concepts. With the help of diagrams, trends in observed data is expressed and highlighted. Students often perceive as difficult diagrams depicting physical situations and trends and answer the questions to draw such diagrams may reveal a vast assortment of errors (Mammino, 2014).

Teaching of science provides a plentiful context for applying what the students know regarding how students learn. The multiple modes of representations can develop opportunities for students to identify the intended meaning in learning activities and construct mental models and share scientific understanding (Murica, 2013). Teachers can employ several strategies in science education to make lesson and concept easy to enhance the quality teaching (Chittleborough, et al., 2017). The diagram's teaching strategy is the most influential to achieve the purpose explicitly (Alsop & Hicks, 2012). It can present for comparison and interpretation of the situation (Minstrell & Kraus, 2005). The pedagogical model of diagram representation illustrates in Figure 1. The illustration depicted that the teachers need to plan students learning outcomes (SLOs) pertinent to diagrams while developing their lesson plans, draw the diagrams from the textbook/content and interpret them or with the help of students, assign the diagrams as homework assignment and lastly use the diagrams in the test for measuring their understanding of science concepts in the exams (Brendzel, 2005; Ferrer, 2008; Hamm & Adams, 2013; Phipps, 2002; Treagust, 2010).

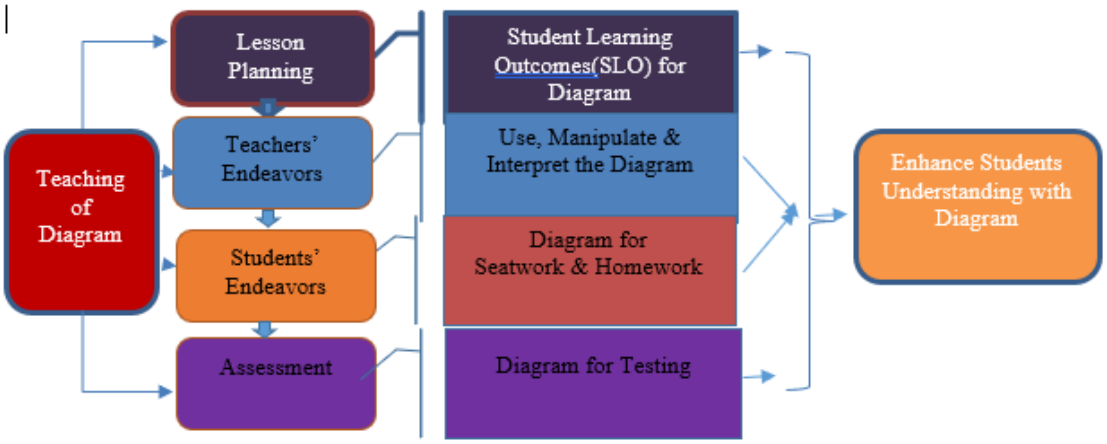

Figure 1: The pedagogical model of diagrammatical representations in primary science lessons and concepts

It is very necessary to mention that the contemporary assessment lays stress upon using the concept map diagrams. The concept map reflects students' understanding of the whole concept learned before and after the lesson (Linfield, 2009). It covers learners' thinking within the wide areas and important concepts of a specific field (Fuss, 2000; Iofciu, Miron, & Antohe, 2011). With help of the pedagogical model of grammatical representations model in Figure 1, teachers can use several effective diagrams such as mind map/ concept map, spider diagrams, Venn diagrams and tree diagrams, etc. to depict knowledge in the science classroom (Ross, 2011). Primary school students draw the Venn diagrams, bar charts, line graphs and tables (Cross & Board, 2014; Hollins, et al., 2012). The fishbone diagrams depict the cause and effect, and flow charts illustrate sequencing the steps in any process in science (Bellanca, 2007; Sharp, et al., 2011).

