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Enhancing Academic Achievement: Integrating STEM Technology in Physics Education for Secondary Level Students in CBSE Schools

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Abstract

This study investigates the impact of integrating STEM (Science, Technology, Engineering, and Mathematics) technology into Physics education for grade IX students in CBSE schools, focusing on academic achievement in Dhule District. Stratifying the population by school, district and randomly selecting representative schools, including Amrishbhai R Patel School and Mukesh R Patel CBSE School in Shirpur Taluka in Dhule District of Maharashtra State in India, the researcher examined the effectiveness of STEM technology compared to traditional methods.

Using an achievement test, the researcher evaluated the efficacy of STEM technology in teaching introductory Physics concepts. The study compared the adjusted mean scores of pre-tests and post-tests between experimental and control groups. Findings indicate that STEM technology is as effective as traditional methods in improving academic achievement when experimental groups were taught with STEM technology and control groups with traditional methods.

Moreover, the study found STEM technology to be more effective than traditional methods for both low-achiever and high-achiever students when groups were matched based on pre-understanding of Physics concepts. This suggests that STEM technology, incorporating toys, models, or educational games, enhances engagement and understanding, leading to improved academic performance.

The study emphasizes the potential of STEM technology to support struggling students while further enhancing the performance of high-achieving students. It underscores the importance of hands-on learning, collaboration, and problem-solving skills fostered by STEM technology, ultimately contributing to holistic development and improved academic achievement for students in Physics education.

Keywords: Pedagogy, Traditional Method, STEM Technology, CBSE School, Secondary Stage Learner, Introductory Physics, Experimental Group, Control Group, High Achievers, Low Achievers.

1. Introduction

The attempt of introducing STEM TECHNOLOGY into the education system: the development of a "school readiness module" mentioned in NEP 2020 is entirely based on activities, games, and making of toys by children to develop their creativity, and critical thinking, 21st-century skills, and competencies. STEM help in developing skills, logical thinking, receptive power, and competencies in children. For example:- toys help in developing Skills and cooperation among students, in understanding the so-called “difficult subjects.” In STEM TECHNOLOGY, teachers and students use Art and Crafts integrated with Science, Technology, Engineering and Mathematics to learn new concepts. STEM TECHNOLOGY is learner-centric and brings about joy and meaningful learning among students. It is important to study the role of integrating STEM technology in the cognitive development of children and their role in igniting creativity and problem-solving skills in them.

STEM technology is designed to be fun and playful and are highly motivating for both children and adults. Commercial toys and child-designed toys can be used both in the

classroom and at home to encourage creativity and to teach science concepts. Much of what children can do with toys and models involves tinkering, defined by Merriam Webster as "to repair, adjust, or work with something in an unskilled or experimental manner: fiddle." Children (and adults) can tinker as they take toys and models apart, experiment with them, and design toys and models for themselves.

This Research Study is inspired to study the effectiveness of Toys and models developed using STEM Technology during the online workshop "STEM 30-30", and "30-30 Eklayva" attended by the author and conducted by CCL IIT Gandhinagar in collaboration with CBSE. The researcher conducted the study to test the effectiveness of STEM TECHNOLOGY in Physics for complex and abstracts topics like Work, Energy, Power, Sound and Gravitation by developing toys for selected topics. To test whether the prepared toys have enhanced learning by doing skills among the learners igniting their interest, understanding, and thus helping them to increase their academic achievements. The researcher tested effectiveness of STEM TECHNOLOGY on academic achievement of grade IX students learning Physics at CBSE Schools.

2. Background

STEM TECHNOLOGY is an innovative teaching method that involves using educational toys and games to enhance the learning experience. The use of toys and models in education is not a new concept, but the concept of using them as a formal pedagogical tool is gaining popularity in recent years.The philosophy behind STEM TECHNOLOGY is in the belief that science, technology, engineering, and mathematics play a crucial role in driving innovation, solving complex problems, and improving the human condition. By fostering interdisciplinary collaboration, encouraging innovation, promoting practical application, cultivating critical

thinking skills, and considering ethical implications, STEM technology seeks to empower individuals to address the challenges of the 21st century and beyond.

STEM TECHNOLOGY can be used across various subject areas and grade levels. In the context of science education, it has been particularly effective in helping students understand abstract concepts and theories. For example, in Physics, students can use toys and games to simulate real-life scenarios and experiments, which can help them better understand complex concepts such as force, motion, and energy. The effectiveness of STEM TECHNOLOGY has been supported by various studies and research. For instance, studies have shown that it can improve students' academic performance, increase their motivation to learn, and enhance their engagement in the classroom.

Overall, STEM TECHNOLOGY is an innovative and effective teaching method that can help students learn in a fun, engaging, and interactive way. By incorporating educational toys and games into the learning process, teachers can create a more stimulating and effective learning environment.

There have been several studies conducted on the effectiveness of STEM TECHNOLOGY in enhancing academic achievement, particularly in the field of science education. These studies have investigated the impact of using educational toys and games on students' learning outcomes, motivation, and engagement.

One such study was conducted by Widyasmah and his colleagues in 2020, which examined Implementation of STEM Approach Based on Project-based Learning to Improve Creative Thinking Skills of High School Students in Physics. This research on the implementation of the STEM approach which is oriented towards project-based learning to enhance student's creative thinking. This research was conducted to find out the improvement of students' creative thinking skills by applying a STEM approach oriented to project-based learning on Pascal's law material. This research was conducted at SMAN 1 Blambangan Umpu in the first

semester of the 2019/2020 academic year. The results of the study represent that the application of the STEM learning approach to pascal's law has increased the creative thinking skills at a significant level of 0,000 and there are differences in the increase in students' creative thinking skills before and after the application of the STEM learning approach.

Another study by Siti Nazirah Butai, Huzaikha Awang, Iziana Hani Ismail, Elnetthra Folly Eldy had studied Effectiveness of PBL-STEM Module in Physics on Students' Interest: A Preliminary Finding of Implementation Amongst Students in Rural Areas of Sabah, Malaysia. This study mainly investigates the preliminary effects of the PBL-STEM module in physics (i.e., electricity, magnetism) on the students' interests. This study adopted the pre-experimental one-group posttest design, with a supplemental questionnaire as its instrument to measure the dependent variable. The results show that the implementation of this module improves the students' self-learning, communication skills, interest in learning science (i.e., physics), and teamwork skills. As this is only an early stage of its implementation, more positive results may be seen if it is more frequently implemented with a longer duration and broader topics of physics being covered.

Similarly, a study by Baytak and colleagues (2019) examined the effectiveness of using educational games in teaching Biology to middle school students in Turkey. The study found that students taught using educational games performed better in Biology compared to those taught using traditional methods.

Overall, these studies suggest that STEM TECHNOLOGY can be an effective teaching method in enhancing academic achievement in science education. By incorporating educational toys and games into the learning process, teachers can create a more stimulating and interactive learning environment, which can enhance students' motivation and engagement, leading to improved academic performance.

3. Importance of the Study

Introductory Physics is a difficult topic for secondary stage learners. It is common for secondary stage learners to find introductory Physics a difficult topic. There are several reasons why this might be the case. Physics involves a lot of abstract concepts that can be difficult for students to understand. For example, the concepts of energy, force, and motion can be challenging to grasp, especially if students have not been exposed to them before. Physics is heavily based on mathematical principles and equations. Students who struggle with mathematics may find it challenging to apply these principles to solve Physics problems. Lack of real-life context. Some students may find it difficult to see the relevance of Physics concepts to their daily lives. Without a clear understanding of how Physics applies to the real world, they may struggle to engage with the subject. Limited practical experience. Physics is a subject that requires practical application to fully understand. However, many students may not have access to laboratory equipment or hands-on experience, which can make it difficult for them to grasp certain concepts. To help secondary stage learners succeed in introductory Physics, teachers can use a variety of teaching strategies. One approach is to break down complex concepts into smaller, more manageable parts, and to provide plenty of opportunities for students to practice applying these concepts to real-world situations. Teachers can also use visual aids and simulations to help students visualize concepts and make them more engaging. Additionally, teachers can emphasize the practical applications of Physics, showing students how it is relevant to their lives and careers. Finally, providing opportunities for students to conduct experiments and participate in hands-on activities can help them to develop a deeper understanding of the subject. STEM TECHNOLOGY helps in developing hand-on learning and helps breaking complex and abstract concept into simple concept making learning interesting and simple to understand.

Academic achievements of Secondary Stage Learners in Physics are low. There could be several reasons why academic achievements of secondary stage learners in Physics are low. Students may not be interested in Physics, or they may find it difficult to understand the subject. As a result, they may not pay attention in class, and their performance may suffer. The quality of teaching may not be up to the mark. Teachers may not be well-versed in the subject, or they may not be able to explain the concepts clearly. This can lead to confusion among students and affect their performance. Students may not get enough practice with Physics problems. Practice is essential to master the concepts and to apply them to solve problems. Without sufficient practice, students may struggle to perform well in Physics exams. Physics involves a lot of technical terms and concepts that may be difficult for students to understand if they are not fluent in the language of instruction. To improve the academic achievements of secondary stage learners in Physics, schools can take several steps such as improving the quality of teaching, providing adequate resources, and encouraging students to practice more. Teachers can use innovative teaching methods to make the subject more engaging and interactive. They can also use real-life examples to help students understand the concepts better. Additionally, schools can invest in modern laboratory equipment and provide students with opportunities to conduct experiments. Encouraging students to participate in making of toys, models using STEM technology and creating mind maps.

Enhances creativity and imagination. Toys and models made using STEM Technology provide children with the opportunity to explore and use their imagination. This type of pedagogy encourages children to think creatively, problem-solve, and experiment with different ways of doing things.

Improves cognitive and motor skills. Toys and models made using STEM Technology promote the development of cognitive and motor skills by challenging children to manipulate objects, solve puzzles, and think critically. This can help improve their memory, attention span, hand-eye coordination, and fine motor skills.

Increases social interaction. STEM TECHNOLOGY allows children to interact with each other, promoting socialization and communication skills. This can help improve their ability to express themselves and develop empathy for others.

Fosters emotional development. Toys and models made using STEM Technology can help children develop emotional intelligence and learn to manage their emotions. For example, dolls can be used to teach children about empathy and compassion, while construction toys can help them learn about perseverance and problem-solving.

Makes learning fun. STEM TECHNOLOGY can make learning more engaging and enjoyable for children. This can help create a positive attitude towards learning, leading to better academic performance and long-term educational success.

Traditional Rote Learning method in Introductory Physics is incapable of developing cognitive abilities in abstract topics like Sound, Gravitation, Work Energy & Power among students studying Physics of grade IX of CBSE board.

