MINOR RESEARCH PROJECT

AN EMPIRICAL INVESTIGATION OF EFFECTIVE SCIENCE LEARNING THROUGH SIMPLE EXPERIMENTS

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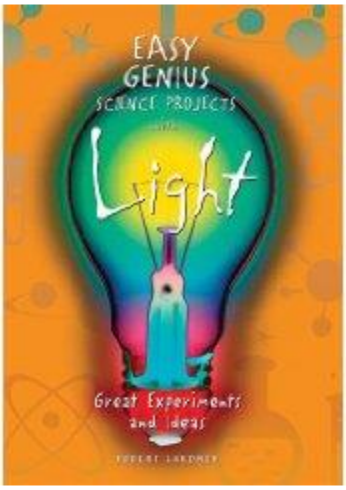

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May 2017

DECLARATION

We hereby declare that the project entitled **'An Empirical Investigation of Effective Science Learning through Simple Experiments'** submitted to Internal Quality Assurance Cell is our original work and the project has not formed the basis for the award of any degree, diploma, associateship, fellowship or similar other titles. It has not been submitted to any other University or Institution for the award of any degree or diploma.

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CERTIFICATE

Certified that the project entitled **'An Empirical Investigation of Effective Science Learning through Simple Experiments'** is a record of project work done by Dr. S. Chamundeswari, Principal Investigator, Dr. Deepa Edwin, Co-investigator, Dr. V.J. Uma Co-investigator, during the academic year 2016-2017 and that the project has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or similar other titles and that is an independent work done by the investigators.

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AN EMPIRICAL INVESTIGATION OF EFFECTIVE SCIENCE LEARNING THROUGH SIMPLE EXPERIMENTS

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1. INTRODUCTION

Learning is a continuous process for the living from birth till death. Developmental Psychologists (Hurlock, 1978) indicate that every human being has got a task of learning several personal and social conditions in order to fulfill the purpose of life. Among the social learning issues, the most important will be the curricular training.

Learning according to the learning theorists, is a process of acquisition of knowledge through study, the cognitive, behavioral, organisimic and social theorists describe the ways and means of building knowledge and applying them through communication. It is thus clear that learning is a life skill and one requires to master this skill. It is therefore obvious, that one has to make several repetitions and experience in order to be effective, which is referred in academic terms as practice or experiment.

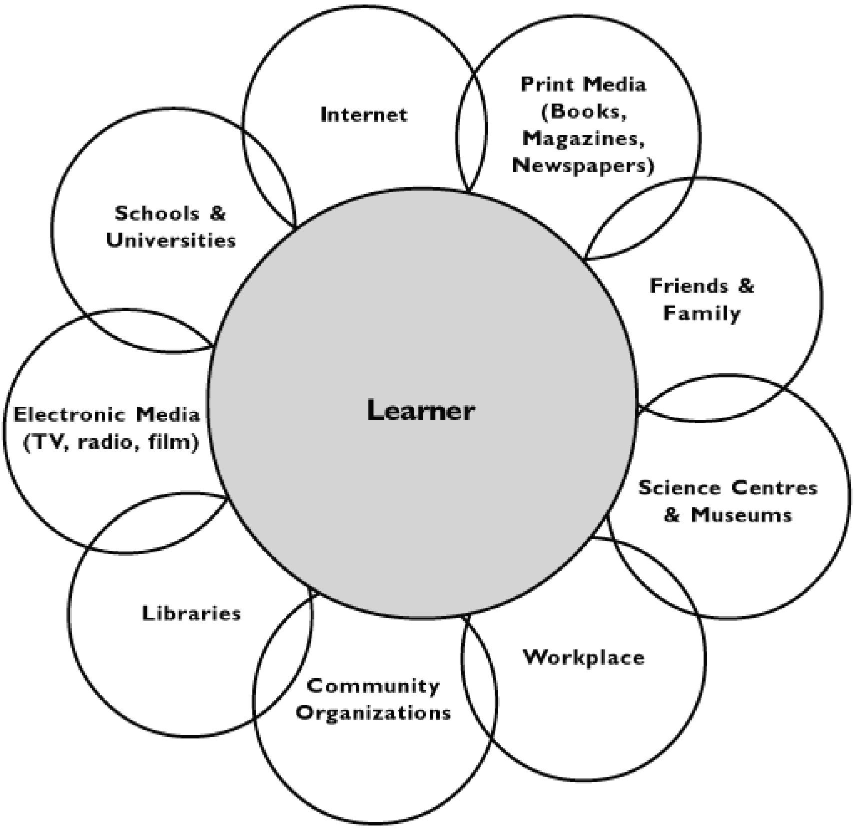
In school there are three components involved in learning-(i) the teacher (ii) the material to be taught and (iii) the learner. It is the teacher's responsibility to teach in the most effective manner that it reaches all pupils. Similarly, the student also has the responsibility of learning what is being taught. Thus, learning at school involves three stages from the part of the pupil-(i) understanding (ii) retaining in the memory (iii) applying through retrieval whenever and wherever necessary. These stages will further decide on the effectiveness of learning and the effort to learn more. Such effectiveness according to educators will be based on the efficient interactions between the teacher and the taught regarding the subject. The basic task of learning then depends more on how the teacher organizes a facilitative environment for learning.

Focusing on Science teaching, in particular, at school is considered essential for improving quality of Science learning in India. Great deal of literature offering significant challenges is available in many reports. In Wagner's (2005) article on the *Best Practices in Teaching Science* has clearly brought forth the importance of Science learning. It is understood that the factors of globalization and exchange of knowledge between countries has brought pressure on the significance of Science teaching and learning for maintaining and improving quality in Science learning.

The diagram below explicitly manifests the ways and means of knowledge building, particularly in Science learning.

Figure – 1

Science and Technology Learning Infrastructure



The diagram above visually presents the need for the student to use various resources for knowledge building in Science.

Laboratory work has special importance in the learning of Science as scientific principles develop and grow on the basis of laboratory work. The training in laboratory work helps to develop skills for handling apparatus and equipment and carry out experiments. In this way, the experimental work helps to promote scientific temper and adopt a cooperative attitude. Working in the laboratory provides a platform for trying novel and creative ideas and giving them concrete shape. Many researchers such as, Bencze and Pedretti set out to identify the common qualities specific to teaching success by Science teachers. Their concerns were with regard to the teaching of the Science teachers. Researchers were conclusive that practical experience is absolutely essential in enabling permanent and exemplary knowledge in Science.

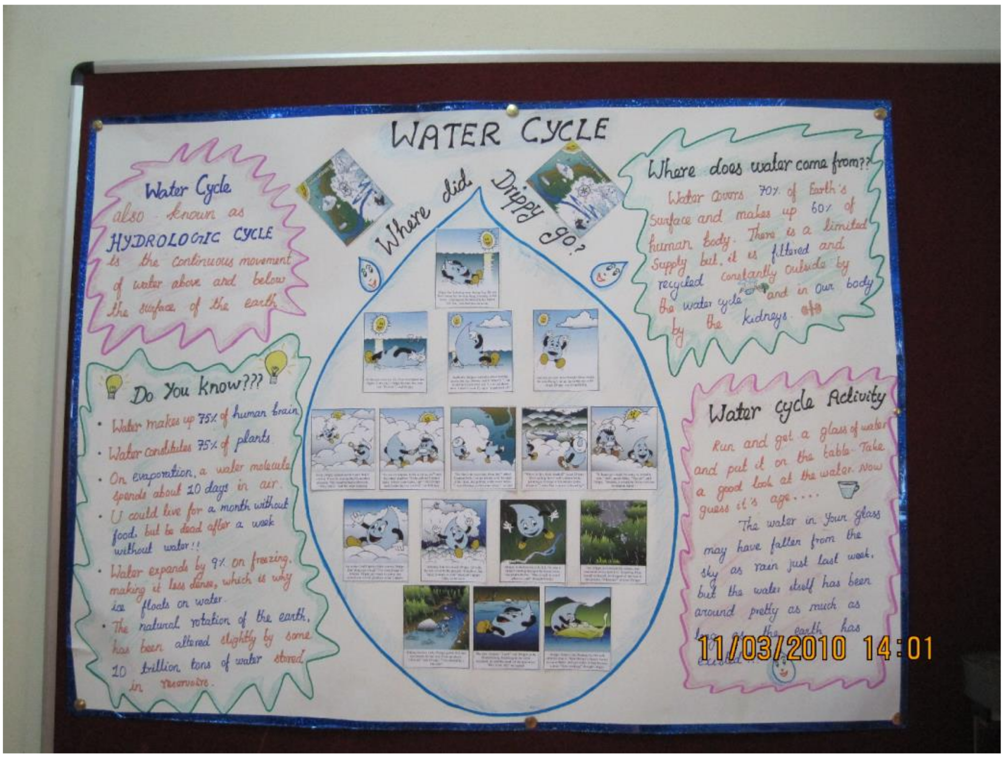
Researchers in Science learning later focused on what methods of teaching were *'well known and innovative'.* These reseaches made a major contribution to effective Science teaching by bringing to light the significance of practical experience. Today even languages are being taught with the help of language laboratories. Therefore, it is understood that Science can be learnt, improved and enhanced only when there is practical training.

Empirical evidence is evidence that one can see, hear, touch, taste, or smell. It is evidence that is susceptible to one's senses and is important because it is evidence that others besides yourself can experience, and it is repeatable. So empirical evidence can be checked by yourself and others after knowledge claims are made by an individual. Empirical evidence is the only type of evidence that possesses these attributes and is therefore the only type used by scientists and critical thinkers to make vital decisions and reach sound conclusions. We can contrast empirical evidence with other types of evidence to understand its value. Hearsay evidence is what someone says they heard another say; it is not reliable because you cannot check its source. Better is testimonial evidence, which, unlike hearsay evidence, is allowed in courts of law. But even testimonial evidence is notoriously unreliable, as numerous studies have shown. Courts also allow circumstantial evidence (e.g., means, motive, and opportunity), but this is obviously not reliable. A theory, therefore, is built of reliable knowledge--built of scientific facts--and its purpose is to explain major natural processes or phenomena (Schafersman, 1994).

One of the most popular methods of scientific communication is the use of posters. The teachers are increasingly making use of the poster presentations in classrooms. The power of the poster is that the communicants can directly discuss their data and interpretations, one-on-one or in a small group atmosphere. All information regarding the concept is visually available and it is very useful as an immediate feedback with the question and answer sessions. Posters help in enabling students present information in concise and logical form. Oral defense is also possible during the question and answer session of poster presentation. Posters enable a great deal of group discussion and exchanger of information improving the quality of learning.

Figure – 2

Designing Effective Posters (Fourtner, 2009)



These are some of the alternate methods of enabling Science learning more effective.

2. REVIEW OF RELATED LITERATURE ON SCIENCE LEARNING

Western literature clearly indicates the nature of Science learning, defining and differentiating it from the rest of the other studies. In 1992, the National Science Foundation of the United States of America, made a statement regarding the principle of Science learning. It was as follows: *the curricula have to promote active learning through enquiry, problem solving, cooperative learning and other instructional methods.* An important statement further made by the National Committee on Science education of the United States (1992) said that school Science education must reflect Science as it is practiced.

Several studies relating to these principles have been made by researchers in the recent years. Novak (1964), a significant contributor to concept mapping has clearly stated that enquiry is the behavior involved in the struggle of human beings for reasonable explanation of phenomena about which they are curious. From a pedagogical perspective, inquiry-oriented teaching is often contrasted with more traditional expository methods and reflects the constructivist model of learning, often referred to as active learning, so strongly held among Science educators today. According to constructivist models, learning is the result of ongoing changes in our mental frameworks as we attempt to make meaning out of our experiences (Osborne and Freyberg, 1985). Many researchers in education have attempted active search for various methodologies. Some of them have provided with lectures alone (Tinnesand and Chan, 1987), while others have reported on guided enquiry (Igelsrud and Leonard, 1988).

Driver (1989) observed that students generally have tendency to develop and restructure their knowledge through experiences, especially with exploratory talk and teacher intervention. The studies of Collins (1986), Rakow (1986) and DeBoer (1991) emphasize the active nature of Science learning with *hands-on* and experiential activity-based instruction. Germann (1991) considered heuristic devices for meaningful learning and skill development in Science. Research findings indicate that, students are likely to begin to understand the natural world if they work directly with natural phenomena, using their senses to observe and using instruments to extend the power of their senses (National Science Board, 1991). Millar and others (1994), Lubben and Millar (1996) explored the influence of procedural understanding in learning the scientific concepts. They developed a model of procedures which they termed as PACKS (P-procedural; A-And; C-Conceptual; K-Knowledge; S-in Science). They conducted several such programmes and collected data regarding understanding of appropriate concepts and developing skills. This procedure had been followed in the works of Foulds and others (1997 and 1998). Watson and Wood-Robinson conducted a series of research (1998; 1999a; 1999b) to develop procedural stages in the understanding of scientific concepts. The findings have been reported in a series of articles published by the UNESCO under the *Role of Practical Work.* Practical work according to them may be used in a variety of formats consisting of equipments, activities, observation and description. They believed that such practices helped both, the teachers and the students learn what they have to learn and they also argued that illustrative tasks stimulate discussions and develop investigative skills.

