A Study of Cognitive Abilities of Class IX Students in Science and Technology in Kachchh District

A Synopsis
of the Thesis to be submitted to
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1.0 INTRODUCTION

The concept of "science" received its modern shape in 19th century when the new titles such as Physics, Biology and Chemistry emerged out of *natural philosophy*; when new institutions and communities were founded, and their unprecedented applications to and interactions with other aspects of society and culture occurred (Cahan, 2003). The word 'science' (Scientia) has the etymological meaning "knowledge". Fitzpatrick (1960) defines Science as a cumulative and endless series of empirical observations which result in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observations. Hence, Science is both body of knowledge and the process of acquiring knowledge. According to Lederman (1983), science is a dynamic, ongoing activity, rather than a static accumulation of information. Science is the approach to the gathering of knowledge rather than a field or subject matter (Best & Kahn (2009)). Therefore, Science is both a human activity and an attitude to understand the nature. Ingenuity, creativity, reason and perseverance are some of the characteristics of science. As a result of them, what yields is knowledge about the natural world that can change as scientists continue their work and come to better understand the natural world (Clough, 2015). The characteristics of science elucidate the dual nature of it. Science has a process aspect that strives to understand the nature as well as a product aspect- the knowledge generated as a result of the attempts made under the process. Both the aspects are interconnected with and interdependent on each other. Such a rich nature and vast applicability of science gives it a prominent place in the curriculum. The main goal of science education is the development of children's ability to inquire scientifically (NCF - 2005). The aims and objectives of science education clearly indicate what is aspired from science education. They provide guidelines for developing instructional objectives for teaching-learning and evaluation in science. For designing instruction objectives, the very first attempt was made by Bloom (1956). His efforts resulted into "Taxonomy of Educational Objectives" also known as Bloom's taxonomy. Beginning in 1948, a group of educators undertook the task of classifying educational goals and objectives. The intent was to develop a classification system for three domains: the cognitive, the affective, and the psychomotor. The cognitive domain deals with the ability to process and utilize (as a measure) information in a meaningful way. The affective domain is concerned with the attitudes and feelings that result from the learning process. Lastly, the psychomotor domain involves manipulative or

physical skills. Work on the cognitive domain was completed in the 1950s and is commonly referred to as Bloom's Taxonomy of the Cognitive Domain (Bloom et al. 1956).

Bloom's taxonomy is a classification system for the domain of knowledge i.e. cognition. The higher the level of cognition, the more complex the thinking ability required. As a result, a person proceeds from gaining of simple facts to comprehension and interpretation of the material to the ability to analyze and synthesize information and finally to evaluate it. The following figure shows each level of cognitive domain as classified by Bloom. The hierarchy proceeds from ***concrete to abstract*** levels.

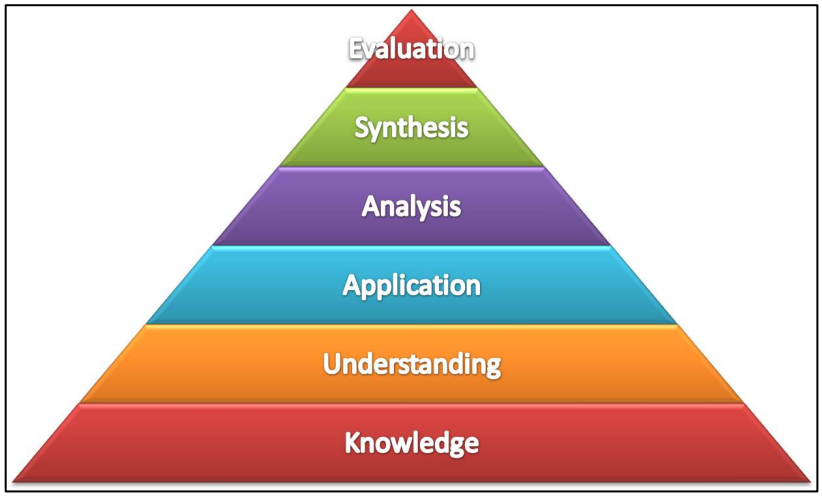

Image Source: McHugh (2013)

Figure 1.1 Bloom's original taxonomy

1. Knowledge

Knowledge represents the lowest level in the cognitive domain. The definition of knowledge for this level is remembering previously learned material. The requirement is to simple ***recall***. The range of information may vary from simple facts to complex theories, but all that is required is to remember the information.

2. Comprehension

Comprehension is the first step beyond simple recall. It is the first level, demonstrating and understanding the information. It is the ability to ***apprehend***, ***grasp***, and ***interpret*** the meaning of material.

3. Application

Application is the ability to show the pertinence of principles to different situations. At this level, student may ***apply concepts or methods to actual concrete problems***. This thinking skill tells you

that a student can transfer selected information to a life problem or a new task with a minimum of direction.