There are several types of diagrams, such as (i) iconic diagrams (e.g. photographs; (ii) schematic diagrams (e.g. Vann diagrams, flow charts, cognitive map); (iii) chart and graph diagrams (e.g. tables, line graphs) (Bloor & Wood, 2006; Gilbert & Afonso, 2014). The iconic diagrams are very effective in depicting the different physical systems' work and facilitating object construction. Schematic diagrams depend on learned conventions. They need mathematical expertise. The charts and graphs diagrams are easy to make but it heavily relies on interpretation skills (Novick, 2006). Thus, keeping in view the pedagogical model of diagrammatical representations illustrated in Figure- 1, the teachers facilitate the teaching and learning of science lesson and concept.

The curriculum (textbooks) of primary classes also presents many diagrammatical representations in science textbooks. The Directorate of Staff Development (DSD), Guidebook for Teachers Professional Development puts emphasis upon students' learning outcomes (SLOs), teaching strategies, effective diagrams and assessment techniques in primary science textbook to enhance pedagogical practices of teachers (DSD, 2012). It is highly unique endeavor by DSD for professional development of teachers. But these prescribed diagrams depict the author's endeavors and competencies. But, this work restricts teachers or students conceptual, imaginative, and creative, as well as comprehension skills of manipulating the scientific diagrams and, in the same way, they are learning by memorizing and imitating the content and knowledge (Linfield, 2009). It is also very important to note that the SLO points out to draw the diagrams, but it has given no hints to draw the diagrams. It is very difficult for students to draw the diagrams. So, it is necessary to

provide some key hint how to draw the diagrams because there are no primary drawing teachers appointed at schools for improving their drawing skills and competencies. Thus, there is a need to provide opportunities to teachers and students that they enhance their own competencies and skills with the help of manipulating the diagrammatical representations and conventions.

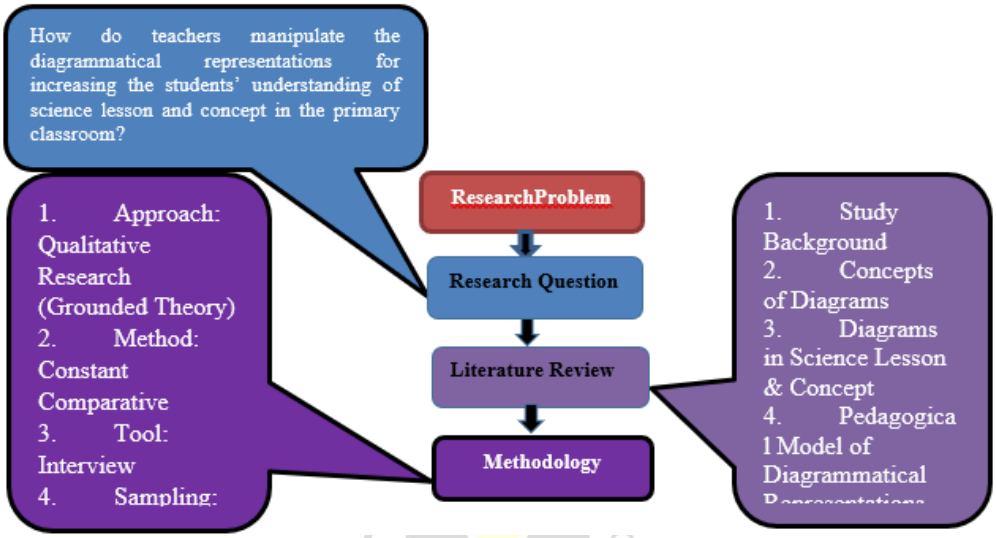

Figure 2: Theoretical framework of the study

There is a dire need of research into the use of diagrams because it is relatively a new area of research (Purchase, 2014). The teachers need the training in literacy and skill of diagrammatical representations in science education because of the ever-increasing use of digital media such as internet. To highlight the significance of diagrammatical representations and conventions in the teaching-learning process and as the new of research, this study focused to investigate the primary teachers' manipulation of diagrammatical representations in the classroom for enhancing students' understanding of science learning and concept.