This study benefits kinesthetics learners and visual learners of grade IX studying at CBSE schools, to improve their academic achievements in Physics. This study benefits students studying in grade IX of CBSE schools to bring joy in learning Physics by involving whole

body and have a multisensory approach in the process of learning. This study provides teachers with lesson plans based on STEM TECHNOLOGY which will enhance creativity, problem solving skills and will help to build 21st Century Skills among learners.

The present study is based on an experiment, in this study the researcher will do an experiment on effectiveness of integrating STEM TECHNOLOGY in teaching learning of Physics on academic achievement of students of grade IX studying at CBSE schools.

Significance of the Problem:

The study of effectiveness of integrating STEM TECHNOLOGY in teaching learning of Physics on academic achievement of students of grade IX studying at CBSE Schools can have several potential significances.

1. Enhancing Learning Experience: The use of toys and models made using STEM Technology can make the learning experience more engaging and interactive for students, which can lead to better understanding and retention of the subject matter.
2. Improving Academic Achievement: By implementing STEM TECHNOLOGY, the study can assess whether the students' academic performance in Physics improves or not. This could help in identifying the effectiveness of this approach in enhancing academic achievement.
3. Innovative Teaching Method: The study can contribute to the development of innovative teaching methods that can help to make the learning process more fun, interesting and effective.
4. Implementing NEP 2020: The study's findings could provide insights for implementing NEP 2020 on the effectiveness of integrating STEM TECHNOLOGY into the curriculum, which could inform future education policies and curricula.

5. Practical Implications: The study can provide practical implications for teachers, school administrators, and education professionals who are looking for new ways to engage students and improve academic performance in science subjects like physics.

Overall, the study of integrating STEM TECHNOLOGY in teaching learning of Physics on academic achievement of students of grade IX studying at CBSE Schools can have significant potential impacts on education and teaching practices.

Statement of the Problem:

A study of effectiveness of integrating STEM TECHNOLOGY in teaching learning of Physics on Academic Achievement of students of grade IX studying at CBSE Schools.

Objectives:

1. To find relevant topics of Physics in grade IX where STEM TECHNOLOGY can be effectively implemented.
2. To prepare learning material using STEM TECHNOLOGY in Physics and design toys based on units for the learning material for grade IX students of CBSE board.
3. To compare the academic achievements of students of PRE-TEST conducted on experimental group and control group of grade IX of CBSE board.
4. To study the effectiveness of STEM TECHNOLOGY in the academic achievement of students studying Physics of grade IX of CBSE board by comparing the POST-TEST Scores of both groups.
5. To compare the academic achievements of Experimental group and Control group students of grade IX of CBSE board.
6. To compare the PRE-TEST and POST-TEST results of low-achiever students of Experimental group who were taught Physics using STEM TECHNOLOGY
7. To compare the PRE-TEST and POST-TEST results of high-achiever students of Experimental group who were taught Physics using STEM TECHNOLOGY

8. To compare the PRE-TEST and POST-TEST results of low-achiever students of Control group who were taught Physics using traditional method.
9. To compare the PRE-TEST and POST-TEST results of high-achiever students of Control group who were taught Physics using traditional method.

4. Hypothesis

The following hypothesis were framed:

1. There is no significant difference between the mean score of PRE-TEST of students from experimental group and control group of grade IX of CBSE board.
2. There is no significant difference between the mean score of POST-TEST of students from experimental group and control group of grade IX of CBSE board.
3. There is no significant difference between the mean score of PRE-TEST and POST-TEST conducted on students of experimental and control group of grade IX of CBSE board.
4. There is no significant difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Experimental group who were taught Physics using STEM Technology.
5. There is no significant difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Experimental group who were taught Physics using STEM TECHNOLOGY.
6. There is no significant difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Control group who were taught Physics using Traditional Method.
7. There is no significant difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Control group who were taught Physics using Traditional Method.

4. Assumptions

The present study is based on following assumptions,

1. Students are capable and interested to observe and study the concepts presented with the help of Toys and Models based on STEM Technology.
2. Students are enthusiastic to make innovative toys, models based on STEM technology and study Science.
3. Students are enthusiastic to study Physics using experiments and innovative Toys and Models based on STEM Technology.
4. Students have potential to solve problems and think for innovative solutions while preparing toys and models based on STEM Technology apply the same to study the concepts of Physics.

5. Operational Definitions

1. Pedagogy : In research, pedagogy can be operationalized by identifying specific teaching methods or strategies used in a particular educational setting. For example, a study might examine the effectiveness of inquiry-based learning versus lecture-based learning in promoting critical thinking skills in students.
2. Traditional Method: In research, the traditional method can be operationalized by measuring the amount of lecture-based instruction delivered in a given educational setting. For example, a study might compare the test scores of students who received traditional lecture-based instruction versus those who received more interactive and student-centred instruction.
3. STEM TECHNOLOGY : The term "STEM technology" typically refers to the integration of technology within the fields of Science, Technology, Engineering, and Mathematics (STEM). STEM technology encompasses the application of

technological tools, methods, and systems to advance scientific research, engineering design, mathematical modelling, and technological innovation. STEM technology encompasses a wide range of technological tools, methods, and applications that are utilized to advance scientific inquiry, engineering design, mathematical modelling, and technological innovation within the broader context of the STEM disciplines.

4. CBSE School: The Central Board of Secondary Education (CBSE) is a national level board of education in India for public and private schools, control and managed by the Government of India.CBSE school in Dhule District, Maharashtra were chosen for the study.
5. Secondary Stage Learner: According to NEP 2020 secondary stage learners are the learners studying from grade 9 to 12 falling in the age group of 14 to 18 years.
6. Introductory Physics: A Physics course for 9 to 11 grade covering essential and basic Physics concepts like Motion, Force and Laws of Motion, Gravitation, Work ,Energy , Power, and Sound.
7. Experimental Group: An experimental group consists of participants who are exposed to manipulation of independent variables. The group on which treatment of STEM TECHNOLOGY is used.
8. Control Group: A control group consists of participants who are not exposed to manipulation of independent variables. The group which will be taught with traditional method.
9. High Achievers: High achievers can be operationally defined as individuals who consistently demonstrate outstanding performance in a particular domain or field, relative to their peers. This can be measured by a variety of objective criteria such as academic grades, standardized test scores, awards, recognition, or accomplishments.

10. Low Achievers: Low achievers can be operationally defined as individuals who consistently demonstrate subpar performance in a particular domain or field, relative to their peers. This can be measured by a variety of objective criteria such as academic grades, standardized test scores, or performance evaluations.

6. Review of Related Literature

Ellermeijer T., Tran T.(2020), had studied Stem, Inquiry Practices and Technology in Physics Education. In this paper they studied How to make Physics Education more challenging, relevant and attractive for our school students? How to stimulate the development of creative thinking, problem solving, and other higher cognitive skills? What are the realistic conditions that must be fulfilled so that teachers can realise this kind of quality Physics Education? Governments in many countries stimulate science and technology in schools; the more recent Alphabet Soup acronyms are IBSE, STEM (or STEAM), and MINT (Germany). What is meant with that, and what are the main expectations? And, can technology applied in physics education bring us closer to the desired goals?

Clearly it has been demonstrated that technology can help to make physics education more relevant, more linked to real life and more authentic. And can increase the opportunities for own investigations by the students. So really has an added value, and not just provides another way of teaching the same. This is known for decades but still applied at a relatively small scale.

A major challenge is the preparation of teachers for using technology in this direction. The authors recently investigated the development of an effective and relatively short course for teachers to prepare them for the use of ICT/Technology in IBSE lessons. The final course setup is based on several rounds of tryouts and improvements, and has been applied in the Netherlands, Slovak Republic and Vietnam. The course will be presented, some attention will

be given to the differences in application in different settings (pre-service and in-service, different cultures) and the learning effects on the participants. Interesting and important conclusion is that such a high-quality course design can be applied broadly.

Petrova H.(2021), had studied , Basic didactic aspects related to the application of STEM technology in science education. In this article she studied, STEM technology as an innovative educational technology. This article is aimed at developing the intellectual abilities of students, at constructive and cognitive-research activity and technical creativity. The article presents the main didactic aspects related to the application of STEM technology in natural science education. Emphasis is placed on practical tasks of a problematic nature, which allow the formation of the competences of the XXI century - creativity, communication, cooperation and critical thinking. The organization of the learning process, the forms of learning work and the new pedagogical role of the teacher are presented. Educational computer simulations and educational robots are considered as didactic tools for the implementation of STEM technology in the study of natural sciences, in particular in physics education.

A. Susanti, R. Diani, E. Octafiona, Dini Qori Lathifah (2023), had studied , Developing physics learning videos with STEM approach (Science, technology, engineering, mathematics).

This research is development research by applying the Borg and Gall development model, modified into seven development steps. This research aims to determine the feasibility and teacher and students' responses toward the developed learning videos. As the research subjects, the researchers selected the eleventh-grade students from SMAN 5 Bandar Lampung, SMAN 13 Bandar Lampung, and SMAN 15 Bandar Lampung. The research instruments used were pre-research questionnaires, validation questionnaires, teacher and student response questionnaires, observations, interviews, and documentation. The analysis discovered that the

average percentage of media validation was 87.6%, material validation was 84.3%, I.T. validation was 87.5%, and language validation was 87.3%. The teacher's response percentage was 87.2%. The students' responses on the small-group trial were 84.3%, and the students' responses on the field trial were 84.2%. Therefore, the learning videos developed using Powtoon based on the STEM approach are feasible in learning.

Anggraeni A.,Distrik I. W, Rosidin U.(2021), had studied , The validity and practicality of the student worksheet using STEM-based multiple representations in physics learning. The objective of this research was to produce a valid and practical student worksheet using Science Technology Engineering and Mathematics (STEM)-based multiple representations and integrated with twenty first century learning in vibration and wave topic. This research used Research and Development (R & D) method by following 4-D model steps. 15 sample students of grade XI were taken with random sampling. Research instruments were validation sheets, student worksheet implementation observation sheets, and questionnaires. Data were analyzed descriptively and qualitatively. The result showed that the student worksheet by using STEM approach based on integrated multiple representations and integrated with twenty first century learning was: 1) valid by content with average score of 85.41 and valid by construct with average score of 83.88; 2) practical to use in vibrations and waves learning materials and it was shown by average student worksheet implementation by above 80% and 86.66% positive students' responses to the student worksheet.

7. Learning Material Of Toy Based Pedagogy

7.1. Introduction

NEP 2020 recommends that, "in all stages, experiential learning will be adopted, including hands-on learning, arts-integrated and sports-integrated education, story-telling-based pedagogy, among others, as standard pedagogy within each subject, and with explorations of relations among different subjects. To close the gap in achievement of learning outcomes, classroom transactions will shift, towards competency-based learning and education. The assessment tools (including assessment "as", "of", and "for" learning) will also be aligned with the learning outcomes, capabilities, and dispositions as specified for each subject of a given class" (NEP 2020, para 4.6).

