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SECONDARY SCHOOL SCIENCE TEACHERS' BELIEFS ON INQUIRY IN THEIR CLASSROOM PRACTICES

Sasmita Bhoi

Research Scholar in Education

Regional Institute of Education, NCERT, Bhubaneswar-751022

Email: sasmitabhoi6@gmail.com

Dr. Laxmidhar Behera

Professor

Regional Institute of Education, NCERT, Bhubaneswar-751022

Email: behera17@yahoo.co.in

Abstract

This study explored the science teachers' inquiry about beliefs and how these beliefs are enacted in the classrooms. A qualitative interpretive approach was adopted to investigate the rudimentary beliefs of science teachers on inquiry. Five high school teachers were purposively selected for this study. Data were generated through questionnaires, interviews, and classroom observations. Findings showed that most of the teachers have student-centered beliefs. Teachers who believed in the inquiry nature of science practiced it in the classroom and vice versa. Thus teachers' beliefs were consistent with their classroom practices. Most of the teachers have a narrow view of inquiry. The perception of inquiry act as a huddle in the implementation of inquiry teaching and learning in the classroom to promote rational thinking. It is observed that the lack of actual meaning of inquiry led to confusion about inquiry teaching among science teachers.

Keywords: *Beliefs, Inquiry and classroom practices*

INTRODUCTION

Teachers come to the classroom with a set of beliefs of what to teach and how to teach. Their decisions affect the teaching and learning process. Recent studies show that more focus is given to the researches on teachers thinking, beliefs, and their decision-making process. There are two major domains in the teaching process (a) Teachers' thought process (i.e. teacher cognition) and (b) teachers' action and their observable effects. Current science education reform recommends the development of inquiry skills in students. Studies on the beliefs of

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teachers concerning inquiry instruction are extensive (Beck, Czerniak, & Lumpe, 2000; Bisogno,2011; Leonard et al, 2011). Kalra & Baveja, (2013) in their review paper on researches on teacher thinking suggested that more studies are required in this area in India. These beliefs are a critical component in the successful implementation of educational reform(Pajare,1992). NCF, (2005) given more emphasis on the development of inquiry skills among children. Thus science teachers' beliefs on inquiry became crucial for the success of current science reform.

Pajare(1992) reviewed many works of literature in his study on "Teachers' Beliefs and Educational Research: Cleaning up a messy Construct" and argued that beliefs are the main indicators which determine individual decision throughout life. Thus he stated belief is a messy construct. Teachers' beliefs on the nature of scientific inquiry may influence their knowledge of classroom inquiry. Thus more stress has been given to the inquiry nature of science. The study of Ergul et al (2011) concluded that the use of the inquiry method significantly improved secondary school students' science process skills, self-efficacy, and attitudes. Pajare(1992) drawing from Ernest (1989) that two teachers may have the same knowledge in mathematics but they teach in different ways. He suggested it is the powerful effect of the belief that shapes the decision. Thus all knowledge is rooted in belief, way of knowing is nothing but the way of choosing. Yet we do not fully understand how belief influences practice Crawford (2007) cited Kgna (1992). Several factors influence teachers' way they do. The content knowledge, context, and belief system affect teachers' actions. Saad & Boujaude(2012) studied teachers' knowledge and beliefs about inquiry and their classroom practices are still few and scattered. Thus the present study will explore the science teachers' inquiry beliefs in the classroom context.

LITERATURE REVIEW

Inquiry

The National Curriculum Frmework 2005 advocated a greater emphasis on constructivist approach and learner-centered pedagogy in the school curriculum, which is an effort to improve science teaching and learning in secondary schools. Hence it is very important to understand what is inquiry science and how it is conducted in a classroom setting. Unfortunately, there is no precise definition of inquiry in literature. The most acceptable & comprehensive definition of inquiry age is given by NRC, USA (1996).It states:

> *"Inquiry is a multiphase activity that involves making an observation, posing questions, examine books and other sources of information, planning an investigation, reviewing what is already known in light of experimental evidence; using tools to gather, analyses, and interpret, proposing answers, explanations, and predictions, communicating the results. Inquiry requires identification of assumption, use of critical and logical thinking, and consideration of alternative explanation. (p.23)."*