Doppelt (2005) experimented with varied techniques of Science learning and he concluded that Science and technology will have to go hand-in-hand.

The techniques are significant in enabling the students understand Science. Therefore, Science and technology according to the researchers are mutually inspiring emphasizing the need for creating and developing innovative techniques in the understanding of Science.

The American studies on Science learning, after series of experiments in understanding techniques that enabled better learning, found that scientific concepts when related to personal experiences using examples familiar to their lives, societal issues, and cultural backgrounds, it becomes more meaningful and therefore, retained better (National Research Council, 1996; Carin, Bass and Contant, 2005; Cruickshank, Jenkins and Metcalf, 2006; Abell and Lederman, 2007). In addition these researchers also suggested that learning environment for Science learning will have to be supporting students to construct active knowledge. These researchers have emphasized the need for continuous teacher-student interaction, employing discrepant events with concrete phenomena activate their interest and exploration. They brought forth the idea of concept mapping where concepts in each subject matter could become inter-related. They also specified the importance of laboratory experiments and use of physical models in understanding scientific concepts (National Research Council, 1996; Carin, Bass and Contant, 2005; Driscoll, 2005; Cruickshank, Jenkins and Metcalf, 2006; Abell and Lederman, 2007).

Thus, use of laboratory in Science learning has been considered as the richest experience students can have. It provides opportunities for the students to practice Science much in the way the professionals do. It is nevertheless necessary to have a highly sophisticated laboratory if the teacher can innovate some simple material to facilitate understanding. Such experience enables the student to understand the worth of the experiment, the purpose it serves and therefore enhances better understanding of a concept, its relationships and process.

The Indian scenario, especially in education, has been continuously improving and enhancing its quality from the time of independence. The extent of illiteracy had been enormous at the time of independence. Our census report shows the percentage of literacy immediately after independence had been only 18.33% and today after 62 years after independence it has grown to 65.38%. These facts presented here, emphasize that educational growth and literacy level had been gradually and slowly improving in India, indicating need for easy learning methods. The investigators, therefore, feel justified that their efforts to find innovative methods of teaching Science at the Primary and Secondary levels are genuine and appropriate.

The economic conditions of Indian schools are varied, some being very affluent, some adequate and yet some other schools struggling to provide an adequate milieu for learning. The question arises as to how these socially deprived schools could compensate for difficulties in procuring sophisticated equipments for their Science laboratories. Even the affluent schools, though may have the facility to procure expensive equipments, are also concerned about the complications involved in, first of all understanding the usage of equipments and enabling the students to comprehend the concepts through these complex equipments, during the formative years of the pupils.

Narlikar (1999) in his book on *Decline in Science Education* in India, has stated that methodology of Science teaching has been changing ever after independence attempting to emulate teaching in the western countries. This according to him has reflected in the brain-drain condition persisting in India over a period of four decades. The lack of employment potentials and lack of accelerated growth in pure Sciences, have been quoted as the major attributes for the decline of Science education in India. Further, the methodology of Science teaching has been gradually deteriorating as the teachers have become ill-equipped along with the poorly equipped and maintained laboratories. As a result, the teachers are demotivated to find ways and methods of making Science learning simple and effective.

The teaching of Science in middle schools is never accompanied by *hands-on* experience. Scientists and educationists, though have been harping on the lack of meaningful learning, many schools were not in a position to provide such sophisticated laboratories for that level. The proportion between the teacher and students in a classroom varies on the basis of the Management type. While the government schools have the highest number of student enrollment, the other aided and self-financed schools take care of the proportion to some extent.

The teachers of the 19^{th} century believed and used only words and educators thought children will assimilate something if they could repeat it. But, contemporary world firmly thinks that children need experiential learning using the sensors, such as seeing, touching, hearing, tasting, smelling, choosing, arranging, putting things together or taking things apart. The need for experiential learning was recognized by the UNESCO and the attempt brought forth a book or a guide by Stevenson (1949) entitled, *Suggestions for Science Teachers*. In 1956, however, UNESCO brought forth a source book for Science teaching and several consequent publications arrived till 1973. Unfortunately, the books are not available in Indian languages. Science educationists have even made use of toys in enabling meaningful understanding among the students (Sudarshan Khanna, 1994). Gupta (2007) in his book on *Ten Little Fingers* has provided a brief history of Science teaching from the olden days to the present. Gupta (2008) has made an exhaustive review literature on Science teaching at the school level and concluded that it is an experimental subject and students can learn effectively only by doing hands-on experiments.

Many researchers in Science teaching have carefully demonstrated the principle of Science, could be brought to the classroom using the simplest and least expensive material. Even these materials could be purchased at the nearest store for those experiments. Common rubber bands, cello tapes, paper cups, foam, string, straw, ruler, coins, scissors, paper and pencil could be useful in preparing the laboratory experiments.

However, it has never been ideal for the simple reason that the student population in India is extremely high and ever increasing. Teachers suffer with stress and burnout (Chamundeswari, 2007) unable to manage classrooms appropriately. Many teachers have observed that students who really want to improve their learning alone are interactive. Others are most of the time never interactive. Research studies reported clearly indicate the need for interactive and participative learning in addition to hands-on experiential learning in Science. This has not been possible in all Indian schools due to the extensive expenditure in building laboratories.

It is interesting to note that Science teaching in formal schools varies in the two environmental levels, the urban and the rural. Unfortunately, the developing countries, like India, are unable to provide facilities in village schools for building sophisticated laboratories and sustenance of it. This has created an inherent discrepancy between the Science learning of urban students and rural students. The exposures the urban students have at home and outside will be more facilitative in understanding scientific terminologies more than the rural students. These discrepancies have a serious impact in their later education and employment opportunities. The knowledge, a rural student has will be of little or no practical value.

A comparison of western Science teaching to Indian Science teaching in schools has brought to light two important issues: (i) teachers lacking in content preparation with the substantial need for professional development to deepen their own Science knowledge (ii) teachers unable to provide hands-on practical experience, more interaction and working in collaborative cooperative groups. Their counterparts in the west are very well equipped in knowledge building, updating, use of technology and laboratory simulations. The researchers attribute the difference and discrepancy for inadequate finance structure and restrictions in expenditure (Fulp, 2002).

These problems were stimulations for the present researchers to focus on innovative techniques of enabling Science teaching and learning with a more convenient and easy methodology. This thinking resulted in the present study with a research question as follows:

Are there simpler methods of conducting experiments in Science with the help of simple materials, easy to procure and manipulate specifically at the Primary and Secondary levels of schooling?

The answer to the question was not simple, because, scientific knowledge takes multiple forms, as a fact, it has to be established and entered in theory. So Science is inclusive of hypotheses, facts, laws and events. The presentation therefore requires a very clear cut understanding of the information. Information processing is inclusive of attention, comprehension and mental mapping. The teacher has to make it interesting and impressive in order to catch the focus of attention to the subject. Her communication skill will have to be effective to enable the student understand the concept. In Science, linkages are equally important with other Sciences, for example, there are common topics in both Physics and Chemistry, dealing with the physical aspects and the chemical aspects, though the topic might be the same, such as, heat, energy, light, water etc.

The research study therefore, selected a target population of the 10 and 11 year olds in school and fabricated simple experiments to be conducted in the class in Biological and Physical Sciences. For this purpose, the topics were chosen on the basis of the curriculum content of the Primary and Secondary levels, where the 10 and 11 year old pupils studied.

Teaching elementary Science can be one of the most rewarding experiences an educator has. It affords the opportunity to both satisfy and cultivate the innate and insatiable curiosity of pre-adolescents. It also provides the opportunity to teach a problem solving methodology that will serve students well not just through their academic career but for the rest of their lives. Teaching elementary Science provides a veritable plethora of opportunities to instill long lasting truths and principles in the lives of students. The wise educator will take advantage of those opportunities and, perhaps, in the process, have the privilege of making permanent, positive changes in a child’s life.

Evolving an experiment was not a simple task as it required a great deal of effort from the part of the investigators. Initially, many teachers of Science were interviewed who were teaching standards V and VI. The information thus gathered consisted of their ideas in fabricating experiments with simple materials without sacrificing the concepts and their meaning. These were latter sorted by the researchers and the faculty of Physical Sciences were invited from other institutions for a brain storming session. These efforts brought forth amassed information on simple ways to conduct Science experiments. The researchers of the present study applied their minds and made final selection of some 100 experiments, apparently simple in nature and fulfilling the need of experimentation without any sophisticated instrument. A manual consisting of the description, procedure and inference of the 100 experiments was prepared and further tested.

3. METHOD OF INVESTIGATION

The present study has been designed to help teachers with innovative and simple methods of experimentation in Sciences for the standards V and VI pupils in schools. The problem for research therefore consisted of two stages.

Stage – 1 : Developing simple laboratory experiments for classes V and VI.

Stage – 2 : Experimenting with these laboratory tests and observe the effectiveness.

The target population was 10 and 11 year old pupils belonging to classes V and VI. A systematic random sampling of the school and the pupils was envisaged. Based on the target population, the Science lesson was selected and experimentation was developed. Finally the draft manual of simple experiments constructed by the investigators, based on relevant literature on developing Science tools for middle school Science curriculum (Apea and Lowe, 1979; Per Christiansen and Bernard Zubrowski, 1980) was subjected to rating by the Science professors and teachers in order to establish the relevance of the experiments. From the judgmental ratings inter-correlation was worked out and those items experiments found relevant with the inter-rater correlation were retained. The experiments thus selected are listed below:

(i) Topic : Air

Experiment : Air contains Water Vapour

(ii) Topic : Water

Experiment : Water exerts Pressure in all Directions

(iii) Topic : Heat

Experiment : Air Expands when Heated and Contracts when Cooled

(iv) Topic : Motion

Experiment : Rollers reduce Friction

(v) Topic : Light

Experiment : Spectrum of Colours

Based on these experiments the investigators formulated relevant questions for assessing the level of understanding and application of the knowledge in the subject before and after exposure to these experiments. To illustrate, a few examples from the questionnaire has been given below:

Example - 1 : What happens when you place a lid on a vessel of hot water? What is the name given to this process?

Example – 2 : Does water pressure vary with depth?

Example – 3 : What happens when air is heated and cooled?

Example – 4 : What is frictional force?

Example – 5 : Why do we see various colours in white light?

3.1 Administration and Scoring

The experiments were conducted as per the conventional procedure and the sample after classification into control and experimental group were subjected to assessment of knowledge in the topic selected for testing. Control group had one assessment and experimental group had two assessments, before and after exposure to experiments. The scoring procedure depended on graded difficulty level. Therefore, the simplest question was assigned 2 marks, followed by questions relating to medium level of difficulty, with 3 marks and a final question at a higher difficulty level, with 5 marks, totally for every topic 10 marks were assigned.

3.2 Sample Selection and Characteristics

The number of schools in India follows multiple systems. No system could be compared to the other. It had been there from the time of independence till date. They are the central board of school education, the state board of school education, the Anglo-Indian board of education, ICSE. It is also observed that in every state there are the matriculation and the government schools. While the matriculation schools follow a high standard of education, the government schools either aided or directly run have a very low standard of education. The government policy being *Education for All*, the allocation of funds has to be shared by numerous schools, either as an aid or in direct contribution. This eventually means that such schools either run by the government or supported by the government have adequate or sometimes inadequate funds as a result of sharing compared to the self-financed matriculation schools. However, the results or the performance of matriculation schools remain to be higher than those of the government schools indicating shortages and lack of academic stimulations at home. The present study therefore, concentrated on those who do not have affluent infrastructure available to them though willing to learn.

It was thought most proper to try the experiment with such government and government-aided schools and extract the relative efficacy of such simple laboratory experiments in Science learning. In order to investigate whether social position of affluence in matriculation schools to provide a good infrastructure, to facilitate Science learning, the study undertook an appropriate sample from matriculation schools. The sample distribution was drawn as follows.

