Effectiveness of Augmented Reality Based e-Contents and Virtual labs on the Basis of Achievement in Science of class IX Students of Schools of Delhi

A Research Report

Principal Investigator

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ACKNOWLEDGEMENT

The research titled "Effectiveness of Augmented reality based e-contents and Virtual labs on the basis of achievement in Science of class IX school students" was conducted with various objectives of the study. The data was collected in six schools, two Kendriya Vidyalaya, two Government Secondary Schools, and two Private Secondary Schools of Delhi. Total number of students sample was 451 out of which 235 were female students and 216 were male students.

Many persons and institutions contributed/helped in conducting this study directly or indirectly. Being an investigator of the research study it is my duty to acknowledge the persons and organizations that help to conduct the investigation. To make this study possible and execute the planned research, various individuals and institutions have contributed as per their capacity. To begin with I would like to thank Prof. Amarendra P. Behera Joint Director of CIET, NCERT for his consistent administrative as well as academic support to make this study possible. I would like to thank Sh. K. Murgan, Joint Director (IT), Directorate of School Education and Assistant Commissioner of Kendriya Vidyalaya Sangathan Delhi for their support to conduct the study in Delhi schools.

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Rajendra Pal

Program Coordinator

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PREFACE

NEP-2020 has recommended creation of virtual laboratories so that all students have equal access to quality practical and hands-on experiment based learning experiences. Policy has also suggested content creation of virtual reality and augmented reality so as to help students understand concepts in a better way by visualizing them with the help of Virtual Reality and Augmented Reality.

The e-Pathshala AR (Augmented Reality) App is an initiative of CIET, NCERT under the aegis of MHRD-Government of India, aiming to energies the textbooks, augment child to child, teacher to teacher, child to adult interaction. This App. aims to enable students to go beyond textbooks and four walls of the classrooms. With the aim to invoke curiosity and intrigue in the students because of the augmented interaction, the students will hence be able to learn concepts by directly experimenting rather than only through reading and memorization. This effort intends to be a revolutionary effort to change the majority of student's community from passive listeners to active learners. This effort is in line with Prime Minister's Digital India vision to empower varied sectors using technology and addressing the triple need of skill, scale and speed.

Virtual Labs (VL) produces computer-simulated physical laboratory experiments that allow users to access media-rich online learning environments to conduct experiments in a digital environment. This innovative technique is enabling the study of experimentation beyond the boundaries of traditional laboratories.

The present study "Effectiveness of Augmented Reality Based e- Contents and Virtual labs on the Basis of Achievement in Science of class IX Students of Schools of Delhi" was conducted with the purpose to (i) To study the effectiveness of usage of Virtual labs and Augmented reality by students and teachers of Class IX and in different schools run by managements

To achieve the objective that study was conducted in the 6 schools of Delhi among them two schools were from Kendriya Vidyalaya, Two schools run by Directorate of Education Delhi and two schools were run by the private managements.

The population of this study was class IX students studying in Kendriya Vidyalaya, Government and Private Secondary Schools of Delhi. There were 495 students and 15 teachers participated in the study. The AR app developed by CIET was used for the investigators

The findings of this study have wider implications for Educational Planners, Head of the Institutions, Teachers, Technologists, Researchers, and Students.

Finally, I congratulate Prof. Rajendra Pal Principal Investigator and coordinator for conducting this research and the efforts made by the whole team.

(Amarendra P. Behera)

Joint Director

CHAPTER I

INTRODUCTION

1.0. Introduction

This study was related to Augmented Reality and Virtual lab. In this chapter information is given under captions like, Concept of Augmented Reality, Identified Augmented Reality Programs of CIET for the study, Concept of Virtual Labs, Virtual labs in India, Selected programs of Amrita OLabs for the study, Summary of Selected Programs of AR & VR, Rationale, Statement of Problem, Objectives, Hypotheses and Delimitations.

1.1. Concept of Augmented Reality

Augmented Reality (AR) was introduced by Louis Rosenbterg in 1992. It is a system that applies interactive experiences from real-world environments where objects are in the real world and enhanced by perceptual information generated by computers or systems. According to Azuma, AR must have characteristics combining the real and virtual world having real time interaction and virtual worlds having real time interaction with the user and being registered in a 3D space. AR allows the user to see the real world and aim to supplement reality without completely immersing the user inside a synthetic environment. Augmented Reality interfaces offer seamless interaction between the real and virtual worlds using augmented reality systems users' interaction with the 3D information, objects and events in a natural way. The educational experience offered by Augmented Reality is different for a number of reasons as Mark Bilighurst (2002) mentioned: Augmentative Reality and Virtual Reality use the same hardware technologies and share lots of factors like computer generated virtual scenes, 3D objects and interactivity. The main differences between them are that real world reality aims to replace the real world while Augmented Reality respectfully supplements it. When learning with AR technology, students use totally different senses and retain additional data for a long time. Augmented Reality makes students a lot more excited regarding learning subjects.

All Augmented Reality is a variation of Virtual Reality and is used with visual object tracking devices. Augmented Reality permits the user to examine the important world, with virtual objects superimposed upon or composited with the important world. However, Virtual Reality completely engages a user inside a synthetic environment. While engaged, the user cannot see the real world surrounding them. Augmented Reality technology has the capacity to both tell and enhance important stories from our past, present, and future. It's also emerging as a powerful learning tool with diverse applications. Museums are using it to enhance how visitors experience art and history, while manufacturers are implementing the technology to drive efficiency, improve training, and reduce errors. However, these use cases can be distilled to something that's universal: education. AR provides a seamless way for learners to view and absorb information. The application of the technology in the education sector can lead to a "smart campus." Smart campuses are designed to benefit professors and students, handle the resources available and improve the experience of the users with proactive services (Ozcan et al., 2017). It is essential to explore how teachers and scientists incorporate AR into teaching-learning procedures if this is the present state of the art for the use of AR in education. AR became visible in the early 2000s and its effectiveness for learning was soon established by educational research (Dede et al., 2017). Education Professionals must tackle several problems intrinsic in the training of science fields such as physics costs or inadequate laboratory equipment, mistakes of equipment, or difficulty in simulating certain experimental circumstances (Cai et al., 2017). Compared to traditional pedagogical schemes, Virtual Reality (VR) and AR have the ability to produce improved teaching environments. 3D learning environments can increase the motivation/engagement of learners, improve the representation of spatial information, improve learning contextualization and create superior technical skills (Pelargos et al., 2017).

1.1.1 New Methodologies of Teaching Based on Augmented Reality:

Augmented Reality is a technology that combines digital information (virtual) and physical information (material), in real time due to different technological devices (tablets, smart phones, glasses...). The main difficulty is to obtain a real vision in three dimensions from a drawing in two dimensions. Augmented Reality is a great help in this problem. This technology offers a special vision from a physical reality such as traditional notes or textbooks. This methodological change requires an effort of all - teachers and students - in the transformation of contents. Therefore, its implementation will be progressive in successive academic courses. First of all, it is important to note that Augmented Reality (AR) is not the same as Virtual Reality (VR). VR is a totally artificial digital environment created ad hoc by computers. VR immerses students in a non-existent world while AR combines the real and the virtual. Thus, the AR is a technology that allows the combination of digital information and physical information in real time through different technological devices (tablet, smart phones, glasses...)

1.1.2 Augmented Reality Mobile Application as Learning Media in Science Subject for the Post Gen Z Generation:

AR is now widely applied in everyday life, one of which is in the field of education. Currently, AR applications can be integrated to increase the standard of the curriculum used, because the text, images, audio, and video are able to be extended to the student in a real-time environment, so they can learn better (Rohendi & Wihardi, 2020). Notebooks and other teaching aids can be marked that, if scanned with an AR device, will be able to produce additional information to students which are displayed in multimedia form (Syahidi et al., 2019). With AR, students will be able to view computer-generated simulations of important history, parts, and organs of the human body, spatial shapes, or geometry in greater depth.

1.1.3 The Impact of an Augmented Reality Application on Learning Motivation of Students:

The main research question was underpinned by several sub questions examining how the attention, relevance, confidence, and satisfaction aspects of learning motivation were affected by using the AR mobile application. AR is said to be a technology that has three key requirements: combining of real and virtual objects in a real environment, aligning of real and virtual objects with each other, and real-time interaction, an example of a light AR would be the Pokémon GO mobile application, which can be used through a Smartphone. An example of a heavy AR is the Star Wars Jedi Challenges mobile application which requires the user to use a headset. The educational value of AR is closely linked to the way in which it is designed, implemented, and integrated into formal and informal learning environments. AR technologies enable users to experience scientific phenomena that are not possible in the real world, such as certain chemical reactions, making inaccessible subject matter available to students. AR does not completely replace the real environment, it provides the user with the perception that virtual and real objects coexist, simultaneously, in the same space. On the other hand, with a focus on computational systems that incorporate AR, Azuma (1997) proposes that these systems should present three essential characteristics: (i) combine virtual elements with the real environment; (ii) be interactive and provide real time processing; and (iii) be conceived in three dimensions.

1.2. Identified Augmented Reality Programs of CIET for the study

Amrita OLabs program of class IX				
S.NO	**Subject**	**Chapter No.**	**Name of the Chapter**	**virtual labs Program**
1.	**Biology**	Chapter 5	The fundamental Unit of life	Onion and Cheek Cells
2.				Adaptation in Animals
3.				Characteristics of Plants
4.		Chapter 6	Tissues	Plant and Animal Tissues
5.				Monocot and Dicot Plants
6.	**Chemis-try**	Chapter 1	Matter in our Surroundings	1.6 Melting Point of Ice
7.		Chapter 2	Is Matter Around us Pure	2.1Distinguish Between Mixture and Compound
8.				2.7 Separation of Components of a Mixture
9.				2.2Distinguishing Between Solutions
10.				2.5 Boiling Point of Water
11.	**Physics**	Chapter 9	Force and Laws of a Motion	9.10 Newton's Third Law
12.		Chapter 10	Gravitation	10.6 Verification of Archimedes Principle
13.		Chapter 11	Work and Energy	11.5 Force Required to Move a Wooden Block on a Horizontal Table
14.		Chapter 12	Sound	12.6 Bell Jar Experiment
15.				12.7 Velocity of a Pulse Propagated Through a Slinky

1.3 Concept of Virtual Labs

A virtual Lab is a simulated lab environment typically implemented as a software program which allows the users to perform their experiments. An experiment is set up in the remote laboratory for users to access through the Internet at any time and any place. Comparing with traditional laboratory, virtual laboratory is particularly useful when some experiment involves equipment that may cause harmful effects to human beings. Another meaning of virtual lab is to implement the laboratory by means of software simulation. A lab facility, on virtual space, to be accessed through the internet.

1.4 Virtual labs in India

Virtual Labs project is an initiative of Ministry of Human Resource Development (MHRD), Government of India under the aegis of National Mission on Education through Information and

Communication Technology (NMEICT). This project is a consortium activity of twelve participating institutes and IIT Delhi is a coordinating institute. It is a paradigm shift in ICT-based education. For the first time, such an initiative has been taken-up in remote experimentation. Under the Virtual Labs project, over 100 Virtual Labs consisting of approximately 700+ web-enabled experiments were designed for remote-operation and viewing. The intended beneficiaries of the projects are:

- All students and Faculty Members of Science and Engineering Colleges who do not have access to good lab facilities and/or instruments.
- High school students, whose inquisitiveness will be triggered, possibly motivating them to take up higher studies. Researchers in different institutes who can collaborate and share resources.
- Different engineering colleges who can benefit from the content and related teaching resources.
- Virtual Labs do not require any additional infrastructural setup for conducting experiments at user premises. The simulations-based experiments can be accessed remotely via the internet.

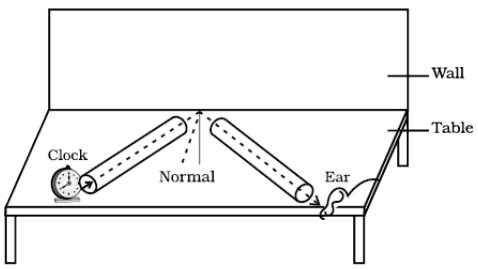
1.5 Selected programs of Amrita OLabs for the study

Amrita OLabs program of class IX				
S.NO	**Subject**	**Chapter No.**	**Name of the Chapter**	**virtual labs Program**
1.	**Biology**	Chapter 5	The fundamental Unit of life	Onion and Cheek Cells
2.				Adaptation in Animals
3.				Characteristics of Plants
4.		Chapter 6	Tissues	Plant and Animal Tissues
5.				Monocot and Dicot Plants
6.	**Chemistry**	Chapter 1	Matter in our Surroundings	1.6 Melting Point of Ice
7.		Chapter 2	Is Matter Around us Pure	2.1Distinguish Between Mixture and Compound

1.6 Summary of selected programs of AR and VL

AR Experiments of Physics

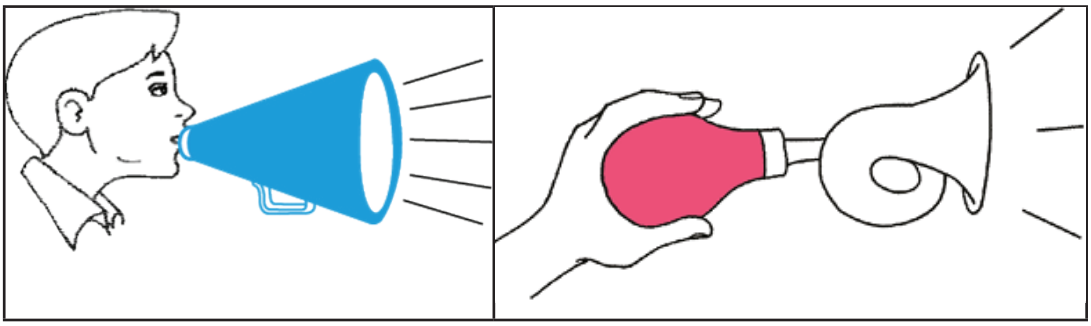
1. **Figure** 12.11: Reflection of Sound



Instruction To run this activity, click on the semi-circle in white color.

Explanation: In this experiment, the app is showing how the sound of the clock is travelling from one to another end of the pipe. The sound is visible in color of red, so that it can be easily noticeable and making the measurement of angles of incidence and reflection easier. The voice over during the experiment is explaining every aspect clearly.

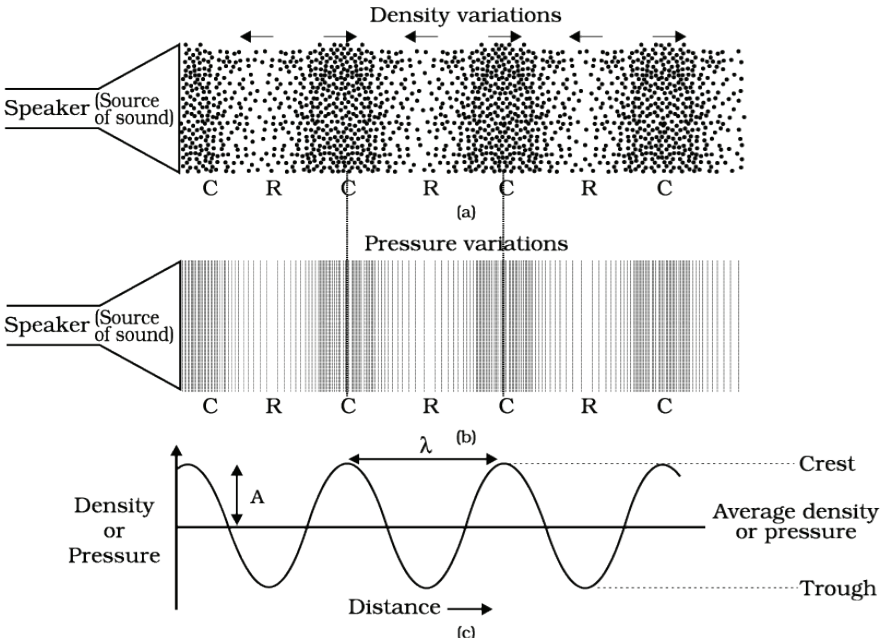
2. **Figure 1**2.12: A Megaphone and a horn



Instruction To run this activity, there are two options, one is speak and the other one is megaphone. To know about them, click on each one by one.

Explanation: The experiment is showing, what is the difference between the sound produced by a horn and megaphone and in which direction the sound is going. The app is making it easier as it is differentiating both sounds with different shapes, so that it is easy to understand the actual difference, which is not possible by looking at pictures in the book or even by trying it in physical mode.

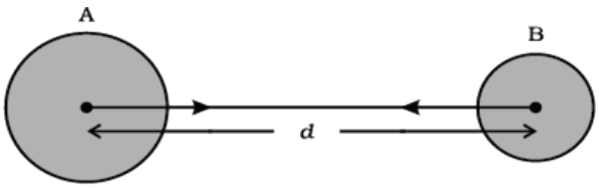
3. **Figure** 12.8: Characteristic of a Sound Wave



Instruction To run this activity, click on the speaker.

Explanation: The experiment is showing that how sound is propagating as density or pressure variations. When we click on sound, we can see the level of variations of pressure or density, which are known as crest and trough. When we click on stop, it stops, then and there only.

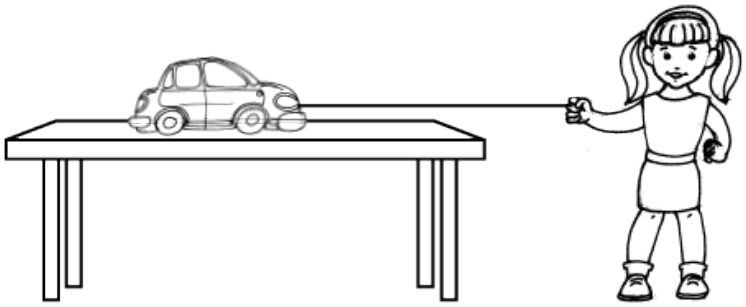
4. **Figure** 10.2: Universal Law of Gravitation



Instruction To run this activity, drag the arrow.