Atar (2007) drawing from Calborn (1996) identifies three different types of inquiry: structured, guided, and open inquiry from simplistic to complicated. In structure inquiry, a problem is given to students to solve along with produce, material, and accepted right answers. In guided inquiry teacher provide a problem for students, but students have to decide the method for solving the problem by themselves. In open inquiry opportunities

given to students to construct their answer and design their investigation. Here asking the right question is very essential, ask questions must be testable, meaningful, and consistent. Inquiry learning is a cluster of learning and teaching approaches in which students conduct inquiries that help them to engage actively with problems or questions associated with learning.

Bisogno, (2011) stated that the main challenge that a teacher faces in implementing inquiry is the confusion over what exactly in inquiry and what it looks like. Won, (2009) adopted John Dewey's theory of inquiry as the analytical framework to investigate science learning activities, student interaction, and educational standards. Findings show that teachers have tried to engage students in meaningful learning but analysis revealed that the meaning of inquiry was diverse. Thus the present study will explore beliefs of inquiry held by teachers, and the challenges they face while implementing inquiry in the classroom context. Inquiry learning refers to critical and reflective learning in which individuals have to constantly question their knowledge, methods, and experience. The only way to trained students in inquiry science is to get actively involved in a scientific investigation. Inquiry teaching implies the process of inquiry and teaching methodologies. For inquiry teaching, teachers must have content knowledge and pedagogical knowledge. (Tobin, Tippins & Gallard, 1994).

Science teachers' beliefs on inquiry and classroom practices

Teacher beliefs and practices have been the most debated topic among educators (Mansour 2009, Pajares 1992, Savasci-Acikalin 2009). Kagan (1990) defines teachers' beliefs as " the highly personal way in which a teacher understands classroom, students, the nature of learning, the teachers' role in the classroom and the goal of education." From the above definition of teachers' beliefs, it can be concluded that personal experiences in the classroom develop teachers' beliefs about students' learning, the ways to teach, about their role in the teaching and learning process.

Some of the science teachers interpret inquiry as a hands-on activity. But experiencing science may take in many forms in the science classroom, such as listing, reading various sources, observing the demonstration, and doing science (Atra 2007). Keys and Brayan (2001) suggested that research is needed in teachers' beliefs about inquiry, teachers' knowledge base for implementing inquiry, and teachers' inquiry-based practices. He also suggested different methods such as case studies, longitudinal studies, naturalistic, interpretative, ethnographic, hermeneutic, and phenomenological with a small no. of participants will generate more valuable understanding regarding the complex relationship among teacher beliefs, practices, and school context.

Research findings on teacher's beliefs indicated that there is a strong correlation between teacher belief and practice (Pajares, 1992; Richardson, 1996, Kuzborska, 2011; Ismail et al, 2019). Atar(2007) drawing from Anderson (2002) stated that "much of the difficulty" that we face in implementing inquiry is "internal to the teacher ". The studies of teacher beliefs and attitudes about inquiry-based learning showed that most teacher's had restricted views of the nature of sciences, unfavorable beliefs, and attitudes about inquiry. (Saad and Boujaoude, 2012; Wallace and Kang, 2004; Ramnarain & Hlatswavo, 2018; Joern, 2009; Sporea & Sporea, 2013). The studies which supported the belief of science teacher on the inquiry have influenced their decision

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in the classroom. These teachers beliefs that inquiry was beneficial for student learning. (Avraamidou & Zembal-Saul, 2010; Cairns, 2019; Alhendal , et al, 2015). Thus the present study investigated the relationship between teachers' beliefs on inquiry and classroom practices.

RESEARCH QUESTIONS

This present study investigates the relationship between beliefs about inquiry and teachers' practices.

1) What are science teachers' beliefs on inquiry as a method of classroom transaction to promote rational thinking?
2) How are beliefs on inquiry enacted in the secondary level science classroom?