STEM Toys have a great potential in terms of their pedagogical value. They can be used as an important pedagogical tool to engage the learners inside and outside the classroom.

7.2. Objectives

1. To Design a teaching method to integrate Toys with Physics.

2.To Expose kids to scientific principles through toys.

3.To develop learning by doing skills among the learners.

4. To ignite learners' interest, understanding and curiosity.

5.To help them to increase their academic achievements.

6. To develop critical thinking, aesthetic skills, collaborative skills, problem solving skills among learners.

7.3. Lesson Procedure

i. Teacher plans the lesson as per the unit.

ii. Selects the topic to be taught using Toy Based Pedagogy , analyses previous learning knowledge of the learners.

iii. Develops the toy.

iv. Teacher provides recapitulation of previous knowledge. Introduces the unit with a story or case.

v. Demonstrates the toy and allows the learners to play with the toy.

vi. Brainstorms the questions based on the content of toy and enables the learners to construct the concept of the desired unit.

vii. Gives necessary study material and evaluates the learning outcomes by providing competency based differentiated worksheet.

viii. Divides students in group of two and guides the students by providing them specific topic on which toys needs to be made ,provides with reference material and links like https://www.arvindguptatoys.com/toys.html

ix. Provides them a time period of 3 weeks to prepare the toy and takes necessary feedback from the students.Schedules the day of Toy submission and presentation of their toy.

x. Conducts formative evaluation and takes necessary feedback.

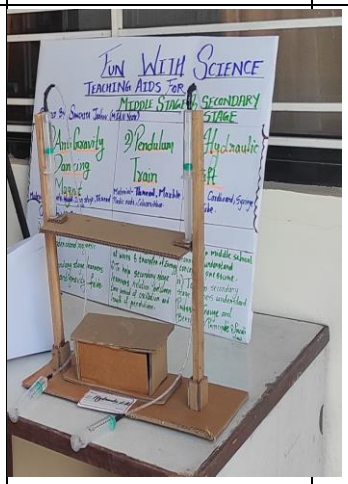
Pedagogical usage of STEM Technology Based Toys

Teacher Developed Toys:Toys developed by researcher.

Table. 1. Table representing Teacher Developed Toys

Teacher Developed Toys for implementing STEM TECHNOLOGY							
Sr. No	**Name of Activity**	**Name of Chapter**	**Units**	**Learning Objectives**	**Image of Toy**	**Materials**	**Explanation**
i)	Water Missile Launcher	Projectile Motion	Motion	To understand Motion of an object.		boa ge, s. ors act	Projectile motion is the motion of an object thrown into the air when, after the initial force

							that launches the object,
				To analyse Projectile Motion.	Figure 4.4.1.i Water Missile Launcher developed by Ms. Sanchita Jadhav, Amrishbhai R Patel School, Shirpur, Maharashtra in AY 2022-23		air resistance is negligible and the only other force that object experiences is the force of gravity.
				To apply concept of Projectile Motion.			The object is called a projectile, and its path is called its trajectory.
ii)	Anti-Gravity Dancing Coin Toy	Gravitation & Floatation.	Gravitational Force	To understand acceleration due to gravity.	 Wooden rod, colours Old speaker magnet thread and glue		*Anti-gravity* (also known as non-gravitational field) is a hypothetical phenomenon of creating a place or object that is free from the force of gravity.
				To analyse	Figure 4.4.1.ii. Anti-Gravity Dancing		

				anti-gravity condition and magnetic force.	Coin Toy developed by Ms. Sanchita Jadhav, Amrishbhai R Patel School, Shirpur, Maharashtra in AY 2022-23.		
				To apply resolution of forces.			
iii)	Hydraulic Lift	Gravitation & Floatation.	Floatation.	To understand Floatation.		Cardboard Syringe, Tubes. Scissors Glue gun.	Hydraulics is a mechanical function that operates through the force of liquid pressure.
				To analyse effect of pressure, pressure gauge and Pascals Law.	Figure 4.4.1.iii Hydraulic Lift developed by By Mr Vipinkumar Yadav.Mukesh R Patel CBSE School,Shirpur,Dhule.		In hydraulics-based systems, mechanical movement is produced by contained, pumped liquid,
				To apply concept of Pressure Gauge.			typically through hydraulic cylinders moving pistons.

iv)	Wave Train	Sound	Propagation of Sound, wavelength, amplitude, phase	To understand Propagation of wave, wavelength, amplitude, phase of particle of propagation.		• Cycle Stokes • Tape • Scissor • Straw	A group of waves of equal amplitude and intervals travelling in a same direction.
				To analyse Propagation of wave, wavelength, amplitude, phase of particle of propagation.	Figure 4.4.1.iv Wave By Mr Vipinkumar Yadav.Mukesh R Patel CBSE School,Shirpur,Dhule.		
				To apply concept of Propagation of wave.			

8. Sample

The researcher used the Stratified Random sample technique for the selection of samples from the population.

8.1. Stratified Random Sampling

Stratified random sampling is a probability sampling technique used in research to ensure a representative sample of a population is obtained. In stratified random sampling, the population is divided into subgroups, or strata, based on some relevant characteristic, such as age, gender, education level, or income. Once the population is stratified, a random sample is then selected from each stratum, ensuring that participants are selected from each group in

proportion to their representation in the population. This approach can help to increase the precision of the sample and reduce the sampling error.

In this study, researcher studied the academic achievement of grade IX CBSE school students in a Dhule District, he stratify the population based on the school district, since academic performance may vary by district. He randomly selected sample schools from Dhule district to ensure that the sample is representative of the entire population. He selected Amrishbhai R Patel School, Mukesh R Patel CBSE School from Shirpur Taluka. He selected grade IX students from the selected sample and randomly selected boys and girls as sample for the study. The design of sample is shown in Figure 1.

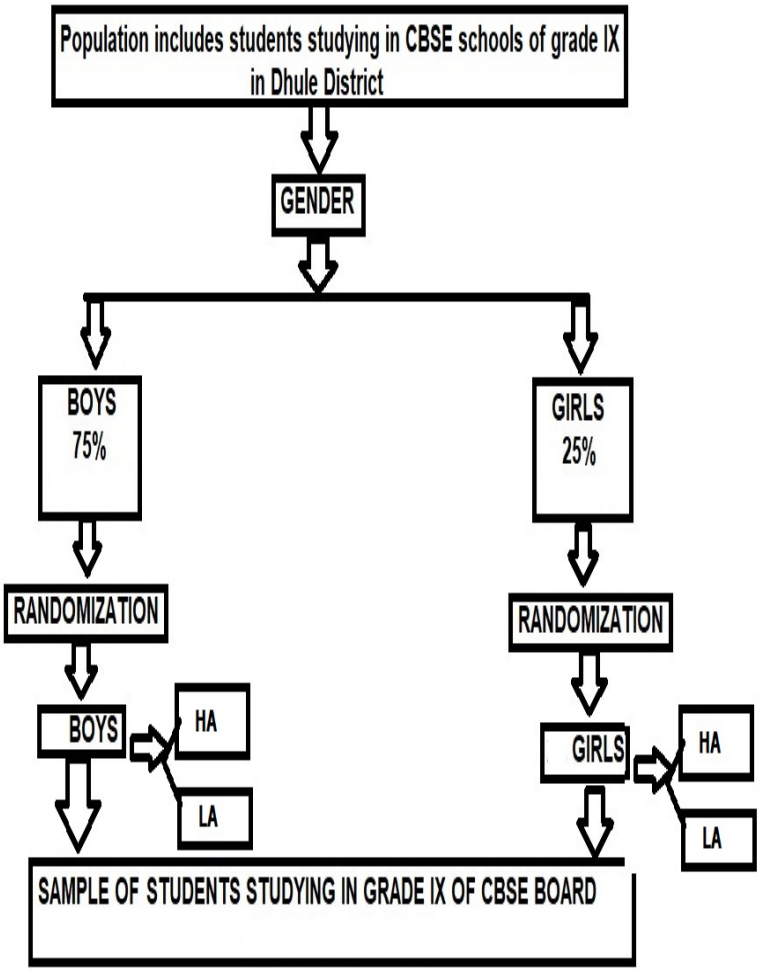


Figure.1. Design of Sample

Where HA- Higher Achiever students (<=60)

NA-Low Achiever students (>=60)

8.2. Design

According to Verhonick and Seaman, the design is the plan for the study, providing the overall framework for collecting data. Once the problem has been concretely formulated, a design is developed to provide a format for the detailed steps in the study. The design is relatively specific consisting of a series of guidance for systematic data gathering. The type of design depends up on the statement of the problem'. Research design also involves the problems associated with the employment of the data in the entire research project. It helps an investigator to obtain answers to the research questions & to control the experimental extraneous and error variances of the particular research problem; therefore, the research design was carefully developed.

The design can also incorporate some elements of randomization, such as randomizing the timing or intensity of the intervention across participants or groups. The treatment group receives the Toy Based teaching method while the control group receives the traditional teaching method. Both groups are measured before and after the intervention to assess the changes in their knowledge and skills. Since participants are not randomly assigned to groups, there may be differences between the groups that could affect the outcome. However, the pre-test measurements can help to control for these differences and provide a more accurate assessment of the intervention's impact. The plan of the present study is depicted in the following Table.2.