This study would add knowledge into the use of diagrammatical representations in science education for teachers at primary level because they support comprehension, inference, and learning of students. It presents useful model and three-step process of diagrammatical representations and conventions in Figure -1 that would enhance teachers' capacity and skill of employing the diagrams in the teaching of science subject. Findings of the study may be beneficial for curriculum developer to improve their insights of presenting diagrams in the science curriculum and useful instructional techniques at the primary level keeping in views contemporary changes and futuristic insights of science subject at primary level. The further research may provide a new area of inquiry in diagrammatical representations for researchers and scholars. The theoretical framework has been presented in figure- 2 to shed a light on the entire study.

Research Questions of the Study

The study sought to answer the following research questions:

1. How do teachers manipulate the diagrammatical representations for increasing the students' understanding of science lesson and concept in the primary classroom?

2. How much skill of the diagrammatical representations has impact on increasing the students' understanding of science lesson and concept in the primary classroom?
3. What are the problems faced by the teachers regarding diagrammatical representations for increasing the students' understanding of science lesson and concept in the primary classroom?

Method

Design of the Study

Qualitative researchis studying the participants' lived experiences in the natural setting to develop a theory through an inductive approach. Grounded theory design was employed to seek the answer to research question to develop theory. It is used when little area is known about the researchproblems and is going to generate the theory (Birks & Mills, 2011). It is also very useful for practitioner research to contribute to developing new theory (Foreman-Peck & Winch, 2010). The grounded theory method was developed by Glaser and Strauss in 1967. The constant comparative method of qualitative analysis is a helpful technique to identify similarities and differences between cases of dataset (Harding, 2013). It involves open, axial, and selective coding. The qualitative data analysis is an iterative process which needs codes, categories and concepts. The researcher adopt five steps of coding, categories and concepts to analyze the qualitative data (Licthman, 2013) and develop the theory of using diagrammatical representations to enhance students' understanding of science lesson and concept at the primary level.

Instrument

A semi-structured interview protocol was developed to collect the qualitative data. It was developed based on a review of the related literature and keeping in view of the objectives and research questions. It contained 26 major and probing questions regarding the purpose and process, types, sources, lesson planning, teaching strategies and assessment of diagrammatical representations and conventions, they manipulated for science education in the primary class. After developing the tool, it was undergoing the validity process, and the validity was determined with the help of experts' opinion. They judged the content of the tool for data collection procedure.

Data Collection

The ten participants (seven females and three males) belonged to primary schools of district Attack, Faisalabad and Nankana Sahib. The informed consent of the participants was attained through mobile phone. They were ensured that their anonymity and confidentiality would be kept hidden and the information they provided would be used only for research. All the participants agreed to contribute to the study voluntarily. They were selected with purposive sampling technique because the participants had homogenous characteristics in nature and they were cases who would provide rich, detailed information up to the point of saturation about the research question of the study. They had the same academic and professional qualification and teaching experience. The data were collected from participants within two weeks. Interviews were conducted at the school sites with participantsby the researchers. Participants agreed to audio tape their voices only. Data were collected using the mobile voice recording system. Researchers transcribed the collected data into text. Constant comparative method of qualitative data analysis employed in the vignette of two cases. The narrations of the participations were sub-divided into similarities and differences summaries and then these narrations used for interpretation and drawing inferences through the iterative process of data analysis.

Data Analysis and Results

Teacher T1
T2 T3 T4 T5 T6 T7 T8 T9 T10
AQ **PQ** MSc (P) B.Ed. M.Phil. (M) B.Ed. MSc (CS) B.Ed. BSc B.Ed. BSc B.Ed.

MSC (M) B. ED. MSC (B) B.Ed. MSC (M)
B.Ed. BSc (M) B.Ed. MSC (P) B.Ed.