Explanation: This experiment is showing the gravitational force between two or more uniform objects, which are directed along the line joining their centers. It is a fun activity through augmentation, because when students drag the line then only the experiment moves further.

5. **Figure** 11.4: Work done by constant forces

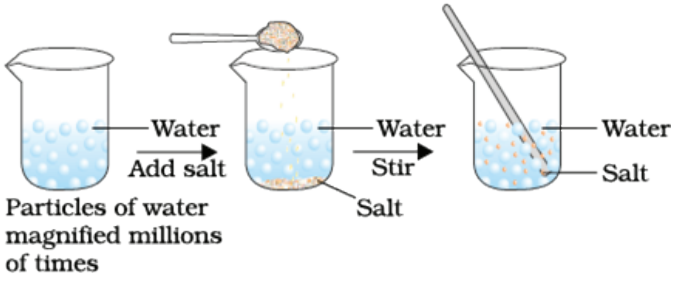


Instruction To run this activity, click on play button.

Explanation: The experiment is showing a situation in which an object is moving with a uniform velocity along a particular direction. When we tap the play button the car moves and the app shows the numbers of force, speed and direction.

AR Experiments of Chemistry

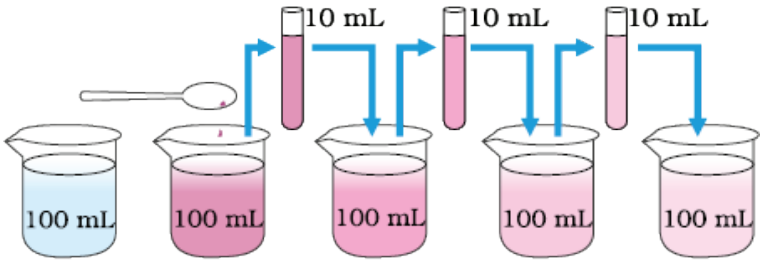
1. **Figure** 1.1: Matter is made up of Particles



Instruction To run this activity, listen to the voice over and click according to that.

Explanation: This experiment is showing that how the salt gets spread throughout the water and the level of water remain same. Through this app, students can navigate the experiment by his own and observe the changes happen. Then it shows the molecular view of the same solution. And at the end it shows all the learning outcomes.

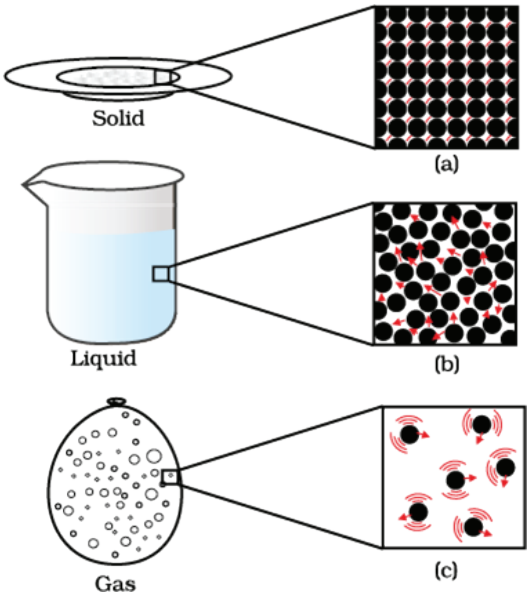
2. **Figure** 1.2: How Small Are These Particles?



Instruction To run this activity, listen to the voice over and click according to that.

Explanation: The experiment shows that just a few crystals of potassium pomegranate can color a large volume of water. It all goes in a 3D form with a proper voice over and navigation.

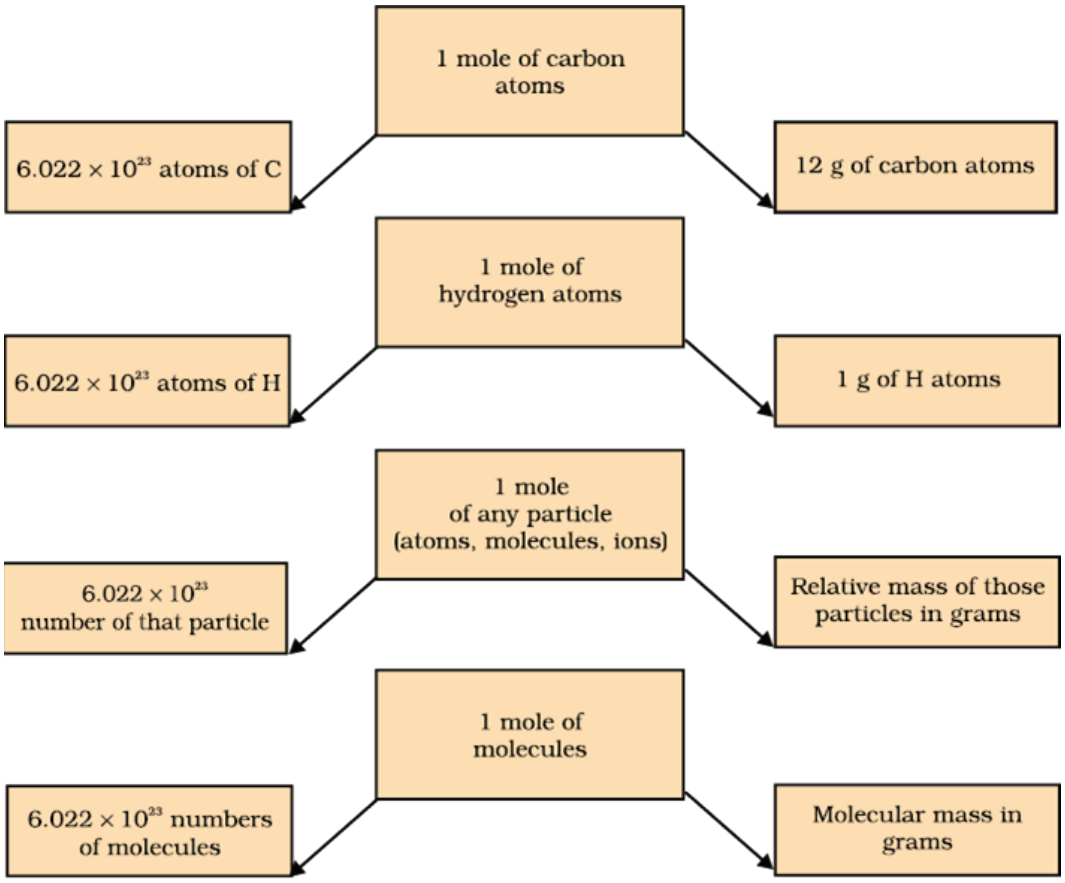
3. **Figure** 1.5: The states of matter



Instruction To see the different states of matter, click on each button one-by-one (solid, liquid, gas).

Explanation: The aim of this objective is to show students, the motion of the particles and comparison in the three states of matter. The app is showing different states of matter and how the particles change their forms, when they enter from one state of matter to another one. During the experiment, the elaboration of voice over is quite helpful to understand the whole Process.

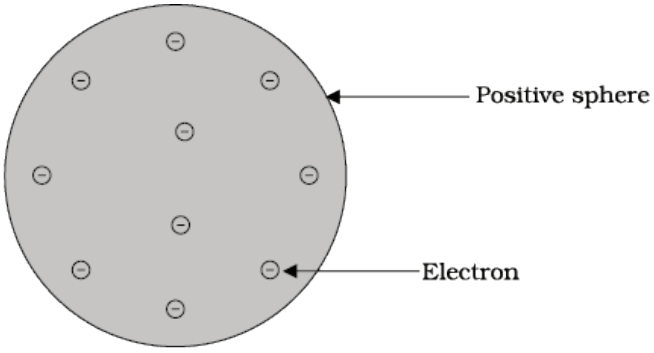
4. **Figure** 3.5: Relationship between mole, Avogadro and mass



Instruction to run this activity, choose a substance and then click on play button.

Explanation: This experiment is showing the relationship between mole, Avogadro number and mass. The app is showing it clearly and one by one for each substance with voice over.

5. **Figure** 4.1: Thomson's Model of an Atom

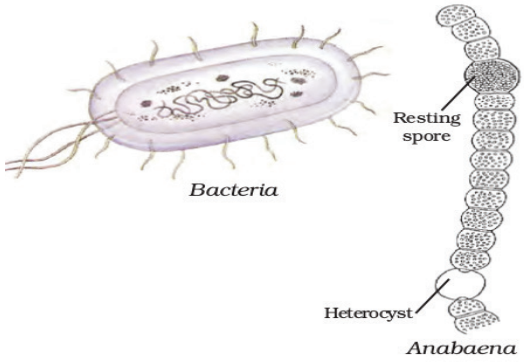


Instruction To run this activity, click on the 'Model of an atom'.

Explanation: This experiment shows that how electrons in a sphere of positive charge are like currants in a spherical Christmas pudding. It has also given an example of watermelon , in which the positive charge in the atom is spread all over like the red edible part of the watermelon, while the electrons are studded in the positively charged sphere, like the seeds in the watermelon.

AR Experiments of Biology

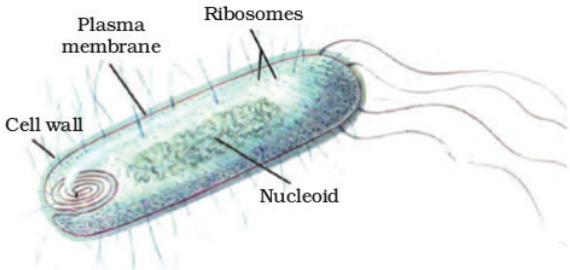
1. **Figure** 7.1: Bacteria (Monera)



Instruction To run this activity, click on the highlighted continue button.

Explanation: The experiment is about the Monera kingdom. First it shows about bacteria inside Monera Kingdom then elaborated everything about the bacteria found inside the Monera kingdom. Then it talks about the cell wall of bacteria. Then it proceeds with pili of bacteria, flagella of bacteria, plasma membrane of bacteria and DNA of bacteria. Then it shows the mode of nutrition for it

2. **Figure** 5.4: Prokaryotic Cell

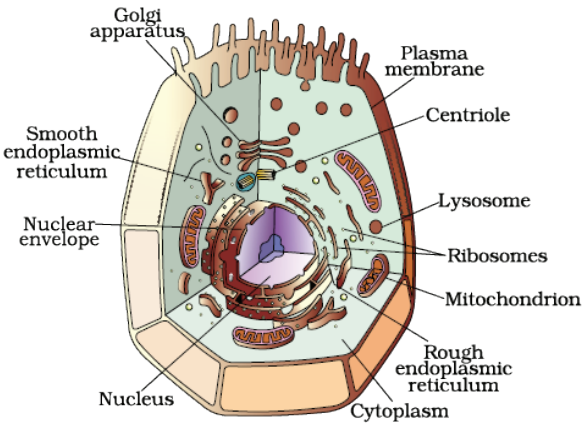


Instruction To run this activity, click on the highlighted continue button.

Explanation: Shape and components of Prokaryotic cells are visible by scanning the figure. Audio instructions of this particular picture explain the plasma parts in 3D view. The audio description talks

about the surrounded and unstructured parts of the Nucleus and Nucleoid. After viewing this figure through the AR app students will learn the parts of the prokaryotic cell and its parts better by observing the cell parts through 3D form.

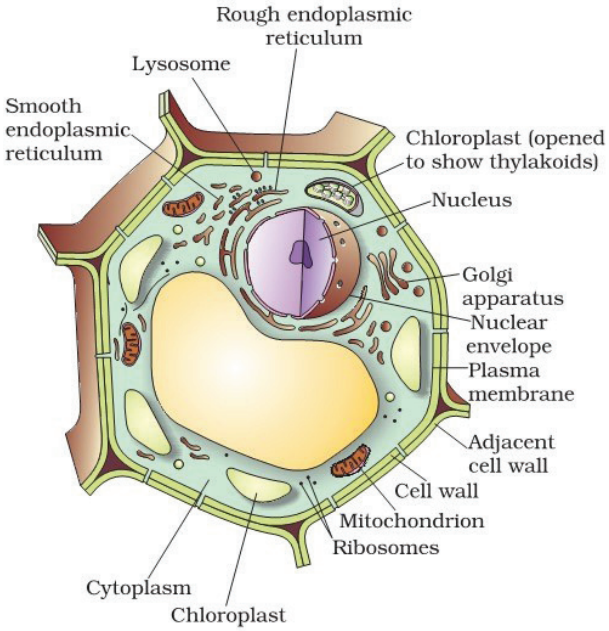
3. **Figure** 5.5: Animal Cell



Instruction To run this activity, click on the highlighted continue button.

Explanation: In the textbook functions and components of the animal cell are explained. By using the AR app students would be able to see the animal cell in 3D animation. After scanning the figure the 3D form of the picture is visible in the display with audio instructions. On the right side of the display various components of the animal cells are displayed and by tapping on it the students would be able to see the components in a cross sectional view. Each component and its functions were explained in audio form as well.

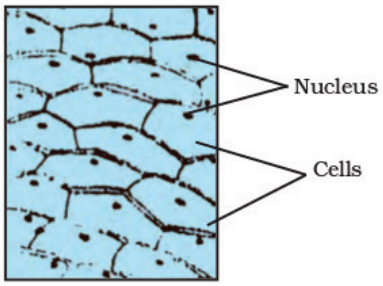
4. **Figure** 5.6: Plant Cell



Instruction To run this activity, click on the highlighted continue button.

Explanation: After scanning the figure the 3D animation view of the plant cell is visible in the display. Audio instructions lead the students to tap on the plant cell. It contains the components of the cells. By tapping on any of the components, students can learn the function and significance of the particular components. Nucleus, Endoplasmic, Lysosome, vacuole, Mitochondria, Golgi apparatus, Chloroplast are the components visible in the display. While taping on any of these, Students get to see it in cross section shape and understand its functions through audio description.

5. **Figure** 5.2: Cells Of an onion peel

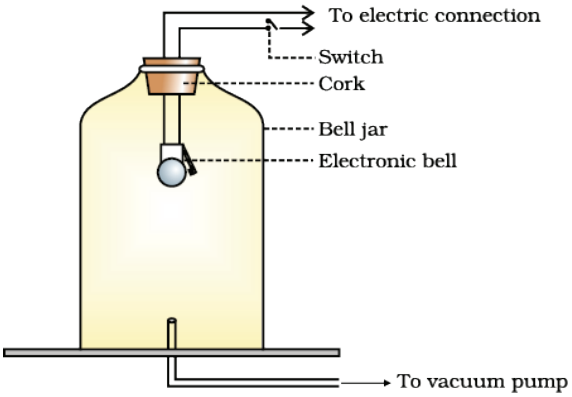


Instruction To run this activity, click on the highlighted continue button.

Explanation: This experiment tries to explain how to take a small piece of onion from an onion bulb. After scanning the figure a piece of onion displayed with the audio instruction. By tapping on the onion figure a piece of onion comes out of the bulb and by following the instruction, students will be able to cut the piece of onion into a slice. By tapping on the slice, a small piece of onion can be picked using the forceps. Then the small piece of onion gets placed on the glass slide for a microscopic view. After using the AR app students will learn how to take out a piece of onion and place it on the glass slide without much effort.

Virtual Labs Experiments

1. **Figure** 12.6: Bell Jar Experiment



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

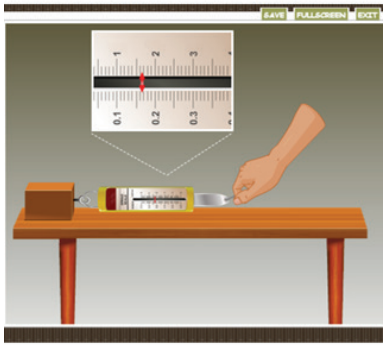
Explanation: Sound is a mechanical wave and needs a medium to travel like air, water, steel etc. for its propagation. This experiment has shown how the electric bell is suspended inside the airtight bell jar. The bell jars are connected to a vacuum pump. On switching it on, the bell can be heard. These entire things have been shown in a 3D form with elaboration. As the air inside the jar decreases, the sound of the bell becomes more feebler.

2.**Figure** 10.6: Verification of Archimedes Principle

Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: The experiment is showing the elongation of the string or the reading of the balance decreases as the stone is gradually lowered in the water. However, no further change is observed once the stone gets fully immersed in the water. The animated video has shown the reading as well throughout the experiment.

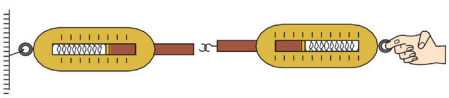
3. **Figure** 11.5: Force Required to Move a Wooden Block on a Horizontal Table



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: This experiment shows an object is moving with a uniform velocity along a particular direction. Then a retarding force is applied in the opposite direction. It states that the rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of force.

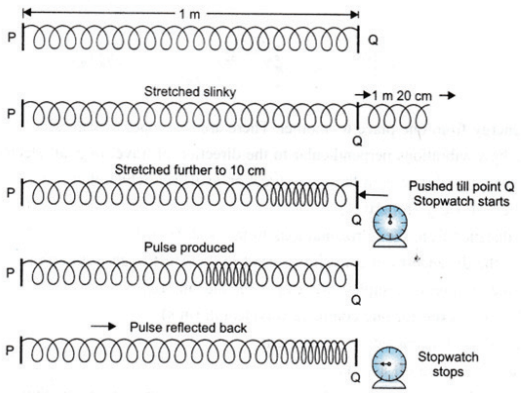
4. **Figure** 9.10: Newton's Third Law



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: The experiment shows two spring balances connected together. The fixed end of balance B is attached with a rigid support, like a wall. When force is applied through the free end of spring balance A, both the spring balances show the same readings on their scales. It means force exerted by spring balance A on balance B is equal to the opposite in direction to the force exerted by the balance B on balance A.