4. Analysis

Analysis requires more than knowledge, comprehension, and application. It also requires an understanding of the underlying structure of the material. Analysis is the ability to break down material to its functional elements for better understanding of the organization. Analysis may include identifying parts and clarifying relationships among parts. This thinking skill tells you that ***a student can examine, take apart, classify, predict, and draw conclusions.***

5. Synthesis

Synthesis requires the formulation of new understandings. If analysis stresses the parts, synthesis stresses the whole. Components of concepts may be reorganized into new patterns and new wholes. ***A student can originate, combine, and integrate parts of prior knowledge into a product, plan, or proposal that is new***.

6. Evaluation

Evaluation is the highest level in the hierarchy. It includes all the other levels plus the ***ability to make judgments, assess, or critique based on evidence and clearly defined criteria.***

1.1 BLOOM'S REVISED TAXONOMY OF COGNITIVE DOMAIN

In 2001, the taxonomy given by Bloom was revised by his students (Anderson et al 2001). Following changes were made in the revised taxonomy.

Terminology Changes

Bloom's six major categories were changed from noun to verb forms. Additionally, the lowest level of the original taxonomy, knowledge was renamed and became remembering. Finally, comprehension and synthesis were retitled to understanding and creating. All these changes are shown in the following figure:

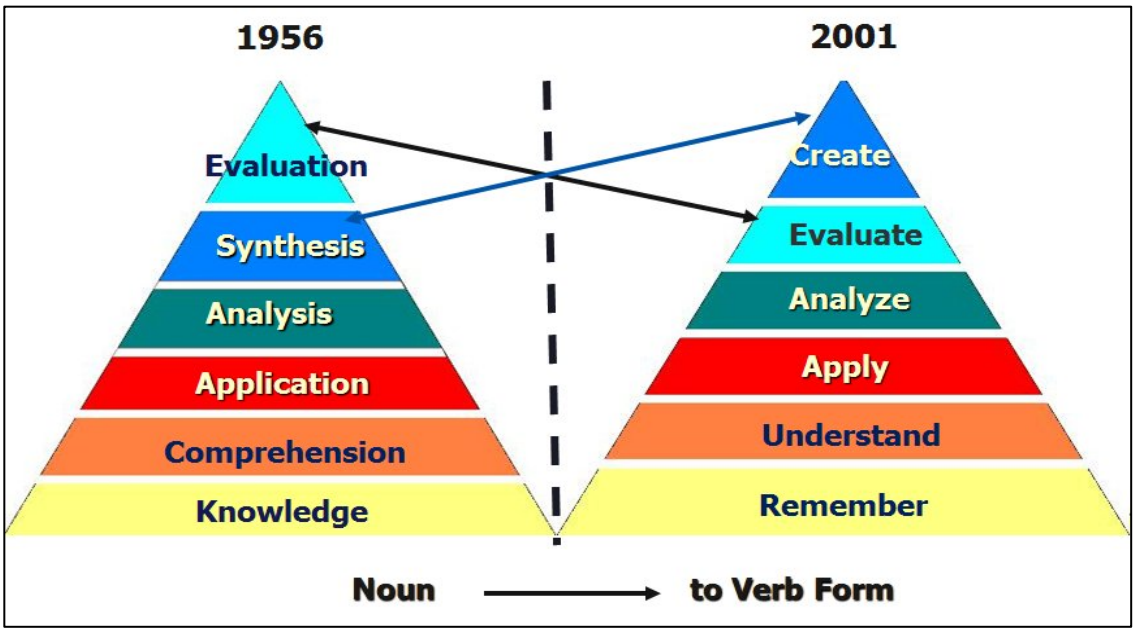

Image Source: McHugh (2013)

Figure 1.2 Bloom's revised taxonomy

Structural changes

Bloom's original cognitive taxonomy was a one-dimensional form. With the addition of products, the Revised Bloom's Taxonomy takes the form of a two-dimensional table. One of the dimensions identifies The Knowledge Dimension (the kind of knowledge to be learned) while the second identifies The Cognitive Process Dimension (or the process used to learn). As represented on the grid below, the intersection of the knowledge and cognitive process categories form twenty-four separate cells as represented on the "Taxonomy Table" below.

The Knowledge Dimension on the left side is composed of four levels that are defined as Factual, Conceptual, Procedural, and Meta-Cognitive. The Cognitive Process Dimension across the top of the grid consists of six levels that are defined as Remember, Understand, Apply, Analyze, Evaluate, and Create.

Following Taxonomy Table (or two-dimensional matrix) shows both the knowledge and the cognitive process dimensions along with some action verbs. It also indicated there are different ***levels of knowledge*** associated with each level in the Bloom's taxonomy. On the other side, each level of knowledge is associated with all the levels of the hierarchy.

Table 1.1 Taxonomy Table (Two-Dimensional Matrix)

The Knowledge Dimension	**The Cognitive Process Dimension**					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	List	Summarize	Classify	Order	Rank	Combine
Conceptual Knowledge	Describe	Interpret	Experiment	Explain	Assess	Plan
Procedural Knowledge	Tabulate	Predict	Calculate	Differentiate	Conclude	Compose
Meta-cognitive Knowledge	Appropriate use	Execute	Construct	Achieve	Action	Actualize

The levels of knowledge under the knowledge dimension are explained in brief as follows:

- Factual knowledge is the basic elements students must know to be acquainted with a discipline or solve problems.
- Conceptual knowledge indicates the interrelationships among the basic elements within a larger structure that enable them to function together.
- Procedural knowledge deals with how to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
- Metacognitive knowledge is knowledge of cognition in general, as well as awareness and knowledge of one's own cognition.