METHODOLOGY

Research Design: In interpretive studies participants provide specific illustrations of their practices and internal perspectives and meanings. The researcher collects descriptive and naturalistic data through the interaction between researchers, participants, and the research setting (Miller, 2017). Thus qualitative research seems to be the most appropriate for the present study as its aim understanding participants' process of making meaning of a particular event. It focuses on understanding the meaning, purpose, and intentions people give to their own actions and interactions with others. In the present study interpretive approach has been used.

Participants: The purposive sampling technique was used to select the participants. One of the main features of this sampling is to work with purposively selected small samples of people, nested in their context, and studied in-depth. Five science teachers were purposively selected from five Govt. High school of Cuttack. Among them, four were female and one male teacher. The teaching experiences of participants range between 7 to 25 years. Two teachers have Msc. with B.Ed and three teachers have B. Sc. with B.Ed. Most of the teachers teach in rural schools of Cuttack. All the participants attended the professional development program conducted under Rastriya Madhyamik Shiksha Abhiyan(RMSA).

Tools and Technique :

Open-ended questionnaire for science teacher:The questionnaire was used to identify the teacher's beliefs about the inquiry to promote rational thinking. Teachers were asked to write their viewpoints and a brief explanation for the response. It consists of six aspects of beliefs. Belief in teaching strategic of science, learning of science, teaching & learning of science through inquiry, teachers and students role in the inquiry classroom.

Interview Schedule for science teachers: The researchers has used a semi-structured open-ended interview to explore the belief of secondary science teachers. The interview was conducted with all 5 teachers. Each teacher is individually interviewed to examine the belief on inquiry to promote rational thinking among students. The sample questions in the interview were about the teachers' beliefs of:

1) What is the best condition for learning science in the classroom?
2) What does inquiry teaching looks like?
3) To you what are the indications of students' learning?
4) What is inquiry? Is it a process, product, or both?
5) What is your opinion about students' correct or incorrect responses to science questions?

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***Classroom Observation schedule for Science Teacher*:** The classroom observation will help the research to visualize the actual implementation of science teacher belief. A self-made tool of 26 items covering three dimensions i.e belief in teaching strategies of science, learning of science, teaching & learning of science through inquiry were selected to counter-check the information given by the teachers.

Data analysis:

Data were collected from the observation schedule, the open-ended questionnaire as well as interview. Both direct classroom observation and video recording were used for accurate analysis of inquiry practices. Data from the questionnaire and interview were organized to find themes and code through repeated reading. Interview results were transcribed verbatim. Placing the code into large categories helps to reduce the data and leads to the emergence of several themes.

RESULT

The data from different tools were triangulated to present the finding in a consolidated manner. The result of the study was presented as per the research questions.

RQ. 1) What are science teachers' beliefs on inquiry as a method of classroom transaction to promote rational thinking?

Theme One: Beliefs on teaching strategies of science

Table 1: Frequency and percentage of science teachers' beliefs on teaching strategies of science

Beliefs on teaching strategies of science	Description of code	N (%)
Providing opportunity	Opportunity to ask questions	2(40%)
	Through teaching & learning material	2(40%)
	Doing own activity in a real-life situation	1(20%)
Type of Activity	Activity	3(60%)
	Investigation/Experimentation/Demonstration	1(20%)
	The answering question, discussion	1(20%)
Inquiry helps to explore own idea	Understanding & strengthening science concept	4(80%)
	Exposure to new knowledge	1(20%)

Table: 1 showed that 40% of the teachers believed in providing the opportunity to the student to ask critical questions. Similarly, another 40% preferred TLM help students to strengthen their science concepts. While only one teacher (20%) stated that discussion and explanation help in concept formation. More than half of the teachers (60%) preferred activities for explaining science concepts. Most of the teachers (80%) stated inquiry helps students to explore their idea to understand and strengthened science concepts.

On asking all teachers stated that they appreciate and encourage students to ask interesting questions in the

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classroom. Only T5 admitted that he bring change in lesson plan when students ask unusual and interesting questions in the classroom.