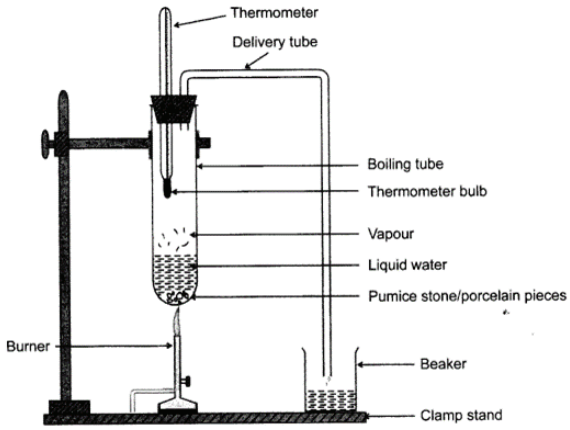
5. **Figure** 12.7: Velocity of a Pulse Propagated Through a Slinky



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: This experiment shows that as crests and troughs are seen when the free end of the slinky is jerked at a right angle to its length, the waves propagated through a slinky are transverse waves. As compressions and rarefactions are seen when the free end of the slinky is compressed periodically, the waves propagated through a slinky are longitudinal waves.

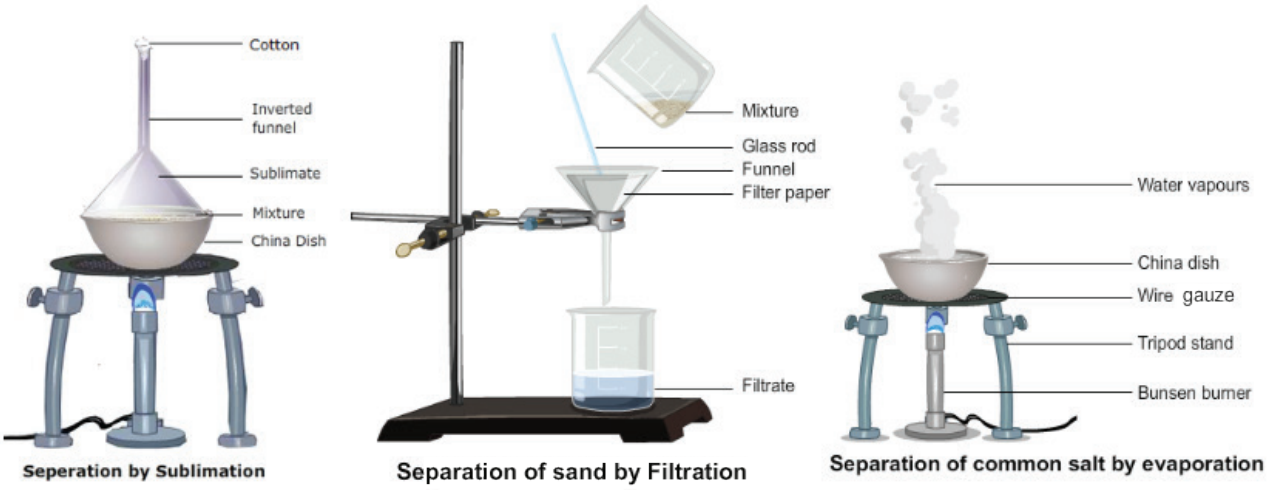
6. **Figure** 2.5: Boiling Point of Water



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: This experiment is showing that Student can identify the components in the mixture based on the knowledge of value, boiling point, density, etc. Student is able to select & design the above techniques based on the chemical and physical properties of the components in the mixture. Students acquire the skill to arrange the requirements for each technique through the animations, simulators and videos. Students will be able to select and perform suitable separation techniques based on the available information about the nature of the components in the mixture.

7.**Figure** 2.7: Separation of Components of a Mixture

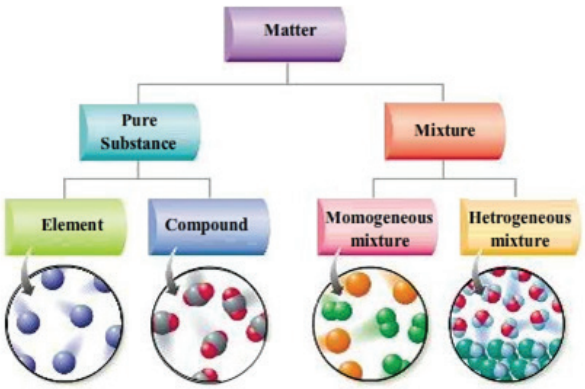


Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: This experiment is helping Students understand the terms mixture, sublimation, filtration and evaporation. Students acquire skills to perform the separation of components of a mixture using the following technique: Sublimation, Filtration, and Evaporation.

Student analyzes the method suitable to separate ammonium chloride, salt and sand from their mixture. Students get strong knowledge about different physical states of the components of the given mixture. Based on the knowledge of solubility, sublimation, etc., the students are able to design suitable separation techniques for the components of the mixture given to them. Students visualize the way these separations are done in the experiment which will help them to arrange the things properly in the lab.

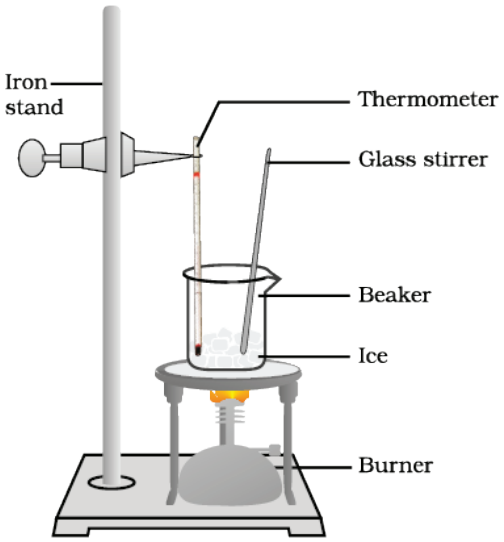
8. **Figure 2**.1: Distinguish Between Mixture and Compound



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: Through this experiment Students understand the terms ‘Mixture’ and ‘Compound’. Student acquires skill to distinguish a mixture of Fe & S and compound of Fe & S (FeS) by observing: Appearance, Behavior towards magnet, Action of heat, Behavior towards carbon, disulphide, Action with dil.HCl. Students obtain knowledge about the properties of mixture and compound. Students will be able to distinguish a mixture from a compound based on the acquired information.

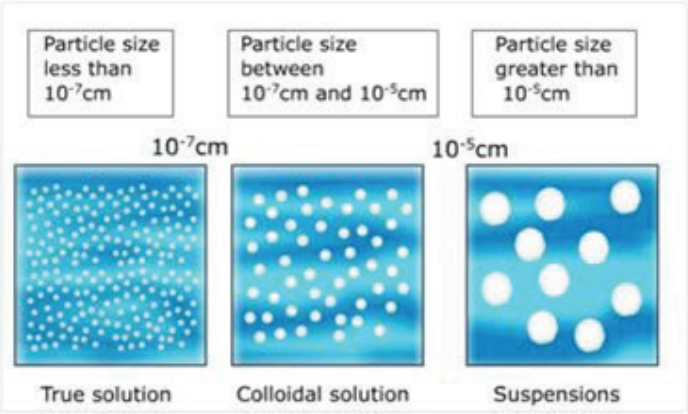
9.**Figure** 1.6: Melting Point of Ice



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: Through this experiment Students understand the term 'melting point' Students perform the experiment for ice cubes & notice the physical change that happens during the melting of ice. Students will be able to do the experiment faster and more accurately in the real lab once they understand the different steps. Students realize that temperature remains constant when a solid melts at its melting point.

10. **Figure** 2.2: Distinguishing Between Solutions

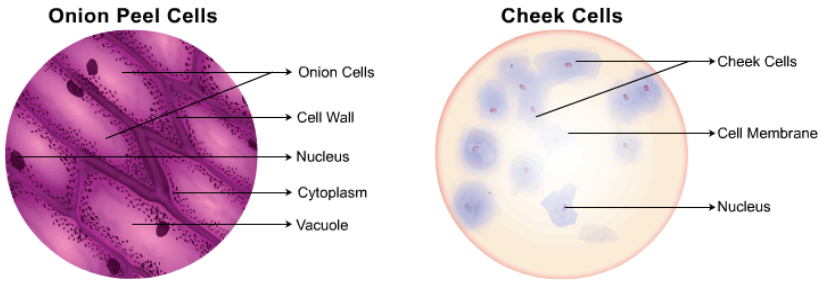


Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: Through this experiment Students understand the terms: true solution, suspension, colloid, transparency, filterability, stability, etc. Students distinguish true solutions, suspensions and colloids based on experiments testing: Transparency, Filtration

Stability. Students classify the mixtures given to them as true solutions, suspensions and colloids based on the information from the experiment. Students acquire skills to perform the experiments for testing the transparency, filtration criterion and stability of true solutions, suspensions and colloids.

11. Onion and Cheek Cell

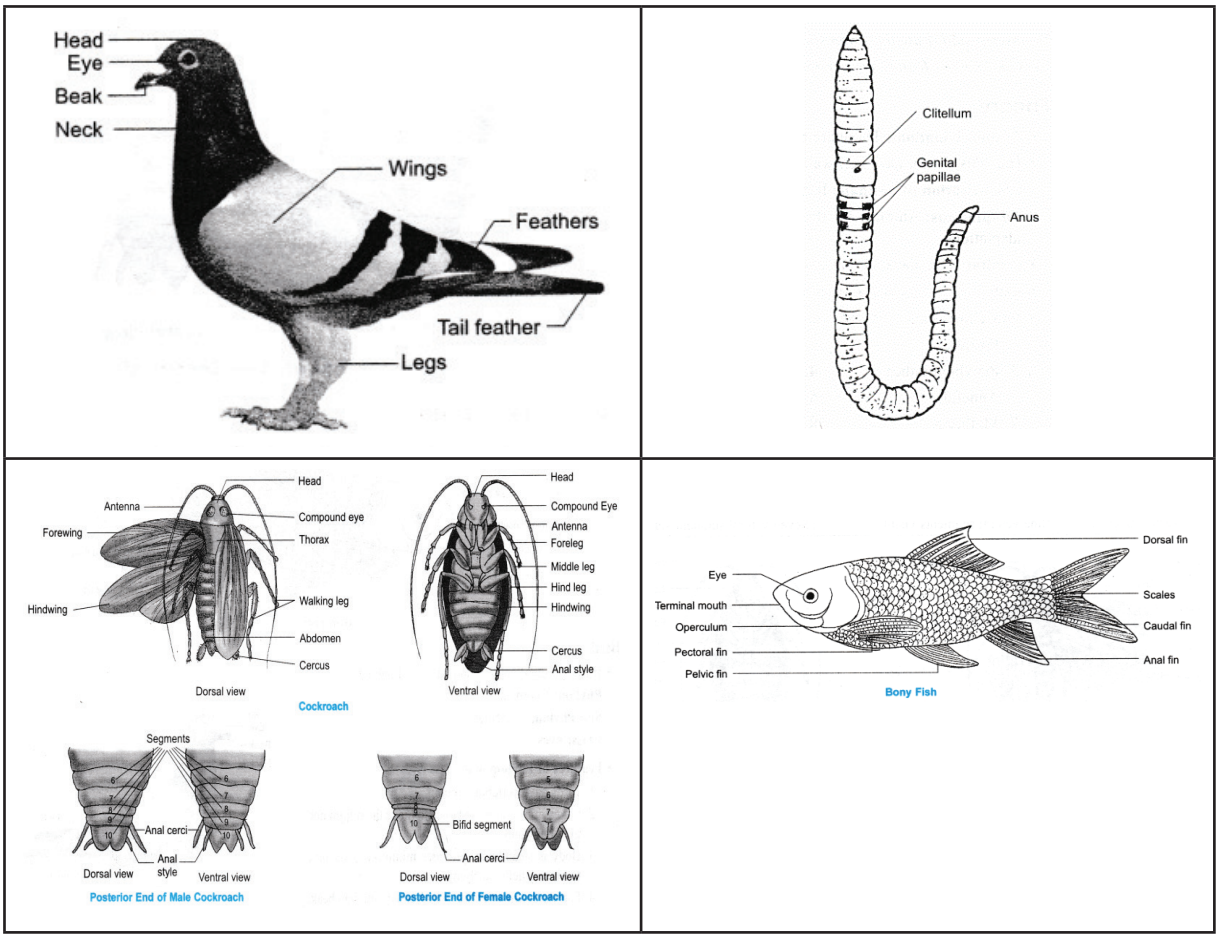


Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: Through this experiment Students understand

- There are a large number of regularly shaped cells lying side by side and each cell has a distinct cell wall.
- A distinct nucleus is present on the periphery of each cell.
- Lightly stained cytoplasm is observed in each cell.
- A large vacuole is present at the center of each cell, and is surrounded by the cytoplasm.

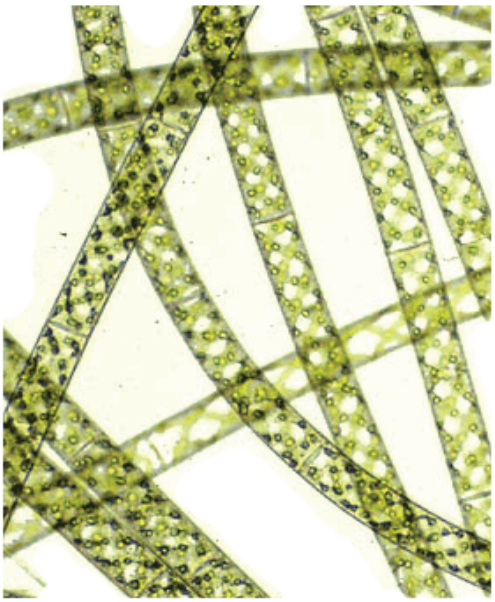
12. Adaptation in Animals



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: Through this experiment Students understand kingdoms and sub kingdoms of animals. This shows the difference between vertebrates and non vertebrates animals. The experiment shows the procedure of their adaptation in 3D form through animated video and stimulations.

13. Characteristics of Plants

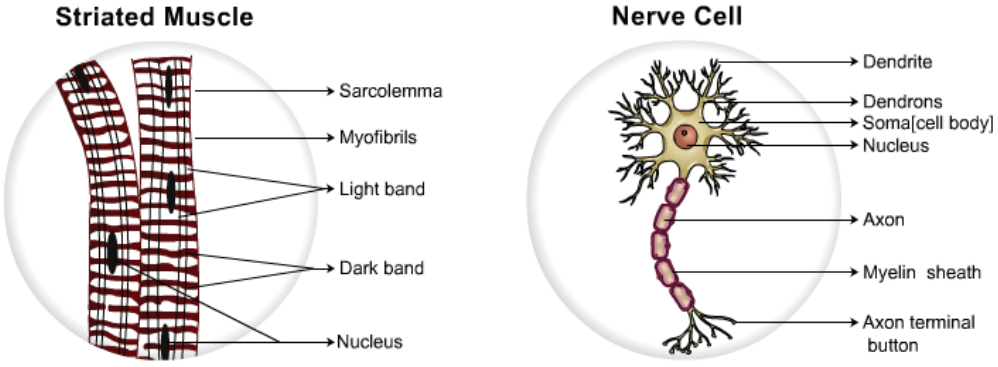


Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation:

1. Students understand terms like thalophytes, bryophytes, pteridophytes, gymnosperms and angiosperms.
2. Students will be able to identify the features of the different divisions of the kingdom Plantae.
3. Students understand the characteristics of spirogyra, agaricus, moss, fern, pinus and angiospermic plants.

14. Plant and Animal Tissues



Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation:

1. Students understand the terms parenchyma tissue, sclerenchyma tissue, striped muscle fibres and nerve cells.
2. Students learn about two types of animal tissue- muscle tissue and nerve tissues.
3. Students learn about two types of plant tissues- parenchyma and sclerenchyma tissues.
4. Students acquires kill to do the experiment after having observed the animation and simulation.

15. Monocot and Dicot Plants

Instruction To run this activity, go to the particular subject, select the class, and select experiment and then click on animated videos.

Explanation: Through this experiment students understand the terms angiosperm, monocot, and Dicot. Students understand the differences between monocot and Dicot plants.

Students understand different parts of the angiosperm plant.

1.7 Rationale

One of the major functions of NCERT is to prepare and publish school level textbooks and supplementary material for the students of the country. NCERT and its constituent units are continuously working to improve the quality of these textbooks. As a result, the quality of textbooks in terms of print, graphics, images, diagrams etc. are progressively improving. However, many models are required to be made attractive for a real feel of experiential learning with visualization. It can be effectively done through 3D modeling which provides more dimensions to the students to comprehend the concept. But these features cannot be provided in printed textbooks. For this purpose, Central Institute of Educational Technology (CIET) is aiming to produce educational media programs in the form of e-Content (non-print) for students and teachers at school level. Therefore, technological innovations need to be incorporated which can enrich the printed material and put the concept in front of learners as in the real world. Augmented Reality has come out as an innovative technology that enables the amalgamation of real-world experience with digital world content (Azuma et al., 2001; Bujak et al., 2013). With the help of digital devices such as mobile smart phones or tablets, the students can acquire the concepts more effectively with experiential learning and visualization. Augmented reality-based e-Content are set out to be pedagogical help for the teachers to supplement their classroom teaching. CIET is working to design and develop augmented reality-based e-Content initially for selected science models. Hence, the present research aims to study the effectiveness of Augmented Reality (AR) based e-Content and Virtual labs of Science on the basis of Students' achievement in Science at secondary stage. The study is likely to provide an authentic review of the augmented reality based e-Content developed by CIET and virtual labs from the real experiences of students who are the primary stakeholder. However, overall findings of the study are likely to provide insights to the planners, producers, teachers and learners towards designing, production, transaction and consumption of virtual labs and Augmented Reality based e-Contents in Science at secondary level.

1.8 Statement of the Problem

The problem was worded as given below:

Effectiveness of Augmented Reality Based e- Contents and Virtual labs on the Basis of Achievement in Science of class IX Students of Schools of Delhi

1.9 Objectives

1. To study the effect of Treatment, Gender and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
2. To study the effect of Treatment, Types of School and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
3. To study the influence of Types of School, Gender and their interaction on Reaction towards Augmented Reality Contents of students belonging to Experimental Group.
4. To study the challenges in developing and using Augmented Reality Contents by Teachers belonging to Kendriya Vidyalaya, Government and Private Secondary Schools.