B.Ed. (Subjects) PM
PM PM MS PM PM BC PM PM PM
B. Ed (Uni.) AIOU AIOU
EU AIOU AIOU AIOU AIOU GCUF AIOU AIOU

Training 1
1 1 2 1 1 1 1 1 1
TE (Years) G 8 F 2
F 4.5 M 4 F 4
F 4 M 3 F 4
F 5 M 5 F

Note: T = Teacher, AQ = Academic qualification, PQ = Professional qualification, PM = Physics and Math, AIOU = Allama Iqbal Open University, GCUF = Govt. College University Faisalabad, EU = Education University, G = Gender, M = Male, F = Female. TE = Teaching experience.

1. Do you use diagrammatical representations during your teaching?

Yes, I used diagram during the teaching of science lesson because it is the requirement to fulfill the need of the students (T1). I use different representations for making the lesson easy for students (T2). I try to use diagrammatical representations during teaching the students (T3).Through this technique, students can easily understand, so; I try to use it (T4). I try to use diagrams (T5). It used during my teaching because it is very important for lesson delivery and students' lesson of science (T6). I use it frequently (T7). Rarely, I use during my teaching (T8). Sometimes, I used diagrams in the teaching of science (T9). When I feel the concept is tough, I try to link it with diagram in the classroom teaching (T10).

2. How do you define the concept with the help of a diagram in the science subject?

I have to make a chart in which important areas have to be mentioned with different colors to make it effective (T1). By labelling each diagram and explain the features of diagram (T2). It is defining diagram and their importance by labelling (T3). I make a chart in which I mention important areas (T4). I draw a diagram, then; we label it because it does the lesson make easy (T5). Diagrams are clear the theory and its application in the daily life problem it shows information of facts attractively (T6). Diagram makes the topic so easy for understanding of students (T7). Students learn easily with the help of diagram (T8). Students learn through diagrams (T9). I define the concept with the help of diagram through labelling (T10).

3. Do you plan any SLO regarding the diagrams in your lesson plan of science lessons?

The important ideas relate to my SLO (T1). By making SLO on parts of diagrams because SLO helps the drawing representation (T2). I plan the SLO because it directs the basic learning point of the topic and lesson (T3). I plan SLO regarding the diagrams in lesson plan (T6). T7, T8, T9, T10 did not narrate the SLO regarding the diagram.

4. Would you like to describe anyone SLO which you draw for diagrams representation? If yes, how do you interpret? If No why do you not interpret the diagrams?

The students can draw the diagram of water cycle with fade black shaded region shows evaporation, while half bluish color shows the cloud and drops (T1). It is to draw the internal parts of seed to understand the structure of seed (T3). To draw the diagram of displacing the body due to force applying in the field (T6). T7, T8, T9, T10 did not have the skill of formulating the SLO regarding the diagram.

5. In which subject do you use diagrams frequently?

I use in mathematics and science subject, especially toward diagrams and their average (T1). I use diagrams in Science, Math and Computer (T2). I particularly use diagrams in science and math subjects (T3). Science and math (T4).

Math, science and computer science (T5). In teaching the mathematics, i use graphs and diagrams frequently (T6). Science and math (T7). Science (T8). Math (T9). Science (T10).

6. What is the purpose of using the diagrams in your teaching?

I use diagrams beacause75% learning depends upon seeing, so it is a major part of learning (T1). By using the diagrams, I make the lesson interesting and students show their interest also and the concept easily convey to the students (T2). It increases the students' understanding of the lesson and improves concepts of science subject (T3). The diagram makes lesson interesting (T4). The diagrams are used to understand the lesson and make concept easy (T5). It can enhance students' learning in short duration (T6). Diagram make lesson very easy for the students (T7).

The diagrams can manage the primary concept of science lesson (T8). Diagrams can highlight the basic concept in science lesson (T9). Diagrams can provide the information about the theory of science (T10).

7. Do the diagrams representations make students' concepts easy?

Yes, Students take interest in making diagrams by themselves and make it comprehensively (T1). Why not, diagrams make students' concepts easy (T2). Surely, diagrams make students' concepts easy (T3). Diagrams make the concept easy (T5). Students' concept of science and math becomes very easy and they get 100% understanding of the concept (T6& T7). Diagram representations make students; concepts easy (T8, T9, T10).