"*For me, No question is silly when a student asks a question it may be important or not. I explain the concept using real-life examples So that they know the principle behind it."*

Theme Two: Belief about learning science

Table 2 Frequency and percentage of science Teacher Belief about learning science.

Belief about learning	Description of code	N(%)
Learning start with a problem	Asking critical questions	3(60%)
	Providing problems to students	2(40%)
Providing clear information	Fundamental clear, no confusion	2(40%)
	Correct answer writing	1(20%)
	Better understand	2(40%)
What is important to learn	Memorizing formula, science concept, definition	3(60%)
	The process to reach science concept	2(40%)
Whose ideas Valuable	Student	3(60%)
	Teacher	1(20%)
	Both	1(20%)

Illustrated the ways by which science can be learned. All of them agreed that learning starts with a problem. The majority of teachers believed (60%) that asking critical questions to the students will initiate the learning process. All the teachers are agreed that providing clear information in the classroom is necessary, which leads to a better understanding of the science concept. On asking what is important for children to learn 60% of teachers stated that memorizing formulas, science definitions and concepts are important for children to learn but at the same time 20% of teachers explained the process to reach science concept is very essential to learn this will automatically help them to learn exactly what science is. Similarly, 60% of teachers agreed that students' ideas are more valuable in the classroom.

On asking how do you feel when students learn all the participants stated they feel good when their students understand science concepts.T1 with a big smile stated that:

> *"I thought I did an excellent job. Handling 46 students in one classroom is not an easy task. Giving individual attention to all is not always possible. Thus when my students learn the concept that I want to teach I feel very happy."*

When asking the indicators of students' learning T5 stated that

"*reflection of science concepts in their day-to-day life is the main indicator of student learning. It shows that T5 has believed in the inquiry nature of science ."*

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Theme Three: Beliefs on inquiry

Table 3 Frequency and percentage of science Teacher Belief and learning science through inquiry

Teaching and learning science through inquiry	Description of code	N (%)
Learner engaging in scientifically oriented questions	The teacher provides scientifically oriented questions to students	3(60%)
	Material & other sources	1(20%)
	Learner poses a question	1(20%)
Encouraging students to plan investigation	Ask critical question	1(20%)
	Giving project/ activity	3(60%)
	Ask them to think in a proper way	1(20%)
Learner formulate explanation from evidence	Teachers guide in the process of formulation of explanation	2(40%)
	Learner provided with evidence	3(60%)

Table 3 showed more than half of the science teachers (60%) stated they provide or ask scientifically oriented questions to the learner. The remaining 20% in each case provided materials, sources, and encouraged students to ask scientific questions. of teachers gave equal importance to investigation, experimentation, are the best way to learn science and real-life situation helps them to learn science in a better way. However, the majority of teachers (60%) said giving projects in real life and through activity, students can plan an investigation. Similarly when asked teachers, how they provide the opportunity to learners to formulate explanations from evidence. More than half of the teachers (600%) stated they guide in the process of formulation of explanation from the evidence that they collected from observation or reading a textbook, conducting the experiment, or from measurement. While 400% of teachers stated that they directly provide the evidence that leads them to generate an explanation.

T1 said

> *"Activity and experimentation are the best conditions for learning science. She also stressed that activities and experiments must be done by students. When students conduct experiments it will stay lifelong in their memory and they will learn science in a better way."*

When asked to define inquiry T1, T2 & T4 stated inquiry is both process and product. T1 and T3 viewed inquiry from scientists' perspectives. Inquiry is what scientists do in the laboratory.

T5 stated

> *" Inquiry is a process. He defines inquiry with a pause…. Inquiry is like a student-driven classroom. Students ask questions that need a scientific explanation. Plan investigation, conduct experiments, communicate the result. I guide them throughout the process."*

Thus it shows T5 has believed in guided inquiry.

