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Innovative Teaching Methodology: A Case of Using Kinesthetic Learning Activity for Teaching Transfer of Heat in Physics in School Curriculum

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Abstract:- The surge in developing concepts rather than being the disseminators of information is the thought reflected in the New Educational Policy 2020, where the National Curriculum Framework emphasises on Outcome Based Education, taking into account all the 6 levels of Bloom's taxonomy to avail the advantage of compassion, empathy and faith which humans possess and is an advantage over AI. The paper evaluates the advantage of the role of Kinesthetic Learning Activity method in understanding basic concepts of Physics over traditional methods. This study was conducted during the year 2023 in two schools in West Bengal on a sample of 39 students on the topic Transfer of Heat for Grade 11 Physics. The samples of students were taught the topic traditionally first, then Kinesthetic Learning Activities were framed and conducted. On the data collected for pre and post KLA statistical analysis was done using SPSS software. The calculated value of t in paired t-test for Transfer of Heat is 15.117 which is highly significant at 1 percent level of significance. Major improvement in post-KLA score is observed which increased from an average value of 9.15 to 21.21 for the topic. Analysis of questions based on 6 levels of Bloom's Taxonomy also showed a major increase in score amongst a majority of students with all taxonomy scoring above 34 on administering KLA .The study clearly shows differences in pre and post-KLA are highly significant. Thus it is concluded that KLA was very effective in teaching the target topics to the target groups.

Keywords:- *Kinesthetic Learning Activity, Physics, Transfer of Heat, Paired T Test*

I. INTRODUCTION

➢ *Education-a General Scenario*

Education has always been the all-encompassing experience which molds human beings into citizens, professionals, innovators and entrepreneurs. A society goes through its phases of growth and transformation through the process of educating its members. The formal education system provides required certification to all young members through various geographies and cultures. The formal education system in our country has always been information dense and theoretical, focusing on norm referenced paper pencil test evaluation. The goal of most students is to score high quantitatively in an examination that can be aced by rote memorisation, leading to a situation where very high scores don't essentially mean a high knowledge quotient.

Till the early years of this millennium, such a scenario didn't become a point of concern as the job market was able to absorb a population with very basic educational skills of the 3Rs reading, writing and arithmetic where the "R's" refer to, "Reading, wRiting, and aRithmetic" (Gafoor and Kottail, 2011). But the scenario drastically changed with heralding of the Information age and the advent of digital technology. Suddenly, it was not just enough for the education system to be the disseminators of information, as that was easily available, just a mouse click away. Thus, memory-based examinations, even with very high scores, were not enough for employment, as those skills were very easily replacing humans with machines. The world sat up and took stock, realising that the traditional format of school education, particularly for the higher classes, will have to undergo tremendous changes. Such thoughts are reflected in the salient features of the New Educational Policy (NEP) 2020 (UGC.gov.in), where the National Curriculum Framework is emphasizing on Outcome-Based Education (OBE), taking into account all the 6 levels of

Bloom's taxonomy (Andersons et. al., 2001) which is no longer a desired direction, but an essentiality, if the human race has to build a future generation that can deal with the challenges of AI, and solve complex problems of human society, with compassion, empathy and faith, three qualities where the human will always be more sensitive as compared to machines.

Bloom's taxonomy (Chandio, et. al., 2016) takes into account educational goals and outcomes across all aspects of the human personality, and that's apt, because an all-round personality development, along with conceptual mastery, is the ultimate purpose of education. Concept development goes through various stages, for effective retrieval and application that include components of comprehension (cognitive domain), interest (affective domain) and strengthening memory with the help of enactment (psychomotor domain). The third domain is generally the one that does not receive much attention as it requires very effective time and space management in the already overburdened education systems. But if utilized well, educational activities designed through the psychomotor domain (Simpson, 1966) can be a game changer in preparing students for future in sciences as well as humanities.

Refering to psychomotor domain it is seen. One learns best by experience, by being involved physically in classroom experiences. There is a group of Kinesthetic Learners (Castolo and Rebusquillo, 2007-2008) who have largely been labelled as disruptive and naughty, mostly unable to settle and focus in traditional classrooms. The present study focuses on methods and plans to engage such students much more in the classroom, and utilise their energy towards better comprehension of concepts, and make them better problem solvers.

- *Education Under the Perspective of the National Education Policy*

The National Education Policy 2020 is embarking on upgrading the education tools used by the educators in the 21st century. For the same the roadmap of pedagogy is distributed in the following innovative pedagogy clusters.

- Blended learning: Rethinking the purpose of the classroom and classroom time,
- Flipped class room: Use of technology and classroom interaction,
- Multi literacies and discussion based teaching: Fostering questioning by critical thinking.
- Embodied learning: Capitalizing on emotions and creativity .
- Experiential learning: Enquiry in complex world,
- Computational thinking: Problem solving approach through logic.