Table.2. Schematic Representation of the Treatment

Activity	**Intact groups were taken up from the Randomly selected CBSE Schools**								
Group Formation									
Random Assignment of Treatment	**Experimental Group -I . Girls**		**Experimental Group-II .Boys**		**Control Group-I Girls**		**Control Group II Boys**		**Time in Periods/days**
	Low Achievers (<=60)	**High Achievers(>=60)**	**Low Achievers (<=60)**	**High Achievers(>=60)**	**Low Achievers (<=60)**	**High Achievers(>=60)**	**Low Achievers (<=60)**	**High Achievers(>=60)**	
Administering Test Of Understanding Concepts of Introductory Physics (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10,11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	Administering Test Of Understanding Concepts of Introductory Physics Chapter 8,9,10, 11,12 of Grade 9 NCERT TEXT BOOK (PRE TEST)	**1 period (50 minute)**
Introducing concept of Motion	Introducing concept of Motion using STEM TECHNOLO	Introducing concept of Motion using STEM TECHNOL	Introducing concept of Motion using STEM TECHNOLOGY	Introducing concept of Motion using STEM TECHNOLOGY	Introducing concept of Motion using Traditional Method	Introducing concept of Motion using Traditional Method	Introducing concept of Motion using Traditional Method	Introducing concept of Motion using Traditional Method	**2 Periods**

	GY	OGY							
Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	Concept Mapping the topic of Motion and Doubt Clearance	**2 Periods**
Introducing concept of Force & Laws of Motion	Introducing concept of Force & Laws of Motion using STEM TECHNOLOGY	Introducing concept of Force & Laws of Motion using STEM TECHNOLOGY	Introducing concept of Force & Laws of Motion using STEM TECHNOLOGY	Introducing concept of Force & Laws of Motion using STEM TECHNOLOGY	Introducing concept of Force & Laws of Motion using Traditional Method	Introducing concept of Force & Laws of Motion using Traditional Method	Introducing concept of Force & Laws of Motion using Traditional Method	Introducing concept of Force & Laws of Motion using Traditional Method	**2 Periods**
Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	Concept Mapping the topic of Force & Laws of Motion and Doubt Clearance	**2 Periods**
Introducing concept of Gravitation & Floatation	Introducing concept of Gravitation & Floatation using STEM TECHNOLO	Introducing concept of Gravitation & Floatation using STEM TECHNOL	Introducing concept of Gravitation & Floatation using STEM TECHNOLOGY	Introducing concept of Gravitation & Floatation using STEM TECHNOLOGY	Introducing concept of Gravitation & Floatation using Traditional Method	Introducing concept of Gravitation & Floatation using Traditional Method	Introducing concept of Gravitation & Floatation using Traditional Method	Introducing concept of Gravitation & Floatation using Traditional Method	**2 Periods**

	GY	OGY							
Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	Concept Mapping the topic of Gravitation & Floatation and Doubt Clearance	**2 Periods**
Introducing concept of Work & Energy	Introducing concept of Work & Energy using STEM TECHNOLOGY	Introducing concept of Work & Energy using STEM TECHNOLOGY	Introducing concept of Work & Energy using STEM TECHNOLOGY	Introducing concept of Work & Energy using STEM TECHNOLOGY	Introducing concept of Work & Energy using Traditional Method	Introducing concept of Work & Energy using Traditional Method	Introducing concept of Work & Energy using Traditional Method	Introducing concept of Work & Energy using Traditional Method	**2 Periods**
Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	Concept Mapping the topic of Work & Energy and Doubt Clearance	**2 Periods**
Introducing concept of Sound	Introducing concept of Sound using STEM TECHNOLOGY	Introducing concept of Sound using STEM TECHNOLOGY	Introducing concept of Sound using STEM TECHNOLOGY	Introducing concept of Sound using STEM TECHNOLOGY	Introducing concept of Sound using Traditional Method	Introducing concept of Sound using Traditional Method	Introducing concept of Sound using Traditional Method	Introducing concept of Sound using Traditional Method	**2 Periods**
Concept Mapping the topic	Concept Mappi	Concept Mappi	Concept Mappin	Concept Mappin	Concept Mappin	Concept Mappin	Concept Mappin	Concept Mappi	**2 Periods**

of Sound and Doubt Clearance	ng the topic of Sound and Doubt Clearance	ng the topic of Sound and Doubt Clearance	g the topic of Sound and Doubt Clearance	g the topic of Sound and Doubt Clearance	g the topic of Sound and Doubt Clearance	g the topic of Sound and Doubt Clearance	g the topic of Sound and Doubt Clearance	ng the topic of Sound and Doubt Clearance	
Feedback of Activities by giving two week time to the students to develop their self made Learning Toys and solve worksheet.	Feedback of Activities by giving two week time to the students to develop their self made Learning Toys and solve worksheet.	Feedback of Activities by giving two week time to the students to develop their self made Learning Toys and solve worksheet.	Feedback of Activities by giving two week time to the students to develop their self made Learning Toys and solve worksheet.	Feedback of Activities by giving two week time to the students to develop their self made Learning Toys and solve worksheet.	Worksheet and Doubt Clearing session.	Worksheet and Doubt Clearing session.	Worksheet and Doubt Clearing session.	Worksheet and Doubt Clearing session.	**2 Weeks/ 14 Days**
Presentation of Self made Toys by students	Presentation of Self made Toys by students	Presentation of Self made Toys by students	Presentation of Self made Toys by students	Presentation of Self made Toys by students	Revision	Revision	Revision	Revision	**2 Periods**
Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	Administering Test Of Understanding Concepts of Introductory Physics (POST-TEST)	**1 Period**

		TEST)							

The researcher implemented the plan and organised the data and conducted data analysis and interpretation.

8.3. Variables

Dependent Variable	**Independent Variable**	**Extraneous Variable**
Academic achievement in Physics.	**Integration of STEM TECHNOLOGY**	**(1) Interest** **(2) Aptitude** **(3) Attitude**

8.4. Tools

The following tools was used for collecting data.

The researcher prepared an achievement Test to study the effectiveness of integrating STEM TECHNOLOGY in teaching learning of Physics on the academic achievement of students of grade IX studying at CBSE schools.

1) Achievement test:-

The researcher prepared Achievement test based on (Chapter no 7) Motion, (Chapter no 8) Force and Laws of Motion, (Chapter 9) Gravitation, (Chapter no 10) Work and Energy and (Chapter 11) Sound from grade IX CBSE NCERT textbooks. An Achievement test comprising of 25 marks was conducted. It consisted of different types of questions in accordance with Bloom's Taxonomy testing knowledge, understanding, application and higher order thinking skills of students. Pre-test and Post-test were conducted each consisting of 25 marks each on same experimental group and controlled group who were taught Physics through STEM TECHNOLOGY and through traditional method.

Achievement test generally measure present proficiency, mastery and the understanding of general and specific areas of knowledge. Largely they are the measures of the effectiveness of instructions and learning.

Table.2. Blue Print of Achievement Test of Physics for grade IX

Ch.NO	CHAPTERS	Marks
8	Motion(Distance,Displacement,Velocity,Acceleration	5
9	Force & Laws Of Motion	5
10	Gravitation	5
11	Work Energy and Power	5
12	Sound	5
	Total	25

8.5. Procedure for data collection

This is an experimental study, in which STEM TECHNOLOGY was used to teach Introductory Physics to grade IX CBSE students. Learning material was developed to implement STEM TECHNOLOGY for grade IX Physics Chapters from NCERT Textbook. Data was collected by following way.

a) Group Formation:

Two groups were formed one was experimental group and second was control group. From the population three CBSE schools were randomly selected. Two CBSE schools belonged to Shirpur Taluka of Dhule District. Experimental group studied Introductory Physics topics with the help of STEM TECHNOLOGY while control group studied the Introductory Physics topics by conventional method.

b) Pre Testing:

First of all the Concepts of Achievement Test were administered on both the Groups. The Test was administered by following the same procedure for both the Groups. Achievement Test to evaluate Introductory Physics Concept is provided in the Appendix II and Blue Print of the achievement test is provided in Appendix I.

c) Demonstration of STEM TECHNOLOGY :

The students were demonstrated the Introductory Physics concept like Motion , Force and Laws of Motion, Gravitation and Floatation , Work ,Energy and Power and Sound using Toys and were motivated to develop their own toys under the guidance of the researcher. Concept Maps were provided along with the worksheet to make the concepts thorough and take necessary feedback. Students were instructed to select particular topic enlisted by the researcher and were given two week time to develop their own toys.

d) Time allotment for Developing Toys and Models:

The students were allotted fifteen days for developing the toys. The students were asked to note down the difficulties faced by them while developing their own toy. The students developed their toy according to their pace and time.

e) Clarification of Doubts:

After developing the toys and models the doubts of the students were clarified.

f) Post Testing:

At the end of the treatment the Achievement Test of Understanding of Introductory Physics Concept developed by the investigator was administered as a post-test on the students of both the groups i.e, experimental and control group.

9. Statistical Analysis

The researcher collected data by calculating scores from the Pre-test and Post-test given by the sample of the research. This collected data was in the form of arithmetic numbers so the researcher used the following statistical technique to interpret the data,

- The measure of Central Tendency
- Measure of Variability
- Skewness
- Kurtosis
- T-test

The measure of Central Tendency:

In statistics, central tendency refers to the measure of the central or typical value of a set of data. There are three common measures of central tendency:

1. Mean: The mean is the arithmetic average of a set of data. It is calculated by adding up all the values in the set and dividing by the total number of values.
2. Median: The median is the middle value of a set of data when the values are arranged in order. If there are an even number of values, the median is the average of the two middle values.
3. Mode: The mode is the value that occurs most frequently in a set of data.

T-tests are widely used in scientific research and are an important tool for making statistical inferences about population parameters based on sample data. However, it is important to ensure that the assumptions of the t-test are met and that the results are interpreted appropriately in the context of the specific research question and data set.

10. Data Analysis and Interpretation

10.1. Descriptive Analysis and Interpretation

The Methodology followed in conducting this study has been given in third chapter. In the same chapter, the statistical techniques used for analysing the data have been given. In the present chapter results and their interpretation have been given objective-wise in different captions.

To find relevant topics of Physics in grade IX where Toy based pedagogy can be effectively implemented.

The first objective was to find relevant topics of Physics in grade IX where Toy based pedagogy can be effectively implemented.

To fulfil this objective the researcher studied NCERT Grade IX Science Textbook and selected the topics where Toy based pedagogy can be effectively.

Table.3. List of Topics from NCERT Grade IX Science Text book

Chapter No.	Name of Chapter	Units
8	**Motion**	Projectile Motion**,** Acceleration
9	**Force & Laws Of Motion**	Force, Newton's Laws of Motion, Momentum, Law of conservation of Momentum.

10	**Gravitation**	i)Acceleration due to gravity, Anti Gravity Condition ii)Floatation- Pressure, pressure gauge and Pascals Law.
11	**Work Energy and Power**	Work, Energy, Kinetic and Potential Energy, Conservation of Energy.
12	**Sound**	Propagation of Sound, wavelength, amplitude, phase

The above listed topics were selected and toys were planned for selected topics.

To prepare learning material using Toy based pedagogy in Physics and design toys based on units for the learning material for grade IX students of CBSE board.

The second objective was to prepare learning material using Toy based pedagogy in Physics and design toys based on units for the learning material for grade IX students of CBSE board. Therefore, Learning Material in the form of Toys, Concept Map was prepared. Details regarding this are given in Table 4.