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T3 has an incomplete view of inquiry. she stated that

> " *I give more emphasis on questioning and providing the opportunity to students to express freely their thought and understanding in the classroom."*
>
> When asked to define inquiry *" she stated to strengthen students' science concepts I used ICT lab, so that they visualize the phenomenon using technology. For me, an inquiry is observing a scientific phenomenon and collecting data using technology ."*

Few of the teachers agreed that students who listen, read and perform well as per the instruction of teachers have not necessarily well understood the concepts. However, most of the teachers stated that it is helpful for betterment in studies.

RQ. 2) To examine science teacher's beliefs on inquiry in their classroom practices.

To examine how science teachers believe in inquiry manifest in their teaching actions, two lessons were observed from each participant. Focusing on the way they implement the inquiry process in the science classroom, organizing the classroom, ask questions, and responded to students' answers. The dimensions upon which science teachers' beliefs were observed similar to the open-ended questionnaire.

Implementation of belief in teaching strategies of science

Table 4: Percentage Frequency of STB in teaching strategies of science

scription of code	**Always**	**Sometime**	**Never**
Providing opportunity	3(30%)	5(50%)	2(20%)
ttivity	3(30%)	2(20%)	5(50%)
oviding explanation	7(70%)	2(20%)	01(10%)
arner identifies question that need scientific investigation	2(20%)	3(30%)	5(50%)
quiry help student to explore their own ideas	2(20%)	2(20%)	6(60%)

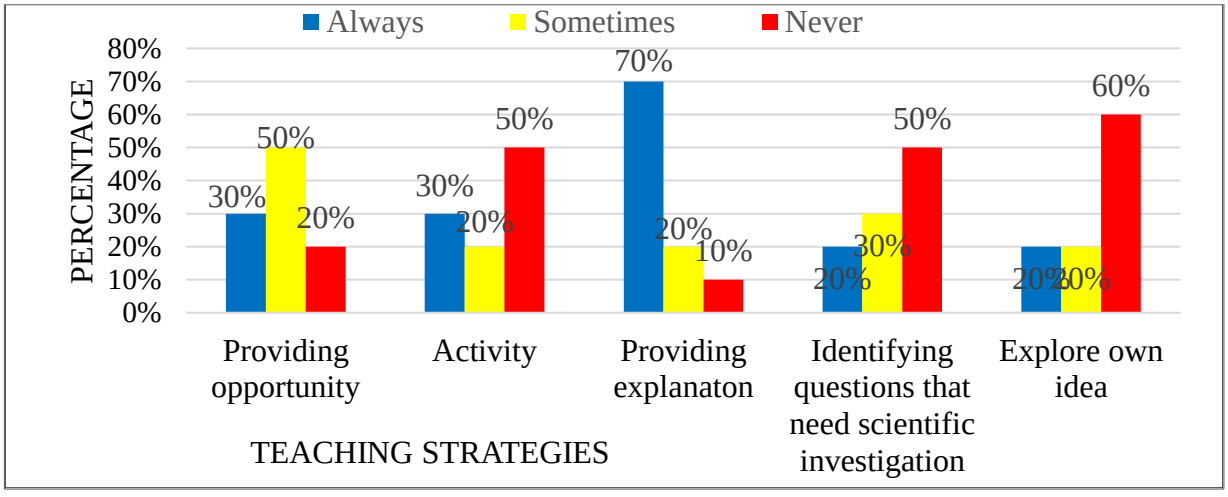

Figure 1. Frequency of STB (%) in teaching strategies of science

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The most frequently teaching strategies included providing opportunities to ask questions in the classroom. Around 30% of teachers frequently help students to lead the classroom by providing the opportunity to conduct an activity or ask questions of their interest. During the activity, a few of the teachers organized students in a small group but mostly verbal explanation with the question and answer session occasionally teacher demonstrate science concept. About 50% of the class's lecture methods were followed. In 70% of classes, teachers stress the explanation of concepts. Thus learners did not get the opportunity to explore their ideas. Only two classes students identified the question that needs scientific explanation. Knight & Mcneil (2011) suggested that teachers' level of successful enactment of reform ideas dependent on initial beliefs and pedagogical content knowledge.