1.10 Hypotheses

1. There is no significant effect of Treatment, Gender and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
2. There is no significant effect of Treatment, Types of School and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
3. There is no significant influence of Types of School, Gender and their interaction on Reaction towards Augmented Reality Contents of students belonging to Experimental Group.

1.11 Delimitations

This study aims to study the Effectiveness of Augmented Reality Based e- Contents and Virtual labs on Achievement in Science of class IX School Students. For this study six schools of Delhi were selected. Out of which two were Kendriya Vidyalaya, two Government Secondary Schools, and two Private Secondary Schools. Students were taught using Augmented reality apps developed by CIET. From the App fifteen programs of 9th class science were selected for the experiment. For virtual lab experiments Amrita online lab were used. Fifteen olabs programs of 9th class science were selected for the experiment.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction:

The Rationale along with objectives and Hypotheses have been given in the previous chapter. The present Chapter is devoted to the Review of Related Literature. It has been given under captions, like, effectiveness of Augmented Reality and effectiveness of Virtual Labs.

2.2 Researches on Effectiveness of Augmented Reality

Twenty two researches were conducted by Delello A. Julie (2015); Sung -Ting Yao (2016); Cai, Liu, Yang & Liang (2018); Lai et al. (2018); Nisaun (2018); Habig (2019); Khan (2019); Khan Tasneem (2019); Sarkar and Pillai (2019); Tanvi (2019); Altmeyer et al. (2020); Chen (2020); Lim & Lim (2020); López-Belmonte et al. (2020); Ajit (2021); Chong Liang Chong Liang (2021); Eldokhny Ahmed Amany (2021); Khan et al. (2021); Tripathy (2021); Yilmaz (2021); Anne Mundy- Marie (n.d.); and Tolba et al. (2022). The details of each research have been given in separate paragraphs to follow.

Delello A. Julie (2015) studied the student's perceptions regarding the usability of the Aurasma tool for learning and how Augmented Reality enhanced students' learning. The study was conducted among undergraduate students in the U.S. This study used a multi- case study method to bring in the three different perspectives from different discipline students. The participants of the study were students from three disciplines which were Education, Human Resource Development, and Marketing. The total number of students was 145. Pre-test was conducted in the beginning of the experiment and participants went through posttest after using Aurasama app which was Augmentative Reality based. The results indicated that AR could enhance a student's experience in the classroom. Not only were students impressed with the technology, they also found relevance to their future careers outside of the classroom.

Sung -Ting Yao (2016) conducted meta- analysis and research synthesis on integrating mobile devices on student learning conducted in National Taiwan Normal University, Taiwan. The objective of this study was to bridge the gap of qualitative analyses of the use of mobile devices in education, systematic quantitative analyses of the effects of mobile-integrated education. Also critically look at the status of the use of mobile devices in educational experimental studies, including who is using them, which domain subjects are being taught, what kinds of mobile devices and software are being used, where such programs take place, how the devices are used in teaching, and the duration of the interventions. For the analysis 110 experimental and quasi experimental journal articles published during the period 1993-2013 were coded and analyzed. In the initial stage 925 articles were selected after screening, out of which 182 experimental and quasi experimental research articles were selected. Based on the various criteria 110 articles were accepted for inclusion in the meta-analysis. In total there were 110 articles, 419 effect sizes, and 18749 participants. The largest proportion of studies involved the college-student-level learning stage (38.4%); the next largest group was elementary-school students (33.9%). More studies used learning-oriented software (62.7%) than general-purpose software (34.5%). It concluded that analysis of the empirical research on the use of mobile devices as tools in educational interventions that were published in peer-reviewed journals revealed that the overall effect of using mobile devices in education is better than when using desktop computers or not using mobile devices as an intervention.

Cai, Liu, Yang & Liang (2018) studied Impacts of AR on students' conceptions and approaches to learning mathematics according to their self-efficacy. Aim of the study was to understand how the AR could affect the learning of abstract mathematics concepts. The study attempted to answer how students' critical conceptions and approaches changed after integrating AR applications in

the classroom? How does AR integrated learning improve the students' self- efficacy? Participants of the study were students from junior high school. Total number of participants was 101 and was between the age group of 13-15. Tools used in the study were questionnaires for both pretest and post test. Students were divided into two groups based on their mathematics learning self-efficacy. Textbook lessons were divided into three lessons which lasted six weeks. Using AR application students performed experiments in every lesson for 15-25 minutes. The data from pretest and post test were analyzed using ANOCVA. The results showed that AR applications in mathematics courses were found to help students with higher self-efficacy to pay closer attention to higher level conceptions. It was also found to help higher self-efficacy students to apply more advanced strategies when learning mathematics.

Lai et al. (2018) developed an augmented reality-based science learning system based on the continuity principle of multimedia learning in order to promote students' science learning. Moreover, an experiment was conducted on a natural science course in an elementary school to assess the effectiveness of the implemented system on students' learning. The experimental results revealed that the students learning with this approach made significant gains in their learning achievements and motivations compared to those learning science with conventional multimedia science learning; moreover, their perceptions of extraneous cognitive load were significantly reduced during the learning activity.

Nisaun (2018) conducted a study on kindergarten, Indonesia. The objective was to study the learning outcomes of kindergarten students using AR book App. AR book app was developed using Augmented Reality Technology based on the curriculum of kindergarten. AR book app included the name, food, place of living, and animals breeding. The aim of using the AR book app was to teach the learning in 3D views. Research design of this study consisted of two groups, experimental group and control group. Participants of this study were 5-6 year old kindergarten children. Total number of samples was 111. The experiment was conducted in three different schools with different backgrounds to ensure the effectiveness of AR book APP in different contexts. After the selection of two groups in each school, both the groups went through pretest before the treatment. The provider of treatment, in control group treatment was given group notes while in experimental group using AR book app learning. The results of the study showed that AR book applications contributed to performance significantly better than those taught using group notes. It may be said that AR App based teaching using smartphones were more effective in different schools and the difference was significant.

Habig (2019) conducted a study whose objective was to study whether students of bachelor chemistry programme were able to use AR representations to solve domain specific problems. The study focused on answering how students evaluate the learning potential of the AR and their interest in learning and critically look at the sex differences in learning the same. Participants of the study were bachelor chemistry students. Total number of students was 31 out of which 16 were female and 15 male. Tools used in the study were questionnaires, in both pre and post tests. The results of analyses of variance indeed revealed a significant effect of sex variable dependent on the type of representation. In addition, a questionnaire was administered to survey the students' attitudes towards learning with the AR app used.

Khan (2019) conducted a study at the University of Cape Town. The purpose of this research was to study the impact of an Augmented Reality mobile application on the learning motivation of undergraduate health science students. 78 undergraduate health science students were participants of the study. Keller's Attention, Relevance, Confidence, and Satisfaction (ARCS) model of motivational design was used to study the effect of Augmentative Reality application. The students' learning motivation was assessed before and after using an AR mobile application. It revealed that the use of an AR mobile application increased the learning motivation of undergraduate health science students.

Khan Tasneem (2019) did an experimental study on student achievement using AR. It was conducted in Ahi Evran University, Vocational School of Technical Sciences, Turkey. The objective was to

study the impact of use of Augmented Reality (AR) on student achievement and self-efficacy in vocational education and training. For this purpose, a marker-based AR application, called Hardware AR, was developed. The research design was quasi experimental. Sample of the study was 46 undergraduate students in the Computer Hardware Course. For the experiment students were divided into two groups such as control group and experimental group. The control group learned theoretical and applied information about motherboard assembly by using their textbooks (print material) while students in the experimental group used Hardware AR application for the same purpose. It was concluded that AR application had no effect on students' motherboard assembly theoretical knowledge self-efficacy and motherboard assembly skills self-efficacy.

Sarkar and Pillai (2019) studied Augmented Reality in Mumbai and Delhi metropolitan cities. The objective was to study the perception towards technology of students and user expectation on characteristics of AR application in school education. Total number of participants of the study was 47, out of which 6 parents,7 teachers and 34 students. Through convenience sampling both parents and teachers were selected and random sampling used to select students. Both the teachers and students belonged to private schools. The teachers belonged to a private school and had been using one of the smart class solutions interactive smart boards in the classroom, along with the regular textbook. Parents and teachers were interviewed through an interview schedule and semi-structured for students. It was found that Students were still dependent on elders to use the accessible technologies and AR applications should be designed effectively with informative, visual cues for their cognitive sustenance and developing interest in exploring the 3D shapes to enhance the learning experiences of the students of different grades in different subjects.

Tanvi (2019) conducted a study on the impact of Augmentative and Virtual reality in Vellore, India. This study tried to examine the impact of AR/VR applications on education and its benefit while comparing it to the traditional method of teaching using textbooks. The survey methods were used for the study. Participants of the study were taken from various age groups. Total number of respondents was 121. Questionnaires were used as a data collection tool. The participants were asked about their experience while using an AR/VR app. The study concluded that the people, of all generations, look at this new technique of teaching and learning as an improvement to what already existed. Also the people were able to readily adapted this technique for teaching, as it helped students to understand the concept easily, and made class more interactive using VR and AR applications.

Altmeyer et al. (2020) developed a tablet-based AR application to support learning from hands-on experiments in physics education. Real-time measurement data were displayed directly above the components of electric circuits, which were constructed by the learners during lab work. In a two group pretest–posttest design, researchers compared university students' (N = 50) perceived cognitive load and conceptual knowledge gain for both the AR-supported and a matching non-AR learning environment. Whereas participants in both conditions gave comparable ratings for cognitive load, learning gains in conceptual knowledge were only detectable for the AR-supported lab work.

Chen (2020) conducted an experimental study on AR videos as scaffolding to foster students' learning achievements and motivation in EFL learning. Aim of the study was to understand how students outperform after learning through AR and how it's different from learning through conventional videos. Participants of the study were four sections of sixth graders. Total numbers of participants were 97 students from the same school. Out of four classes two were allotted as experimental groups and two were control groups. The experimental group was taught about conventional English learning about animals through AR videos. The control group was taught the same through conventional video based methods. Tools used in the study were questionnaires, for pre-test and post test. Pre- test evaluated the fundamental English knowledge of animals with the 10 multiple choice questions. Post- test conducted with 20 multiple choice questions to study their understanding on characteristics and habits of insects. Results of the study were analyzed through a one-way ANCOVA to evaluate the impact of AR method. This study concluded that AR based learning enhances students' intrinsic motivation and receives a high degree of satisfaction.

Lim & Lim (2020) conducted a study on Semiotics, memory and Augmented Reality. Aim of the

study was to critically analyze to broaden the application of AR in education, contextualized in history education, by exploring the affordances of such technology in mediating student-led learning activities, using an approach known as learner-generated augmentation. The significance of the study says that the current Singapore Secondary History syllabus adopts an inquiry-based approach. Majority of AR- based intervention was designed from the perspective of the technical experts and there was no perception of student - centered based AR learning. Participants of the study were five Student- teachers who were doing their major in History and will become secondary school history teachers upon their graduation. Tools of the study were rating scales. The study involved the design of a learning activity to help students memorize historical information more effectively by building upon the established memory technique of Memory Palace/method of location. In this activity, students used a free AR mobile application—Just a Line—to sketch out memory palaces of key information from a prose passage. Result of the study revealed that this intervention helped the students to remember the historical information which the participants stated was difficult for students to remember in secondary level.

López-Belmonte et al. (2020) used augmented reality in the educational field. This study focused on knowing the performance and scientific production of augmented reality in the field of education. This research was approached from a bibliometric perspective. A novel documentary analysis technique based on scientific mapping and co-word analysis was used. Researchers analysed 777 reported publications of Web of Science. The results revealed the language, knowledge areas, type of document, institutions, authors, sources of origin, countries and most cited articles on augmented reality in the entire educational field. In addition, it revealed that research on augmented reality focused on teaching people to use this technology effectively, in the learning environments it generates, in its educational application, and in attending to the diversity of students.

Ajit (2021) investigated the studies in which Augmented Reality (AR) was used to support Science, Technology, and Engineering and Mathematic (STEM) education. In this framework, the general status of AR in STEM education was presented and its advantages and challenges were identified. The study investigated 42 articles published in journals indexed in SSCI database and deemed suitable for the purposes of this research. The obtained data were analyzed by two researchers using a content analysis method. It was found that the studies in this field became more significant and intensive in recent years and that these studies were generally carried out at schools (class, laboratory etc.) using marker-based AR applications. It was concluded that mostly K-12 students were used as samples and quantitative methods were selected. The advantages of AR-STEM studies were summarized and examined in detail in 4 sub-categories such as "contribution to learner, educational outcomes, interaction and other advantages". On the other hand, some challenges were identified such as teacher resistance and technical problems.

Chong Liang Chong Liang (2021) studied the effect of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning. The objective of the study was to understand the students learning self-efficacy change during the learning process in an AR learning environment and students' conceptions of learning change in their learning process in an AR learning environment. Participants of this study were students from two classes of grade 11 of a high school. A total of 98 students aged between 16 and 18 years old were randomly divided into an experimental group and a control group, each with 49 students developed an AR-based wave-particle duality learning application, "AROSE," to explore the effect of AR technology on students' self-efficacy and conceptions of learning physics. The study revealed that using AR technology can significantly enhance student's self-efficacy in Physics learning.

Eldokhny Ahmed Amany (2021) conducted this study in King Faisal University. The objective of the study was to study the effectiveness of Argumentative Reality in online distance education during covid. Population of the study was 40 students. The sample was selected using a purposeful sampling method. Students were divided into control group and experimental group. The control group was taught through a virtual classroom set weekly and the experimental group was provided with the course plan through the Blackboard Plan icon, with a note of each procedure. The statistical

analysis software SPSS version 22 was used for analysis of the data. The study concluded that AR was effective at the level of both academic achievement and instructional software design skills, as it worked to build a strong relationship between the learner's interaction and perceptions about the content.

Khan et al. (2021) experimentally studied the effectiveness of Augmented Reality and it was conducted in Peshawar, Pakistan. The aim of the research was to investigate the effectiveness of the AR learning methods for primary school students as compared to traditional methods of learning. Learning activities were conducted using both traditional and advanced AR learning methods. The study used the quantitative research method based on the quasi- experimental design. Participants of the study were selected from the three different schools. Students were divided into three different groups. The size of samples was 150, each group had fifty students. During the experiment groups A and B were taught through AR based mobile applications. Group C taught by using traditional teaching methods. The study concluded that as compared to the traditional learning methods, AR learning techniques made the learning process easy, fast, and enjoyable. Students also showed a positive attitude and behavior towards the AR learning method.

Tripathy (2021) studied the resources available among the teacher educators, pre-service teachers and awareness level of application of Augmented Reality in the educational field. This study was conducted in various teacher education institutions of Odisha. Sample of the study consisted of 21 educators and 216 pre- service teachers. Tools of the study were questionnaires. Results revealed that teacher education instructions, Teacher educators and pre-service teachers had adequate resources to use Augmented Reality in teaching and learning purposes but awareness level among them was very poor.

Yilmaz (2021) investigated the effect of using AR technologies in science education. Students' experiences of AR were gathered using a prepared questionnaire form. Within the scope of science education, AR was used in a university-level chemistry course. Using theme analysis, descriptive themes were created by analyzing the content of completed questionnaires in written texts. Descriptive expressions obtained from the written text were determined by free coding. These codes were then matched with appropriate themes and illustrated in the form of branched trees. The study demonstrated that AR was an optimal tool for teaching abstract subjects that did not feature direct observation and examination in science education. Students also had positive opinions about the use of AR in other courses in science education. Another important result from this study revealed that AR software interfaces require improvements to be suitable as teaching material.

Anne Mundy- Marie (n.d.) conducted an online survey using various social media platforms. The objective was to study the AR educators' perceptions of student interest and engagement, knowing different types of AR tools used in the classroom, and challenges of using the AR in the classroom. Both qualitative and quantitative methods were used to collect the data. Tools of the study were questionnaires and the collected data were analyzed using ANOVA. It was found that using the AR technology in classrooms facilitated and improved the learning process for students.

Tolba et al. (2022) conducted a study in Cairo, Egypt on Argumentative Reality in Technology. The study aimed to conduct a systematic review that described the current state of using AR as a learning tool. Taking into consideration the needs of all students including those with a disability, in different levels of education. A review method was used for the study. A total of 103 studies between 2011 and 2021 were analyzed through searching in four interdisciplinary databases: Springer, IEEE Xplore, Research Gate, and Google Scholar. It was concluded that it had potential and benefits in the education sector. It can be designed to stimulate any academic scenario. It was used mostly in science education and medical training. It helped the students to be more motivated and engaged with the learning materials. It was used and explored at all levels of education.

2.3 Researches on Effectiveness of Virtual Laboratories

Dyrberg et al. (2016); Wolski & Jagodziński (2017); Aljuhani (2018); Dixit (2021); and Fatih (2021) conducted researches related to effectiveness of Virtual Labs. The details of each research are given in separate paragraphs to follow.

Dyrberg et al. (2016) studied potential benefits of simulations and virtual laboratory exercises in natural sciences. This study reported findings from a pilot study on student attitude, motivation and self-efficacy when using the Virtual Laboratory programme Labster. The programme allowed interactive learning about the workflows and procedures of biological and biochemical experiments, the operation of relevant apparatuses, including the ability to adjust parameters, and the production of results. The programme was used as a supplement to mandatory laboratory exercises in two undergraduate courses (i. microbiology and ii. pharmaceutical toxicology) at the University of Southern Denmark. With a theoretical basis in motivational theories, students' (n = 73) motivation and attitude towards the virtual exercises were evaluated. After completing virtual laboratory cases, the students felt significantly more confident and comfortable operating laboratory equipment, but they did not feel more motivated to engage in Virtual Laboratories compared to real laboratories. Teachers observed that students were able to participate in discussions at higher levels than in previous years where the programme was not used. The study concluded that virtual laboratories have the potential to improve students' pre-laboratory preparation.