Table.4. Learning Material

Chapter No.	Name of Chapter	Units	Name of Toy
8	**Motion**	Projectile Motion**,** Acceleration	Water Missile Launcher, Gravity Car.
9	**Force & Laws Of Motion**	Force, Newton's Laws of Motion, Momentum, Law of conservation of Momentum.	Gravity Car, Pendulum Train Toy, Spinning Ball, Toy Tensegrity model,
10	**Gravitation**	i)Acceleration due to gravity, Anti-Gravity Condition**,** Free Fall ii)Floatation- Pressure, pressure gauge and Pascals Law.	Dark Hole Toy, Anti-Gravity Dancing Coin Toy, Free Fall Toy, Hydraulic Lift.
11	**Work Energy and Power**	Work, Energy, Kinetic and Potential Energy, Conservation of Energy.	Pendulum Train Toy, Spinning Ball Toy.
12	**Sound**	Propagation of Sound, wavelength, amplitude, phase	Wave Train.

Analysis based on mean, median, mode, standard deviation, kurtosis and skewness of the scores from Pre Test of students studying Physics through Toy Based Pedagogy (Experimental Group) and through Traditional Method (Control Group)

Objective 3: To study **the effectiveness of Toy based pedagogy** in the academic achievement of students studying Physics of grade IX of CBSE board by comparing the **PRE-TEST** scores of Experimental and Control groups.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table No 5: Showing analysis based on mean, median, mode, standard deviation, kurtosis and skewness of the scores from Pre-Test of students studying Physics through Toy Based Pedagogy (Experimental Group) and through Traditional Method (Control Group)

Group	No. Of Students	Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness
Experimental Group	89	13.71	14	15	5.63	2.65	0.0325
Control Group	72	16.27	16	15	4.01	3.24	0.071

Note: Absentees for PRE-TEST

Group	Boys	Girls
Experimental Group	1	0
Control Group	0	1

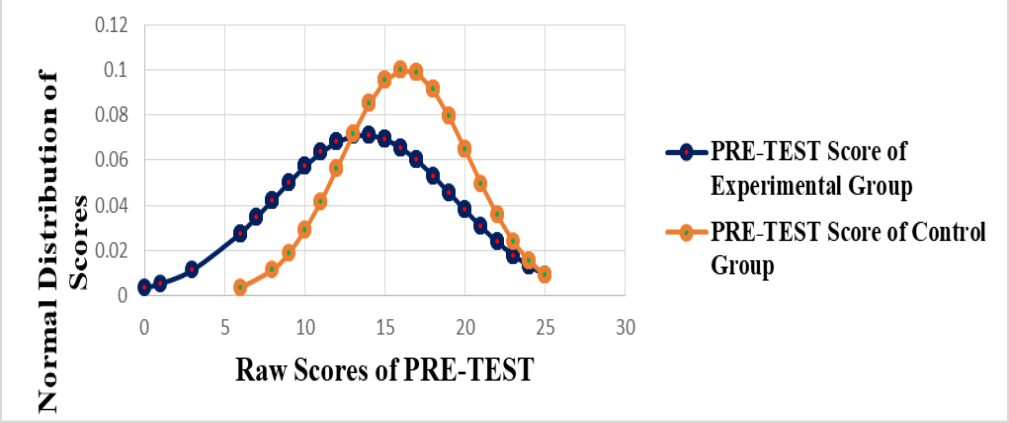


Figure.2. Graph of Scores from Pre Test of Students Studied Physics through Toy based (Experimental Group) and through Traditional method (Control Group)

Thus, from the graph and given data it is observed that

- Mean score of Control group is greater than mean score of Experimental group before administering the treatment.
- The values of Mean, Median and Mode are nearly equal and are valid measures of central tendency.
- Skewness is positive for both groups, a distribution with a long right tail is right-skewed, or positively skewed.
- Kurtosis is higher for Control group, High kurtosis means that a data set has tail data that is more extreme than a normal distribution whereas kurtosis is less for Experimental group, Low kurtosis means the tail data is less extreme than a normal distribution.

Analysis based on mean, median, mode, standard deviation, kurtosis and skewness of the scores from Post Test of students studying Physics through Toy Based Pedagogy (Experimental Group) and through Traditional Method (Control Group)

Objective 4-To study **the effectiveness of Toy based pedagogy** in the academic achievement of students studying Physics of grade IX of CBSE board by comparing the **POST-TEST** scores of Experimental and Control groups.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table No 6: Showing analysis based on mean, median, mode, standard deviation, kurtosis and skewness of the scores from Post Test of students studying Physics through Toy Based Pedagogy (Experimental Group) and through Traditional Method (Control Group)

Group	No. Of Students	Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness
Experimental Group	90	17.93	18	25	5.501	1.83	-0.184
Control Group	73	17	18	19	5.511	2.105	-0.24

Note: Absentees for Pre Test

Group	Boys	Girls
Experimental Group	0	0
Control Group	0	0

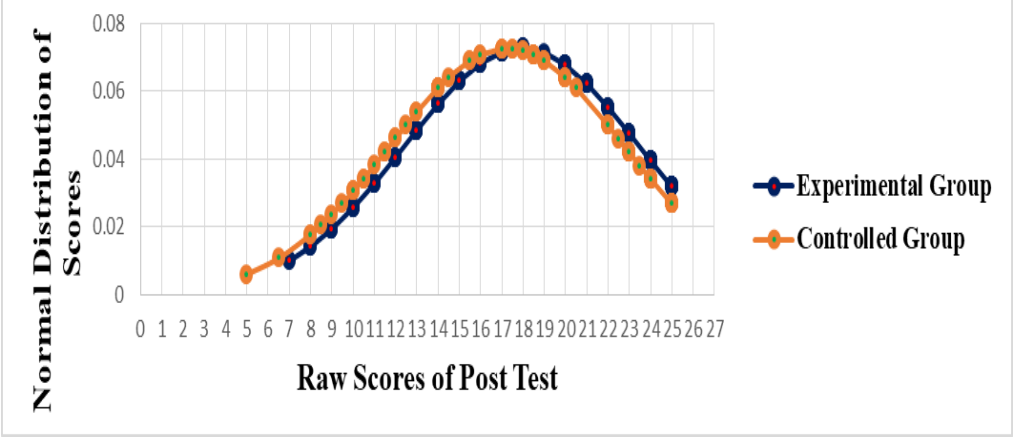


Figure.3. Graph of the Scores from post Test of Students Studied Physics Toy pedelogy (Experimental Group) and through Traditional Method (Control Group)

Thus, from the graph and given data it is observed that,

- Mean score of Experimental groups is greater than mean score of Control group after administering the treatment to Experimental group.
- Skewness is negative for both groups, a distribution with a long-left tail is left-skewed, or negatively skewed.
- The values of Mean, Median and Mode are nearly equal and are valid measures of central tendency.
- Kurtosis is higher for Control group, High kurtosis means that a data set has tail data that is more extreme than a normal distribution whereas kurtosis is less for Experimental group, Low kurtosis means the tail data is less extreme than a normal distribution.

Analysis based on mean, median, mode, standard deviation, kurtosis on PRE-TEST and POST-TEST conducted on Experimental group and Control Group of grade IX of CBSE board.

Objective 5- To **compare the academic achievements of Experimental group and Control group students** grade IX of CBSE board.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table.7. Showing analysis based on mean, median, mode, standard deviation, kurtosis on Experimental group and Control Group students of grade IX of CBSE board.

Group	No. Of Students		Mean		Median		Mode		Standard Deviation		Kurtosis		Skewness	
	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group
PRE-TEST	72	89	16.3	13.7	16	14	15	15	4	5.6	3.2	2.6	0.07	0.03
POST-TEST	73	90	17	18	18	18	19	25	5.51	5.50	2.1	1.83	-0.24	-0.184

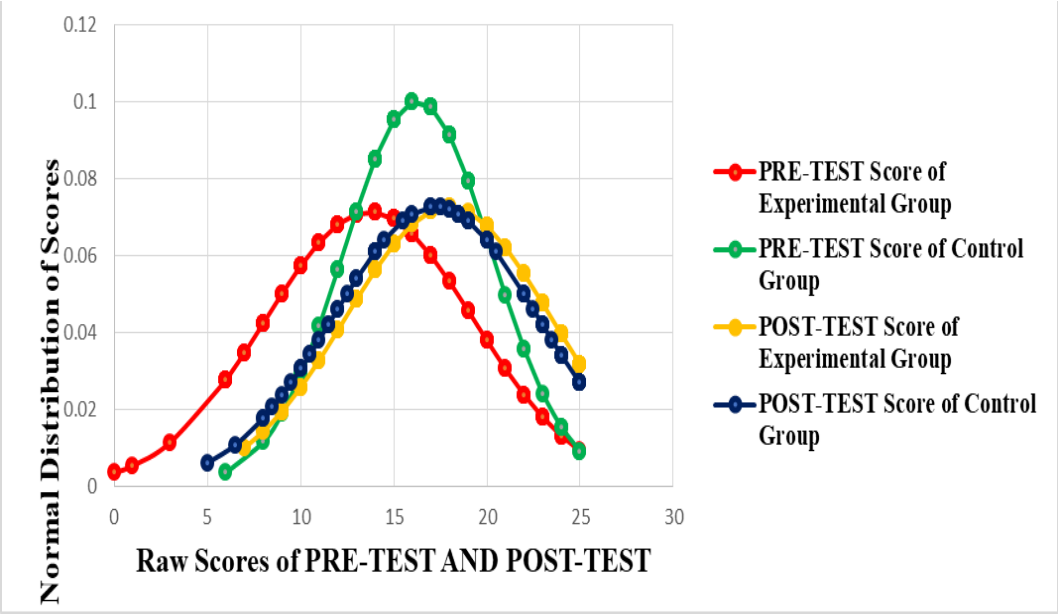


Figure.4. Graph of the scores from Pre Test Students Studied Physics through Toy Based Pedagogy (Experimental Group) and through Traditional Method (Control Group)

- Thus, from the graph and given data it is observed that mean score of PRE-TEST conducted on Control group is greater than the mean score of PRE-TEST conducted on Experimental group before administering the treatment.

- Thus, from the graph and given data it is observed that mean score of POST-TEST conducted on Experimental group is greater than mean score of POST-TEST conducted on Control group after administering the treatment and teaching Physics to students of Experimental group by Toy Based Pedagogy and teaching Physics to students of Control Group by traditional method.

- Thus, from the graph and given data it is observed that mean score of POST-TEST conducted on Experimental group is greater than PRE-TEST conducted on Experimental group after administering the treatment and teaching Physics to students of Experimental group by Toy Based Pedagogy.

- Thus, from the graph and given data it is observed that mean score of POST-TEST conducted on Control group is greater than PRE-TEST conducted on Control group after teaching students with Traditional Method.

- Thus, teaching Physics through Toy Based Pedagogy has helped to increase learning achievement of students.

Analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of low-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

Objective 6-To compare the PRE-TEST and POST-TEST results of low-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table No.8. Showing analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of low-achiever students of Experimental group who were taught Physics using Toy-Based Pedagogy.