Among different innovative practices which the Ministry of Education is emphasizing, the important approaches are; collaborative approach, reflective approach, constructivist approach, metacognitive approach, E-teacher education approach, value-based approach, blended learning approach, soft skill approach. (MHRD,2021)

Benjamin Bloom in 1956, an educational psychologist at the University of Chicago with his team proposed "The taxonomy of Educational objectives" in the year 1956 which laid the foundation of educational research. Further research in time introduced the "National Education Policy" in 2020 in India and the National curriculum Framework which prescribes the goals and framework of Education that needs to be implemented. This needs intervention in terms of innovation in teaching methodology. Further going deep into teaching Physics in the School curriculum to the students in Senior secondary school in the Science stream having Physics major has always been a challenge for the School educators as there is very little scope of experiments in this level. The abstractness of the Physics topics further adds to the challenges of reaching out to the students. A lot of researchers in Physics probed further for different pedagogical tools to improve teaching Physics in the School curriculum in the senior secondary level for the Science stream students with Physics major. Hence innovative teaching tools need to be researched and identified to make understanding Physics easy in the topics like Transfer of Heat.

- *Kinesthetic Learning Activity – an Innovative Teaching Technique*

Kinesthatic Learning Activity is an innovative learning methodology (Subramani et.al. 2018) that can address many of the shortcomings of the traditional classroom teaching by raising the level of engagement during instruction, and can re-energize a class. These activities engage learning preferences which improves learning outcomes for all students (Mylott, et. al., 2014). KLAs can positively affect the culture of interaction in the classroom, encouraging student participation and collaboration (Bagel, et. al., 2004). There is evidence to suggest kinesthetic learning may prove especially beneficial to psychologically vulnerable students. KLAs draw new ideas in the minds of the students (Honigsfeld and Dunn, 2009) and serve as useful formative assessment tools for instructors, thus helping in monitoring the learning process (MOEGOI, 2021).

And finally, these activities induce great deal of excitement and enthusiasm into the classroom and the topics dealt are etched in their memory (Sweeten, 2017) with clarity and depth.

The minds of students are not like empty vessels (Lynch, 1996). Lynch writes "Giving students different types of activities without exploring their conceptual frameworks poses difficulties for their understanding of new concepts. When children encounter a new concept, they tend to think of the concept in terms of what they already know." Student's prior knowledge has far reaching effects on their learning (Khan, 2004). This reiterates that Kinesthatic activities performed create a prior knowledge in students mind, which would help understand abstract topic better.

- *Research Objectives*

To apply the innovative teaching technique in 'Transfer of Heat' and to analyze statistically the effect of KLA on the Physics topic.

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II. METHODOLOGY

➢ *Sampling*

In a survey (a sample of 39 students) from different schools in West Bengal, Physics has been described as the most difficult subject in Science after Mathematics by the average school students. 44.4% of the students have identified that Physics concepts are very difficult to understand as it involves a lot of assumptions, mathematical deductions and no visualization.

Based on random sampling Techno India Group Academia, Survey Park in South 24-paragana, Techno India Group Public School, Ariadaha in North 24-pargana of class XI participated in this research.

➢ *Identification of an Innovative Teaching Methodology 'Kinesthetic Learning Activity' to Teach a given Topic in the given Subject.*

- *Research Process for Kinesthetic Learning Activity*

In the first stage of research, a workshop of 20 High school Physics teachers was conducted from West Bengal, where they were asked to identify topics in Grade 11 and 12 which were difficult for the children to conceptualize in Physics.

Based on their feedback and literature survey (Viskarta, et. al. 1962) the topic 'Transfer of Heat' of Class XI was taken up for this research.

Second step was to teach the topics in the traditional way.

Third step was to frame a multiple-choice question based testing process covering all six major cognitive skills based on Bloom's taxonomy: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation.

Fourth step was to administer the pre KLA test on the sample of students and collect the data through a Google form.

In the fifth step different kinesthetic learning activities were framed and explained pictorially to the class to introduce the topics in a play way method to the children.

In the sixth step the Kinesthetic learning activities KLA were conducted either in the classroom or in school field or the school staircase on the same sample of students.

In the seventh step the same questionnaire was administered on the sample of students post kinesthetic learning activity and the data post KLA was collected.

In the final lap, the data was statistically analyzed in SPSS software using tools like paired t test to study the effectiveness of the KLA as to how this innovative way of introducing Physics topics through KLA to Senior secondary students help them understand Physics better.