The taxonomy helps teachers and researchers in not only framing the objectives for teaching-learning and evaluation but also in deciding the difficulty level of the test items.

1.2 ASSESSING STUDENTS' COGNITIVE ABILITIES THROUGH SCIENCE AND TECHNOLOGY

Bloom's classification of educational objectives addresses cognitive domain versus the psychomotor and affective domains of knowledge. It was developed to provide a framework for

organizing a continuum along an underlying structure. Bloom's taxonomy was designed to provide a more reliable procedure for assessing students and the outcomes of educational practice. The major idea of the taxonomy is that what educators want students to know (encompassed in statements of educational objectives) can be arranged in a hierarchy from less to more complex. The levels are understood to be successive, so that one level must be mastered before the next level can be reached. Bloom's taxonomy provides structure to categorize instructional objectives and instructional assessment. His taxonomy was designed to help teachers and instructional designers to classify instructional objectives and goals. The foundation of his taxonomy was based on the idea that not all learning objectives and outcomes are equal. For example, memorization of facts, while important, is not the same as the learned ability to analyze or evaluate. In the absence of a classification system (a taxonomy), teachers and instructional designers may choose, for example, to emphasize memorization of facts (which make for easier testing) than emphasizing other (and likely more important) learned capabilities. In this way the taxonomy helps teachers go beyond mere reproduction of science knowledge while assessing the students.

The goal of an educator using Bloom's taxonomy is to encourage higher-order thought in their students by building up from lower-level cognitive abilities. Behavioural and cognitive learning objectives are given to highlight how Bloom's taxonomy can be incorporated into larger-scale educational goals or guidelines. The key phrases can be used to prompt for these skills during the assessment process.

Bloom's Taxonomy is a popular and extremely helpful tool that is used by most teachers. It provides a common language for teachers to assess learning on a lower as well as higher cognitive levels. According to Sunny (2012) the level of questions asked during assessment play a significant role in assessing student performance, when high level questions are used in preparing examination questions, the students' cognitive development can be ascertained. A goal of teachers is to help students to not only learn basic information but also improve cognitive abilities. In other words, it is helpful to improve students' ability to think. Students should not just memorize the information. After all, memorizing something is not the same as thinking about it or understanding it. Helping someone improve their thinking skills isn't easy, but Bloom's Taxonomy can be very helpful to reach the goal.

On the other side, the nature of science provides ample opportunities for developing cognitive abilities of students. Through science, children learn to understand the phenomena of nature

occurring around them. As a result, cognitive processes take place in a child's mind which develop certain cognitive abilities. Cognitive abilities play an essential role in handling and processing of information. As a part of the science education, pupils have to develop the capacity to deal with the problems in their day to day life. It can be achieved only through their constant involvement with doing of science. Therefore a process oriented approach to science education can serve as the foundations of science education. NCF-2005 states that good science education is true to the child, true to life and true to science. Here 'true to science' means the science we teach can convey significant aspects of science content at appropriate level and engage the child in learning the processes of acquiring and validating scientific knowledge.

The nature of science and the cognitive abilities are closely interlinked to each other. Science can serve as a means of intellectual stimulation among the learners. In order to understand the nature of science, there are certain abilities associated to the cognitive domain which enable students in many ways to deal with the content of science. Those abilities assist students in memorizing the statements/facts, in using the acquired knowledge of science in new situations, in making decisions, in assessing their present knowledge and in creating new knowledge. In other words, it can be said that proper development of cognitive abilities facilitates the students in acquiring and updating knowledge of science. On the flip side, science education promotes cognitive development among students. Dillon (2003) explains that cognitive development is not just a matter of becoming faster or fuller of knowledge. There are qualitative changes in the way children process new information as they develop cognitively. Such qualitative change in processing is capable of enhancing higher levels of thinking abilities.

According to Yadav (2011), for upper primary schools there have been six periods allotted for science and technology subject and the duration of one period is 35 minutes in Gujarat. The textbooks of science subject have been revised and renamed as 'Science and Technology' by Gujarat State School Textbook Board (GSSBT). Science textbook of class VIII was revised in the year 2004; those of class V and VI were revised in 2007 followed by the revision of class VII textbook in 2008. But major part of the contents of these textbooks contains concepts of science and very less weightage has been given to the technology aspect. Therefore, the term "Science and Technology" will be used in this study now onwards.

2.0 Review of Related Studies

The investigator has reviewed a total of 70 studies; directly or indirectly relevant; for arriving at the present research problem. The reviewed studies have been divided in 3 major parts. Part 1 is again divided in three subparts. The categorization has been done according to the nature of the studies and the objectives with which they were conducted.