Experimental Group Low Achiever Students	No. Of Students	Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness
PRE-TEST	58	10.46	11	15	3.645	0.1890	-0.6994
POST-TEST	36	12.17	13	13	2.36	-0.898	-0.538

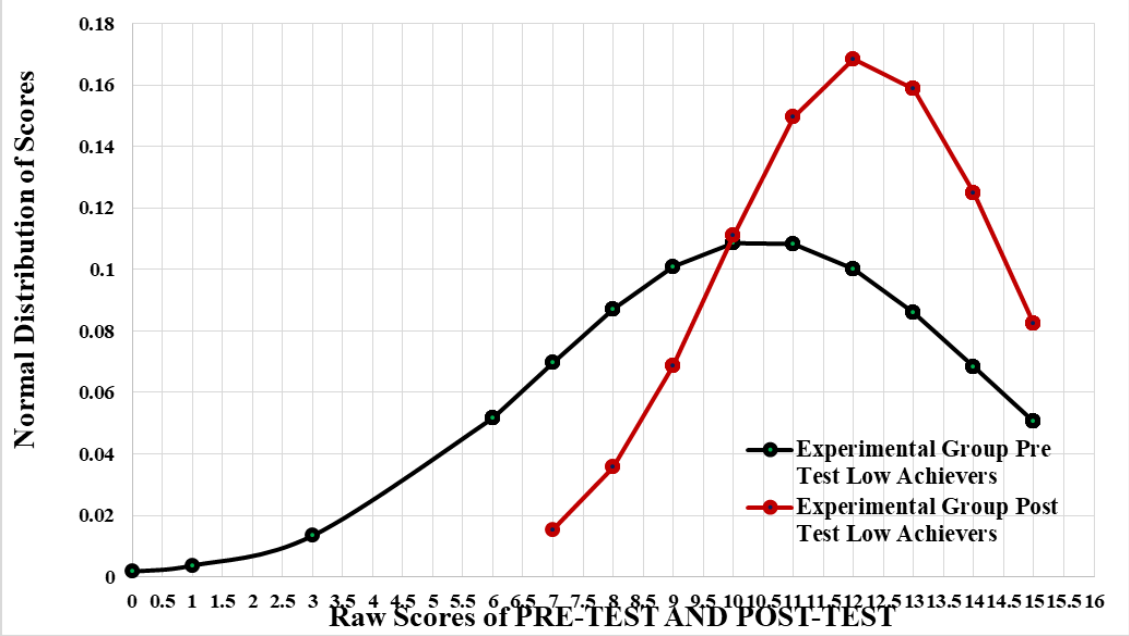


Figure.5. Graph of the Scores of Pre Test and post Test Results of low Achiever Students of Experimental Group who were taught Physics using Toy Based Pedagogy

Thus, from the graph and given data it is observed that,

- Thus, from the graph and given data it is observed that the mean score of POST-TEST is greater than the mean score of PRE-TEST conducted on low achiever students of Experimental group .

- Skewness is negative for both PRE-TEST and POST-TEST scores of low achiever students of Experimental group with a long left-tail or left-skewed or negatively skewed.
- Kurtosis is high for PRE-TEST score of students of Experimental group, High kurtosis means that a data set has tail data that is more extreme than a normal distribution whereas kurtosis is less for POST-TEST score of students of Experimental group, Low kurtosis means the tail data is less extreme than a normal distribution.
- The values of Mean, Median and Mode are nearly equal and are valid measures of central tendency.

Analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of high-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

Objective 7-To compare the **PRE-TEST** and **POST-TEST** results of high-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table.9. Showing analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of high-achiever students of Experimental group who were taught Physics using Toy-Based Pedagogy.

Experimental Group High Achiever Students	No. Of Students	Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness
PRE-TEST	31	19.77	20	17	2.92	-1.45	0.17759
POST-TEST	54	21.77	23	25	3.034	-1.01	-0.583

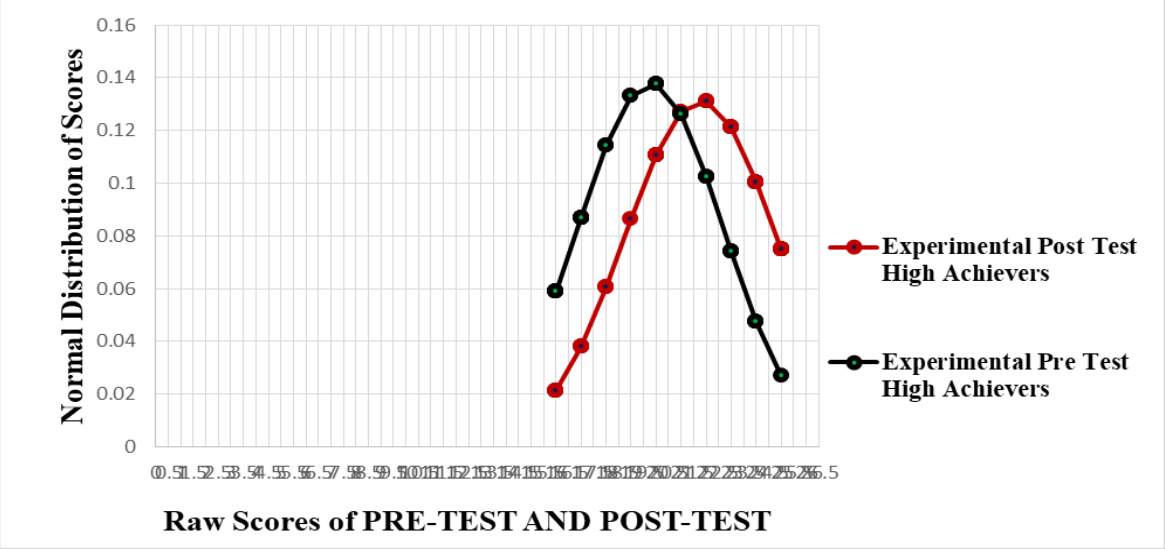


Figure.6. Graph of Scores of Pre Test and Post Test Results of Higher Achiever Students of Experimental Group who were taught Physics using Toy Based Pedagogy

Thus, from the graph and given data it is observed that,

- Thus, from the graph and given data it is observed that the mean score of POST-TEST is greater than the mean score of PRE-TEST conducted on high achiever students of Experimental group.
- Skewness is negative for scores of POST-TEST of high achiever students of Experimental group with a long left-tail or left-skewed or negatively skewed whereas positive for PRE-TEST of high achiever students of Experimental group with a long right-tail or right-skewed or positively skewed.
- Kurtosis is high for PRE-TEST score of students of Experimental group, High kurtosis means that a data set has tail data that is more extreme than a normal distribution whereas kurtosis is less for POST-TEST score of students of Experimental group, Low kurtosis means the tail data is less extreme than a normal distribution.
- The values of Mean, Median and Mode are nearly equal and are valid measures of central tendency.

Analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of low-achiever students of Control group who were taught Physics using Traditional method.

Objective 8- To compare the **PRE-TEST** and **POST-TEST** results of low-achiever students of Control group who were taught Physics using traditional method.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table.10. Showing analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of low-achiever students of Control group who were taught Physics using Traditional method.

Control Group Low Achiever Students	No. Of Students	Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness
PRE-TEST	33	12.90	14	15	2.32	-0.99	-1.23
POST-TEST	27	11.12	11.5	14	2.50	-0.26	-0.579

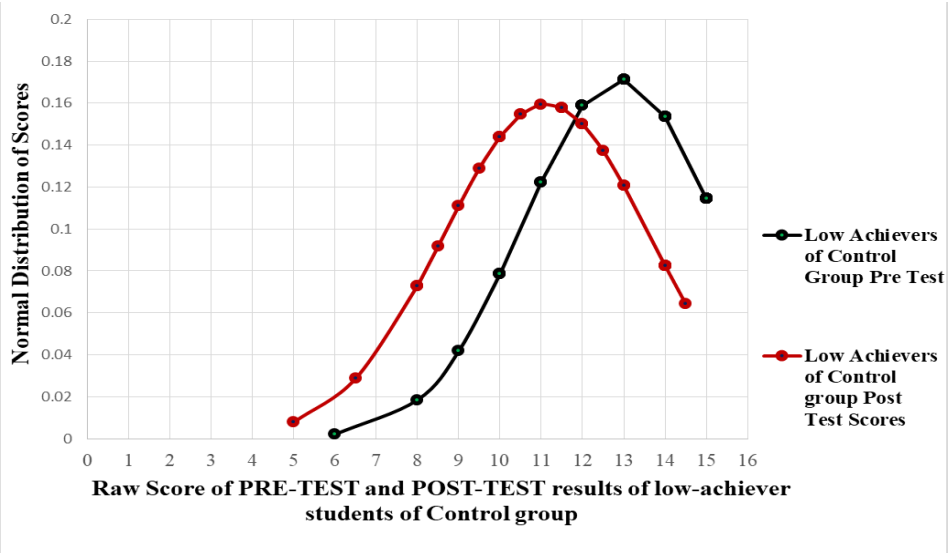


Figure.7. Graph of the Scores of Pre Test and Post Test Results of Low Achiever of Control Group who were taught Physics using Traditional Method

Thus, from the graph and given data it is observed that,

- Thus, from the graph and given data it is observed that the mean score of PRE-TEST is greater than the mean score of POST-TEST conducted on low achiever students of Control group.

- Skewness is negative for PRE-TEST and for POST-TEST scores of high achiever students of Control group with a long left-tail or left-skewed or negatively skewed.

- Kurtosis is high for POST-TEST score of students of Control group, High kurtosis means that a data set has tail data that is more extreme than a normal distribution whereas kurtosis is less for PRE-TEST score of students of Control group, Low kurtosis means the tail data is less extreme than a normal distribution.

- The values of Mean, Median and Mode are nearly equal and are valid measures of central tendency.

Analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of high-achiever students of Control group who were taught Physics using Traditional method.

Objective 9- To compare the **PRE-TEST** and **POST-TEST** results of high-achiever students of Control group who were taught Physics using traditional method.

To fulfil this objective the researcher collected data using the tool and obtained following data analysis.

Table.11. Showing analysis based on mean, median, mode, standard deviation, kurtosis on the PRE-TEST and POST-TEST results of high-achiever students of Control group who were taught Physics using Traditional method.