Table - 1

Distribution of Sample

Types of Schools/ Gender	Boys	Girls	Total
Government	42	48	90
Government-aided	48	45	93
Matriculation	46	46	92
Total	136	139	275

Figure - 3

School-wise Distribution of Sample

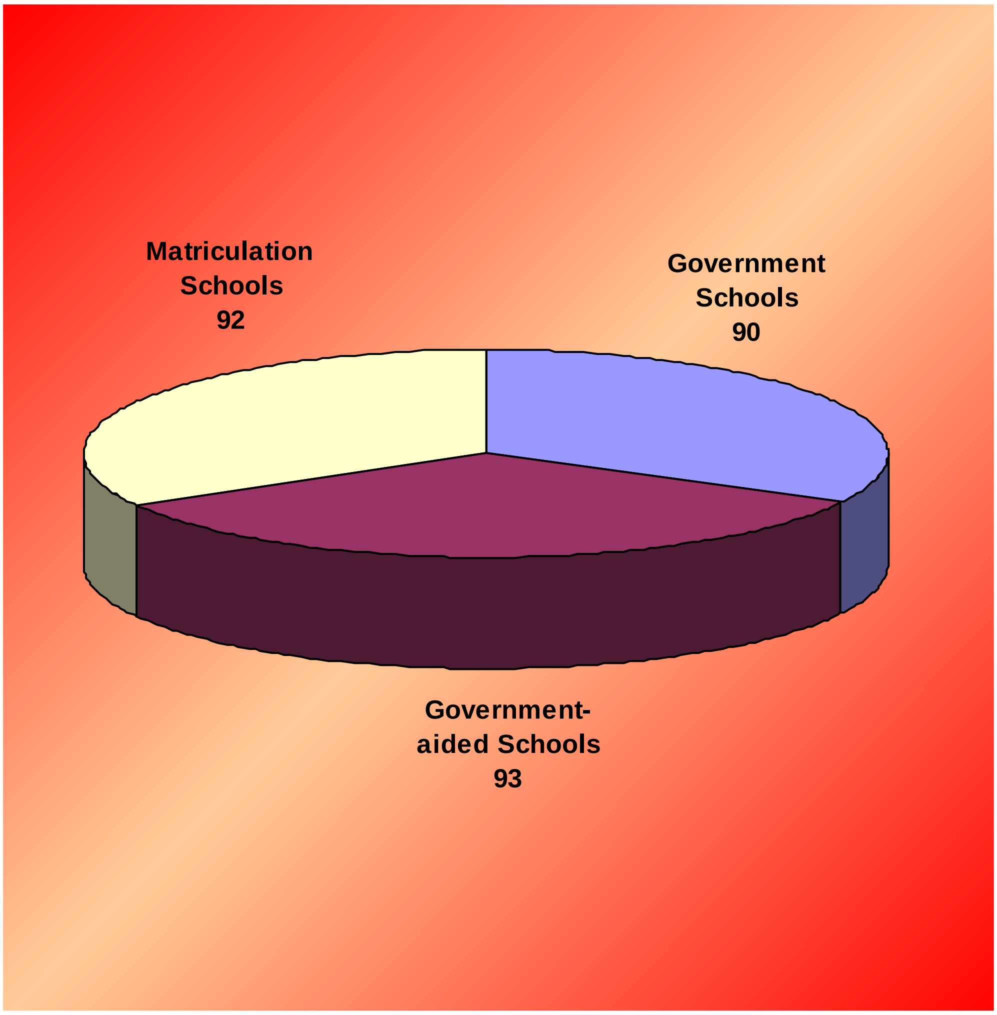


Figure - 4

Sex-wise Distribution of Sample

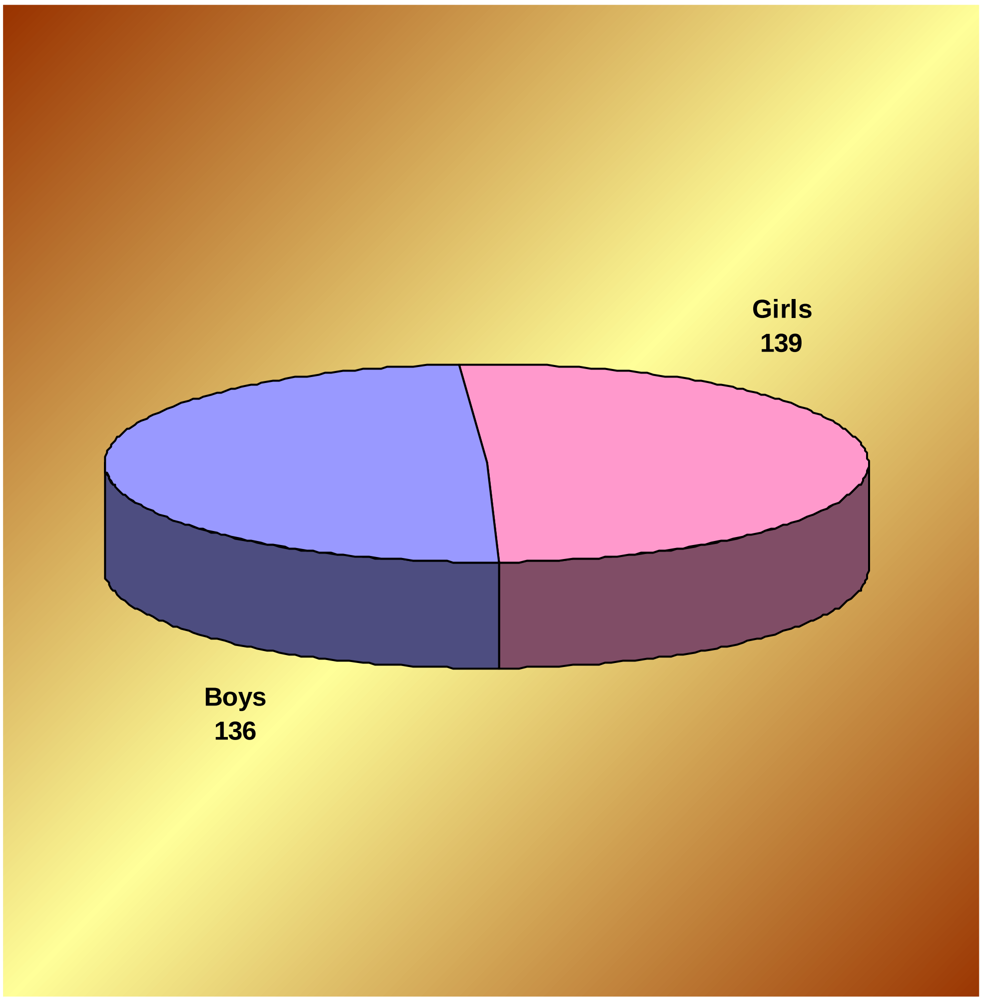
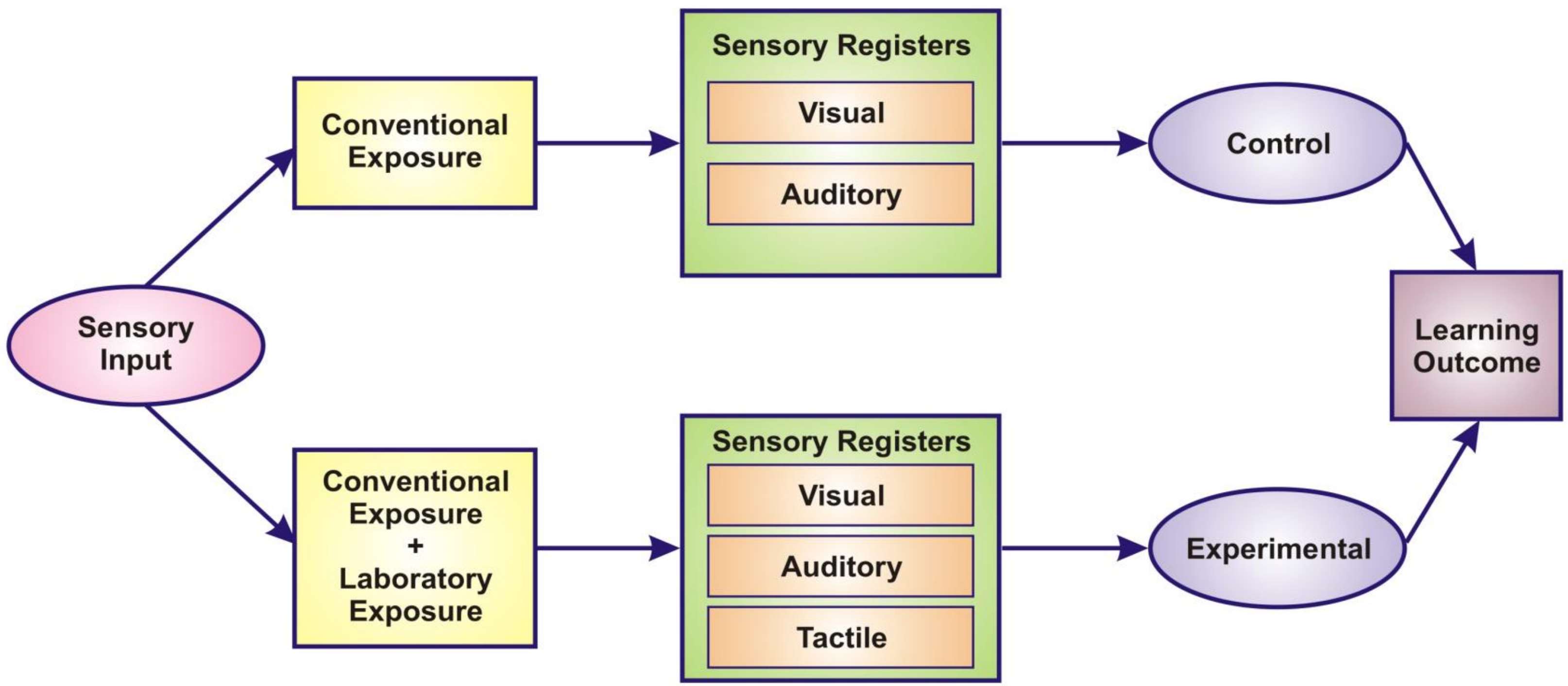


Figure - 5

Hypothetical Model of the Present Study



3.3 The Present Study

The present research investigation was envisaged with a hypothetical research model in order to ascertain the superiority of hands-on experience in Science learning. This model has been presented below.

The figure above clearly evidences the nucleus of the present research indicating how knowledge in Science could be qualified using dissemination of theory and hands-on experience in practicals. Thus, the information that is disseminated in the class by the teacher with a lecture is combined with the practical experience to form a more sustained learning. Theory alone, through oral description, according to many researchers, will be inadequate for in depth or meaningful learning, as it concerns itself only with visual and auditory sensations alone. When laboratory experiments are combined, then the information will be received through auditory, visual and tactile stimulations. Hence, the permanence or sustenance of learning will be more.

3.4 Procedure

Five experiments were finalized, for the government, government-aided and matriculation schools. The study was undertaken in two schools belonging to each of the three educational systems. The research investigation took abundant precaution in order to partial out the existence of learning disability among the target population.

The experiments finalized by experts were used for teaching the classes V and VI pupils in the subject of Science with a pre-test knowledge in the subject to be taught. After the experiment, the pupils were again tested within a week's time and not immediately in order to ascertain the permanence and quality of learning. The Investigators also collected the marks the pupils obtained in these subjects with traditional teaching. It is to be noted that the pupils belonging to standards V and VI have minimal exposure to laboratories. The class was divided into two groups using a systematic randomization, odd numbers participated in the experimental group and even numbers were grouped with the controls. The nature of learning provided to these two groups was schemed as follows :

Experimental Group : Conventional Teaching + Laboratory Exposure

Control Group : Conventional Teaching

The data thus collected were scored and two types of scores in Science learning were obtained, one before the use of the researchers' manual of laboratory experiments and after the use of the manual. The scores were then subjected to two kinds of variance analyses with comparisons.

4. ANALYSES

The scores thus obtained provided scope for within group and between groups comparisons. For this purpose the investigators utilized bivariate techniques of statistical analyses. They were paired-t tests, independent samples t-tests and one-way analyses of variance.

4.1 Analyses using Paired-t Tests

The first part of statistical analyses consisted of computing paired-t tests among the groups of government, government-aided and matriculation school students based on the scores they obtained in Science learning before and after exposure to laboratory experiments constructed by the present research investigators. The results of the paired-t tests have been presented below (Table-2a, 2b, 3a, 3b, 4a and 4b).

Table - 2a

Summary of Significance of Mean difference in Science Learning Before and After Exposure to Experiments among Boys in Government Schools

Variable	N	Mean	SD	Mead Difference	Paired-t
Before Exposure	42	13.57	3.08	22.48	28.17**
After Exposure	42	36.05	4.16		

**Significant at 0.01 level

The table above shows the paired t values obtained which clearly indicates the significance of mean difference between the two scores of the boys before and after exposure to the experiments conducted. The significance has led the investigations to draw inference that the boys of the government schools have significantly improved in their knowledge, understanding and application of Science, the subject taught in the class. It is therefore interpreted that laboratory experiments made easy has definitely helped the students gain knowledge in the subject matter.