Wolski & Jagodziński (2017) conducted a study on Virtual Laboratory-using a hand movement recognition system to improve the quality of chemical education. Aim of the study was to understand how the virtual lab was effective to learn chemistry through virtual experiments. This study attempted to answer to what extent using virtual chemical laboratories affects student's ability to remember information about chemistry and enhances their ability of problem solving. Participants of the study were secondary school and second year middle school students. Total number of participants was 130. Tools used in the study were questionnaires for both pretest and post- test. During experiments using virtual laboratory middle school students studied issues concerning acids and hydroxides. Secondary students studied issues concerning salts. 25 Students were divided in 5 groups, each student was given 5 minutes to perform one experiment and the other four students could watch the actions. The collected data from pretest and post test were analyzed statically. The result of the study revealed that students had better performed the experiments and that concerned remembering information, understanding information, applying their experience in situations familiar to them from school and in solving chemical problems remembered the information.

Aljuhani (2018) conducted a survey study on virtual labs. The aim of the study was to critically look at the science education in Saudi schools from their work experience and examine the advantages and drawbacks of using virtual labs instead of traditional teaching methods. The study used multiple methods to conduct the survey. The data collection tools were questionnaire and interview. The data responses were received from various cities across Saudi Arabia. Sixty-eight percent of the participants were science teachers, 14.2% were students, and 8.4% were parents. Virtual labs were one of the best ways to teach students and allowed them to conduct experiments instead of simply viewing them. Moving from HOLs to VLs could also reduce costs and increase teaching efficiency.

Dixit (2021) conducted an experimental study on virtual labs. This study aimed to introduce a systematic platform of experiments that were practically not possible to conduct in our physical labs. The objective of the virtual labs was to understand the concept of time dilation by employing the techniques of virtual labs, so the respective lab becomes user-friendly to experience a feeling of the physical lab in the theory classroom. Experimental design was used to conduct the study; questionnaires were used as a data collection tool. Participants of the research were students. The selected participants went through pre-test before the experiment and post test after the experiment. The study concluded that teaching physics via interactive simulations imposes a positive impact on users' academic achievement. It was revealed that virtual laboratories made learning physics concepts less complicated and effectively changed the mood of users that negative insights of the theory course.

Fatih (2021) conducted an experimental study on virtual laboratory application. The aim of this study was to reveal the effect of using virtual lab application in science teaching on students' academic achievement and students' views on virtual lab application. The study used mixed methods to conduct the experiment. Data collection tools were semi-structured interviews for the quality part of research and questionnaire for quantitative part. Participants of the experiment were 8th grade students studying at a secondary school in Antalya. Total number of the sample of the study was 62. Students were divided into two groups such as control group and experimental group. Both groups were tested before the experiment. Control group taught by the prescribed traditional teaching method and experimental group taught using virtual lab application. This study concluded that the Virtual Laboratory application contributed positively to the academic success of the students. In addition to the statistical results of the research data, the qualitative findings obtained in the study showed that the educational process carried out with Virtual Laboratory applications contributed to students' learning by concretizing abstract subjects.

2.4 Sum Up

Delello A. Julie (2015); Sung -Ting Yao (2016); Cai, Liu, Yang & Liang (2018); Lai et al. (2018); Nisaun (2018); Habig (2019); Khan (2019); Khan Tasneem (2019); Sarkar and Pillai (2019); Tanvi (2019); Altmeyer et al. (2020); Chen (2020); Lim & Lim (2020); López-Belmonte et al. (2020); Ajit (2021); Chong Liang Chong Liang (2021); Eldokhny Ahmed Amany (2021); Khan et al. (2021); Tripathy (2021); Yilmaz (2021); Anne Mundy- Marie (n.d.); and Tolba et al. (2022) researchers conducted researches related to Augmented Reality and fond that Augmented Reality was superior to Lecture Method in teaching different subjects at different levels in schools as well as Universities. Only a few researches have been conducted in India related to Augmented Reality.

Dyrberg et al. (2016); Wolski & Jagodziński (2017); Aljuhani (2018); Dixit (2021); and Fatih (2021) conducted researches related to Virtual Labs. Almost all researchers reported that Virtual Labs were found to enhance achievement in different subjects. The number of researches is too small to draw any conclusion. There is a need to conduct more research related to Virtual Labs. Research should also be conducted wherein Augmented Reality and Virtual Labs should be compared on the basis of achievement in different subjects. These should also be used in combinations and compared with the lecture method so that people can make decisions regarding their use in teaching.

CHAPTER 3

METHODOLOGY

3.1. Introduction

In the previous chapter the researches related to Augmented Reality and Virtual Labs. have been given. The present chapter is devoted to Methodology. The information has been given under captions like Sample, Tool, Experimental Design, Procedure of Data Collection and Data Analysis.

3.2. Sample

The population of this project was class IX students studying in Kendriya Vidyalaya, Government and Private Secondary Schools of Delhi. For this study sample was selected with the help of Stratified Random Sampling Method. The Stratification was done on the basis of types of School and Gender of Class IX students. In all, six schools were selected for this study. Of these, two will be Kendriya Vidyalaya, two Government Secondary Schools, and two Private Secondary Schools. In each type of school care was taken to select either co-education schools or one Girls' School and one boys' school. After selecting schools, all students of class IX admitted in the selected school will be part of the sample. Normally in one section of Class IX 40 students are admitted. So the sample was comprised of about 451 students of Class IX belonging to Kendriya Vidyalaya, Government and Private Secondary Schools of Delhi.

3.3. Tool

The data was collected related to Achievement in Science, Reaction towards Augmented Reality Contents & Virtual labs and Challenges in developing and using virtual labs and Augmented Reality. The details are given separately in the following captions.

Achievement in Science: For assessing Achievement in Science, Achievement in Science Test was developed by the investigator. The Achievement in Science Test had Multiple Choice Types items. The questions were related to the content selected for the study.

Reaction towards Virtual labs and Augmented Reality Contents: For assessing Reaction towards Virtual labs and Augmented Reality Contents, Reaction towards Virtual labs and Augmented Reality Contents Scale was developed. The scale had statements related to different aspects of Virtual labs and Augmented Reality. Against each statement, a five point scale was used. The five points will be Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. There were both positive and negative statements in equal number. Reaction towards Virtual labs and Augmented Reality Contents Scale were developed separately for Teachers and students.

Challenges in developing and using Virtual labs and Augmented Reality: For assessing Challenges in developing and using Virtual labs and Augmented Reality, Challenges in developing and using Virtual labs and Augmented Reality Questionnaire was developed. There were both Closed and Open ended questions related to different aspects of developing and using Virtual labs and Augmented Reality.

3.4. Experimental Design

Non-Equivalent Control group design was used for this study conducted in Kendriya Vidyalaya, Government and Private Secondary Schools of Delhi separately. The layout of this design is as follows:

O X O

O O

Both the selected groups were pretested with the help of Achievement in Science Test developed by the investigator. Two selected groups were taught Science with the help of Textbook integrated with the Virtual labs and Augmented Reality. The treatment duration was of about three months at the rate of one period per day. At the end of the treatment, the same Achievement in Science Test was administered to the students of the experimental group. The students of the control group will also be pretested with the help of the same Achievement in Science Test which was used for the experimental group. The control group was taught the same topics at the rate of one period per day for three months through textbook (Traditional) Method. At the end of the three months, the same Achievement in Science Test was administered. Also the students of the experimental group were assessed for their Reaction towards Virtual labs and Augmented Reality Contents at the end of the treatment only.

3.5. Procedure of Data Collection

After getting permission from Kendriya Vidyalaya Sangathan for the Kendriya Vidyalaya namely- KV JNU and KV RK Puram sector-8 and Principals of Private management schools of Delhi i.e., Mount Carmel School, Dwarka and Kalka Public School, Kalka ji, the permission was obtain from Delhi Administration for two Government schools namely Dr. B.R Ambedkar School of Excellence and Veer Sawarkar Sarvodaya Kanya Vidyalaya Kalkaji, all students of Class IX admitted in the selected schools were taken for the study. Of the two selected schools, class IX students of one school were from Experimental Group and of another Control Group. The researcher visited the school and met the students of the selected schools to brief about the project. This was done in all the two selected schools one by one on the same day and the following day. The Achievement in Science Test was administered to all class IX students of selected schools one by one. This was the Pre- Achievement in Science Test. Students of the Experimental Group were taught the selected topics with the help of Textbooks integrated with Virtual labs and Augmented Reality at the rate of one period per day for three months. At the end of three months, the same Achievement in Science Test was administered to get the Post- Achievement in Science Scores. Similarly the students of the Control Groups were Pre-tested with the help of the same Achievement in Science Test which was used for the Experimental Group. The same topics were taught to the Control Group with the help of textbook Method for three months at the rate of one period per day. At the end of the three months, the same Achievement in Science Test was administered. Also at the end of the treatment, Reaction towards Virtual labs and Augmented Reality of students of Experimental Group were assessed with the help of Reaction towards Virtual labs and Augmented Reality Scale developed for the Teachers and students. Also the teachers were asked to list Challenges in developing and using Virtual labs and Augmented Reality. The same procedure was followed in all selected schools of Kendriya Vidyalaya, and Private Secondary Schools of Delhi. The scoring of all tools will be done as decided by the investigator.

3.6. Data Analysis

The collected data has been analyzed with the help of Two Way ANOVA, Two way ANCOVA, and Content analysis.

CHAPTER 4

RESULTS AND INTERPRETATION

4.1 Introduction

The Methodology followed in this study has been given in the previous chapter. In the same chapter, the statistical technique used for analyzing the data has been given. The present chapter is devoted to the presentation of Results and Interpretation. It has been given Objective-wise in the following captions.

4.2 Effect of Teaching Strategy, Gender, Types of Schools and Their Various Interactions on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The first objective was to study the effect of Teaching Strategy, Gender, Types of Schools and their various interactions on Achievement in Science of students by considering their Pre-Achievement in Science as covariate. Augmented Reality and Lecture Method were the two levels of Teaching Strategy; Male and Female the two levels of Gender while Public Schools, State Government Schools and Central Schools were three Types of Schools. Pre-Achievement in Science was taken as covariate. Thus the data were analysed with the help of 2X2X3 Factorial Design ANCOVA and the results are given in Table 4.1.

Table 4.1: Summary of 2X2X3 Factorial Design ANCOVA of Achievement in Science of students by taking their Pre- Achievement in Science as covariate.

Source of Variance	Df	SSY.X	MSSY.X	FY.X - Value
Teaching Strategy (A)	1	18.69	18.69	1.06
Gender (B)	1	6.94	6.941.39	0.39
Types of Schools (C)	2	207.52	103.76	5.91**
A X B	1	0.15	0.15	0.01
A X C	2	11.02	5.51	0.31
B X C	2	513.19	256.59	
A X B X C	2	5.75	2.87	
Error	419	7356.31	17.56	
Total	431			

**Significant at 0.01 level

4.2.1 Effect of Teaching Strategy on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

From Table 4.1, it can be seen that the adjusted F-Value for Teaching Strategy is 1.06 which is not significant. It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of students taught through Augmented Reality Mode and Lecture Method by taking students Pre- Achievement in Science as covariate. So there was no significant effect of Teaching Strategy on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of Teaching Strategy on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that both Augment Reality Mode and Lecture Method were found to be equally effective in terms of Achievement in Science of students when their Pre-Achievement in Science was taken as covariate.

4.2.2 Effect of Gender on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The adjusted F-Value for Gender is 0.39 which is not significant (Vide Table 4.1). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of Male and Female students by taking students Pre- Achievement in Science as covariate. So there was no significant effect of Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in the case of Augmented Reality Mode, both Male and Female were found to have Achievement in Science to the same extent when their Pre-Achievement in Science was taken as covariate.

4.2.3 Effect of Types of Schools on Achievement in Science of Students by Taking Their Pre- Achievement in Science as Covariate

From Table 4.1 it can be seen that the adjusted F-Value for Types of Schools is 5.91 which is significant at 0.01with df=2/419. It indicates that there is a significant difference in adjusted mean scores of Achievement in Science of students studying in Public Schools, State Government Schools and Central Schools when their Pre- Achievement in Science was taken as covariate. So there was a significant effect of Types of Schools on Achievement in Science of students by taking their Pre-Achievement in Science as covariates. Thus the null hypothesis that there is no significant effect of Types of Schools on Achievement in Science of students by taking their Pre- Achievement in Science as covariates is rejected. In order to know which Type of Schools students were found to have significantly higher Achievement in Science, the data were further analyzed with the help of t-Test and the results are given in Table 4.2.

Table 4.2: Type of Schools-wise adjusted M, SE, N and t-values of Achievement in Science of students

Type of Schools	Adjusted M	SE	N	State Government Schools	Central Schools
Public Schools	15.76	0.40	52	1.57	3.54**
State Government Schools	14.83	0.43	109		1.62
Central Schools	13.94	0.34	74		

From Table 4.2, it can be seen that the t-Value for Public Schools and State Government Schools is 1.57 which is not significant. It indicates that there is no significant difference in adjusted mean scores of Achievement in Science of students studying in Public Schools and State Government Schools when their Pre- Achievement in Science was taken as covariate. It may be said that in the case of Augment Reality Mode, students studying in Public Schools and State Government Schools

were found to have the same degree of Achievement in Science when their Pre- Achievement in Science was taken as covariate.

The t-value for Public Schools and Central Schools is 3.54 which is significant at 0.01 level with df=124 (Vide Table 4.2). It means that there is a significant difference in adjusted mean scores of Achievement in Science of students studying in Public Schools and Central Schools when their Pre-Achievement in Science was taken as covariate. Further the adjusted mean score of Achievement in Science of Public Schools students is 15.76 which is significantly higher than those of Central Schools whose adjusted mean score of Achievement in Science is 13.94. It may be said that in the case of Augmented Reality Mode, Public Schools students were found to have significantly higher Achievement in Science as compared to Central Schools when their Pre- Achievement in Science was taken as covariate.

Lastly the t-value for State Government Schools and Central Schools is 1.62 which is not significant (Vide Table 4.2). It indicates that there is no significant difference in adjusted mean scores of Achievement in Science of students studying in State Government Schools and Central Schools when their Pre- Achievement in Science was taken as covariate. It may be said that in the case of Augmented Reality Mode, students studying in State Government Schools and Central Schools were found to have the same degree of Achievement in Science when their Pre- Achievement in Science was taken as covariate.

4.2.4 Effect of Interaction Between Teaching Strategy & Gender on Achievement in Science of Students By Taking Their Pre- Achievement in Science as Covariate

The adjusted F-Value for interaction between Teaching Strategy and Gender is 0.01 which is not significant (Vide Table 4.1). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of Male and Female students taught through Augmented Reality Mode and Lecture Method by taking students Pre- Achievement in Science as covariate. So there was no significant effect of interaction between Teaching Strategy and Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction between Teaching Strategy and Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in case of Augment Reality Mode, both Male and Female were found to benefit equally from Augmented Reality Mode and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

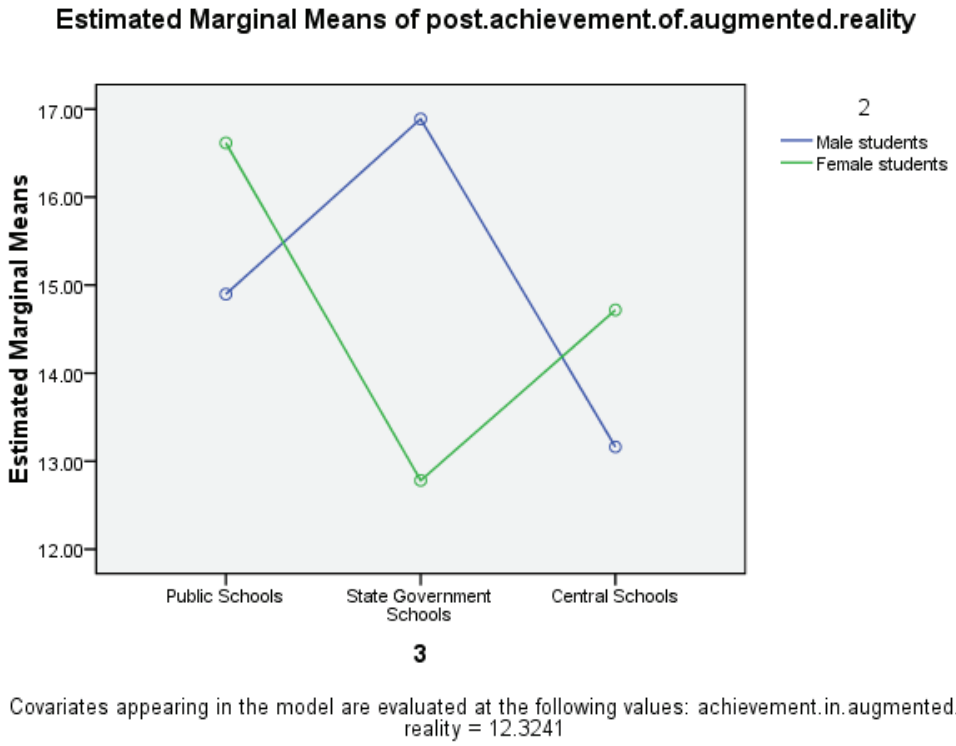
4.2.5 Effect of Interaction between Teaching Strategy & Types of School on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The adjusted F-Value for interaction between Teaching Strategy and Types of School is 0.31 which is not significant (Vide Table 4.1). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of students taught through Augmented Reality Mode and Lecture Method belonging to Public Schools, State Government Schools and Central Schools by taking students Pre- Achievement in Science as covariate. So there was no significant effect of interaction between Teaching Strategy and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction between Teaching Strategy and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in case of Augment Reality Mode, students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Augmented Reality Mode and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

4.2.6 Effect of Interaction between Gender and Types of School on Achievement in Science of Students by Taking Their Pre- Achievement in Science as Covariate

The adjusted F-Value for Gender and Types of School is 14.61 which is significant at 0.01 level with df=2/419 (Vide Table 4.1). It reflects that there is a significant difference in adjusted mean scores of Achievement in Science of Male and Female students studying in Public Schools, State Government Schools and Central Schools when their Pre- Achievement in Science was taken as covariate. So there was a significant effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is rejected. In order to know the trend of effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate, Graph 4.1 has been plotted.