Implementation of beliefs in learning

Table 5. Percentage Frequency of STB in learning

Description of code	Always	Sometime	Never
Practice problem solving	2(20%)	2(20%)	6(60%)
Accurate way to solve problem	1(10%)	3(30%)	6(60%)
Finding the right answer	5(50%)	4(40%)	1(10%)

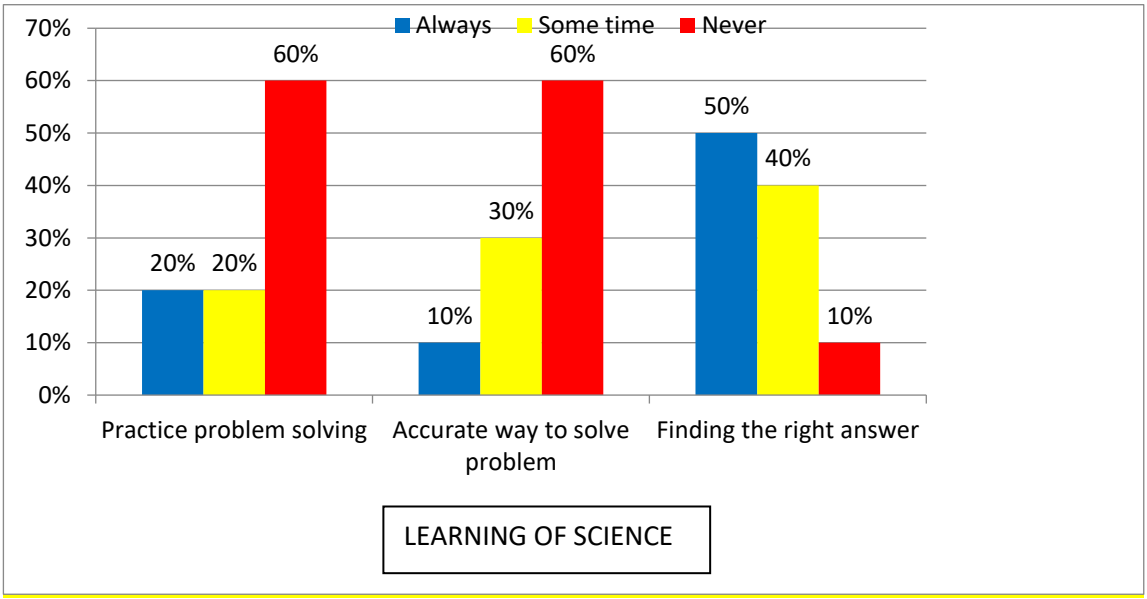

Fig 2. Frequency of STB (%) in learning

During classroom observation, it was found that most of the teachers gave importance to finding the right answer which was found in 50% of classroom observation. But still, some of the teachers did not emphasize the right answer only in one class of T5 process to reach answer was given importance. Very few teachers 20% practice problem-solving in most of the classes. According to data, most of the teachers 60% in their classroom neither given importance to the right answer as well as appropriate way to solve the problem. Very few teachers practice problem solving most of the teachers provided explanations.

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Further, most of the teachers' practice memorization of important facts and principal, for them it will help students in higher studies and better understanding. The experienced participants supported the problem-solving and critical thinking orientation in the classroom. While classroom observation of T5, it was found that students explained concepts according to their understanding.

Implementation of inquiry

Table 6: Percentage Frequency of STB in teaching science through inquiry

Description of code	**Always**	**Sometime**	**Never**
Teacher ask question that promote rational thinking	4(40%)	5(50%)	1(10%)
Designing & implementing scientific inquiry	1(10%)	2(20%)	7(70%)
Conducting inquiry/Investigation	1(10%)	2(20%)	7(70%)
Collect evidence from observation & measurement	3(30%)	2(20%)	5(50%)
Student construct explanation	3(30%)	4(40%)	3(30%)