Figure - 6

Means of Science Learning Scores Before and After Exposure to Experiments of Boys in Government Schools

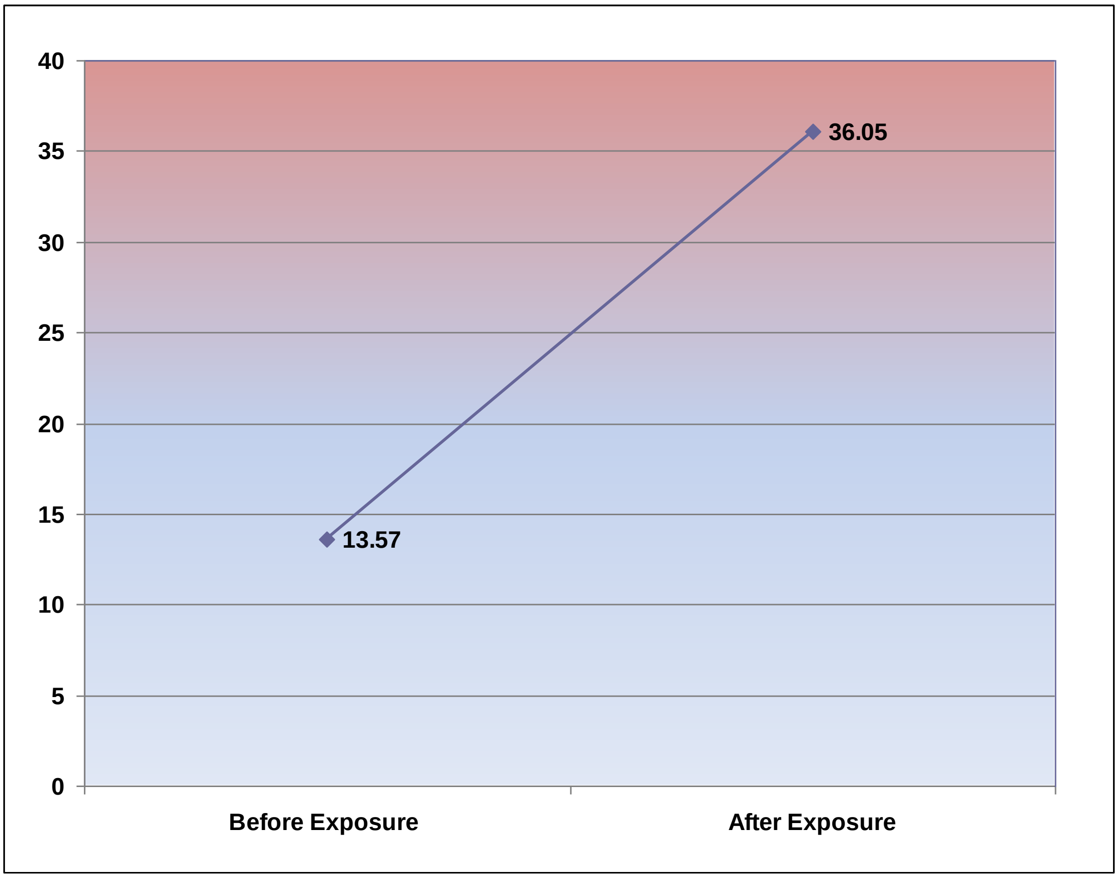


Table - 2b

Summary of Significance of Mean difference in Science Learning Before and After Exposure to Experiments among Girls in Government Schools

Variable	N	Mean	SD	Mean Difference	Paired-t
Before Exposure	48	15.33	2.90	17.92	23.14**
After Exposure	48	33.25	4.51		

**Significant at 0.01 level

It is interpreted from the table that the girls of the government schools have performed better in the subject matter of Science after they were exposed to simple laboratory activities. This is authenticated by the significant t value obtained using the paired t test. The mean value for the girls after learning through such experiments had been enormous, compared to what they secured in the before tests. It is further interpreted that the students have enriched their knowledge in Science with the understanding of the concepts through a laboratory exercise.

Figure - 7

Means of Science Learning Scores, Before and After Exposure to Experiments of Girls in Government Schools

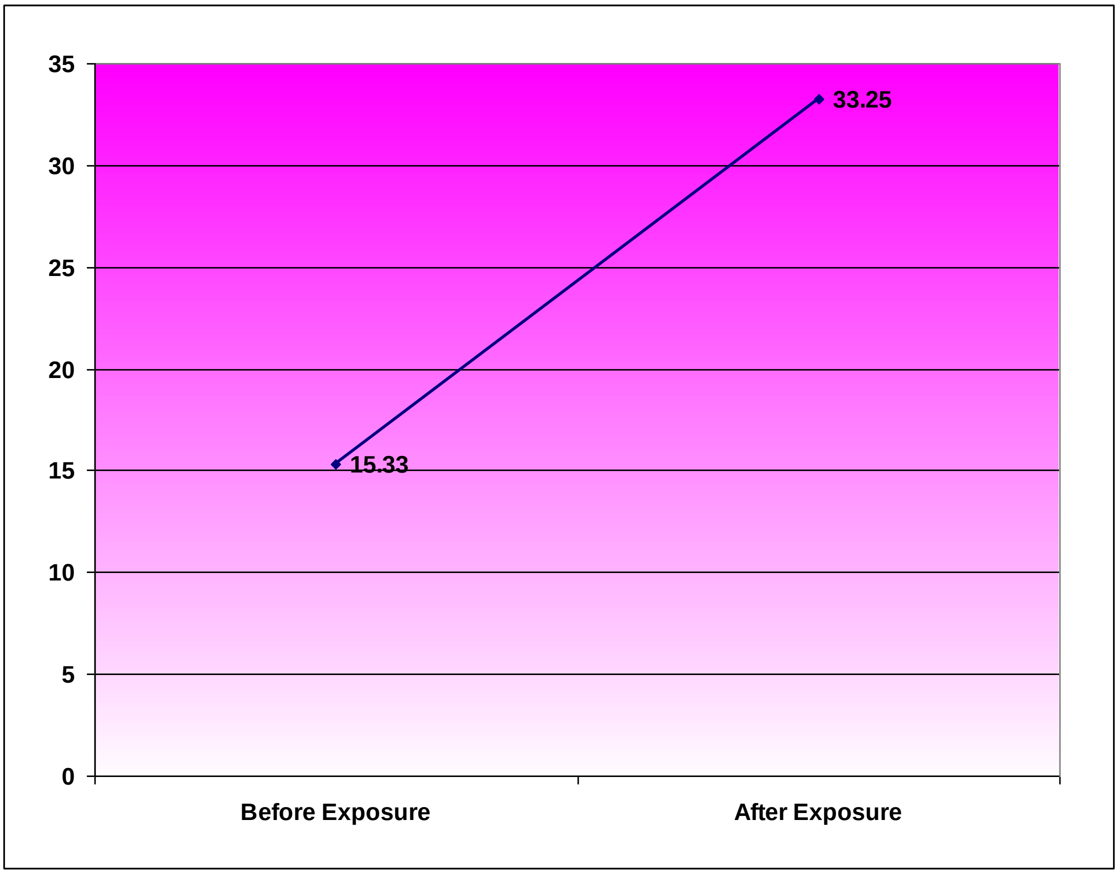


Table - 3a

Summary of Significance of Mean difference in Science Learning Before and After Exposure to Experiments among Boys in Government-aided Schools

Variable	N	Mean	SD	Mean Difference	Paired-t
Before Exposure	48	24.46	3.43	10.63	15.67**
After Exposure	48	35.08	3.12		

**Significant at 0.01 level

The results presented in the above table is quite interesting due to the fact that the students belonging to the government-aided schools though have shown statistically significant difference before and after administration of simple experiments constructed by the research investigators, the extent of difference had not been so wide such as that of the government school boys. This is worthy of mention and requires explanation. However, the difference among the boys belonging to the government-aided schools before and after laboratory exercises is significant at the 0.001 level.

Figure - 8

Means of Science Learning Scores Before and After Exposure to Experiments of Boys in Government-aided Schools

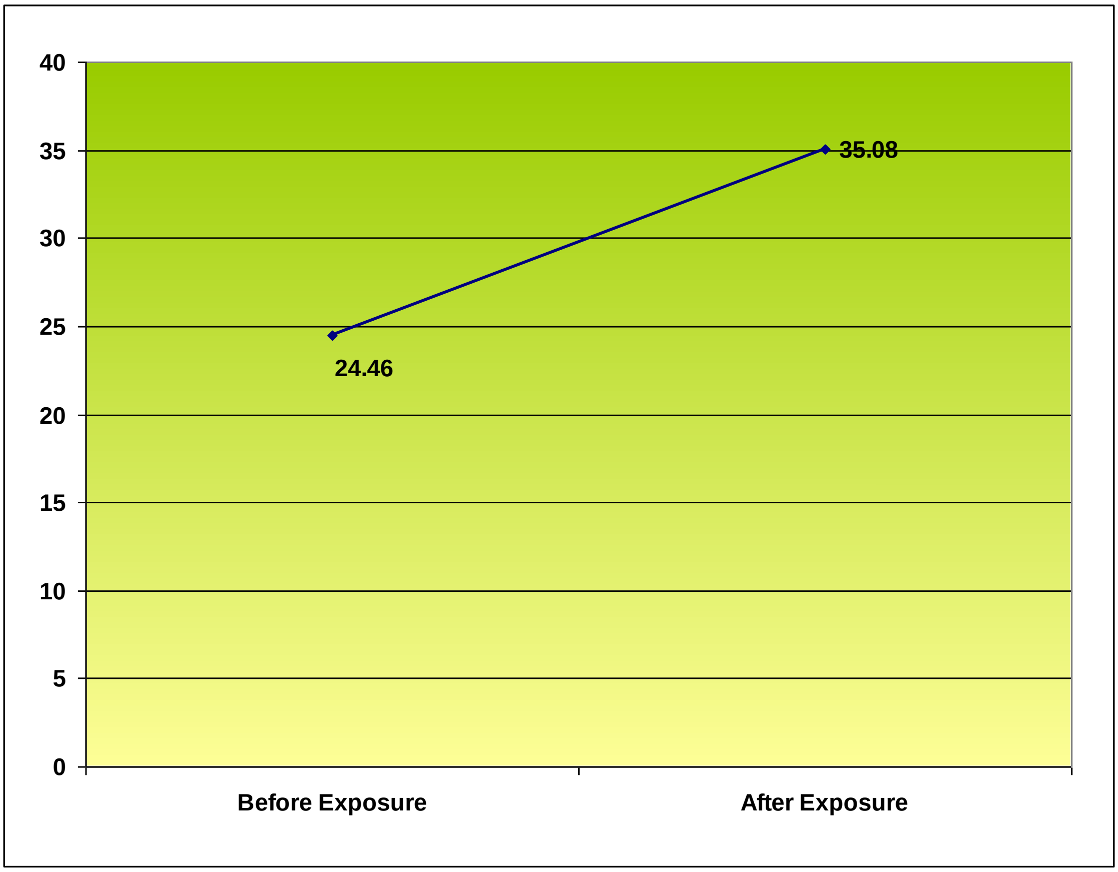


Table - 3b

Summary of Significance of Mean difference in Science Learning Before and After Exposure to Experiments among Girls in Government-aided Schools

Variable	N	Mean	SD	Mean Difference	Paired-t
Before Exposure	45	26.00	3.25	8.89	11.32**
After Exposure	45	34.89	4.15		

**Significant at 0.01 level

The table given above, has brought forth the crucial information regarding efficacy of laboratory exercises. It has shown that the performance of the students in Science has improved to a significantly large extent after they had a hands-on experience. The factor has established the strength of activity in effective learning.

Figure - 9

Means of Science Learning Scores Before and After Exposure to Experiments of Girls in Government-aided Schools

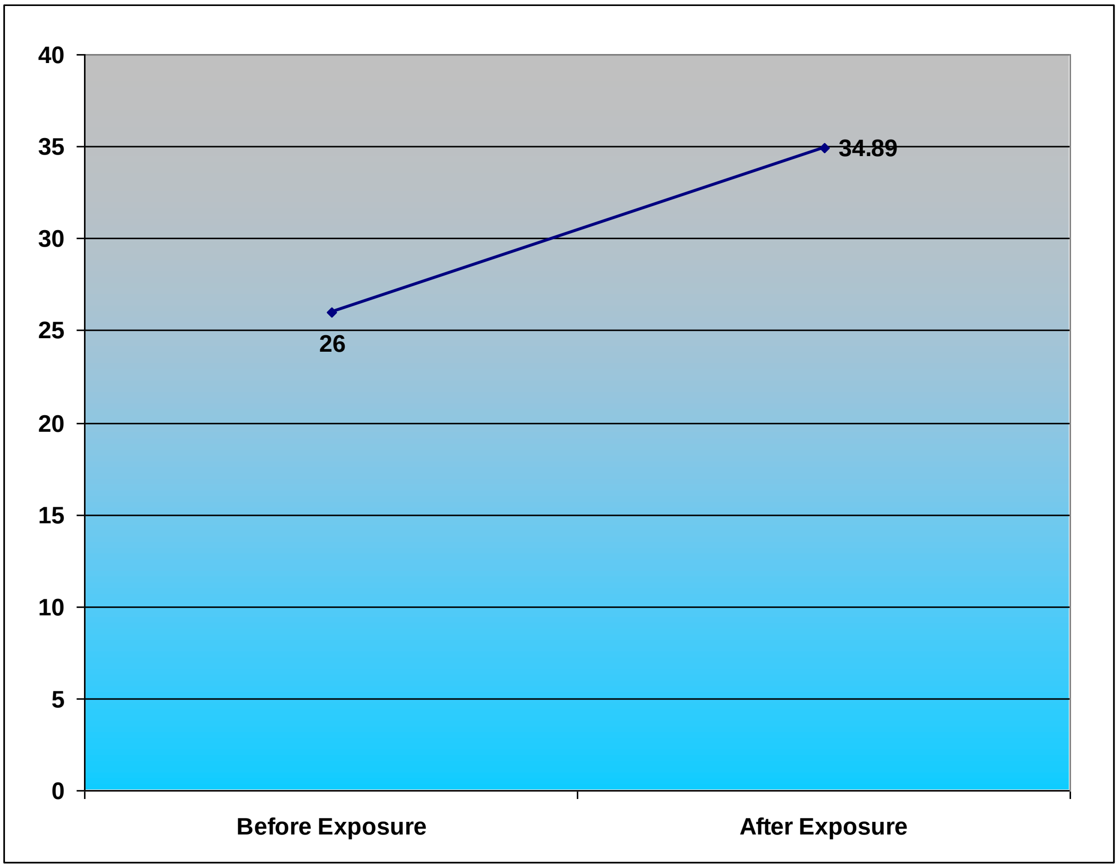


Table - 4a

Summary of Significance of Mean difference in Science Learning Before and After Exposure to Experiments among Boys in Matriculation Schools

Variable	N	Mean	SD	Mean Difference	Paired-t
Before Exposure	46	33.13	3.17	12.00	17.45**
After Exposure	46	45.13	3.42		

**Significant at 0.01 level

The mean values of Science learning tests shows interesting outcome before and after experimentation in matriculation schools. It is worthy of mention that the score of the boys remained to be higher than the scores of the students belonging to the government and government-aided schools. One important inference out of this will be to understand that there is a basic difference in the output of knowledge between the students of the government schools, government-aided schools and the matriculation schools. Nevertheless, matriculation boys also improved their knowledge in Science after exposure laboratory experiments. The laboratory experiments were made easy and it could be interpreted that they facilitated better understanding.