1. Surveys conducted in science education
    1.1. Construction of scientific attitude and aptitude tests
    1.2. Construction of achievement tests
    1.3. Construction of other tests including factors, correlates and predictors of achievement
2. Experimental studies conducted in science education
3. Studies conducted abroad

The summary of the reviewed studies is presented here. In all the studies related to scientific attitude and aptitude tests the sample of the study was class IX students (Venkataraman, 1970; Sharma, 1975; Ghosh, 1986; Patel, 1997) and class X students (Dave, 1964). The studies were conducted in various parts of India – Gujarat (Dave, 1964; Patel, 1997), Andhra Pradesh (Venkataraman, 1970), Delhi (Sharma, 1975) and West Bengal (Ghosh, 1986). Through these studies, the correlates and determinants of scientific attitude were sought. The variables considered in the studies were sex and place of location (Venkataraman, 1970; Ghosh, 1986; and Patel, 1997), SES (Ghosh, 1986 and Patel, 1997) and management (Venkataraman, 1970). It was found out in the above studies that scientific attitude and scientific aptitude had a positive correlation with and could serve as determinants of each other (Venkataraman, 1970 and Ghosh, 1986) whereas achievement in science and general achievement of students were other determinants of scientific attitude (Patel, 1997).

Second section of the review was related to studies focusing on construction and standardization of achievement tests in science (Aram et al., 1957; Buch, 1960; Saxena, 1960; Gupta, 1962; SIE (Kerala), 1965; Sheth, 1967; Dash, 1967; Rup Prakash, 1968; Vanajakshi, 1970; Bhatt, 1971; SCERT, 1971; Singh, 1973; Islam, 1975; Sharma, 1975; Sharma, 1976; Ansari, 1984) and subjects of science – Ravindranathan (1983), in Physics and Chemistry (Bountra, 1970; Bhola, 1978;) in Physics (Sali, 1977; Chhaya, 1978; Khandelwale, 1981;) and in Chemistry (Ghosh, 1985). The studies were conducted in various parts of the nation – Gujarat (Buch, 1960; Bhatt, 1971); Uttar Pradesh (Saxena, 1960; Boutra, 1970); Kanpur (Gupta, 1962); Orissa (Dash, 1967); Punjab (Rup

Prakash, 1968); Andhra Pradesh (Vanajakshi, 1970; SCERT, 1971); Bombay (Bhatt, 1971; Singh, 1973; Chhaya, 1978; Ansari, 1984); Haryana (Gupta, 1974; Bhola, 1978); Bihar (Islam, 1975); Rajasthan (Sharma, 1975; Sharma, 1976); West Bengal (Ghosh, 1985) and Delhi, Calcutta and Madras (Chhaya, 1978). The tests were constructed for students of Telugu medium (SCERT, 1971); Sindhi medium (Singh, 1973); English and Malayalam medium (Raveendranathan, 1983) and Hindi medium (Ansari, 1984). The methodology adopted in these studies was in phases – tryout and main administration of the tools. Validity and reliability were ensured for the achievement tests constructed by the researchers. Sex was one variable utilized in the studies by SIE (Kerala) (1965); Vanajakshi (1970); Bhatt (1971); SCERT (1971); Islam (1975); Sharma (1975); Sharma (1976); Ansari (1984); Ghosh (1985). There was significant difference found in the achievement and/or performance of boys and girls. (SIE (Kerala), 1965; Bhatt, 1971; SCERT, 1971; Sharma, 1975; Sharma, 1976; Ansari, 1984).

In the third section of the review of related literature, different predictors of achievement were either tested or found out. Interest in science (Chatterjee et. al., 1978; Srivastava, 1980;), intelligence (Jha, 1970; Mishra, 1978; Srivastava, 1980;), SES (Srivastava, 1980; Vijayalakshmi, 1980), creativity (Mishra, 1978; Vijayalakshmi, 1980), attitude towards science, verbal meaning, inductive reasoning, numerical ability, reasoning ability, conceptual understanding, problem solving ability were the major predictors and/or correlates of achievement in science (Baqer, 1965; Senapati, 1980; Chhikara, 1985; Paltasingh, 2008; and Devi Uma, 2009). In the studies which considered sex-wise difference in the achievement, significant differences were observed (Jha, 1970; Nayar, 1971). However, not each of the reviewed studies found that the above mentioned factors were positively or statistically correlated predictors. There were studies which showed even negative (Jha, 1970) or no correlation (Baqer, 1965; and Jha, 1970) between some of these factors and the achievement in science. In the light of experimental studies reviewed, it was found that the treatments given in all those studies were effective and superior to traditional ways. The experimental groups were found to be superior to the control groups. In the reviewed studies the science was taught through creative methods (Nair, 1978), system approach (Anjaria, 1984), environmental approach (Deopuria, 1984), using filmstrips (Barve, 1986), instructional strategy (Joshi, 1987), Gagne's conditions of learning (Pillai, 1987), metacognitive skill based package (Padma Priya, 2012), constructivist approach (Tandel, 2012), Project based learning (Masalegoo, 2013) and Science-Technology-Environment-Society (STES) approach (Mishra, 2016). The

various purposes for which the experiments were carried out were enhancement of comprehension/achievement (Adinarayan, 1984; Deopuria, 1984; Joshi, 1987; Vaidya, 1991; and Padma Priya, 2012), higher order abilities (Upadhyaya, 2001; Masalegoo, 2013 and Mishra, 2016) and metacognitive skills (Padma Priya, 2012 and Tandel, 2012) and achievement in science (Padma Priya, 2001 and Vaidya, 1991).