8. Which type of diagram is most influential in making science concepts easy?

For the process of science phenomena, I make water cycle and Lever and its type's diagrams (T1). It depends on the lesson and concept, so keeping in mind, different diagrams are drawn (T2). Frequently, a colorful and labelled diagram (T3). Labeling diagram activity (T5). Graphical diagram is most influential in making science concepts easy (T6 &T7). Scientific diagrams are most influential in making science concept easy (T8, T9, T10).

10. What is your strategy of teaching to assign diagrams to students?

Initially to make flags, later, I will suppose them to draw their own then I will further suggest some of them to make picture related to topic so that other student can influenced by the best student to motivate towards diagram and enhance learning (T1). By drawing labeled diagram (T2). I assign diagram to students in groups and for assessment as homework (T3). I help them understand the diagram and then provide an opportunity for students' practice and then the students can draw it (T3). I assign the students for some experiment activity and then instructed them to draw the diagram (T5). My teaching strategy for diagrammatical task is that students draw diagram many times

on their notebooks (T6). (T7, T8, T9 & T10 could not describe the strategy of teaching.

10. Do you or class students draw or label the diagrams?

Some student draw it with keen interest, to draw group activity is being used, each group comprises four students and supervision of each group is still being conducted by myself (T1). We draw diagram from related lesson and also label it (T2). I help them understand the diagram and then I give some hints and provide an opportunity for students' practice and then the students can draw it (T3). Usually, I draw and label it (T5). First, I draw and label the diagram, then I assign the task to the students (T6; T7). I draw the diagram and try to involve the students in this work (T8, T9 & T10).

11. Do you or class students label the diagrams?

Some of them label the diagram, later the groups are made and the students help to label the diagram (T1). Sometime individual student label the diagram, later the group of students label the diagram (T2). I help them understand

the diagram and then provide an opportunity for students' practice and then the students can draw it (T3). We draw and label it according to the lesson (T5). Sometimes I just draw the diagram on the whiteboard and I give labeling task to the students (T6). We draw it and label it according to their lesson (T7). I label the diagram and then ask questions of the students (T8). I label the diagram by inquiring about the students (T9 & T10).

12. Do you or class students learn the concept from the diagrams in the science textbooks?

It is easy, but the direction of the teacher is the key component that how she takes it and makes it effective (T1). No, because one line dimensions can't give full theme of topics so make it easy by looking at diagrams from others means therefore, I also use other diagrams for making the lesson easier (T2). Textbooks are helpful and easy source of specific and given diagrams because, in this process, students use sense of hearing and seeing to learn the concept of science (T3). The diagrams in science textbook are used to learn the concept because they mostly related these with the phenomena (T5). When I feel book diagram is difficult or not clear, then I add here another diagram (T6). I draw the diagram from the books (T7). Diagrams in the science textbook is very clear and easy for students (T8, T9 & T10).

13. Do you feel the textbook diagrams sufficient for students understanding the concept of science lesson?

Some topics describe the SLOs, but they needed extra diagrams to explore the topic (T1). Textbook diagrams mostly related to the topic (T2). At the primary level, given diagrams are enough and there is a need for further diagrams in science text book (T3). No, the diagrams of science books are not sufficient, so, I use extra material for students' understanding (T5). Textbooks diagram does not enhance the understanding of the concept because application of the lesson is not clear in one diagram, so other diagrams require (T6). Textbooks are sufficient (T7). Textbook diagrams are sufficient (T8, T9 & T10).

14. Do you yourself or your students make diagrams from the text of science lessons? They draw diagrams from textbook but for new diagrams they need as group activity (T1). We draw the diagrams from the text and, by looking over the diagrams when some complications are faced, then we use printed diagrams of text of science lessons (T2). Students make diagrams from the textbooks of science lesson because students can understand the science lesson by drawing them (T3). Sometimes, I and sometime students draw the diagram from the science content (T5). First, I introduce the diagram on whiteboard, then it is assigned to students for practice and learning (T6). We try to draw diagrams from the text of science (T7). Sometime I prefer students (T8). Only I draw the diagram (T9). I draw the diagrams (T10).