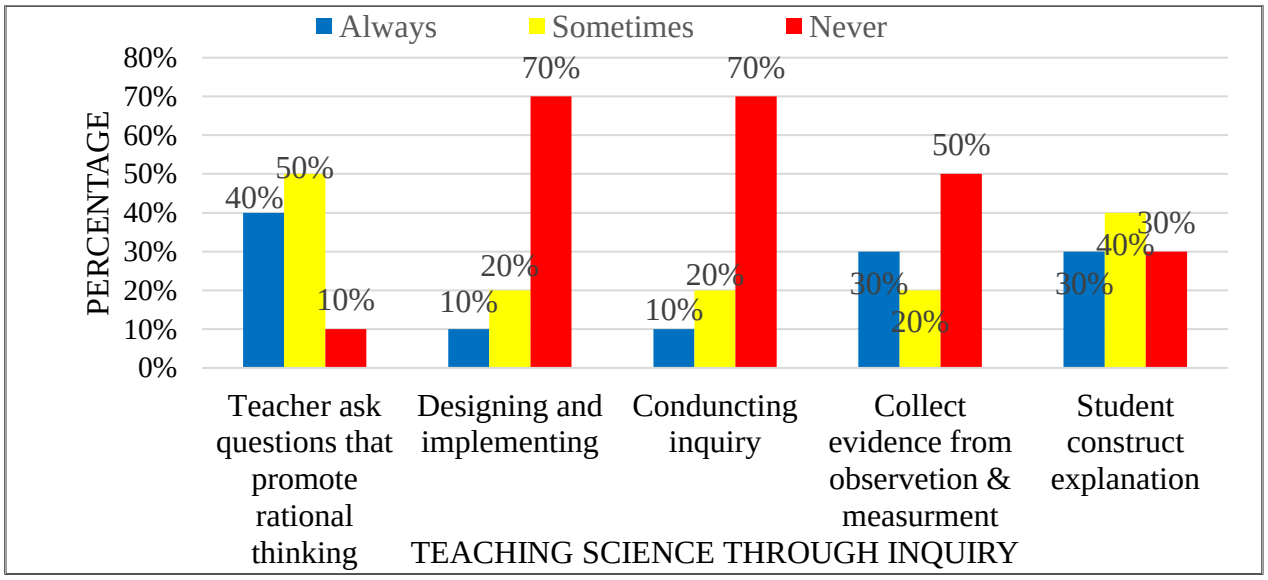

Fig. 3 Frequency of STB(%) in teaching science through inquiry

During the classroom observation, it was reviled that most teachers asked questions that promote rational thinking. Only 40% of teachers frequently as critical questions that need deep thinking to answer. For example, T3 asked in the classroom why atoms form bonds? Why Helium and neon are inert gases? It was also found that most of the teachers did not allow students to conduct or plan experiments in the classroom. Very few teachers combine activity and experimentation in their classrooms. Most of the students of T3 & T5 gave explanations from observation and communicated their findings. From the table, it can be concluded that 70% of teachers in each case neither given scope to students to design and implement scientific inquiry nor conducted inquiry learning in the classroom.

Further, it was found that all the teachers checked the prior knowledge of students by asking questions. Most

of the teachers gave clear information to students, according to them it helps in the betterment of study. Very few teachers did not give clear information they given probable answers so that students can analyze the answer. T5 experimented with the reflection of light. He asked many critical questions to the students but did not give answers rather he experimented directly involving students in the inquiry process. Through observation, students collected evidence that strengthens their idea relating to the concept. T5 preferred guided inquiry. Blonness & Enain (2018) suggested that open inquiry is a way to motivate students and opposed rote learning.

RESEARCH FINDINGS: A SYNTHESIS OF ALL INSTRUMENTS

It was found through questionnaires mostly teachers provide the opportunity to students to ask questions and provide an explanation to understand the concepts. Which were reflected in their classroom practices. The teachers stated that activity, experimentation, investigation, and answering questions were the ways to teach science. However, most science teachers adopted the lecture method for explanation and understanding of science concepts. Very few teachers adopted demonstration and inquiry methods in the classroom to promote rational thinking. Most of the teachers believed in providing the opportunity to students to explorer their ideas. Which help them to strengthen and a better understanding of the science concept, but in the actual classroom it was practiced very little. They preferred explanations in the classroom.