Under the category of studies conducted abroad, the review included studies conducted utilizing Bloom's taxonomy (original as well as revised) and higher order skills. It was found that Bloom's taxonomy was a well-known tool to direct the teaching-learning and assessment practices not only in school education (Saido et al, 2018) but also in the higher education (Wruck, 2010). It was used and accepted for instructing medical course students (Starnes, 2005) and management course students (Betts, 2008). It was also used as a framework for evaluating e-learning content (Halawi et. al., 2009). With the support of Bloom's taxonomy studies were conducted for development of higher order skills among the students (Nicholas et. al., 2003 and Crowe, 2008).

From the review of related studies, following gaps have been identified: No any studies have been conducted on test construction and standardization in recent times. Thought the reviewed studies on test construction were conducted for various medium of instruction other than English medium, not all of them presented comparative scenario of English medium with other medium. Except Ansari (1984) no other studies examined whether types of school affects students performance.

2.1 RATIONALE OF THE STUDY

Science education is an integral part of school curriculum. Science as a discipline has distinct nature and characteristics. Scientific theories and principles are the outcome of the processes of Science. Science is about being curious and following a process to make new discoveries. Science education practices have a potential for enhancing intellectual level of students. The effectiveness of science education to a very large extent depends upon the methods of teaching incorporated in science education. Therefore, according to National Science Teachers Association (NSTA 2002), all the efforts must begin in the early grades when students are naturally curious about the world around them and eager to explore. An understanding of science will spontaneously occur when students have active and rich learning experiences with their surroundings. Under such circumstances, the students may learn and build their understanding through simple investigations. It can further lead to all the possibilities for their cognitive development from lower to higher

levels. Since various national documents gave their suggestions for quality improvement in science education, if science education is properly implemented in all the schools across the country, it can fulfil all the objectives of science education and can stimulate and excite pupils' curiosity about phenomena and events in the world around them. It also satisfies the curiosity with knowledge because the process aspect of science leads to experimentation and verification of the present ideas. In this way, it can engage learners at many levels. Scientific method is about developing and evaluating explanations through experimental evidence and modelling. This is a limb to critical and creative thought. Through science, pupils understand how major scientific ideas contribute to technological change – impacting on industry, business and medicine and improving quality of life. They learn to question and discuss science-based issues that may affect their own lives, the direction of society and the future of the world.

However, the present status of science education is not up to the mark. There is over domination of teachers' centeredness in the classroom practices while teaching science (Umasree, 2003; Vaidya, 2003; NCF, 2005). With an objective of improving quality of science teaching, various committees and commissions have given many recommendations. An important one of them is to move away from teacher centered approach to student centered approach.

Science at primary level acts as a preparatory point for children's intellectual and personal development. It prepares children to understand basic scientific concepts and its application. It develops attitudes and values. Before entering secondary level, students have already learnt certain scientific principles over a period of eight years of their elementary education which may have helped them in constructing certain knowledge. At the age of eleven to thirteen students are in concrete operational stage. If students at this level are provided enough opportunities for mental exercises, they may show remarkable performance in their concrete operational stage which in turn can help to achieve expertise in the tasks based on hypothetical thinking, abstract thinking and creativity which are the underlying characteristics of formal operational stage. Such expertise prepares children to opt for science in higher education.

Assessment also plays very important role in enhancing students' cognitive abilities. The types of assessments that students go through in science education affects the cognitive abilities that students will apply while studying science. If exams call for mere reproduction of facts, then students are unlikely to engage in conceptual thinking and higher-order thinking; in contrast, if

assessments focus on being able to solve real-world problems then students are more likely to engage in complex cognitive processes during science instruction.

In the context of the literature reviewed by the researcher, Major implications to be drawn from the reviewed studies are that achievement in science plays an important role as a determinant of scientific attitude, scientific aptitude, effectiveness of the any new method or approach of teaching science and students' higher order ability. Another implication to be drawn is that sex wise students do show significant difference in their performances. Hence, it is important to consider it as a variable while conducting a research in science education. With regard to test construction almost all the studies have tried to determine students' performance at lower levels of cognition. Therefore, there is a dire need of constructing a test which covers lower as well as higher levels of cognition.

Additionally, almost all the national documents have recommended using child's mother tongue as the medium of instruction at least for elementary education. Even the study of Nair (2015) has revealed that the medium of instruction does impact learning outcomes at primary level. This gives rise to a question that weather use of any other than mother tongue as the medium of instruction hinders the intellectual development of children. A few of the reviewed studies considered language as a variable and compared students' performance with regard to medium of instruction. Since medium of instruction highly affects child's cognitive development, it must find a place in the research.