15. Have you got any training regarding the manipulation of diagrams? Did you provide any knowledge and skills during your professional degree, such as B.Ed. regarding how to use diagrams in the classroom during science teaching? If yes, mention it.

Yes, by Directorate of Staff development I have learned much knowledge regarding the lessons presentation, and my mentor guides me at one topic and its importance as well (T1). No, I did not receive any training on diagrams representations, however; I got some points in B. Ed. on diagrams and I have not so much practice in this respect (T2). Not any formal training during my career and profession (T3). In training sessions, barely the diagrams were discussed (T5). I got skills during the B.Ed. (T6). During B.Ed. (T7). No, any training (T8, T9 & T10).

16. Which source such as whiteboard, charts, books, copies, and computers do you use mostly to exhibit the diagrams?

I usually use the charts and sometime laptop simulations for my students (T1). Whiteboard is suitable for drawing the diagrams because

students pick and understand the topic easily (T2). I prefer using the whiteboard, copy and book for drawing the diagrams (T3). Chart, board and model (T5). Whiteboard, copies and books are used for drawing the diagrams to improve the learning of science concepts (T6). Textbooks (T7). Audio-visual aids (T8). Charts, books and whiteboard (T9). Whiteboard and charts (T10).

17. Do you have sufficient time for drawing diagrams during seatwork and homework assignments?

I assign the homework for drawing the diagram (T1). I consider 40 minutes is enough for drawing the diagram (T2). The drawing of diagram is difficult and practical work so it requires sufficient time and I normally spend one period, e.g. 30 minutes, for this purpose (T3). Students need a period contained 45 minutes to draw diagrams easily (T5). Time issue is the problem for drawing because drawing takes too much time for students (T6). I allocate considerable time for this activity (T7). No time limit for drawing the diagram (T8). 50 minutes (T9). 60 minutes (T10).

18. Do you assess your students' competencies of drawing the diagrams during their testing?

Evaluation is the key factor which assesses students' competencies and I try my best to give any diagram during testing procedure (T1). I usually ask one question about drawing the diagram in the assessment for improving their competencies and knowledge (T2). During the testing, I allocate one question for assessing students' skill and understanding of science lesson and concept (T3). Sometimes, I examine their understandings through tests (T5). Some students have good working power in drawing the diagram and they draw a diagram in a brief period in the tests (T6). I prepare one item regarding the diagram (T7). I try to assess it (T8, T9 & T10).

Findings

Analysis of data revealed the following major findings:-

1. Majority of the teachers seldom used, manipulated and interpreted the diagrammatical representations while teaching in the classroom.
2. It was also found from results of the study that use of diagrams made students' understanding of science lesson and concept easy.
3. It was further found that due to lack of training; they were facing problems in the classrooms while using diagrammatical representations.
4. Majority of the teachers pointed out that teachers needed in-service training, which may enhance science teachers' capacities and competencies of employing the diagrammatical representations.

Conclusion and Discussion

Summary of the findings of the current study showed that use of diagrammatical representations in science education for teachers at primary level is the need of the time, as it supports comprehension, inference, and learning of students. It was revealed that careful consideration of the learning goals, information content of representations, and prior knowledge regarding use of diagrammatical representations would enhance student learning concepts. A classroom-based diagrammatical representation has a positive impact on improving students' learning. It was further revealed that teachers were facing problems due to lack of training to use diagrammatical representations while teaching in the classroom, so professional development agencies must provide teachers further training to improve teaching competency in science subject.

Recommendations

Keeping in view of the findings of the study, it made the following recommendations:

1. Proper utilization of diagrammatical representations by the teachers in the

classrooms has a positive impact on improving students' understanding of science lessons.

2. To have professional competency for using diagrammatical representations, it may provide teachers with further in-service training in the subject of science.

3. It may carry out further research to explore the effective teaching strategies of visualization representation in primary science pedagogy and their impact on students' educational achievement.

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