Graph 4.1: Trend of effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate.



From Graph 4.1, it can be seen that in the case of Augmented Reality Mode, as the Type of School changes from Public to State Government, there is a sharp decline in Achievement in Science of Female students while there is a sharp improvement in Achievement in Science of Male Students. On the other hand, the Achievement in Science of Female students improved sharply as Type of School changes from State Government to Central Schools but Male students Achievement in Science declines sharply. Further Male students belonging to State Government Schools and Female students studying in Public Schools and Central Schools were found to have better Achievement in Science as compared to their counterparts.

4.2.7 Effect of Interaction among Teaching Strategy, Gender and Types of School on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The adjusted F-Value for interaction among Teaching Strategy, Gender and Types of School is 0.16 which is not significant (Vide Table 4.1). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of Male and Female students taught through Augmented Reality Mode and Lecture Method belonging to Public Schools, State Government Schools and Central Schools by taking students Pre- Achievement in Science as covariate. So there was no significant effect of interaction among Teaching Strategy, Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction among Teaching Strategy, Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in case of Augment Reality Mode, Male and Female students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Augmented Reality Mode and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

4.3 Procedure of Data Collection

4.3.0 Effect of Teaching Strategy, Gender, Types of Schools and Their Various Interactions on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The second objective was to study the effect of Teaching Strategy, Gender, Types of Schools and their various interactions on Achievement in Science of students by considering their Pre-Achievement in Science as covariate. Virtual Lab and Lecture Method were the two levels of Teaching Strategy; Male and Female the two levels of Gender while Public Schools, State Government Schools and Central Schools were three Types of Schools. Pre-Achievement in Science was taken as covariate. Thus the data were analyzed with the help of 2X2X3 Factorial Design ANCOVA and the results are given in Table 4.3

Table 4.3: Summary of 2X2X3 Factorial Design ANCOVA of Achievement in Science of students by taking their Pre- Achievement in Science as covariate

Source of Variance	df	SSY.X	MSSY.X	FY.X - Value
Teaching Strategy (A)	1	9.49	9.49	0.42
Gender (B)	1	63.60	63.60	2.81
Types of Schools (C)	2	243.72	121.86	5.38**
A X B	1	89.62	89.62	3.95*
A X C	2	3.17	1.59	0.07
B X C	2	143.90	71.95	3.17*
A X B X C	2	75.14	37.57	0.66
Error	419	9496.41	22.66	
Total	431			

**Significant at 0.01 level

4.3.1 Effect of Teaching Strategy on Achievement in Science of Students by Taking Their Pre- Achievement in Science as Covariate

From Table 4.3, it can be seen that the adjusted F-Value for Teaching Strategy is 0.42 which is not significant. It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of students taught through Virtual Lab Mode and Lecture Method by taking students Pre- Achievement in Science as covariate. So there was no significant effect of Teaching Strategy on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of Teaching Strategy on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that both Virtual Lab and Lecture Method were found to be equally effective in terms of Achievement in Science of students when their Pre-Achievement in Science was taken as covariate.

4.3.2 Effect of Gender on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The adjusted F-Value for Gender is 2.81 which is not significant (Vide Table 4.3). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of Male and Female students by taking students Pre- Achievement in Science as covariate. So there was no significant effect of Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in case of Virtual Lab, both Male and Female were found to have Achievement in Science to the same extent when their Pre-Achievement in Science was taken as covariate.

4.3.3 Effect of Types of Schools on Achievement in Science of Students by Taking Their Pre- Achievement in Science as Covariate

From Table 4.3 it can be seen that the adjusted F-Value for Types of Schools is 5.38 which is significant at 0.01with df=2/419. It indicates that there is a significant difference in adjusted mean scores of Achievement in Science of students studying in Public Schools, State Government Schools and Central Schools when their Pre- Achievement in Science was taken as covariate. So there was a significant effect of Types of Schools on Achievement in Science of students by taking their Pre-Achievement in Science as covariates. Thus the null hypothesis that there is no significant effect of Types of Schools on Achievement in Science of students by taking their Pre- Achievement in Science as covariates is rejected. In order to know which Type of Schools students were found to have significantly higher Achievement in Science, the data were further analysed with the help of t-Test and the results are given in Table 4.4.

Type of Schools	Adjusted M	SE	N	State Government School	Central Schools
Public Schools	17.29	0.44	52	1.75	3.56**
State Government Schools	16.15	0.48	109		1.32
Central Schools	15.33	0.39	74		

From Table 4.4, it can be seen that the t-Value for Public Schools and State Government Schools is 1.75 which is not significant. It indicates that there is no significant difference in adjusted mean scores of Achievement in Science of students studying in Public Schools and State Government Schools when their Pre- Achievement in Science was taken as covariate. It may be said that in the case of Virtual Lab, students studying in Public Schools and State Government Schools were found to have the same degree of Achievement in Science when their Pre- Achievement in Science was

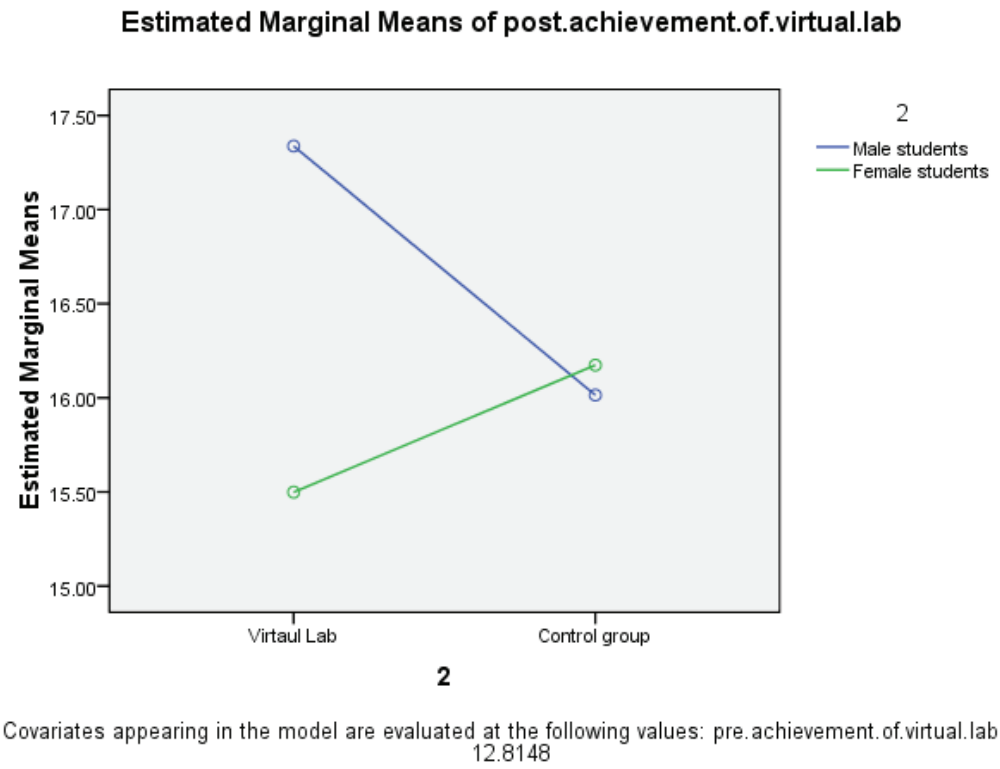
taken as covariate.

The t-value for Public Schools and Central Schools is 3.56 which is significant at 0.01 level with df=124 (Vide Table 4.4). It means that there is a significant difference in adjusted mean scores of Achievement in Science of students studying in Public Schools and Central Schools when their Pre-Achievement in Science was taken as covariate. Further the adjusted mean score of Achievement in Science of Public Schools students is 17.29 which is significantly higher than those of Central Schools whose adjusted mean score of Achievement in Science is 15.33. It may be said that in the case of Virtual Lab, Public Schools students were found to have significantly higher Achievement in Science as compared to Central Schools when their Pre- Achievement in Science was taken as covariate.

Lastly the t-value for State Government Schools and Central Schools is 1.32 which is not significant (Vide Table 4.2). It indicates that there is no significant difference in adjusted mean scores of Achievement in Science of students studying in State Government Schools and Central Schools when their Pre- Achievement in Science was taken as covariate. It may be said that in the case of Virtual Lab, students studying in State Government Schools and Central Schools were found to have the same degree of Achievement in Science when their Pre- Achievement in Science was taken as covariate.

4.3.4 Effect of Interaction Between Teaching Strategy & Gender on Achievement in Science of Students By Taking Their Pre-Achievement in Science as Covariate

The adjusted F-Value for interaction between Teaching Strategy and Gender is 3.95 which is significant at 0.05 level with df= 1/419 (Vide Table 4.4). It reflects that there is a significant difference in adjusted mean scores of Achievement in Science of Male and Female students taught through Virtual Lab and Lecture Method by taking students Pre- Achievement in Science as covariate. So there was a significant effect of interaction between Teaching Strategy and Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction between Teaching Strategy and Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is rejected. In order to know the trend of effect of interaction between Teaching Strategy and Gender on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate, Graph 4.2 has been plotted.



Graph 4.2: Trend of effect of interaction between Teaching Strategy and Gender on Achievement in Science of students by taking their Pre- Achievement in Science as covariate

From Graph 4.2, it can be seen that in the case of Virtual Lab, as Treatment changes from Virtual Lab to Lecture Method there is a sharp decline in Achievement in Science of Male students but there is a sharp increase in Achievement in Science of Female students. Male students benefited more from the Virtual Lab as compared to Lecture Method while Lecture Method suits both Male and Female students.

4.3.5 Effect of Interaction Between Teaching Strategy & Types of School on Achievement in Science of Students By Taking Their Pre-Achievement in Science as Covariate

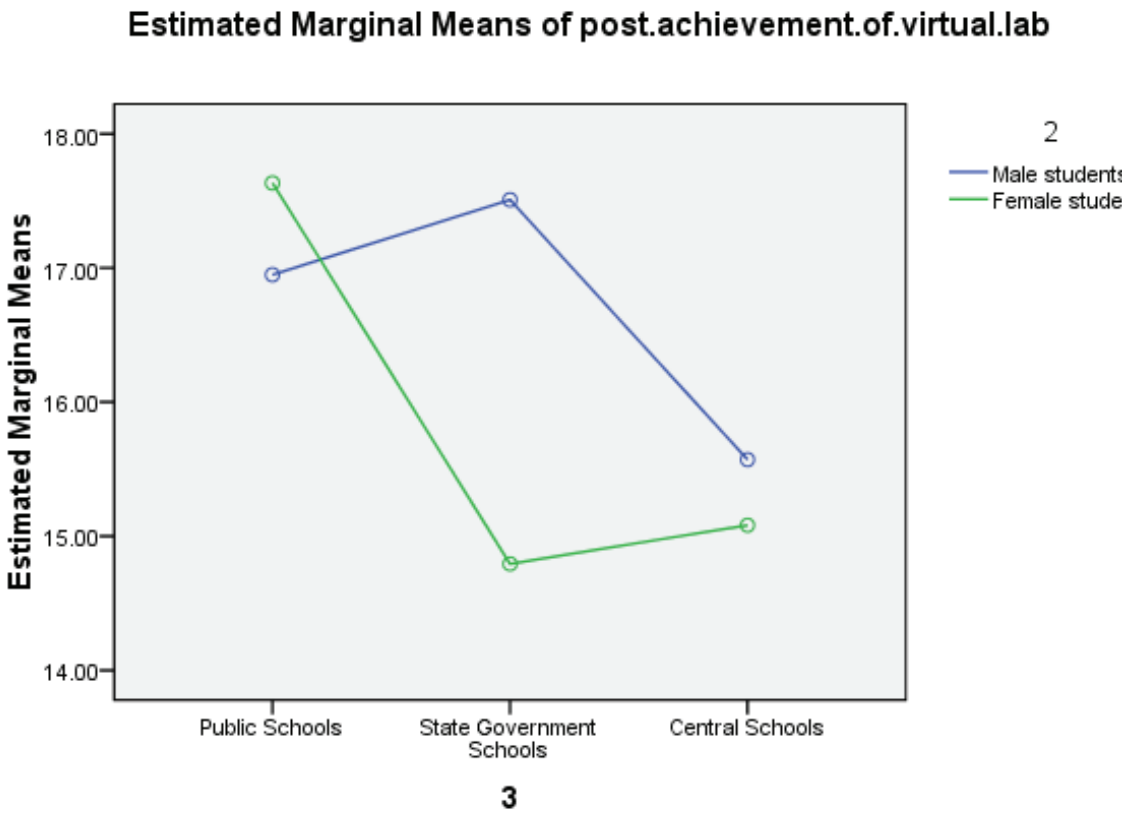
The adjusted F-Value for interaction between Teaching Strategy and Types of School is 0.07 which is not significant (Vide Table 4.4). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of students taught through Virtual Lab and Lecture Method belonging to Public Schools, State Government Schools and Central Schools by taking students Pre- Achievement in Science as covariate. So there was no significant effect of interaction between Teaching Strategy and Types of School on Achievement in Science of students when their Pre-Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction between Teaching Strategy and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in the case of Virtual Lab, students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Virtual Lab and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

4.3.6 Effect of Interaction between Gender and Types of School on Achievement in Science of Students by Taking Their Pre-Achievement in Science as Covariate

The adjusted F-Value for Gender and Types of School is 3.17 which is significant at 0.05 level with df=2/419 (Vide Table 4.1). It reflects that there is a significant difference in adjusted mean scores of

Achievement in Science of Male and Female students studying in Public Schools, State Government Schools and Central Schools when their Pre- Achievement in Science was taken as covariate. So there was a significant effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is rejected. In order to know the trend of effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate, Graph 4.3 has been plotted.

Graph 4.3: Trend of effect of interaction between Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate.



From Graph 4.3, it can be seen that in the case of Virtual Lab, as the Type of School changes from Public to State Government, there is a sharp decline in Achievement in Science of Female students while there is a sharp improvement in Achievement in Science of Male Students. On the other hand Achievement in Science of Female students improved as Type of School changes from State Government to Central Schools but Male students Achievement in Science declines sharply. Further Male and Female students studying in Public Schools had better Achievement in Science when their Pre- Achievement in Science was taken as covariate. State Government Schools were found to suit more to Male Students than Female students and Central Schools were slightly more beneficial to Male students rather than Female students when their Pre-Achievement in Science was taken as covariate.

4.3.7 Effect of Interaction among Teaching Strategy, Gender and Types of School on Achievement in Science of Students by Taking Their Pre- Achievement in Science as Covariate

The adjusted F-Value for interaction among Teaching Strategy, Gender and Types of School is 1.66 which is not significant (Vide Table 4.1). It reflects that there is no significant difference in adjusted mean scores of Achievement in Science of Male and Female students taught through Virtual Lab and Lecture Method belonging to Public Schools, State Government Schools and Central Schools by taking students Pre- Achievement in Science as covariate. So there was no significant effect of interaction among Teaching Strategy, Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate. Thus the null hypothesis that there is no significant effect of interaction among Teaching Strategy, Gender and Types of School on Achievement in Science of students when their Pre- Achievement in Science was taken as covariate is not rejected. It may be said that in the case of Virtual Lab, Male and Female students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Virtual Lab and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

4.4 Challenges faced by students and teachers while using AR app in class

The use of augmented reality (AR) app in the classroom can offer numerous benefits, such as enhancing engagement, promoting interactive learning, and providing immersive experiences. However, there are also many challenges faced by both students and teachers while using AR app in their class. During the data collection in the field, the investigators have found that most of the schools, does not allow mobile phones inside the school premises. Therefore, suitable arrangements were made jointly by the investigators and teachers to use mobile phones in order to conduct the experiment by using AR app in the class. Even the numbers of devices were very less as compare to number of students in the school that made learning difficult. Here are some other common challenges based on the interaction with teachers, they faced during the experiment:

- **Technical Issues:** Augmented Reality app requires compatible devices, such as smart phones or tablets, to function properly. Technical issues, such as device compatibility problems, software glitches, or connectivity issues, can hinder the seamless integration of AR technology into the classroom, which led to irritation and interruptions in the learning process.
- **Familiarity with App:** Students and teachers may need to invest time and effort to become familiar with using Augmented Reality app effectively. The learning associated with mastering the app's features and functionalities may depend on the complexity of the app. Some students and teachers may find it challenging to adapt to the new technology, which may temporarily impact their engagement with the concept and confidence levels.
- **Limited Resources and Access:** Access to devices and AR resources can be a barrier in some educational settings. Not all schools may have the necessary resources, such as a sufficient number of devices or reliable internet connectivity, to support the widespread use of AR app in the classroom. This limitation can impede the equitable integration of AR technology into the learning environment.
- **Classroom Management:** Integrating AR app into the classroom requires effective classroom management strategies. Teachers need to strike a balance between facilitating the use of AR app and ensuring that students remain focused and engaged in the learning process. Managing distractions, setting clear guidelines for app usage, and addressing any technical or behavioral issues that arise can pose challenges for teachers.
- **Time Constraints:** Integrating AR activities into the curriculum may require additional time for setup, instruction, and troubleshooting. Teachers need to allocate sufficient time for students to understand how to use the AR app, complete the tasks or assignments, and debrief the experience. Time constraints within the classroom schedule can limit the extent to which AR can be effectively utilized.