Furthermore, it was found in the trend report of science education presented by Chunawala (2006) in Sixth Survey of Educational Research (1993 to 2000) that majority of the studies (32%) were cognitive studies in science education which contained categories in understanding of science, conceptions as well as misconceptions of both elementary and secondary students. Apart from this, Buch (1983) also observed the need of constructing tests in various other parts of science and also for certain grade levels which are still unexplored.

Hence, the researcher would like to focus on assessing students' cognitive abilities in science. Researcher wishes to assess the cognitive abilities of students developed during their elementary education. For this purpose, researcher wants to take up those students as the sample for present study who have successfully completed their elementary education up to class VIII and have entered first stage of secondary level i.e. class IX. Researcher is also curious to know whether cognitive abilities of students have any influencing factors such as gender, medium of instruction,

type of schools and academic achievement. Keeping in mind the distinct nature of science researcher wishes to determine whether the present science curriculum is transacted in such a way that makes learners competent enough for dealing with the things in an intellectual manner. Researcher conducted the present study in Kachchh district since the district has undergone several developmental changes after the earthquake of 2001 which has even led to increased number of varied educational institutions. Moreover, the feasibility and accessibility, which are important characteristics of research, are more in Kachchh district.

3. 0 SPECIFICATIONS OF THE PROBLEM

3.1 STATEMENT OF THE PROBLEM

A study of cognitive abilities of class IX students in science and technology in Kachchh district

3.2 OBJECTIVES OF THE STUDY

1) To study the cognitive abilities of class IX students in science and technology.
2) To study the cognitive abilities of class IX students in science and technology with respect to medium of instruction.
3) To study the cognitive abilities of class IX students in science and technology with respect to gender.
4) To study the cognitive abilities of class IX students in science and technology with respect to types of school.
5) To study the cognitive abilities of class IX students in science and technology with respect to academic achievement in science.

3.3 HYPOTHESES

$H_0$1: There will be no significant difference in the mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction.

$H_0$2: There will be no significant difference in the mean achievement scores on cognitive abilities of class IX students with respect to gender.

$H_0$3: There will be no significant difference in the mean achievement scores on cognitive abilities of class IX students with respect to types of schools.

$H_0$4: There will be no significant difference in the mean achievement scores on cognitive abilities of class IX students with respect to academic achievement in science.

$H_0$5: There will be no significant interaction between mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction and gender.

$H_0$6: There will be no significant interaction between mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction and types of schools.

$H_0$7: There will be no significant interaction between mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction and academic achievement in science.

$H_0$8: There will be no significant interaction between mean achievement scores on cognitive abilities of class IX students with respect to gender and types of schools.

$H_0$9: There will be no significant interaction between mean achievement scores on cognitive abilities of class IX students with respect to gender and academic achievement in science.

$H_0$10: There will be no significant interaction between mean achievement scores on cognitive abilities of class IX students with respect to types of schools and academic achievement science.

$H_0$11: There will be no significant interaction among mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction, gender and types of schools.

$H_0$12: There will be no significant interaction among mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction, gender and academic achievement in science.

$H_0$13: There will be no significant interaction among mean achievement scores on cognitive abilities of class IX students with respect to gender, types of schools and academic achievement in science.

$H_0$14: There will be no significant interaction among mean achievement scores on cognitive abilities of class IX students with respect to medium of instruction, gender, types of schools and academic achievement in science.

3.4 OPERATIONALIZATION OF THE TERMS

Cognitive abilities: Researcher took into consideration all the levels of cognitive domain given by Anderson et. al. (2001). Students' performance in terms of their achievement scores in the Test

on cognitive abilities containing Multiple Choice Questions (MCQ) items constructed and standardized by the researcher based on first five levels; and in the Test on creativity containing test items focused on top most level of cognitive domain given by Anderson et. al. (2001); were considered as their cognitive abilities for the present study.

3.5 EXPLANATION OF THE TERMS

Types of schools: Government schools, grant-in-aid schools and private schools were taken up for the present study. The category of government schools included government funded schools; schools under the scheme Rashtriya Madhyamik Shiksha Abhiyan (RMSA), Border Area Develop Project (BADP) and Model schools.

Academic achievement in science: students' scores in science and technology subject of class IX in the academic year 2018-19 were considered as their academic achievement in science.

3.6 DELIMITATION OF THE STUDY

The study was delimited to the schools managed by Gujarat Board of Secondary Education (GSEB) in Kachchh district during the academic year 2018-19. The study was also delimited to the content of Science and Technology subject from class six to class eight.

4. METHODOLOGY OF THE STUDY

Following are the details for the methodology of the study.

4.1 DESIGN OF THE STUDY

The present study was a normative survey in nature. A normative study is essentially a cross – sectional, mostly of the "what exists" type study. It does not aspire to develop an organized body of scientific laws but provides information useful to the solution of local problems. It may, however, provide data to form the basis of research of a more fundamental nature (Sukhia et. al., 1966). Mean, median and standard deviation were considered as the norms in the study.

4.2 POPULATION

There were total 282 secondary schools managed by GSEB in Kachchh district. From those 282 schools, 186 government schools; 96 grand-in-aid and 96 private schools were selected for data collection. All class IX students, in the academic year 2018-19, of those schools formed the population for the present study.