Figure - 10

Means of Science Learning Scores Before and After Exposure to Experiments of Boys in Matriculation Schools

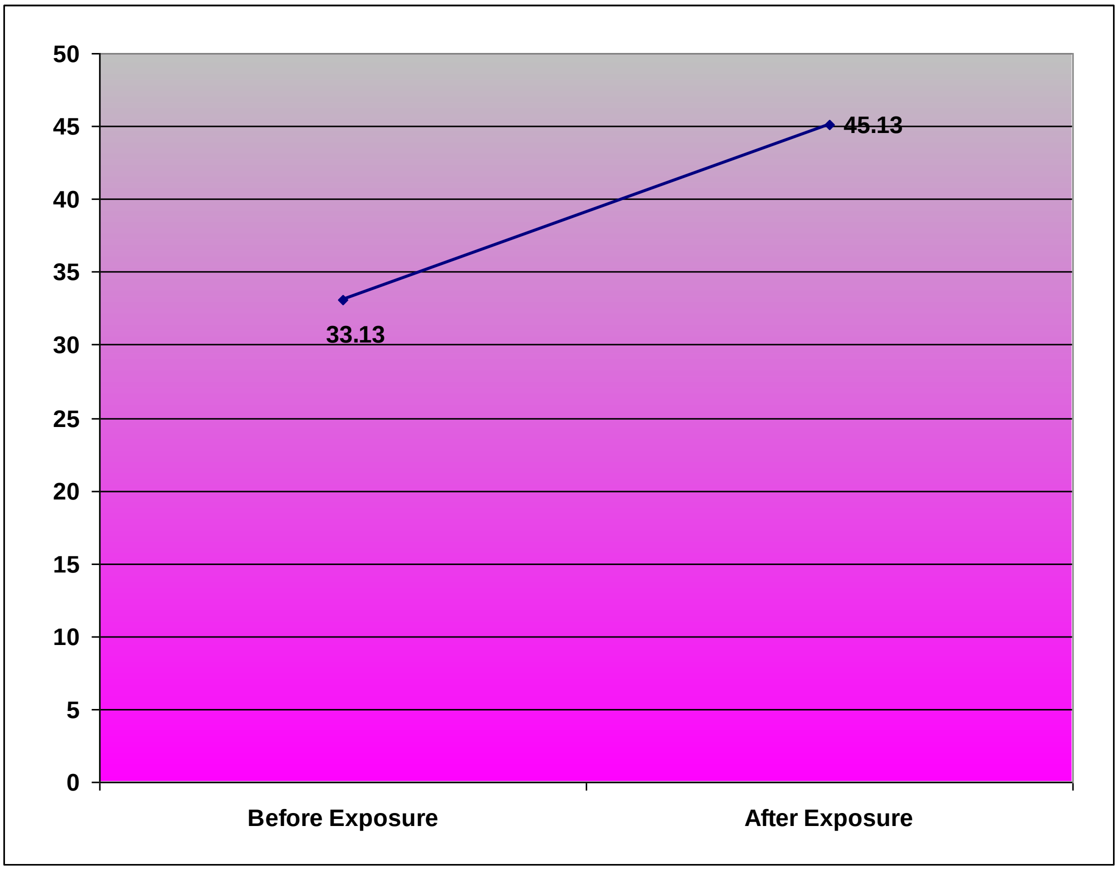


Table - 4b

Summary of Significance of Mean difference in Science Learning Before and After Exposure to Experiments among Girls in Matriculation Schools

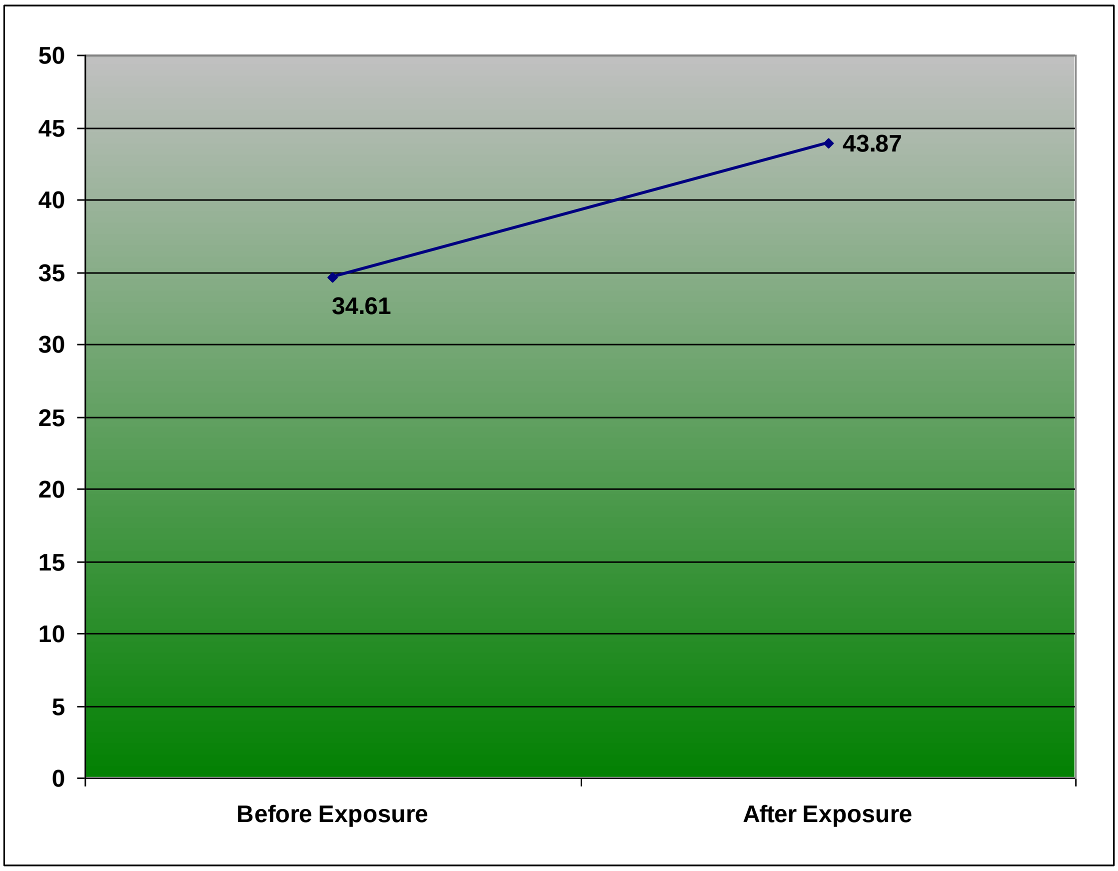
Variable	N	Mean	SD	Mean Difference	Paired-t
Before Exposure	46	34.61	2.02	9.62	15.18**
After Exposure	46	43.87	3.61		

**Significant at 0.01 level

The table above shows evidence that the girls of the matriculation schools significantly improved after they were subjected to laboratory activities in Science. The extent of difference however has not been as wide as it was in the case of the students belonging to the government and government-aided schools.

Figure - 11

Means of Science Learning Scores Before and After Exposure to Experiments of Girls in Matriculation Schools



4.2 Discussion pertaining to Paired-t Tests

The purpose of the research study had been to emphasize the significance of what is popularly known as *hands-on* experience or laboratory activity as Science is becoming more and more important in channelizing the younger generation for enhancement and enrichment of technology. As a result the research investigation was targeted to focus on the students belonging to the formative years of learning particularly during 10 and 11 years studying in standards V and VI. The laboratory experiments were fabricated with utmost care to include the right concepts with the right methodology. An added advantage of these experiments was the fact that they were simple and straight with materials easy to procure.

In order to establish the relative efficacy of these exercises a *Before and After* research design was planned and subjected to testing. The results of the scores obtained by the students were then compared in order to observe whether the exercises made any difference in the positive direction. For the purpose paired-t test technique was utilized and the results yielded very interesting outcome. At the macro level, it is found that students belonging to standards V and VI in whatever school they may be, did show a significantly improvement in their Science learning performance despite the gender (Tables-2a, 2b, 3a, 3b, 4a and 4b). the government schools had shown a maximum change towards better learning observing the mean values. The least change was observed among the girls belonging to the matriculation schools after the laboratory experiments. It is to be noted that whatever be the extent of difference, all of them were statistically significant.

The probable reason for less improvement and more improvement could be due to the facilitative infrastructure available with the self-financed matriculation schools. The matriculation schools do have very good teachers well-trained with a record of high academic skills. This is not the situation in the case of government and government-aided schools. The poor social strata from which the students hail from deprives them from having added facilities in addition to the fact that the school is just adequate with a bare minimum of facilities. Another reason which could be thought of for the most and the least difference is the fact that matriculation schools are self-financed and have a right over the employment of teachers. When the management is not satisfied they terminate the service of the teachers. But the government and government-aided schools have a very high job security and automatic advancements in salary and promotion, which probably gives the teachers indifference toward teaching with maximum efforts. This intervenes with the learning of Science in the case of students who go to such government and aided schools. Basically they hail from very poor families, socially disadvantaged in promoting academic skills. The added problem of teachers also not taking interest could be a logical explanation for the scores in Science learning being very low before and very high after the exposure to laboratory exercises., it could also be inferred that these experiments, therefore could be very well used in teaching Science for their simplicity facilitating better understanding and knowledge.

4.3 Statistical Analyses with regard to Comparisons between Groups

The second stage of statistical analyses consisted of comparisons of Science learning scores between genders and between types of schools. The results have been presented below in tables Table-5, 6, and 7.

Table – 5

Summary of Significance of Mean difference in Science Learning after Exposure to Experiments among Boys and Girls in Government Schools

Variable	N	Mean	SD	SEM	SED	CR
Boys	42	36.05	4.16	0.64	0.92	3.04**
Girls	48	33.25	4.51	0.65		

**Significant at 0.01 level

The table presented above evidences the extent of gain the boys and girls have had in Science learning after they were subjected to laboratory exercises developed by the research investigators. It is clear that the boys have gained more than the girls. However, the significance of difference had been authentic. It is interpreted that the boys of the government schools were able to gain more knowledge in Science with the experiments than the girls.

Table – 6

Summary of Significance of Mean difference in Science Learning after Exposure to Experiments among Boys and Girls in Government-aided Schools

Variable	N	Mean	SD	SEM	SED	CR
Boys	48	35.08	3.19	0.46	0.77	0.25^{NS}
Girls	45	34.89	4.15	0.62		

NS-Not Significant

The table above shows that girls and boys have improved their scores after the laboratory experiments. However, after the exposure to the experiments it was found that *hands-on* experience in laboratory exercises, have made both boys and girls secure similar scores indicating that they did not maintain the difference afterwards.