Control Group High Achiever Students	No. Of Students	Mean	Median	Mode	Standard Deviation	Kurtosis	Skewness

PRE-TEST	39	19.12	18	17	2.64	-0.22	0.92
POST-TEST	46	20.82	20.25	25	3.09	-1.41	-0.096

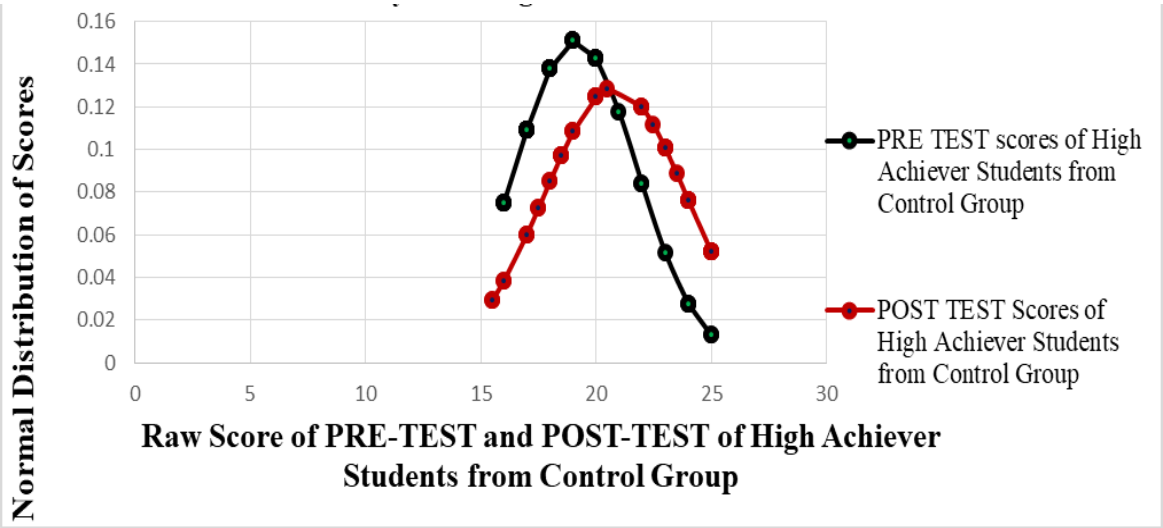


Figure.8. Graph of the Scores of Pre Test and Post Test Results of High achiever Students of Control Group who were taught Physics using Traditional Method

Thus, from the graph and given data it is observed that,

- Thus, from the graph and given data it is observed that the mean score of POST-TEST is greater than the mean score of PRE-TEST conducted on low achiever students of Control group.
- Skewness is negative for POST-TEST scores of high achiever students of Control group with a long left-tail or left-skewed or negatively skewed whereas skewness is positive for PRE-TEST scores of high achiever students of Control group with a long right-tail or right-skewed or positively skewed.
- Kurtosis is high for POST-TEST score of students of Control group, High kurtosis means that a data set has tail data that is more extreme than a normal distribution whereas kurtosis is less for PRE-TEST score of students of Control group, Low kurtosis means the tail data is less extreme than a normal distribution.

- The values of Mean, Median and Mode are nearly equal and are valid measures of central tendency.

11. Inferential Analysis and Interpretation

11.1. Testing of Null Hypothesis

Comparison of adjusted mean score of PRE-TEST of students from Experimental group and Control group of grade IX of CBSE board.

Null Hypothesis 1

The null hypothesis stated that there is no significant difference between the mean score of PRE-TEST of students from Experimental group and Control group of grade IX of CBSE board.

To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.12. Difference between Mean scores of PRE-TEST conducted on Experimental Group and Control Group.

Group	No Of Students N	Mean	Standard Deviation	df	Table t value At 0.01 Level of Significance	Obtained t value	Decision on Hypothesis
Control	72	16.27	4.01	159	2.6071	3.2616	**Null Hypothesis is rejected at the 0.01 level of significance.**
Experimental	89	13.71	5.63	159			

Interpretation

- The calculated t value exceeds the critical value (3.2616 > 2.6071), so the means are significantly different at 0.01 level of significance, hence, the null hypothesis is rejected.

Conclusion

- It can be concluded that there is significant difference between the mean score of PRE-TEST of students from Experimental group and Control group of grade IX of CBSE board.

Findings

- Toy Based Pedagogy was found to be more effective than Traditional Method in improving academic achievement of students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts.

Comparison of adjusted mean score of POST-TEST of students from experimental group and controlled group of grade IX of CBSE board.

Null Hypothesis 2

The null hypothesis stated that there is no significant difference between the mean score of POST-TEST of students from experimental group and controlled group of grade IX of CBSE board. To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.13. Difference between Mean scores of POST-TEST conducted on Experimental Group and Control Group.

Group	No Of Students N	Mean	Standard Deviation	Df	Table t value At 0.01 Level Of significance	Obtained t value	Decision on Hypothesis
Control	73	17	5.4537	161	2.6067	0.6389	**Null Hypothesis is accepted at the 0.01 level of significance.**
Experimental	90	18	5.4707	161			

Interpretation

- The calculated t value is less than the critical value (0.6389<2.6067), so the means are not significantly different at 0.01 level of significance, hence, the null hypothesis is accepted.

Conclusion

- It can be concluded that there is no significant difference between the mean score of POST-TEST of students from Experimental group wherein students were taught Physics with Toy Based Pedagogy and Control group where students were taught Physics with traditional method of grade IX of CBSE board.

Findings

- Toy Based Pedagogy was found to be as effective as Traditional Method in improving academic achievement of students of grade IX studying Physics when Experimental Method Group was taught Introductory Physics concept using Toy Based Pedagogy and Control Group was taught with Traditional Method.

5.2.15 Comparison of adjusted mean score of PRE-TEST and POST-TEST conducted on students of Experimental group and Control group of grade IX of CBSE board.

Null Hypothesis 3

The null hypothesis stated that there is no significant difference between the mean score of PRE-TEST and POST-TEST conducted on students of Experimental group and Control group of grade IX of CBSE board.

To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.14. Difference between scores of PRE-TEST and POST-TEST conducted on students of Experimental Group and Control Group

Group	No. Of Students		Mean		Standard Deviation		dof		Table t value at 0.01		Obtained t value		Hypothesis Discussion
	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	Control Group	Experimental Group	
PRE-TEST	72	89	16.3	13.7	4.01	5.63	159		2.6071		3.2616		Null Hypothesis
POST-TEST	73	90	17	18	5.45	5.47	161		2.6067		0.6389		Null Hypothesis is accepted at the 0.01 level of significance.

Interpretation

- The calculated t value exceeds the critical value (3.2616 > 2.6071), so the means are significantly different at 0.01 level of significance, hence, the null hypothesis is rejected.

- The calculated t value is less than the critical value (0.6389<2.6067), so the means are not significantly different at 0.01 level of significance, hence, the null hypothesis is accepted.

Conclusion

- It can be concluded that there is significant difference between the mean score of PRE-TEST of students from Experimental group and Control group of grade IX of CBSE board.

- It can be concluded that there is no significant difference between the mean score of POST-TEST of students from Experimental group wherein students were taught Physics with Toy Based Pedagogy and Control group where students were taught Physics with traditional method of grade IX of CBSE board.

5.2.16 Comparison of adjusted mean score of PRE-TEST and POST-TEST of low-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

Null Hypothesis 4

The null hypothesis stated that there is no significant difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.15. Difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Experimental group.

Group	No Of Students N	Mean	Standard Deviation	df	Table t value at 0.01 Level Of significance	Obtained t value	Decision on Hypothesis
PRE-TEST	58	10.46	3.64	92	2.63	2.715	**Null Hypothesis is rejected at the 0.01 level of significance.**
POST-TEST	36	12.16	2.36				

Interpretation

- The calculated t value exceeds the critical value (2.715 > 2.63), so the means are significantly different at 0.01 level of significance, hence, the null hypothesis is rejected.

Conclusion

- It can be concluded that there is significant difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

Findings

- Toy Based Pedagogy was found to be more effective than Traditional Method in improving academic achievement of low achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts.

- The mean score of POST-TEST of low achiever students conducted after implementing the treatment by teaching Introductory Physics using Toy Based Pedagogy was found to be greater than the mean score of PRE-TEST of low achiever students.

5.2.17 Comparison of adjusted mean score of PRE-TEST and POST-TEST of high-achiever students of Experimental group who were taught Physics using Toy-based pedagogy.

Null Hypothesis 5

There is no significant difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Experimental group who were taught Physics using Toy-based pedagogy.

To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.16. Difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Experimental group.

Group	No Of Students N	Mean	Standard Deviation	df	Table t value at 0.01 Level Of significance	Obtained t value	Decision on Hypothesis
PRE-TEST	31	19.77	2.92				**Null Hypothesis is**

POST-TEST	54	21.77	3.03	64	2.65	2.96	**rejected at the 0.01 level of significance.**

Interpretation

- The calculated t value exceeds the critical value (2.96 > 2.65), so the means are significantly different at 0.01 level of significance, hence, the null hypothesis is rejected.

Conclusion

- It can be concluded that there is significant difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Experimental group who were taught Physics using toy-based pedagogy.

Findings

- Toy Based Pedagogy was found to be more effective than Traditional Method in improving academic achievement of high achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts.
- The mean score of POST-TEST of high achiever students conducted after implementing the treatment by teaching Introductory Physics using Toy Based Pedagogy was found to be greater than the mean score of PRE-TEST of high achiever students.

5.2.18 Comparison of adjusted mean score of PRE-TEST and POST-TEST of low-achiever students of Control group who were taught Physics using Traditional Method.

Null Hypothesis 6

There is no significant difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Control group who were taught Physics using Traditional Method.

To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.17. Difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Control group

Group	No Of Students N	Mean	Standard Deviation	df	Table t value at 0.01 Level Of significance	Obtained t value	Decision on Hypothesis
PRE-TEST	33	12.9	2.32	54	2.66	2.78	**Null Hypothesis is rejected at the 0.01 level of significance.**
POST-TEST	27	11.12	2.5				

Interpretation

- The calculated t value exceeds the critical value (2.78 > 2.66), so the means are significantly different at 0.01 level of significance, hence, the null hypothesis is rejected.

Conclusion

- It can be concluded that there is significant difference between the mean score of PRE-TEST and POST-TEST of low-achiever students of Control group who were taught Physics using Traditional Method.

Findings

- Toy Based Pedagogy was found to be more effective than Traditional Method in improving academic achievement of low achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts.

5.2.19 Comparison of adjusted mean score of PRE-TEST and POST-TEST of high-achiever students of Control group who were taught Physics using Traditional Method.

Null Hypothesis 7

There is no significant difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Control group who were taught Physics using Traditional Method.

To verify this hypothesis the researcher collected data using the tool and obtained following data analysis.