- **Poor Voiceover or Audio Features:** Some figures/ experiments incorporate voiceover or audio components to provide instructions, explanations, or additional information. However, some figures/ experiments has poor voiceover quality that hinders the learning experience. Students may struggle to comprehend the instructions or miss out on crucial information, impacting their engagement and understanding.
- **Scanning Issues:** AR app often require the scanning of markers or objects to activate the augmented content. Sometime scanning process was unreliable; students had faced difficulties in triggering the desired AR elements. This led to disappointment and disrupts the flow of the lesson or activity.
- **Network Problems:** AR app may rely on an internet connection for downloading content, accessing additional resources, or synchronizing data. In areas with poor or unstable network connectivity, students may encounter delays or disruptions while using AR app. This can hinder the real-time interactive experience and potentially impede the learning process.
- **Accessibility and Inclusion:** AR app should be inclusive and accessible to students with diverse learning needs. However, certain features of AR app, such as visual components or reliance on touchscreens, may present barriers for students with visual or physical disabilities. Addressing accessibility challenges and ensuring equal participation and engagement for all students can be a significant concern.
- **Difficulty to develop AR content:** The investigators experienced that the process of development of AR e-content is difficult than producing audio/video programs. Because it needs specialized programmers who know content as well as technologies.
- **Expensive and time consuming:** Since the process of developing AR e-content is complex and lengthy, therefore it is time consuming and expensive too.

Overcoming these challenges requires careful planning, adequate technical support, professional development for teachers, and a commitment to ongoing evaluation and improvement. With the right support and strategies in place, AR app can be effectively integrated into the classroom, providing valuable learning experiences for students and enhancing teaching practices for educators.

4.5 Challenges faced by students and teachers, while using Virtual OLab in class

Using Virtual OLab, a virtual laboratory environment, in the classroom can provide students with valuable experiences and enhance their understanding of scientific concepts. However, there can be certain challenges that students and teachers may encounter when using Virtual OLab. Here are some common challenges based on the interaction with teachers:

- **Absence of Physical Interaction:** Unlike a traditional laboratory, Virtual OLab lacks physical interaction with lab equipment and materials. Students may miss the tactile experiences of conducting experiments, manipulating objects, and observing real-world phenomena. This limited physical engagement can obstruct their ability to develop essential laboratory skills and may require additional efforts to bridge the gap between virtual and physical experiences.
- **Technical Issues:** Virtual OLab relies on technology, such as computers or tablets, to create the virtual laboratory environment. Technical issues like software glitches, compatibility problems, or hardware limitations can disrupt the smooth functioning of Virtual OLab. These technical challenges can cause disappointment among students and teachers and may result in waste of instructional time.
- **Familiarities with Virtual OLab:** Students and teachers may need time to become familiar with navigating and using the Virtual OLab interface. The virtual laboratory environment might have a learning requirement such as: to understand how to access experiments, use various tools, collect data, and analyze results. Similarly, teachers may need to invest time in understanding the features and functionalities of Virtual OLab to effectively guide students through experiments.
- **Authenticity and Realism:** While Virtual OLab attempts to replicate laboratory experiences, it may not fully capture the authenticity and realism of a physical laboratory. The virtual environment lacks the complexity, unpredictability, and sensory aspects of a real laboratory experience. This hinders students'

ability to develop critical thinking skills, make accurate observations, and draw conclusions based on real-world contexts.

- **Collaboration and Communication**: Collaborative learning and communication among students are essential components of a classroom laboratory setting. Virtual OLab presents challenges in fostering effective collaboration and communication. Students may find it challenging to work together virtually, exchange ideas, or engage in group discussions during experiments. Teachers need to establish alternative methods and tools to promote collaboration in the virtual environment.
- **Assessment and Feedback:** Assessing students' performance and providing timely feedback can be more challenging in a virtual laboratory setting. Monitoring students' progress, evaluating their techniques, and providing individualized feedback requires additional effort and creativity from teachers. Developing effective assessment strategies that align with the virtual laboratory experiences is crucial to ensure accurate evaluation of students' skills and understanding.

Addressing these challenges requires a thoughtful approach to integrate Virtual OLab into the curriculum. Providing guidance, training, and technical support to students and teachers can help mitigate the challenges associated with the virtual laboratory environment. Regular assessment and feedback mechanisms can also help refine the use of Virtual OLab and optimize its benefits for student learning.

Chapter 5

Summery, Findings and Implications

5.1 Introduction

The study has been given in detail in the previous chapters. The present chapter is devoted to Summary, Findings and Implications. The details are being given under different captions to follow.

5.2 Rationale

One of the major functions of NCERT is to prepare and publish school level textbooks and supplementary material for the students of the country. NCERT and its constituent units are continuously working to improve the quality of these textbooks. As a result, the quality of textbooks in terms of print, graphics, images, diagrams etc. are progressively improving. However, many models are required to be made attractive for a real feel of experiential learning with visualization. It can be effectively done through 3D modeling which provides more dimensions to the students to comprehend the concept. But these features cannot be provided in printed textbooks. For this purpose, Central Institute of Educational Technology (CIET) is aiming to produce educational media programs in the form of e-Content (non-print) for students and teachers at school level. Therefore, technological innovations need to be incorporated which can enrich the printed material and put the concept in front of learners as in the real world. Augmented Reality has come out as an innovative technology that enables the amalgamation of real-world experience with digital world content (Azuma et al., 2001; Bujak et al., 2013). With the help of digital devices such as mobile smart phones or tablets, the students can acquire the concepts more effectively with experiential learning and visualization. Augmented reality-based e-Content are set out to be pedagogical help for the teachers to supplement their classroom teaching. CIET is working to design and develop augmented reality-based e-Content initially for selected science models. Hence, the present research aims to study the effectiveness of Augmented Reality (AR) based e-Content and Virtual labs of Science on the basis of Students' achievement in Science at secondary stage. The study is likely to provide an authentic review of the augmented reality based e-Content developed by CIET and virtual labs from the real experiences of students who are the primary stakeholder. However, overall findings of the study are likely to provide insights to the planners, producers, teachers and learners towards designing, production, transaction and consumption of virtual labs and Augmented Reality based e-Contents in Science at secondary level.

5.3 Statement of the Problem

The problem was worded as given below:

Effectiveness of Augmented Reality Based e- Contents and Virtual labs on the Basis of Achievement in Science of class IX Students of Schools of Delhi

5.4 Objectives

1. To study the effect of Treatment, Gender and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
2. To study the effect of Treatment, Types of School and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
3. To study the influence of Types of School, Gender and their interaction on Reaction towards Augmented Reality Contents of students belonging to Experimental Group.
4. To study the challenges in developing and using Augmented Reality Contents by Teachers belonging to Kendriya Vidyalaya, Government and Private Secondary Schools.

5.5 Hypotheses

1. There is no significant effect of Treatment, Gender and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
2. There is no significant effect of Treatment, Types of School and their interaction on Achievement in Science of students by considering their Pre-Achievement in Science as covariate.
3. There is no significant influence of Types of School, Gender and their interaction on Reaction towards Augmented Reality Contents of students belonging to Experimental Group.

5.6 Sample

The population of this project was class IX students studying in Kendriya Vidyalaya, Government and Private Secondary Schools of Delhi. For this study sample was selected with the help of Stratified Random Sampling Method. The Stratification was done on the basis of types of School and Gender of Class IX students. In all six schools were selected for this study. Of these, two will be Kendriya Vidyalaya, two Government Secondary Schools, and two Private Secondary Schools. In each type of school care was taken to select either co-education schools or one Girls' School and one boys' school.

5.7 Tools

Achievement in Science: For assessing Achievement in Science, Achievement in Science Test was developed by the investigator. The Achievement in Science Test had Multiple Choice Types items. The questions were related to the content selected for the study.

Reaction towards Virtual labs and Augmented Reality Contents: For assessing Reaction towards Virtual labs and Augmented Reality Contents, Reaction towards Virtual labs and Augmented Reality Contents Scale was developed. The scale had statements related to different aspects of Virtual labs and Augmented Reality. Against each statement, a five point scale was used. The five points will be Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. There were both positive and negative statements in equal numbers. Reactions towards Virtual labs and Augmented Reality Contents Scale were developed separately for Teachers and students.

5.8 Experimental Design

Non-Equivalent Control group design was used for this study conducted in Kendriya Vidyalaya, Government and Private Secondary Schools of Delhi separately. Both the selected groups were pretested with the help of Achievement in Science Test developed by the investigator. Two selected groups were taught Science with the help of Textbook integrated with the Virtual labs and Augmented Reality. The treatment duration was of about three months at the rate of one period per day. At the end of the treatment, the same Achievement in Science Test was administered to the students of the experimental group. The students of the control group will also be pretested with the help of the same Achievement in Science Test which was used for the experimental group. The control group was taught the same topics at the rate of one period per day for three months through textbook (Traditional) Method. At the end of the three months, the same Achievement in Science Test was administered. Also the students of the experimental group were assessed for their Reaction towards Virtual labs and Augmented Reality Contents at the end of the treatment only.

5.9 Procedure of Data Collection

After getting permission from Kendriya Vidyalaya Sangathan for the Kendriya Vidyalayas namely- KV JNU and KV Rk Puram sector-8 and Principals of Private management schools of Delhi i.e., Mount Carmel School, Dwarka and Kalka Public School, Kalka ji, the permission was obtain from Delhi Administration for two Government schools namely Dr. B.R Ambedkar School of Excellence and Veer Sawarkar Sarvodaya Kanya Vidyalaya Kalkaji, all students of Class IX admitted in the selected schools were taken for the study. Of the two selected schools, class IX students of one school were from Experimental Group and of another Control Group. The researcher visited the

school and met the students of the selected schools to brief about the project. This was done in all the two selected schools one by one on the same day and the following day. The Achievement in Science Test was administered to all class IX students of selected schools one by one. This was the Pre- Achievement in Science Test. Students of the Experimental Group were taught the selected topics with the help of a Textbook integrated with Virtual labs and Augmented Reality at the rate of one period per day for three months. At the end of three months, the same Achievement in Science Test was administered to get the Post- Achievement in Science Scores. Similarly the students of the Control Groups were Pre-tested with the help of the same Achievement in Science Test which was used for the Experimental Group. The same topics were taught to the Control Group with the help of textbook Method for three months at the rate of one period per day. At the end of the three months, the same Achievement in Science Test was administered. Also at the end of the treatment, Reaction towards Virtual labs and Augmented Reality of students of Experimental Group were assessed with the help of Reaction towards Virtual labs and Augmented Reality Scale developed for the Teachers and students. Also the teachers were asked to list Challenges in developing and using Virtual labs and Augmented Reality. The same procedure was followed in all selected schools of Kendriya Vidyalaya, and Private Secondary Schools of Delhi. The scoring of all tools will be done as decided by the investigator.

5.10 Data Analysis

The data were analyzed with the help of Two Way ANOVA, Two Way ANCOVA and Content Analysis.

5.11 Findings

The following were the findings of this study.

1. Both Augment Reality Mode and Lecture Method were found to be equally effective in terms of Achievement in Science of students when their Pre-Achievement in Science was taken as covariate.
2. In case of Augment Reality Mode, both Male and Female were found to have Achievement in Science to the same extent when their Pre-Achievement in Science was taken as covariate.
3. In case of Augment Reality Mode, both Male and Female were found to benefit equally from Augmented Reality Mode and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.
4. In case of Augment Reality Mode, Students studying in Public Schools and State Government Schools while State Government Schools and Central Schools were found to have the same degree of Achievement in Science when their Pre- Achievement in Science was taken as covariate. Students studying in Public Schools had significantly higher Achievement in Science as compared to Central Schools when their Pre-Achievement in Science was taken as covariate.
5. In case of Augment Reality Mode, Students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Augmented Reality Mode and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.
6. In case of Augment Reality Mode, Public Schools and Central Schools are more suited to Female students while State Government Schools more benefited to Male students when their Pre-Achievement in Science was taken as covariate.
7. Male and Female students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Augmented Reality Mode and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.
8. In case of Augment Reality Mode, both Virtual Lab and Lecture Method were found to be equally effective in terms of Achievement in Science of students when their Pre-Achievement in Science was taken as covariate.
9. In the case of Virtual Lab, both Male and Female were found to have Achievement in Science to the same extent when their Pre-Achievement in Science was taken as covariate.

10. In the case of Virtual Lab, Students studying in Public Schools and State Government Schools while State Government Schools and Central Schools were found to have the same degree of Achievement in Science when their Pre- Achievement in Science was taken as covariate. Students studying in Public Schools had significantly higher Achievement in Science as compared to Central Schools when their Pre-Achievement in Science was taken as covariate.

11. Male students benefited more from the Virtual Lab as compared to Lecture Method while Lecture Method suits both Male and Female students.

12. In case of Virtual Lab, students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Virtual Lab and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

13. In the case of Virtual Lab, Male and Female students studying in Public Schools had better Achievement in Science when their Pre- Achievement in Science was taken as covariate. State Government Schools were found to suit more to Male Students than Female students and Central Schools were slightly more beneficial to Male students rather than Female students when their Pre-Achievement in Science was taken as covariate.

14. Male and Female students studying in Public Schools, State Government Schools and Central Schools were found to benefit equally from Virtual Lab and Lecture Method in terms of Achievement in Science when their Pre-Achievement in Science was taken as covariate.

15. As far as challenges faced by students and teachers while using Augment Reality Mode, many difficulties were faced by students and teachers such as: Technical Issues, Time Constraint, Limited Resources, Accessibility and Inclusion of students with diverse need.

16. In case of experimenting through Virtual OLab, many challenges were faced by students and teachers such as: Nonexistence of Physical Interaction, Unfamiliarity with Virtual OLab Interface, Authenticity and Realism, Collaboration and communication among students, Assessment and feedback of students.

5.12 Implications

This study has implications for Researchers, Educational Planners, Heads, Teachers, and Students. The details are as given below:

Researchers:

As can be seen from the review of related literature, a few researches have been conducted in India. The findings of researches conducted outside India and a few researches conducted within India are very encouraging. The researches have been conducted mostly on School students and a few on students from higher education. Students from the field of Information and Communication Technology have enough scope to conduct researches related to Augmented Reality and Virtual Labs. Researchers may also integrate them and compare its effectiveness with the Augmented Reality and Virtual Labs.

Educational Planners:

This is the age of Information Technology. It is being used in all areas. New areas are coming up where researches are required. Educational Planners should encourage teachers as well as researchers to explore Augmented Reality and Virtual Labs areas. The Educational Planners must keep money for research and development of infrastructure required for conducting researches Augmented Reality and Virtual Labs. In case there is a need to train manpower, it should be done at the earliest. India has potential to take Augmented Reality and Virtual Labs at a different plate form. Lots of patents can be registered.

Heads:

It is important for the Head of the institution to read the latest researchers related to e-learning, Use of Artificial Intelligence in teaching, evaluation and administration, Augmented Reality and Virtual Labs. Head of the institute must attend seminars and conferences where lectures are being given by experts and papers are presented by researchers. Not only this, heads must purchase books related to Augmented Reality and Virtual Labs as well as upcoming technologies. The infrastructure must be developed which can be used by teachers wishing to use Augmented Reality and Virtual Labs. Teachers should be trained in the use of new technology.

Teachers:

Researches cited in the report indicate that Augmented Reality and Virtual Labs can be used by teachers for teaching different subjects at different levels both in schools as well as higher education. Teachers must upgrade their knowledge regarding the latest technology which has a potential to be used in teaching, evaluation and research. School teachers can use Augmented Reality and Virtual Labs for conducting Action Research in their subject.

Students:

These-days students are ahead of their teachers in the use of the latest IT tools. The students must be provided an opportunity to learn different subjects through the use of Augmented Reality and Virtual Labs. Even students may be encouraged to develop material which can be used in Augmented Reality and Virtual Labs.

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Appendices

APPENDIX - I

Central Institute of Educational Technology (CIET)
National Council of Educational Research and Training (NCERT)

Achievement test in Science for class IX

Augmented Reality and Virtual Lab Achievement Test

Name: _____

Gender (Male/Female/others)_____

School: _____

Section _____

Instructions

Dear Students,

In this achievement test, there are 30 items, which are either multiple choice questions or fill in the blanks type questions. Based on your observations on AR experiments, you are requested to choose appropriate alternatives or write correct options in the fill in the blanks type of questions. These responses will be kept confidential and will be used only for the research purpose.

Biology

Programme 1: Prokaryotic Cell

Q1. Which one is part of Prokaryotic Cell?

(*a*) Nucleoid
(*b*) Golgi
(*c*) Mitochondrion
(*d*) Lysosome

Q2. In addition to the plasma membrane, the Prokaryotic cells are surrounded by ……

Programme 2: Animal Cell

Q3. Which cell organ consists of digestive enzymes?

(*a*) Centriole
(*b*) Cytoplasm
(*c*) Lysosome
(*d*) Vacuole

Q4. Centriole in animal cells helps in ……

Programme 3: Plant Cell

Q5. Which cell organelle is called the powerhouse of the cell?

(*a*) Mitochondrion
(*b*) Golgi
(*c*) Lysosome
(*d*) Chloroplast

Q6. In a plant cell Photosynthesis occurs in ……

Programme 4: Cells of an onion peel

Q7. Which dye is used for staining a piece of onion peel during preparation of a temporary slide?

(*a*) Methyl blue
(*b*) Saffron
(*c*) Turmeric
(*d*) Acetocarmine

Q8. The part of the onion taken for microscopic view is ……..

Programme 5: Bacteria (Monera)

Q9. DNA of bacteria is located in a region of the cytoplasm called as:

(*a*) Nucleoid
(*b*) Chromosome
(*c*) Flagella
(*d*) Cell wall

Q10. Bacteria move with the help of one or more ……..

Chemistry

Programme 6: Matter is made up of Particles

Q11. What happens when we dissolve common salt in water?

(*a*) Color of water changes into black
(*b*) Changes the level of water
(*c*) Formation of bubbles in the water
(*d*) common Salt gets into particles of water

Q12. This activity explains about ……nature of matter. (Particulate /continuous)

Programme 7: How Small Are These Particles

Q13. What happens when 2-3 crystals of potassium permanganate are dissolved in water?

(*a*) Changes the color of water
(*b*) The Level of water increases
(*c*) The Level of water decreases
(*d*) Pink color foam forms in the water

Q14. If we keep on diluting the solution 5-8 times, the color of the solution becomes…. ……..

Programme 8 : The states of matter

Q15. In which state of matter, particles move randomly at high speed?