Table – 7

Summary of Significance of Mean difference in Science Learning after Exposure to Experiments among Boys and Girls in Matriculation Schools

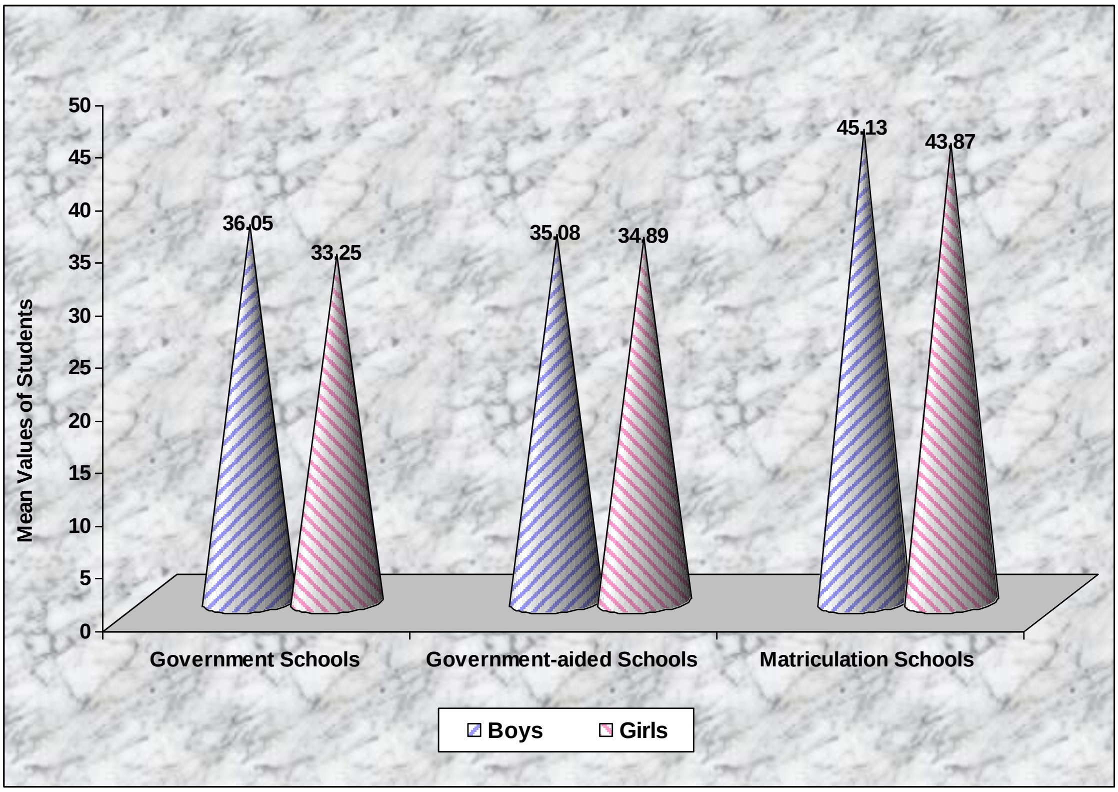
Variable	N	Mean	SD	SEM	SED	CR
Boys	46	45.13	3.42	0.50	0.73	1.72^NS
Girls	46	43.87	3.61	0.53		

NS-Not Significant

From the above table, it could be observed that the boys and girls in matriculation schools after exposure to laboratory experiments have shown similar gain nullifying the difference, established by the t value not being significant.

Figure - 12

Means of Science Learning Scores After Exposure to Experiments of Boys and Girls in Different Types of Schools



4.4 Discussion pertaining to Comparisons between Groups

The study was made with an objective of comparing the students on gender and types of schools. In comparison using t tests the results clearly evidenced the importance of having a facultative learning environment for enrichment. It was found that in government schools, the girls were better than the boys when tested before exposure to the experiments. It is inferred that the girls were able to enhance their knowledge better than the boys with whatever exposure they were subjected to in the classroom. However, providing them with a *hands-on* experience with the laboratory experiments developed by the present research investigators had a significant change in their acquisition of knowledge. It is also interesting to observe that the boys gained more than the girls after the experience of experimentations. The probable reason could be that boys were made to concentrate with a new teacher (the researcher) with new materials and a fresh presentation and therefore, gained more. Surprisingly, this difference between the boys and girls in government schools was also significant. The girls on the other hand by and large are studious and prepared for learning indicating a sense of responsibility. The improvement had been there unlike the boys, the girls have probably maintained stability even prior to exposure to experiments.

The second group of students selected from government-aided schools has shown results similar to that of their counterparts in government schools. Before the exposure to experiments the boys have obtained significantly less scores than girls found to be significant at 0.01 level. On the other hand after subjecting themselves to laboratory exercises the Science learning scores have improved for both boys and girls almost identical. It is inferred that these exercises have helped the boys and girls secure similar scores in Science learning. It is pertinent to explain that the knowledge and the understanding has been made easy and comprehendible through the exercises facilitating experiential learning. Hence, both boys and girls have scored similarly in Science learning.

It is extremely interesting to note that even in self-financed schools, such as the matriculation schools, where the girls were found to be superior to the boys in Science learning prior to the laboratory exercises have gained similar knowledge after exposure to laboratory experiments. This result goes along with others in support of the robustness of the experiments enabling students understanding knowledge building and application.

4.5 Analyses with regard to Comparison of Experimental Groups with Control Groups

The third set of tables presented below shows the result of comparison between the experimental and control groups. The variation was made with exposure to experiments and without exposure to experiments (Tables-8a, 8b, 9a, 9b 10a and 10b).

Table - 8a

Summary of Significance of Mean difference in Science Learning between Experimental and Control Groups among Boys in Government Schools

Variable	N	Mean	SD	SEM	SED	CR
Experimental Group	42	36.05	4.16	0.64	0.79	26.96**
Control Group	42	14.81	2.97	0.46		

**Significant at 0.01 level

The table above very clearly signifies the improvement in the quality of performance among the students. There is a statistically significant difference between the experimental and control groups enabling the researchers to interpret that the boys in government schools performed far better than the boys in the control groups belonging to the same system of education.

Table - 8b

Summary of Significance of Mean difference in Science Learning between Experimental and Control Groups among Girls in Government Schools

Variable	N	Mean	SD	SEM	SED	CR
Experimental Group	48	33.25	4.51	0.65	0.82	20.81**
Control Group	48	16.25	3.42	0.49		

**Significant at 0.01 level

From the table above, it is evident that the girls belonging to the experimental group performed much higher than the girls belonging to the control group which was found to be statistically significant. It could be interpreted that the exposure to experiments improved the quality of performance among the girls belonging to the experimental groups.

Figure - 13

Means of Science Learning Scores among Experimental and Control Groups of Boys and Girls in Government Schools

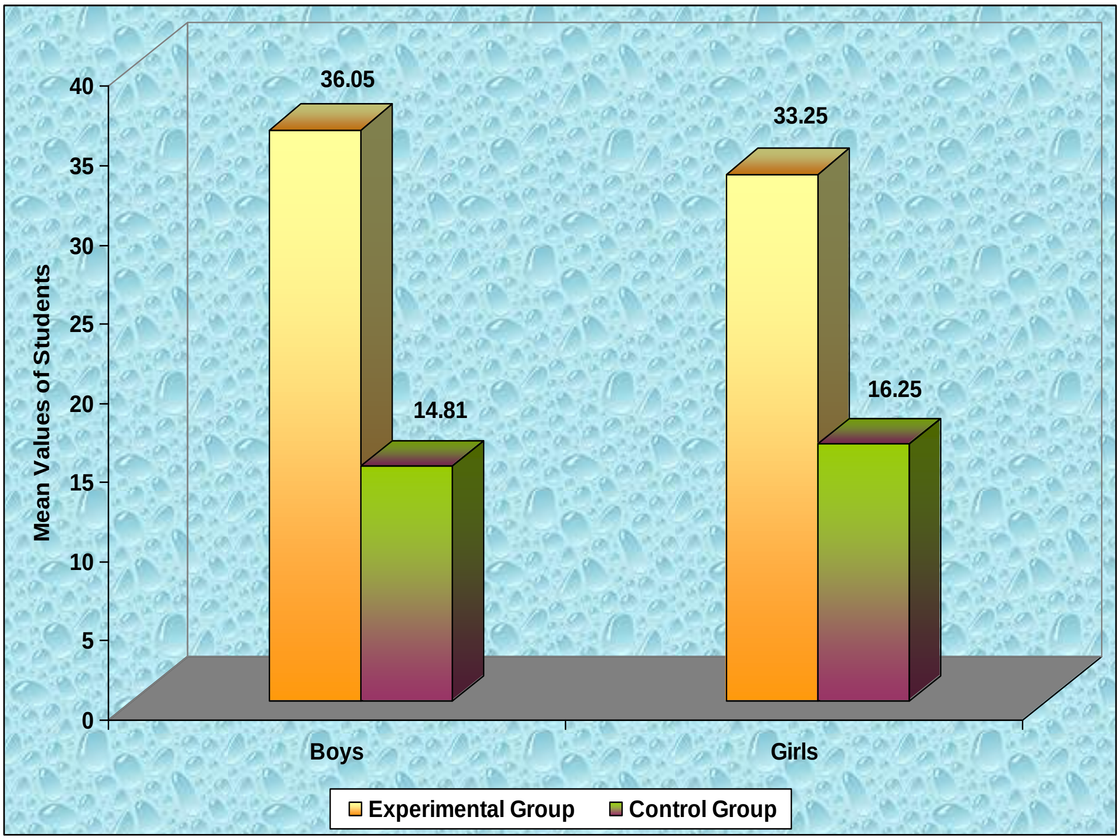


Table - 9a

Summary of Significance of Mean difference in Science Learning between Experimental and Control Groups among Boys in Government-aided Schools

Variable	N	Mean	SD	SEM	SED	CR
Experimental Group	48	35.08	3.20	0.46	1.07	9.12**
Control Group	48	25.33	6.68	0.96		

**Significant at 0.01 level

The boys from the government-aided schools who participated in the experiment performed significantly better than the boys belonging to the control group who had no exposure to experiments. The interpretation therefore is that the boys learnt better when had an exposure to experiments than when had an exposure only to conventional classroom teaching.

Table - 9b

Summary of Significance of Mean difference in Science Learning between Experimental and Control Groups among Girls in Government-aided Schools

Variable	N	Mean	SD	SEM	SED	CR
Experimental Group	45	34.89	4.15	0.62	0.79	11.82**
Control Group	45	25.51	3.34	0.50		

**Significant at 0.01 level

The significant critical ratio value has manifested that the girls belonging to the experimental group were able to perform better than their counterparts who participated as control group. The interpretation therefore, is that exposure to hands-on experience does improve the quality of performance.

Figure - 14

Means of Science Learning Scores among Experimental and Control Groups of Boys and Girls in Government-aided Schools

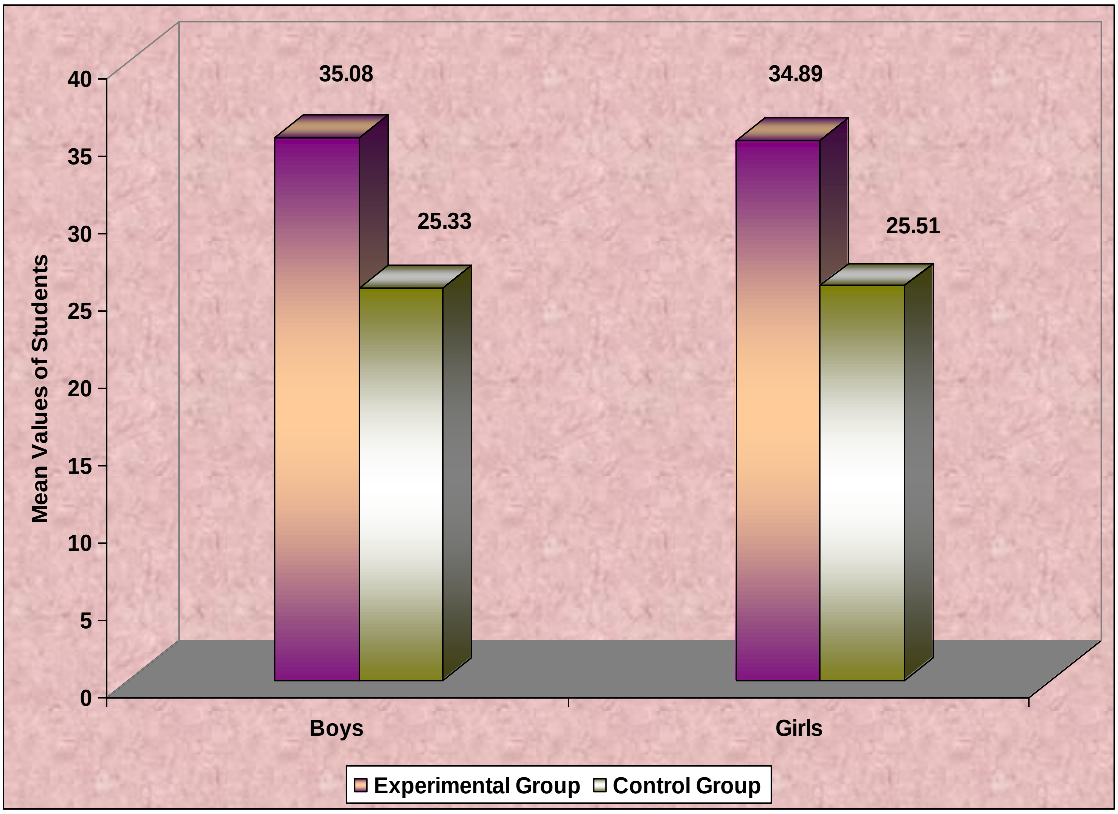


Table - 10a

Summary of Significance of Mean difference in Science Learning between Experimental and Control Groups among Boys in Matriculation Schools

Variable	N	Mean	SD	SEM	SED	CR
Experimental Group	46	45.13	3.42	0.50	1.09	11.92**
Control Group	46	32.17	6.53	0.96		

**Significant at 0.01 level

The standard VI boys of the matriculation schools after classification into two groups, the experimental and the control, and one subjected to conventional teaching in the classroom and the other was subjected to additional teaching using experiments, were tested for performance. The critical ratio value, highly significant, has clearly evidenced superior learning among the boys belonging to the experimental group compared to their counterparts in the control group.