4.3 SAMPLE

The sample schools were selected through Multistage cluster sampling technique (Creswell, 2015) for the present study. It is shown below:

1st stage: 186 government schools + 96 grant-in-aid schools + 96 private schools

2nd stage: 7 government schools + 8 grant-in-aid schools + 5 Gujarati medium private schools + 7 English medium private schools were selected through lottery method of random sampling technique

3rd stage: All students i.e. 2458 students of class IX belonging to 27 schools selected in second stage were selected in cluster

4.4 TOOLS FOR DATA COLLECTION

To achieve objectives of the present study, a test to measure cognitive abilities in science and technology was constructed. Detailed procedure was followed by the researcher for the construction of tool is given as under:

Test on cognitive abilities: The researcher constructed a test containing Multiple Choice Questions (MCQ) in science and technology subject. Items focused on ***Remembering, Understanding, Applying, Analyzing and Evaluating*** levels of Bloom's revised taxonomy (Anderson et. al., 2001). The Constructed test was standardized by researcher. The questions focused on all the mentioned levels of cognitive domain.

Test on Creativity: the researcher constructed a test focusing on ***Creating*** level of Bloom's revised taxonomy (Anderson et. al., 2001). The test contained divergent type question.

4.4.1 CONSTRUCTION OF THE TOOL

1. TEST ON COGNITIVE ABILITIES

Below mentioned steps were followed for construction and standardization of Test on cognitive abilities. These steps have been adapted from Groundlund and Linn (1990).

1. Content analysis

Researcher went through the content of science and technology textbooks of class six to class eight designed by Gujarat State Board of School Textbooks (GSBST). Researcher referred the content of these textbooks for the preparation of the test. Based on the content analysis, researcher established horizontal as well as vertical relationship among the chapters of science and technology textbooks of class VI, VII and VIII designed by Gujarat State Board of School Textbooks (GSBST).

2. Construction of items

Based on analyzed content of science and technology textbooks researcher constructed an item pool which consisted of 581 test items. Action verbs suitable for all six levels of cognitive domain given by Bloom were used in each test item. The test contained Multiple Choice Questions (MCQs). Researcher kept in mind the following criteria for writing the test items:

1. Each item tested only one outcome.
2. Each question had at least four alternates.
3. Language of the instruction was clear and simple.
4. Each item had only one correct answer.

The item pool contained test items in the following manner:

Content area	Remember	Understand	Apply	Analyse	Evaluate	Total
Chemistry	66	33	26	13	2	140
Physics	42	34	35	12	11	133
Biology	154	76	39	11	6	292
Grand total	**262**	**143**	**100**	**36**	**19**	**567**

3. Experts' Validation

The tool was sent to **15** experts of science and technology subject. All the experts were secondary school science teachers. The minimum qualification of the experts was M. Sc., B.Ed. However, majority experts had qualification M. Sc., M. Ed. while some had earned a Ph. D. in Education too. The tool was to be examined in terms of following criteria:

1. The instruction part given for each question.
2. The coherence between instruction and the item.
3. The language used in the/for the preparation of items.

Apart from this, experts were also asked to select the most appropriate items for each level of the taxonomy for every identified concept. When the experts returned the item pool with their selected items, it was prominent that there were some items which had received huge convergence of experts' selection. It is to be noted here that no any maximum or minimum number was decided for selection of items. The purpose was to prepare a comprehensive and holistic tool for the present study.

4. Pre-pilot testing

Researcher personally administered the constructed item pool on a group of 13 students other than the sample to check it from language aspect and unambiguity of items. The item pool was administered in parts for three days on the same group of students. There was no any time limit to fill the tool as the purpose of the administration was not to measure the speed of the students for responding. However, the approximate time taken by students was noted down by the researcher. Additionally, Students' queries and discussion with them during the administration were recorded by the researcher. Following are the points concluded from the discussion:

- The language used by the researcher in the test items was not understandable by class IX students. Students did face difficulty in understanding higher order questions of the tool. They frequently needed clarifications and explanations of the terms as well as the statements of the items.
- Though the tool was prepared with the purpose of covering all the identified concepts of science and technology textbook, it was too long for the students.
- However, students felt challenged while answering the test items.

- According to students, the tool contained some thought provoking questions which were not directly answerable from the textbook content. Hence, the tool was valid in itself for higher order level question.

Based on the findings of the pre pilot administration and experts' comments and selection in validation on the item pool, a draft of the tool was prepared which contained 192 Multiple Choice Questions.

5. Pilot study

5.1 Empirical evidence

Researcher carried out a pilot study for gathering empirical evidence. The sample was 312 class IX students. The students were selected from government, grant-in-aid and private schools. The tool was administered in both Gujarati and English languages. Following instructions were given to students:

→ Attempting all the questions was mandatory.

→ Each question had only one correct answer.

→ There was no negative marking for incorrect answer.

→ There was no time limit to complete the test.

a). Item analysis

Item analysis brings into light general areas requiring attention; reveal ambiguities, technical defects with regard to language of instruction, mode of presentation. The test constructed being a norm reference test, a suitable procedure of comparing upper and lower of 27% of the group on the basis of the test performance was adopted. The responses of the remaining pupils not included in the analysis, were assumed to follow the same trend as those in the upper and lower groups.