In the present study, 60% of cases problem-solving or accurate way to solve a problem was not practice in the classrooms. It showed most of the teachers provide clear information to students to get the right response, which is the traditional orientation to words learning science. However, few teachers' beliefs on the process of inquiry they less preferred memorization of science concepts, encouraged students to plan investigation by providing projects or involving in activities. It's showed that they had a constructive belief towards learning. From the above synthesis, it can be concluded that most of the teachers' beliefs on what they believe they do. It was found through questionnaires and interview all the teacher believed active participation should be the nature of science classroom. Whereas in the classroom they practiced teacher instruction they gave importance to memorization and the right responses of students.

Classroom observation showed that only T5 has constructivist beliefs. He preferred guided inquiry in the classroom while teaching "Reflection of light " to students. He encouraged students to identify questions that need scientific explanation, and prefer less memorization. He followed inductive reasoning, most of the students actively participated in the experiment process, they observed the phenomenon collect evidence, asked questions to the teacher to develop their understandings, used data to give explanations, communicate their findings with peers and teacher. Whereas teacher who believed traditional way of teaching they prefer explanation and discussion in the classroom. Classrooms were more formal, routine activities were followed, teachers provided clear information to get the desire response of students mostly preferred memorization of science concepts.

From the synthesis of all the data, it can be concluded that most of the teachers have a narrow view of inquiry. Although they provide freedom to express, allow asking questions but they are less willing to carry out inquiry

teaching in the classroom this is due to a lack of actual meaning of inquiry. When asked to define inquiry most of the teachers stated authentic inquiry is what scientists do in the laboratory, inquiry is like activity or experimentation. The perception of inquiry act as a barrier in implementing inquiry teaching and learning in the science classroom. Thus it can be concluded that teachers who believed in inquiry practiced it in their classroom and vice versa. It showed teachers' beliefs were consistent with their classroom practices.

DISCUSSION OF THE RESULT

In response to the first question, most of the teachers believe in some of the inquiry components of science i.e. providing freedom to ask questions and express their ideas. It was supported by the study of Avraamidou & Zembal-Saul (2010) that teachers enact certain aspects of scientific inquiry such as engaging students in investigation and working with data to answer posed questions. These practices were congruent with their knowledge and beliefs about science teaching. Leatham (2006) suggested that some beliefs are more central than affect other beliefs. For example, the wish to control the class is more central that it affects the belief in group work. Similarly in this study providing clear information in the science classroom became more central believe that it affect investigative or process-oriented science teaching and learning.

Further, the present study says that few teachers beliefs in the process of inquiry rather than the correct answer. The most encouraging result of the present study is that participants who believe in the inquiry nature of science practiced it in the classroom whereas teachers who had a traditional orientation towards teaching and learning science were less willing to perform inquiry in their classrooms. Hoq, 2019; Kuzborska, (2011); Ramnarian & Hlatswayo, (2018) teachers had a positive attitude towards inquiry in teaching and learning but they were less inclined to enact inquiry-based learning in the classroom. In the present study, most of the teachers have a narrow view of inquiry. They viewed inquiry from researchers and scientists' prospects. The perception of inquiry act as a huddle in the implementation of inquiry teaching and learning in the classroom to promote rational thinking. The finding is supported by the study of (Binsogn, 2011; Chabalengula & Mumba, 2012).

EDUCATIONAL IMPLICATIONS

Teachers' ability to integrate reform ideas with their existing belief system is highly essential for the success of any reform activity. Teacher to teacher collaboration and development of the learning community will help in the successful implementation of Inquiry-based learning. To develop a positive attitude and belief towards inquiry and improving the conception of the nature of science more focus should be given to pre-service training at the graduate level. Administrative autonomy should be provided to teachers to implement various teaching methods in the classroom. Teachers should constantly implement inquiry into school science. It will not only help students to develop inquiry skill and a better understanding of nature of science but also it helps teachers to gain more experience in managing inquiry classroom. Thus this will lead to conceptual change in teachers' traditional beliefs to constructivist beliefs.

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