(a) Solid
(b) Liquid
(c) Gas
(d) Both Solid and liquid.

Q16. Arrange the states of matter (Liquid, Solid, Gas) in an increasing order of their inter-particle spaces ……..…….

Programme 9: Relationship between mole, Avogadro and mass

Q17. What is the molar mass of one mole of oxygen molecule (O2)?

(*a*) 12g
(*b*) 16g
(*c*) 8g

(*d*) 32 g

Q18. 12g of carbon atom contains …….…….... number of atoms

Programme 10: Thomson's Model of an Atom

Q19. Based on Thomson's model, the atom as a whole is electrically:

(*a*) Positive
(*b*) Negative
(*c*) Neutral
(*d*) Depending upon the size of the atom

Q20. The ……..……. charge of an atom is compared with red edible part of watermelon

Physics

Programme 11 : Characteristic of a Sound Wave

Q21. In the propagation of sound waves the distance between two consecutive compressions and two consecutive rarefactions is known as:

(*a*) Density
(*b*) Distance
(*c*) Wavelength
(*d*) Frequency

Q22. In waves, a peak is called a crest and a valley is called .....

Programme 12 : Reflection of Sound

Q23. Based on the law of reflection of sound, "i" stands for angle of .....

(*a*) Incidence
(*b*) Intensity
(*c*) Interval
(*d*) Identification

Q24. If the angle of incidence is 45 degrees, the angle of reflection would be .....

Programme 13 : A Megaphone and a horn

Q25. Megaphone and horn are used to send sound in which direction?

(*a*) Particular direction
(*b*) All direction
(*c*) Two directions
(*d*) No particular direction

Q26. Which one of the following instrument will not send sound in a particular direction: (Drum, Shehanias, and Trumpets) ……

Programme 14 : Universal Law of Gravitation

Q27. Where does the gravitational force act between two objects act along the line joining the center?

(*a*) The line joining their center
(*b*) The line joining their left side
(*c*) Edge of the object line
(*d*) The line joining their right side

Q28. If we increase the distance between two bodies then the gravitational force between them ……

Programme 15 : Work done by different forces

Q29. If a force of 6 N acting on a toy car and it is displaced through 2.5 m in the direction of force, then find the work done

(*a*) 15Nm
(*b*) 15 J

(*c*) Both a and b
(*d*) None of the above

Q30. If the force acting on an object is in the direction of displacement then the work done is ……...

Central Institute of Educational Technology (CIET)
National Council of Educational Research and Training (NCERT)

Achievement test in Science for class IX

Name: _____

Gender (Male/Female/others)_____

School: _____

Section _____

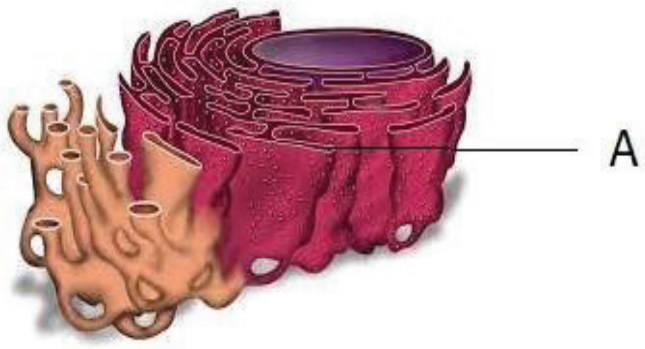
Instructions

Dear Students,

In this achievement test, there are 30 items, which are either multiple choice questions or fill in the blanks type questions. Based on your observations on AR experiments and virtual labs experiences, you are requested to choose appropriate alternatives or write correct options in the fill in the blanks type of questions. These responses will be kept confidential and will be used only for the research purpose.

Programme 1: Onion and Cheek Cells

Q1. Identify the label structure 'A' in the diagram



(*a*) Mitochondria
(*b*) Rough Endoplasmic Reticulum
(*c*) Chloroplast
(*d*) Golgi Apparatus

Q2. The outermost covering which is present in plant cells but absent in animal cells is ....

Programme: 2 Plant and Animal Tissues

Q3. Which tissues found in plants:

(*a*) Epithelial Tissues
(*b*) Parenchyma
(*c*) Sclerenchyma
(*d*) Parenchyma and Sclerenchyma

Q4. The part of the nerve cell which helps in conduction of nerve impulse is called .....

Programme 3: Adaptation in Animals

Q5. Cockroach is protected by an exoskeleton of a thick cuticle which is made Up of

(*a*) Chitin
(*b*) Tissues
(*c*) Bones
(*d*) Keratin

Q6. How many chambers are there in the hearts of birds?

Programme 4: Characteristics of Plants

Q7. Match the following and choose the correct options among A, B, C, D

(*a*)	Bryophyta	(*i*)	Moss
(*b*)	Gymnosperm	(*ii*)	Hibiscus
(*c*)	Angiosperm	(*iii*)	Pinus
(*d*)	Pteridophyte	(*iv*)	Ferns

A	**B**	**C**	**D**
(*a*) (*i*)	(*a*) (*i*)	(*a*) (*i*)	(*a*) (*ii*)
(*b*) (*iii*)	(*b*) (*iii*)	(*b*) (*iv*)	(*b*) (*i*)
(*c*) (*iv*)	(*c*) (*ii*)	(*c*) (*iii*)	(*c*) (*iv*)
(*d*) (*ii*)	(*d*) (*iv*)	(*d*) (*ii*)	(*d*) (*iii*)

Q8. The Saprophytic type of nutrition is found in …… (Fungi/ Algae)

Programme 5: Monocot and Dicot Plants

Q9. The reticulate venation is characteristic of-

(*a*) Dicot Plant
(*b*) Monocot plant
(*c*) Gymnosperms
(*d*) Pteridophytes

Q10. The plants that have stalks in their leaves are known as……..……. (Monocot / Dicot Plants)

Programme 6: Distinguish Between Mixture and Compound

Q 11. On strong heating the mixture of Iron (Fe) and Sulphur (S) a black colored Compound is obtained which is known as:

(*a*) Ferrous Sulphate
(*b*) Copper Sulphide
(*c*) Ferrous Sulphide
(*d*) Carbon disulphide

Q12. When dilute HCl is added into a mixture of sulphur and iron……. gas produced.

Programme 7: Separation of Components of a Mixture

Q13. Which method is used to separate ammonium chloride from the mixture of …….. ammonium chloride, salt and sand?

(*a*) Filtration
(*b*) Sublimation
(*c*) Decantation
(*d*) Evaporation

Q14. The separation method which is used to separate salt from sand is ……..

Programme 8: Distinguishing Between Solutions

Q15. Which of the following properties are not shown by chalk powder solution?

(*a*) Filtration
(*b*) Transparency
(*c*) Instability
(*d*) Opaque

Q16. Solid particles cannot be separated by filtration in case of ……. (True solution/ Suspension)

Programme 9: Boiling Point of Water

Q17. What is the boiling point of the water at the atmospheric pressure?

(*a*) 1000 °C
(*b*) 100 °C
(*c*) 90 °C
(*d*) 200° C

Q18. On heating water, the intermolecular forces between particles ……..…….... (Increase/decrease/ remains same)

Programme 10: Melting Point of Ice

Q19. The constant temperature at which a solid change to a liquid at atmospheric Pressure is called its……

(*a*) Evaporation point
(*b*) Freezing Point
(*c*) Melting point
(*d*) Solid point

Q 20. The Melting point of the ice at the atmospheric pressure is …….

Programme 11: Bell Jar Experiment

Q21. Which tool is used to pump out the air from the bell jar?

(*a*) Vacuum Pump
(*b*) Bell jar
(*c*) Electronic bell
(*d*) Cork

Q22. The sound needs ……..…… to travel. (Medium/ vacuum)

Programme 12: Velocity of a Pulse Propagated Through a Slinky

Q23. The regions where the coils are further apart is called as

(*a*) Rarefactions
(*b*) Compressions
(*c*) Distance
(*d*) Longitudinal

Q24. The regions where the coils become closer are called as ……..

Programme 13: Verification of Archimedes Principle

Q25. If the density of the object is lessthan that of the fluid, then the object will

(*a*) Float
(*b*) Sink
(*c*) Either sink or float
(*d*) Disappear

Q26. Buoyant force is dependent on:

(*a*) Volume of block
(*b*) Density of fluid
(*c*) Mass of fluid
(*d*) All of the above

Programme 14: Forces Required Moving a Wooden Block on a Horizontal Table

Q27. Which expression holds true for Newton's Second Law of motion

(*a*) F= ma
(*b*) F= a/m
(*c*) F= m/a
(*d*) F= ma2

Q28. Newton's second law of motion discusses the relation between force, mass and .....

Programme 15: Newton's Third Law

Q29. Which of the following is not based on Newton's third law of motion?

(*a*) Catching a ball
(*b*) Pushing a box
(*c*) Firing a bullet from gun
(*d*) both (*a*) and (*b*)

Q30. According to Newton's Third Law action and reaction forces act

(*a*) Along the same line
(*b*) Along the same direction
(*c*) In opposite directions
(*d*) both (*a*) and (*b*)

APPENDIX - II

Central Institute of Educational Technology (CIET)
National Council of Educational Research and Training (NCERT)

Reaction towards Augmented Reality e-Content Scale for Students

Name of Student……Gender (M/F/O)……..…….....….

Name of School……...…….…….....……

Instructions:

You have been taught Science through Augmented Reality (AR) e-content. You have formed your opinion about different aspects of Augmented Reality (AR) e-content. This Scale is meant to assess your Reaction towards Augmented Reality e-Content. There are 20 statements related to different aspects of Augmented Reality (AR) e-content. A Five point scale is given against each statement. The five points are Strongly Agree (SA), Agree (A), Undecided, (UD) Disagree (DA) and Strongly Disagree (SD). Read each statement carefully and put tick mark (✓) on an appropriate alternative which shows your reaction. Your response will be kept confidential and used only for research purpose only.

S.NO.	Statements about AR e-content	SA	A	UD	DA	SD
1.	I find it difficult to understand e-content presented through AR.					
2.	I can use smart device(s) for learning through AR.					
3.	I think content in other subjects should not be developed in AR form.					
4.	Textbook is not essential for learning science content with the help of AR.					
5.	I need both virtual and physical labs for science experiments.					
6.	AR leads to joyful learning.					
7.	AR does not encourage collaborative learning.					
8.	AR helps me to learn Science.					
9.	AR does not enhance my understanding of science concepts.					
10.	AR enhances my motivation to learn.					
11.	AR makes learning of science concepts difficult.					
12.	AR helps me to visualize complex chemical reactions.					
13.	AR does not help me in individual learning at home.					
14.	AR ensures my safety, as I don't perform experimentation physically.					
15.	AR does not help in solving my science subjects related problems.					

16.	I can observe content through AR which is not visible in physical environments.					
17.	AR hinders my real world experience in operating laboratory devices.					
18.	AR facilitates creativity.					
19.	Use of AR requires multitasking, leading to increased workload for me.					
20.	AR helps in innovation.					

Reaction towards Virtual Labs Content Scale for Students

Name of Student……..Gender (M/F/O).....

Name of School…….....

Instructions:

You have been taught Science through the use of Virtual Labs (VL). You might have formed your opinion about different aspects of Virtual Labs (VL). This Scale is meant to assess your Reaction towards Virtual Labs (VL).There are 20 statements related to different aspects of Virtual Labs (VL). A Five point scale is given against each statement. The five points are Strongly Agree (SA), Agree (A), Undecided, (UD) Disagree (DA) and Strongly Disagree (SD). Read each statement carefully and put tick mark (✓) on an appropriate alternative which shows your reaction. Your responses will be kept confidential and used only for research purposes only.

S.NO.	Statements about AR e-content	SA	A	UD	DA	SD
1.	I can teach AR content with the help of my own smart device.					
2.	Teaching through AR is difficult.					
3.	It is not difficult to arrange Smart devices in the classrooms for AR.					
4.	Using AR in the classroom consumes more time.					
5.	I need to be oriented towards using AR content.					
6.	Government should arrange smart devices for students' learning in AR classrooms.					
7.	Content in other subjects should also be developed in AR form.					
8.	It will be difficult to safeguard technological devices in schools.					
9.	It will be difficult to manage technological devices in schools.					
10.	Textbook is not essential for learning e-content with the help of AR.					
11.	I am not able to cover all content in specified time, if I use AR.					
12.	Students will be attentive during use of AR content.					
13.	All the students need to have their own smart devices for learning in the AR classrooms.					
14.	After teaching through AR e-content app, I will not be able to teach Without this app.					
15.	Using AR e-content devoid students' physical experiences.					
16.	Using AR e-content devoid students' real world experiences.					
17.	AR establishes flexible interactive learning environment.					

18.	I need both virtual labs and physical labs for teaching.					
19.	AR makes learning joyful for students.					
20.	AR leads to inability to teach in a real world context requiring use of senses.					
21.	AR content help students to make active observations during their learning.					
22.	AR takes away the flexibility to accommodate according to students' needs.					
23.	AR content encourages collaborative learning.					
24.	There is a lack of equipment that hinders use of AR.					
25.	I have limited knowledge of AR.					
26.	I have a fear of failure in using technology.					
27.	Learning through AR increases students motivation to learn.					
28.	AR leads to superficial knowledge.					
29.	AR e-content increases students' learning outcomes.					
30.	Use of AR requires multitasking, leading to increased workload for students.					

Reaction towards Augmented Reality Content Scale for Teachers

Name of Teacher……...…….....……..…Gender…….....……..

Name of School……...…….....……..…Class …….....……..

Subject taught …….....…… Experience …….....……..

Instructions

Dear Teachers,

This scale is developed for assessing Teachers' Reaction towards Augmented Reality (AR) content. There are 30 statements related to different aspects of Augmented Reality (AR) content. A five point scale is given against each statement. The five points are Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (DA) and Strongly Disagree (SD). You are requested to read each statement carefully and put ticks (✓) on appropriate alternatives which best represent your Reaction towards Augmented Reality (AR) content. Your response will be kept confidential and used only for research purposes.

S.NO.	Statements about AR e-content	SA	A	UD	DA	SD
1.	I can teach VL content with the help of my own smart device.					
2.	Teaching through VL is difficult.					
3.	It is not difficult to arrange Smart devices in the classrooms for VL.					
4.	Using VL in the classroom consumes more time.					
5.	I need to be oriented towards using VL content.					
6.	Government should arrange smart devices for students' learning in VL Classrooms.					
7.	Content in other subjects should also be developed in VL form.					
8.	It will be difficult to safeguard technological devices in the schools.					
9.	It will be difficult to manage technological devices in the schools.					
10.	Textbook is not essential for learning e-content with the help of VL.					
11.	I am not able to cover all content in specified time, if I use AR.					
12.	Students will be attentive during use of VL content.					
13.	All the students need to have their own smart devices for learning in the AR classrooms.					
14.	After teaching through AR e-content app, I will not be able to teach Without this app					
15.	Using AR e-content devoid students' physical experiences.					

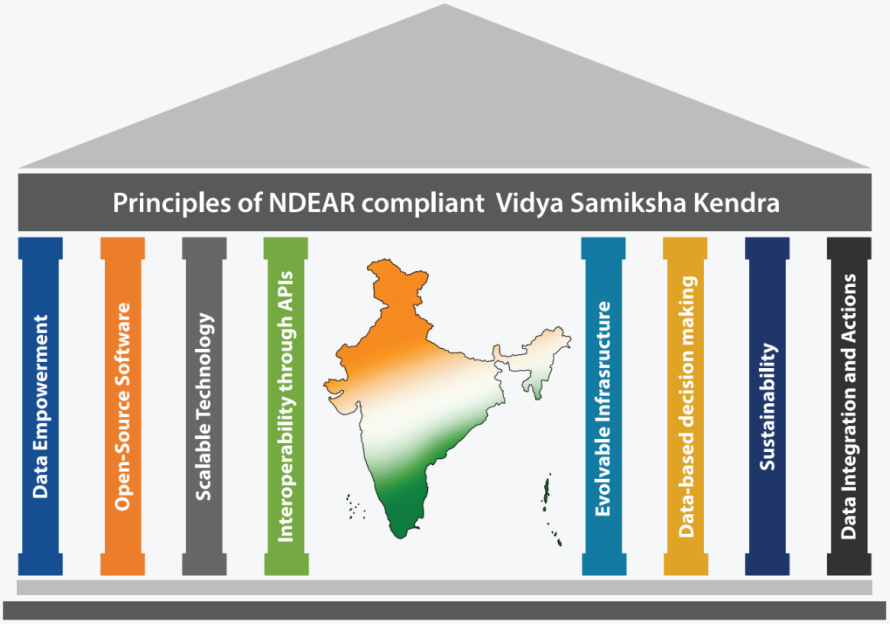
16.	Using AR e-content devoid students' real world experiences					
17.	AR establishes flexible interactive learning environment.					
18.	I need both virtual labs and physical labs for teaching.					
19.	VL makes learning joyful for students.					
20	AR leads to inability to teach in a real world context requiring use of senses					
21	VL content help students to make active observations during their learning.					
22.	VL takes away the flexibility to accommodate according to students' needs.					
23.	VL content encourages students to learn collaboratively.					
24.	There is a lack of equipments that hinders use of VL.					
25.	I have limited knowledge of VL.					
26.	I have a fear of failure in using technology.					
27.	Learning through VL increases students motivation to learn.					
28.	VL leads to superficial knowledge.					
29.	VL e-content increases students' learning outcomes.					
30.	Use of VL requires multitasking, leading to increased workload for Students.					

ICT INITIATIVE

VSK: Vidya Samikshya Kendra

National Digital Education Architecture (NDEAR)
Vidya Samiksha Kendra (RVSK)

The "Force Multiplier" for the education ecosystem in India NDEAR compliant Vidya Samiksha Kendra (NVSK) at NCERT provides all key stakeholders an institutional avenue that enables integrated and shared 'seeing' for amplifying data-based decision making and bringing in transformative impact towards outcomes.



Physical Insfrastructure for NDEAR compliant national - level VSK has been set up at NCERT.