Table - 10b

Summary of Significance of Mean difference in Science Learning between Experimental and Control Groups among Girls in Matriculation Schools

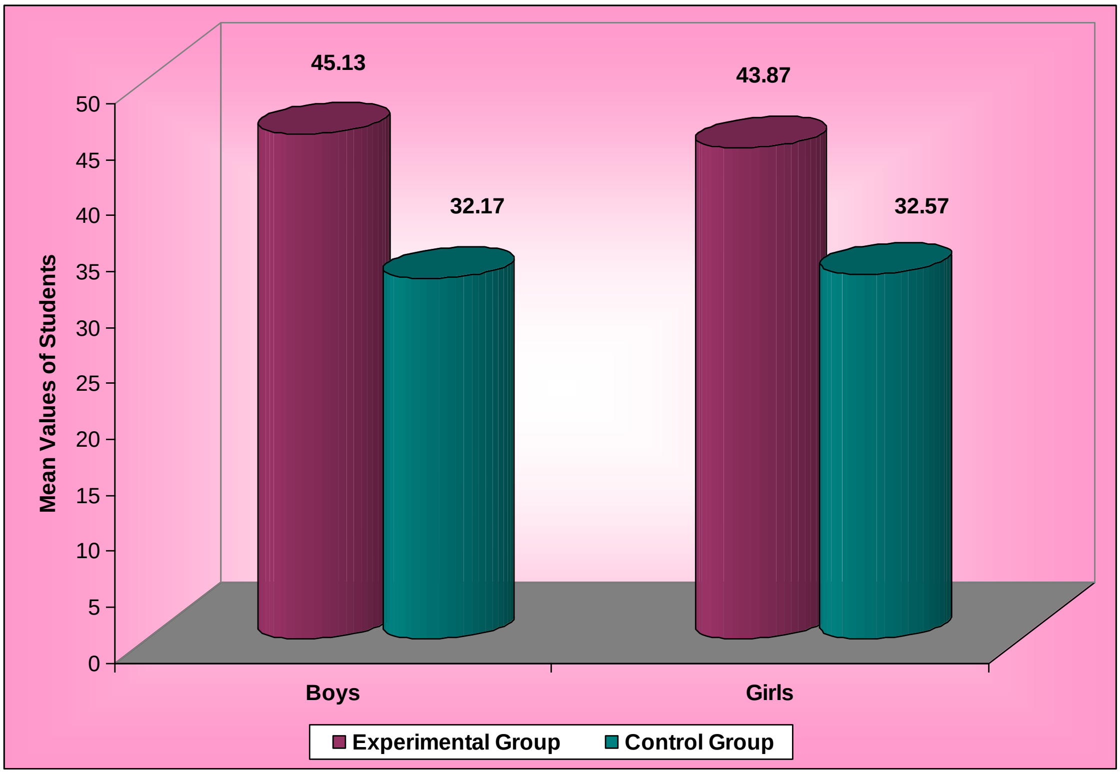
Variable	N	Mean	SD	SEM	SED	CR
Experimental Group	46	43.87	3.61	0.53	0.90	12.58**
Control Group	46	32.57	4.91	0.72		

**Significant at 0.01 level

The table presented above shows a significant critical ratio value when girls belonging to the experimental group were compared with the girls belonging to the control group in the matriculation schools. It is interpreted therefore, that exposure to experiments clearly improves the quality of learning in Science.

Figure - 15

Means of Science Learning Scores among Experimental and Control Groups of Boys and Girls in Matriculation Schools



4.6 Discussion pertaining to Comparisons of Experimental Groups with Control Groups

The results subjected to statistical analyses with performance of experimental groups compared to the performance of control groups in the three types of schools, in both genders, has brought forth salient information with which inferences and attributions are possible. The first set of comparison with boys and girls of the government schools show that, they have shown significant differences with exposure to experiments and without exposure to experiments. It is significant to observe that those students both, boys and girls, manifested better performance when they had exposure to experiments. Similarly, their counterparts, who were in the government-aided and matriculation schools, also manifested better performance compared to the group not having exposure to experiments. Thus, the main finding could be that experiments go a long way, probably, in enabling the learning climate much more meaningful. In the present context this is manifested in the higher performance as shown in tables. It is also interesting to note that the extent of difference between the experimental group and the control group in government schools, is the highest, when compared to the differences or gains found between the experimental and control groups of boys and girls in both government-aided and matriculation schools.

4.7 Analyses of Variance between Students belonging to the Three Types of Schools

In order to establish the robustness of introducing experiments in middle school Science learning which is not conventionally done, in addition to usage of critical ratios, enabling comparison of two groups at a time, the present study attempted to use analyses of variance between schools for confirmation of the proficiency the students gain when helped with laboratory experiments. Thus, there have been two sets of analyses of variance tables, computed for boys and girls. Each set contained a comparison of boys in three types of schools and girls in three types of schools.

Table – 11

Analysis of Variance of Science Learning among Boys in different Types of Schools

Source of Variation	***df***	**Sum of Square**	**Mean of Sum of Square**	***F*-ratio**
Between groups	2	2824.59	1412.30	109.67**
Within groups	133	1712.79	12.88	
Total	135	4537.38		

**Significant at 0.01 level

The table presented above shows that the *f* ratio to be significant at 0.01 level. The interpretation therefore is, the three groups of boys in the experimental groups, belonging to the three types of schools vary significantly. This result therefore has initiated further in depth analyses using t tests in order to find the direction of difference within the three groups of boys belonging to three types of schools. The comparison thus made is presented hereunder.

Table - 11a

Summary of Significance of Mean difference in Science Learning among Boys in Government, Government-aided and Matriculation Schools

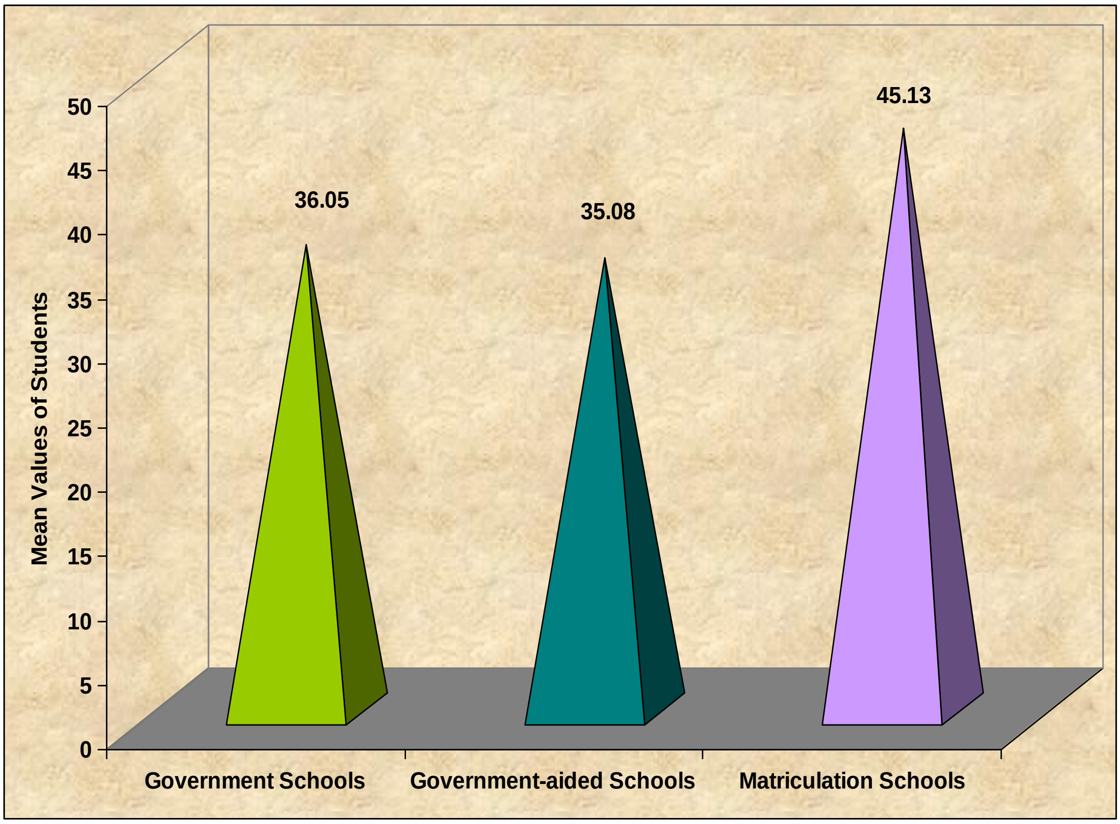
Variable	N	Mean	SD	SEM	SED	CR
Government	42	36.05	4.16	0.64	0.78	1.24^{NS}
Government-aided	48	35.08	3.20	0.46		
Government	42	36.05	4.16	0.64	0.81	11.24**
Matriculation	46	45.13	3.42	0.50		
Government-aided	48	35.08	3.20	0.46	0.68	14.73**
Matriculation	46	45.13	3.42	0.50		

**Significant at 0.01 level

NS-Significant

Figure - 16

Means of Science Learning Scores among Boys in Government, Government-aided and Matriculation Schools



The above table and figure very clearly manifests the direction of difference due to comparisons. It is important to note that while the boys belonging to the government and government-aided schools are similar in their performance the matriculation school boys manifest a significantly higher performance, though all of them have been in the experimental group. This means that the matriculation boys who have had exposure to laboratory experiments have gained significantly more than their counterparts in the government and government-aided schools, enabling them to perform better.

Table - 12

Analysis of Variance of Science Learning among Girls in different Categories of Schools

Source of Variation	*df*	Sum of Square	Mean of Sum of Square	*F*-ratio
Between groups	2	3034.25	1517.12	89.68**
Within groups	136	2300.66	16.92	
Total	138	5334.91		

**Significant at 0.01 level

The table presented above shows significant *f* ratio indicating that the girls of the experimental group belonging to the three types of schools, namely, government, government-aided and matriculation differ significantly in their performance in Science learning. The three groups have been provided with identical experiments. Nevertheless, manifest difference in the output of Science learning. This has further necessitated computing of t values in order to establish the direction of difference. The table below shows the t values obtained, when the three groups of girls were compared.

Table - 12a

Summary of Significance of Mean difference in Science Learning among Girls in Government, Government-aided and Matriculation Schools

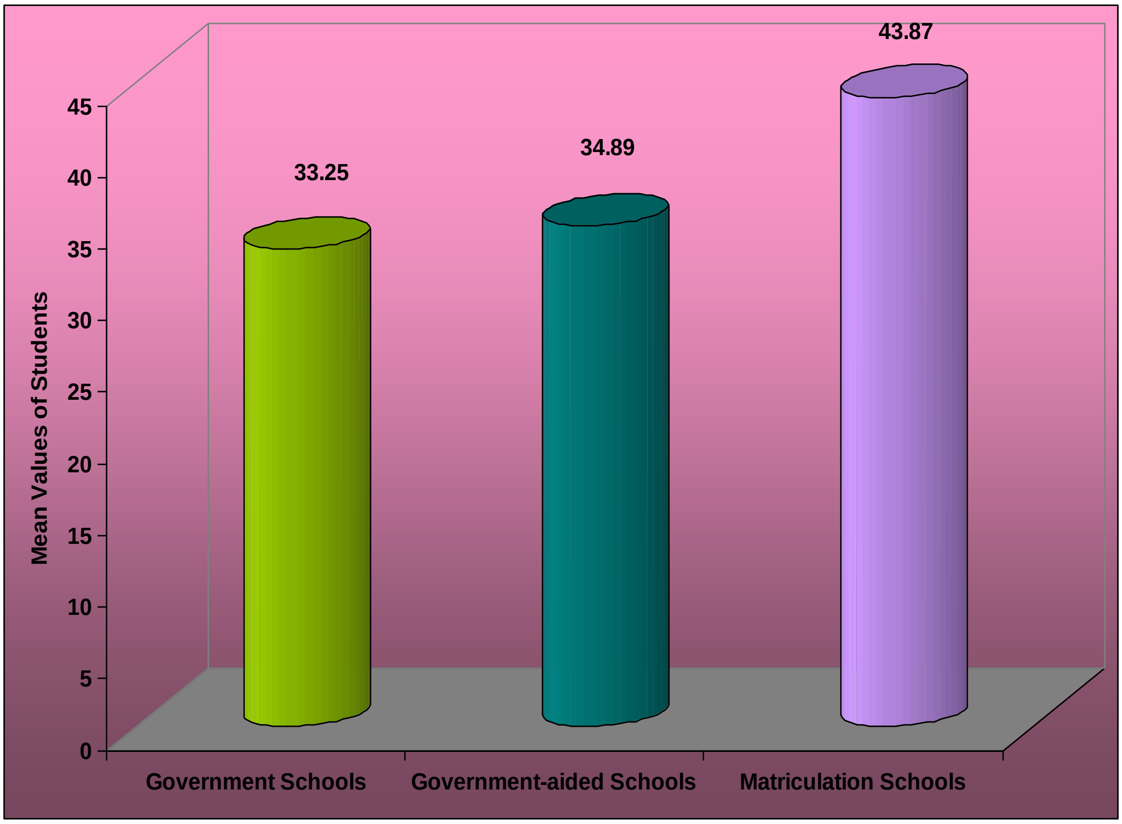
Variable	N	Mean	SD	SEM	SED	CR
Government	48	33.25	4.51	0.65	0.90	1.82^{NS}
Government-aided	45	34.89	4.15	0.62		
Government	48	33.25	4.51	0.65	0.85	12.56**
Matriculation	46	43.87	3.61	0.53		
Government-aided	45	34.89	4.15	0.62	0.82	11.02**
Matriculation	46	43.87	3.61	0.53		

**Significant at 0.01 level

NS-Significant

Figure - 17

Means of Science Learning Scores among Girls in Government, Government-aided and Matriculation Schools



The t values of comparison of girls belonging to the government, government-aided and matriculation schools indicate the girls belonging to the government and government-aided schools were similar in their a very clear trend of performance among the three groups. It was found that while Science learning performance they differed significantly when compared with their counterparts in matriculation schools. It is interpreted therefore, that the matriculation girls manifested a higher level of performance compared to the girls belonging to government and government-aided schools.