Table.18. Difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Control group

Group	No Of Students N	Mean	Standard Deviation	df	Table t value at 0.01 Level Of significance	Obtained t value	Decision on Hypothesis
PRE-TEST	39	19.12	2.64	83	2.6363	2.695	**Null Hypothesis is rejected at the 0.01 level of significance.**
POST-TEST	46	20.82	3.09				

Interpretation

The calculated t value exceeds the critical value (2.695 > 2.6363), so the means are significantly different at 0.01 level of significance, hence, the null hypothesis is rejected.

Conclusion

- It can be concluded that there is significant difference between the mean score of PRE-TEST and POST-TEST of high-achiever students of Control group who were taught Physics using Traditional Method.

Findings

- Toy Based Pedagogy was found to be more effective than Traditional Method in improving academic achievement of high achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts.

- The mean score of POST-TEST of high achiever students conducted after implementing the treatment by teaching Introductory Physics using Traditional Method was found to be greater than the mean score of PRE-TEST of high achiever students.

12. Findings

1. STEM TECHNOLOGY was found to be more effective than Traditional Method in improving academic achievement of students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts.
2. STEM TECHNOLOGY was found to be as effective as Traditional Method in improving academic achievement of students of grade IX studying Physics when Experimental Method Group was taught Introductory Physics concept using STEM TECHNOLOGY and Control Group was taught with Traditional Method.
3. STEM TECHNOLOGY was found to be more effective than Traditional Method in improving academic achievement of low achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts. The mean score of POST-TEST of low achiever students conducted after implementing the treatment by teaching Introductory Physics using STEM

TECHNOLOGY was found to be greater than the mean score of PRE-TEST of low achiever students.

4. STEM TECHNOLOGY was found to be more effective than Traditional Method in improving academic achievement of high achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts. The mean score of POST-TEST of high achiever students conducted after implementing the treatment by teaching Introductory Physics using STEM TECHNOLOGY was found to be greater than the mean score of PRE-TEST of high achiever students.

13. Implications

In this research study above findings were derived. In this caption the discussion on these findings were carried out.

- **Comparison of adjusted mean score of PRE-TEST and POST-TEST conducted on students of Experimental group and Control group of grade IX of CBSE board.**

STEM TECHNOLOGY was found to be as effective as Traditional Method in improving academic achievement of students of grade IX studying Physics when Experimental Method Group was taught Introductory Physics concept using STEM TECHNOLOGY and Control Group was taught with Traditional Method.

The study conducted on students of grade IX studying Physics, concluded that STEM TECHNOLOGY was more effective in improving academic achievement compared to the Traditional Method, provided that the groups were matched with respect to their pre-understanding of introductory Physics concepts.

This implies that when students of similar pre-understanding of Physics concepts were separated into two groups, one taught using the traditional method and the other taught using STEM TECHNOLOGY, the group taught using the STEM TECHNOLOGY showed better academic performance.

STEM TECHNOLOGY involves the use of toys, models or educational games to teach a concept by integrating Science, Technology, Engineering and Mathematics making it more interactive and engaging for students. This approach may have helped students better understand and retain the Physics concepts taught to them, leading to better academic performance.

It's important to note that this conclusion is based on a specific study and may not necessarily apply to all situations or contexts. However, it does suggest that using innovative teaching methods such as STEM TECHNOLOGY can be an effective way to enhance learning outcomes, especially in subjects like Physics where concepts can be challenging to grasp.

- **Effectiveness of use of STEM TECHNOLOGY on low-achiever students of Experimental group who were taught Physics using STEM TECHNOLOGY**

  STEM TECHNOLOGY was found to be more effective than Traditional Method in improving academic achievement of low achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts. The mean score of POST-TEST of low achiever students conducted after implementing the treatment by teaching Introductory Physics using STEM TECHNOLOGY was found to be greater than the mean score of PRE-TEST of low achiever students.

The study conducted on low achiever students of grade IX studying Physics, STEM TECHNOLOGY was found to be more effective in improving academic achievement

compared to the Traditional Method, provided that the groups were matched with respect to their pre-understanding of introductory Physics concepts.

This implies that when students with similar pre-understanding of Physics concepts and lower academic achievement were separated into two groups, one taught using the traditional method and the other taught using toy-based pedagogy, the group taught using the STEM TECHNOLOGY showed better academic performance.

This finding is significant as it highlights the potential of STEM TECHNOLOGY to enhance learning outcomes for students who are struggling academically. The use of toys and educational games in teaching can make the learning experience more interactive and engaging for these students, which can improve their understanding and retention of Physics concepts.

It's important to note that this statement is based on a specific study and may not necessarily apply to all situations or contexts. However, it does suggest that using innovative teaching methods such as STEM TECHNOLOGY can be an effective way to support and improve the academic achievement of low achiever students in subjects like Physics.

- **Effectiveness of use of STEM TECHNOLOGY on high-achiever students of Experimental group who were taught Physics using STEM TECHNOLOGY**

  STEM TECHNOLOGY was found to be more effective than Traditional Method in improving academic achievement of high achiever students of grade IX studying Physics when groups were matched with respect to Pre-understanding of Introductory Physics concepts. The mean score of POST-TEST of high achiever students conducted after implementing the treatment by teaching Introductory Physics using STEM TECHNOLOGY was found to be greater than the mean score of PRE-TEST of high achiever students.

This study conducted on high achiever students of grade IX studying Physics, STEM TECHNOLOGY was found to be more effective in improving academic achievement compared to the Traditional Method, provided that the groups were matched with respect to their pre-understanding of introductory Physics concepts.

This implies that when students with similar pre-understanding of Physics concepts and higher academic achievement were separated into two groups, one taught using the traditional method and the other taught using toy-based pedagogy, the group taught using the STEM TECHNOLOGY showed better academic performance.

This finding is significant as it suggests that even high achiever students can benefit from innovative teaching methods such as STEM TECHNOLOGY While high achievers may have a good understanding of Physics concepts, the use of toys and educational games in teaching can further enhance their understanding and retention of these concepts, leading to better academic performance.

It's important to note that this statement is based on a specific study and may not necessarily apply to all situations or contexts. However, it does suggest that using innovative teaching methods such as STEM TECHNOLOGY can be an effective way to further improve the academic achievement of high achiever students in subjects like Physics, and not just for struggling students.

It's important to note that this statement is based on a specific study and may not necessarily apply to all situations or contexts. However, it does suggest that using innovative teaching methods such as STEM TECHNOLOGY can be an effective way to support and improve the academic achievement of low-achiever boys in Physics, and that this approach can be more effective than traditional methods.

Thus, it can be concluded that STEM TECHNOLOGY will strengthen conceptual understanding of Physics in students of class IX, to help in holistic development, foster creativity, imagination and enhance the emotional quotient in students ultimately helping them to improve academic achievement. Hand on learning**,** learning by doing, collaborative skills, peer learning helps the learners irrespective of their gender to improve academic achievement. STEM TECHNOLOGY enhances problem solving skills, aesthetic skills, critical thinking among learners as a result their academic achievement increase.

14. Comparison with Previous Research

Different studies have been conducted in the area of STEM TECHNOLOGY and its effectiveness is studied for different types of learners such as Pre service Teachers, Undergraduate students, Pre School Students. Studies were also conducted on effectiveness of toys used in teaching learning process by Science Teachers.

Jarrett and Jafri (2019), had studied Teaching science through toys, both commercial toys and toys children design themselves is an effective and inexpensive way to introduce children to scientific inquiry. In their study on 7^{th} graders they concluded, that most teachers are familiar with simple toys such as Slinkys, spinning tops, balloons, balls, paper airplanes, balancing birds and butterflies, kaleidoscopes, wind-up toys, and pull-back cars. They can easily learn ways to engage children in inquiry through these toys.**Present study** uses different toys for grade IX Physics learners like Wave train model can be used to explain topics like wave, transfer of energy, amplitude, wavelength, nodes and antinodes from Chapter 12.Sound (NCERT SCIENCE TEXTBOOK Class IX), Pendulum Bob Train toy helps students to understand wavelength and velocity of sound relation, Relation between Time period of oscillation and its length. Topics of wavelength and velocity of sound, time period from

Chapter 12.Sound (NCERT SCIENCE TEXTBOOK Class IX) can be easily visualised using Pan Flute Toy and all these toys concluded that STEM TECHNOLOGY will strengthen conceptual understanding of Physics in students of class IX, to help in holistic development, foster creativity, imagination and enhance the emotional quotient in students ultimately helping them to improve academic achievement. Hand on learning**,** learning by doing, collaborative skills, peer learning helps the learners irrespective of their gender to improve academic achievement. STEM TECHNOLOGY enhances problem solving skills, aesthetic skills, critical thinking among learners as a result their academic achievement increase.

Hong-he Gao, Jin-hua Fu, and Xiao-cheng Xing(2020), had studied Research on The Design of Children's Toys and Teaching AIDS Based on Sound Science whereas present study studies effectiveness of STEM TECHNOLOGY on different complex and abstracts topics like Work, Energy ,Power, Sound and Gravitation by developing toys for selected topics for grade IX students.

Elif Ince, Yavuz Acar, Senem Temur(2015), had studied, Physics Toys Effectiveness of Undergraduates' Understanding Physics Principles whereas present study studies effectiveness of STEM TECHNOLOGY on different complex and abstracts topics like Work, Energy ,Power, Sound and Gravitation by developing toys for selected topics for grade IX students.

15. Suggestions for further Research

Here are some suggestions for further research on the effectiveness of integrating STEM TECHNOLOGY in teaching and learning of Physics on academic achievement of students of grade IX studying at CBSE schools:

1. Longitudinal study: Conduct a longitudinal study to determine the long-term impact of STEM TECHNOLOGY on students' academic achievement in Physics. Follow the same cohort of students over a period of time to assess their progress.

2. Comparative study: Conduct a comparative study between students who received traditional Physics instruction and those who received STEM TECHNOLOGY Compare their academic achievements and assess the effectiveness of STEM TECHNOLOGY in promoting student learning.
3. Qualitative study: Conduct a qualitative study to gather in-depth insights into students' experiences with STEM TECHNOLOGY Explore students' perceptions, attitudes, and opinions about the effectiveness of STEM TECHNOLOGY in enhancing their learning of Physics.
4. Teacher training study: Conduct a study to assess the effectiveness of teacher training programs on the implementation of STEM TECHNOLOGY in Physics classrooms. Evaluate the impact of teacher training on student learning outcomes and identify best practices for training teachers to effectively use STEM TECHNOLOGY
5. Cross-cultural study: Conduct a cross-cultural study to examine the effectiveness of STEM TECHNOLOGY in teaching Physics to students from different cultural backgrounds. Compare the academic achievements of students in different cultural settings and explore the impact of cultural factors on the effectiveness of STEM TECHNOLOGY

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