Step I: After collecting the test papers from the students, students responses were scored, one mark for the correct response and no marks for the incorrect responses.

Step II: When all the test papers were scored they were arranged in ascending order of marks. The upper 27% and the lower 27% of the students arranged in ascending order with regard to their scores were selected. Here, 85 students made 27% of the total. Therefore, the item analysis process was done with responses of 170 students.

Step III: the scores were tabulated against the test items. For each test item responded correctly, entries were made in the table. Thus, total number of correct responses for each item were found.

The tabulation of responses facilitated in obtaining estimate of item difficulty and item discrimination power. Although item analysis revels the general effectiveness of a test item, it is desirable to obtain item difficulty and discrimination power.

b). Item difficulty (P value)

The item difficulty of a test item is indicated by the percentage of pupils who get the correct item. It was calculated by using the formula given by Groundlund and Linn (1990). It is to be noted here that the items left unanswered by the students were omitted from the item analysis procedure.

→ From the calculated item difficulty it could be concluded that lower the difficulty value, higher was the difficulty.

c). Item discrimination (D value)

An item discriminates in a positive direction if more pupils in the upper group than the lower group get the correct item. The discriminating power of a test item refers to the degree to which it discriminates between pupils with high and low achievement. Following formula was used to find out discriminative power given by Groundlund and Linn (1990).

5.2 Validity, Reliability and Norms

The researcher ensured content validity of the Test on cognitive abilities during the tool validation phase. Experts' comments and suggestions were taken into consideration while modifying the tool. In this way, the tool was content validated. Reliability of the test was established using KR 21 formula and split-half reliability. Reliability was calculated using the KR 21 formula given by Gay and Airasan (1999).

Mean, median and standard deviation of the obtained scores were set as the norms of the Test on Cognitive Abilities. Following are the findings for the Test on Cognitive Abilities:

→ The mean score for the cognitive ability test was found to be 73. 67. The mean score for boys was found to be 73.58 and for girls was 73.67.

→ Median was found to be 71.5.

→ The value of standard deviation was found to be 17.10.

→ The value of KR 21reliability was found to be 0.8492.

→ For calculating Split half reliability the respondents were divided into two groups by odd – even method. The value of split half reliability test was found to be 0.8571.

6. Final administration of the test

The decision regarding selection of test items for the final draft was taken based on the discrimination values for the items.

- → The items having negative discrimination negative values were discarded from the final draft of the tool.
- → The test items for which the discrimination values were positive but less than 0.1 were discarded from the final draft of the cognitive ability test.
- → The difficulty values for discarded items ranged from 4.70 to 47.06. Therefore, 30 such items were removed from the final version of the test.
- → The final draft of the test of cognitive ability contained 162 test items. The test items were of Remember, Understand, Apply, Analyze and Evaluate levels of Bloom's revised taxonomy (Anderson et. al., 2001).

The finalized draft of the cognitive ability test was administered on 2458 class IX students of Kachchh district selected through Multistage cluster sampling technique..

2. TEST ON CREATIVITY

1. Content analysis

Researcher went through the content of science and technology textbooks of class six to class eight designed by Gujarat State Board of School Textbooks (GSBST). Researcher referred the content of these textbooks for the preparation of the test. Based on the content analysis, researcher established horizontal as well as vertical relationship among the chapters of science and technology textbooks of class VI, VII and VIII designed by Gujarat State Board of School Textbooks (GSBST).

2. Construction of items

Based on analyzed content of science and technology textbooks researcher constructed test items using action verbs suitable for Creation level of cognitive domain given by Bloom. The test contained divergent questions.

Content area	Create level questions
Chemistry	2
Physics	7
Biology	5
Total	**14**

3. Experts' validation

The tool was sent to the experts of science and technology subject to examine it in terms of following criteria:

1. The instruction part given for each question.
2. The coherence between instruction and the item.
3. The language used in the/for the preparation of items.

4. Pilot study

The constructed test was administered on a group of 13 students other than sample to check it from language aspect and unambiguity of items.

5. Final administration of the test

The constructed test was finally administered on the selected sample of class IX students of Kachchh district.

4.5 PROCEDURE FOR DATA COLLECTION

The researcher sought permission from the District Education Office (DEO) of Kachchh district. A forwarding letter addressing to the principals was prepared and assurance was given that data collected would be used for research purpose only and would be kept strictly confidential. The data was collected personally by the researcher through administration of the tool.

4.6 DATA ANALYSIS

Since the data for the Cognitive Ability test was in interval scale and the sampling was probability sampling, the researcher would analyze the data obtained by Analysis of Variance (ANOVA). Following are the assumptions of ANOVA (Groundlund and Linn, 1990):

1. The data must be normally distributed.
2. there must not be any outliers.
3. There must be homogeneity of variances.
4. Data of criterion variable must be on Interval or Ratio scale.

For Test of Creativity, the data would be analysed in descriptive manner.

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