4.9 Overall Discussion

The research on the whole has revealed certain facts regarding the use of hands-on experience, specifically in Science learning these activities are possible in laboratory exercises. It has conferred that hands-on experience has certain significant advantages over conventional classroom lectures. In a country like India, where the student population is manifold and disproportionate to the number of teachers available, such alternate methods of teaching will definitely control rote learning and dilution of standards.

The educators and the education researchers have been concerned about the dilution of standards and a learned helplessness in maintaining a ideal proportion between the teacher and the students. It is a fact that the Indian student-teacher ratio is almost 1:50 at all levels. A very important constraint is this population explosion everywhere. But educators cannot afford to ignore or overlook the fact that our students are lagging behind in their educational standards due to the teacher not being able to reach the entire crowd in the class. Parents approach external coaching in order to bridge the gap of knowledge among their children. The interference of the parents is based on career opportunities. The problem of teaching and learning hence become complicated with too much interference. The Management of the schools is focused only on the pass percentage in order to gain more student consumers. The parents also are focused on the extent of performance through marks. As a result, both the teacher and the student suffer a great deal of external pressure.

The pressure induces a performance need in every learner. The orientation then becomes performance rather than learning. The ultimate outcome then is one of scoring marks rather than acquiring knowledge. As the student moves up in the ladder of education, whatever inadequacy has been there in knowledge remain so as time go by. The discrepancies between the students who have had the fortune of proper learning and those who have been simply scoring marks with rote learning is becoming wider and wider in India. The awareness has now become a compulsion for betterment. Even the government is seriously working on better education on the future Indian citizen with the focus on globalization of careers and on the whole uplift Indian education on par with the developed countries.

The present study is intended to develop and improve innovative teaching techniques to better the knowledge of the Indian students, as teachers are aware of these problems they only need some support to diversify instructional approaches. In which case the students can remember the learning material better, feel a sense of accomplishment, be able to transfer the classroom learning to actual situations. The experts in memory and retrieval have always shown the superiority of learning and retaining when students are subjected to facilitative hands-on experiences. With these objectives, the present research was planned and executed.

The results, by and large manifest the most important fact that, hands-on learning has helped students to learn better and perform better. Those who did not participate in the laboratory experiments were not able to gain to the extent the students who had exposure to lab experiments. Of course, it also indicates that the teacher has to initiate a great deal of preparation. However, once a package is developed, teaching becomes fun to the students.

It is interesting to note from the study that boys have gained more after exposure to experimentation compared to the girls in the present research. The probable attribute could be in the present context, is that the boys are more fun loving and more curious or exploratory in nature. In India, the girls are generally restricted to be exploratory from the time they are born as female. The result that we observe is that, when government and government-aided schools are compared with the matriculation schools, the students by and large, belonging to the government and government supported schools have been similar though have significantly gained in performance. However, they have been different from the students of the matriculation schools. This may be attributed to a pertinent reason that exists between government schools and self-financed schools. While the self-financed schools are oriented to performance, the government schools do not focus significantly on performance. Multiple factors operate to hinder the general performance of students in these government and government-aided schools. Some of them are, the lack of accountability, the prevalence of automatic career advancements, lack of periodical performance appraisals for teachers, lack of motivation for both, the teacher and the student, due to certain personal and educational factors.

The main focus and target of the present research fulfilled its objective, by empirically proving the benefits of laboratory experiments developed out of simple materials and easy administration. It does not require any sophisticated equipment to teach simple Science concepts at that level of schooling. Therefore, it is necessary for every teacher and the school Management to initiate such hands-on experience from elementary school to middle school to high school. The motivation for this will have to be extrinsically made by the Management.

5. CONCLUSION

Within the restricted realm of the study, the following conclusions have been drawn:

- **Conclusions with regard to Before and After Comparisons**

(i) it was found that the boys in the government schools improved their performance significantly after exposure to laboratory experiments

(ii) it was found that the girls in the government schools improved their performance significantly after exposure to laboratory experiments

(iii) It was found that the boys belonging to government-aided schools gained in theor performance after exposure to experiments

(iv) It was found that the girls belonging to government-aided schools gained in theor performance after exposure to experiments

(v) the boys of the matriculation schools manifested high performance after exposure to experiments

(vi) the girls of the matriculation schools manifested high performance after exposure to experiments

- **Conclusions with regard to Comparison of Genders in Science Performance**

    (vii) it was found that after exposure to experiments, the boys gained more than the girls in government schools

    (viii) it was found that after exposure to experiments, the boys gained more than the girls in government-aided schools

    (ix) it was found that after exposure to experiments, the boys gained more than the girls in matriculation schools

- **Conclusions with regard to Comparisons of Experimental and Control Groups**

    (x) it was found that the boys of experimental group performed significantly higher in Science compared to their counterparts in control group in government schools

    (xi) it was found that the girls of experimental group performed significantly higher in Science compared to their counterparts in control group in government schools

    (xii) it was found that the boys of experimental group performed significantly higher in Science compared to their counterparts in control group in government-aided schools

    (xiii) it was found that the girls of experimental group performed significantly higher in Science compared to their counterparts in control group in government-aided schools

(xiv) it was found that the boys of experimental group performed significantly higher in Science compared to their counterparts in control group in matriculation schools

(xv) it was found that the girls of experimental group performed significantly higher in Science compared to their counterparts in control group in matriculation schools

- **Conclusions with regard to Comparisons of Student Performance in the Three Types of School**

(xvi) It was found that the three groups of boys belonging to the three types of schools, namely, the government, government-aided and the matriculation schools, significantly differed in their Science performance after exposure to experiments. Through further analyses it was found that the boys belonging to the government and the government-aided schools were similar in their performance, whereas the government and matriculation boys significantly differed indicating the superiority of matriculation students in Science learning. Similarly the boys belonging to government-aided schools were also found to be lower in their performance compared to the performance of the matriculation boys.

(xvii) It was found that the three groups of girls belonging to the three types of schools, namely, the government, government-aided and the matriculation schools, significantly differed in their Science performance after exposure to experiments. Through further analyses it was found that the girls belonging to the government and the government-aided schools were similar in their performance, whereas the government and matriculation girls significantly differed indicating the superiority of matriculation students in Science learning. Similarly the girls belonging to government-aided schools were also found to be lower in their performance compared to the performance of the matriculation girls.

6. IMPLICATIONS

Science teaching and learning poses significant challenges to all educators as growth of Science is an indicator of growth of technology in a nation. With this global objective towards national progress, our educators and the government have focused on the best practices of Science teaching. Effective Science teaching practices may be evolved by studying and analyzing successful teaching. When successful teaching becomes the central focus, then it necessitates the ways and means of training teachers to evolve effective strategies of teaching techniques. This in turn offers involvement of certain related issues with regard to both the teacher and the student. It is dependent on their interest, knowledge and motivation. In India, particularly, it is not sufficient if the teacher and the students are equally interested and motivated. Over and above these, we have certain external constraints. The major constraint is the ratio between the teacher and the student. It is far away from an ideal situation, where for every 20 students, there has to be a teacher. The reality is for every 60 students there is one single teacher. This was the main question for the researchers to take up and investigate o alternative teaching strategies.

The results are beneficial to the educators in making them understand two important issues to be responded. (i) the finance involved in alternate teaching techniques (ii) in enabling students have meaningful learning. Within the constraint of over population, the teacher can be most effective and bring about success by trying to use simple inexpensive materials and easy administration of certain experiments in Science. The study has established the fact that it is possible to procure these materials and conduct such experiments comprehended easily and therefore retained more permanently. The information thus generated in the present research can go a long way in enabling teachers generate more and more innovative techniques of Science teaching for success.

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SCIENCE ON 100 WHEELS

AIR

Experiment: Air contains Water Vapour–(i)

1. Define condensation. (K)

Ans : Condensation is the process of water vapour being cooled to water droplets.

2. What happens when you place a lid on a vessel of hot water? What is the name given to this process? (U)

Ans : Water vapour from the hot water condense as tiny drops of water o n the surface of the lid. This phenomenon is called condensation.

3. Describe the action produced by a mixture of salt and ice. (A)

Ans : When a mixture of salt and ice (cooling mixture) is taken in a test tube, it is seen that water vapour present in the air condenses in the form of drops on the surface of the test tube. This is due to the cooling produced by the mixture of salt and ice. This proves that air contains water vapour.

WATER

Experiment : Water exerts Pressure in all Directions-(ii)

4. Does water pressure vary with depth? (K)

Ans : Yes, water pressure increases with the vertical depth below the free surface.

5. Explain the phenomenon of water pressure. (U)

Ans : The phenomenon of water pressure can be explained by considering the liquid as made up of a large number of their horizontal layers, each layer supporting the weight of those above. The lower the layer, the greater the weight of liquid it has to support; hence the greater the pressure exerted upon it.

6. List any one application of fluid pressure explain. (A)

Ans : Blood pressure is the pressure exerted by circulating blood on the walls of blood vessels. The mean blood pressure is due to pumping by the heart and resistance in blood vessels, dearea as the circulating blood moves away from the heart through arteriss.

HEAT

Experiment : Air Expands when Heated and Contracts when Cooled (i)

7. What happens when air is heated and cooled? (K)

Ans : Air expands when it is heated

8. Why does air expand and become lighter when heated? (U)

Ans : Since molecules are particles of matter, if takes energy to move them. Heat is a form of energy. It causes molecules to bounce into each other separating them. As molecules separate, their dencity – the account of matter found in a given space decreases. Air that is heated will thus rise, because the gravitional force of the earch on the heated molecules is less than it was on the higher density collection of molecules.

9. Why does hot air inside the balloon cause it to rise?

Ans : The hot air inside the balloon bag increases in size faster than the container (baloon), it stretches the balloon so that it expands and displaces the colder (heairer) an outside the balloon. The difference between the lower density of air inside the balloon compared to the lower density of air outside the balloon causes it to rise.

MOTION

Experiment : Rollers reduce Friction

10. What is frictional force? (K)

Ans : The force that stops a moving today is called 'force of friction' or frictional force.

11. How is the intensity of frictional force in (i) between smooth surfaces and (ii) between rough surfaces. (U)

Ans : The frictional force is less in case of smooth surfaces but more in case of rough once.

12.(i) Give the factors on which frictional force depends. (A)

Ans : Frictional force depends on the following factors

a) Texture of the objects – rough / smooth.

b) Amound of pressure during the impact

(ii) Give the application of frictional force. (A)

Ans : Frictional force is employed in brakes and tyres, soles of shoes.

LIGHT

Experiment : Spectrum of Colours

13. How many colours is white light composed of? (K)

Ans : White light is compressed of seven colours -VIBGYOR (colours of the rainbow)

14.(i) Can you name the process of white light splitting into its spectrum? (U)

Ans : White light is split into a colours spectrum by the process of dispersion.

(ii) Why do we see various colours in white light? (U)

Ans : We see various colours in white light because of different wavellenghts of colour.

15.(i) List the various natural occurences of spectures. (A)

Ans : Rainbow, oil droplets with sun shining on them exhibit spectrum.

(ii) What are the three primary colours?

Ans : The three primary colours are red, yellow and blue.