➢ *To Apply the Innovative Teaching Technique KLA in 'Transfer of Heat' and to Analyze Statistically the Effect of KLA on the Topic from Physics Syllabus in Class XI*

'Transfer of Heat' was identified as the target topic to teach the sample of students from Class XI of Techno India Group Academia, Survey Park in South 24-paragana and Techno India Group Public School, Ariadaha in North 24-pargana. Next a multiple-choice question based testing process with 24 questions was framed covering all six major cognitive skills based on Bloom's taxonomy: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Then the pre KLA test was conducted on the sample of students and the data was collected through a Google form.

The next step was to frame different kinesthetic learning activities and explain pictorially the topics "Transfer of Heat" in a play way method. Finally the Kinesthetic learning activities KLA were conducted in the classroom and in the school field on the same sample of students. Here again this was done in multiple small steps. In the first step 10 students performed the activity, while the remaining sample observed. In the second step another group of 10 students performed the next activity, while the others observed. Thus different groups of students performed different Kinesthetic learning activities.

After the KLA was performed, the students made hypotheses and discussed them and made further conclusions. The same 24 multiple-choice questions were again shared to the same sample of students post kinesthetic learning activity and the data post KLA were collected. Next, the data was statistically analyzed by using paired t test to study the effectiveness of the KLA.

➢ *Research Process of KLA for Transfer of Heat*

The Class XI was divided into three groups of 13 students each. They were made to stand in three different lines. The first student of each line had a tag stating HOT, indicating near the heat source and the last student had a tag stating COLD, indicating far away from the heat source. Then the first student with tag HOT was given a red ball each identified as the heat energy.

In the first line the first student passed the ball to the second student, who further passed it to the third student, who further passed it to the fourth student and so on. In this method the red ball (heat energy) reached the last student (Cold) from the first student (Hot) without the actual movement of the students from their place. This KLA explained Transfer of heat by Conduction method where heat is transferred from the hotter region to the colder region without the actual movement of the molecules but with the aid of the intervening medium (Fig-1).

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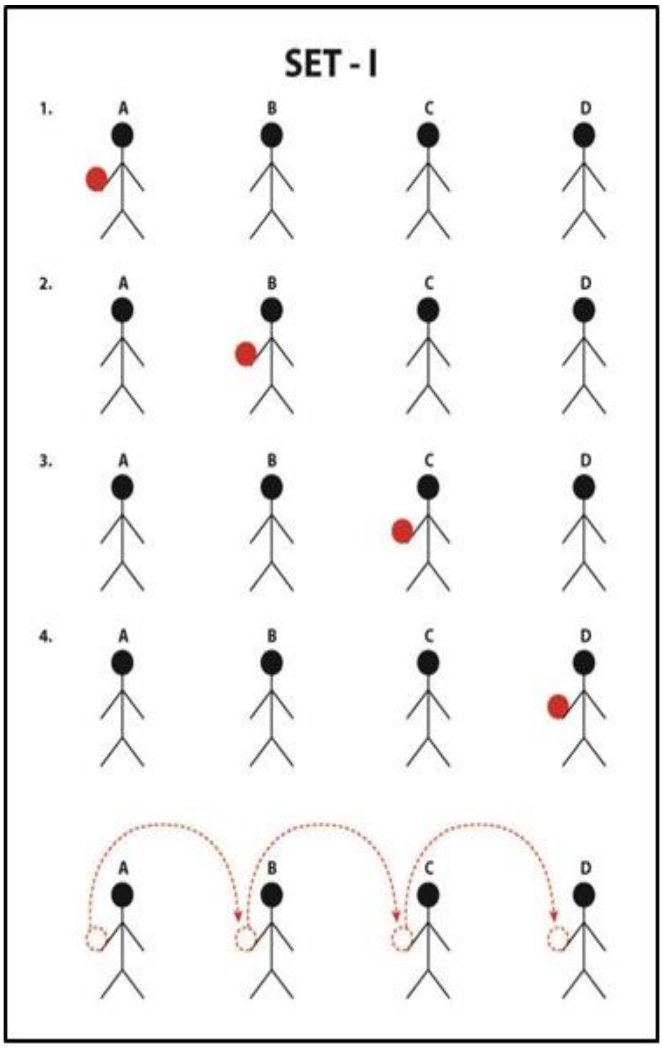


Fig 1 In this Method the Red Ball (Heat Energy) Reached the Last Student (Cold) from the First Student (Hot) without the Actual Movement of the Students from their Place. This KLA Explained Transfer of Heat Through Conduction Method.

In the second line the first student (Hot) took the red ball and traveled to the last student (Cold), hence the place of the first student became vacant. The second student moved forward to take the place of the first student leaving the second place vacant. The third student moved forward to take its place, thus the process continued .In this method the first student (Hot) with the red ball (heat energy) reached the last student (Cold) with the actual movement of the students from their place forming a flow of current, This KLA explained Transfer of heat through convection current, thus explaining transfer of heat through Convection method where heat is transferred from the hotter region to the colder region with the actual movement of the molecules in the form of convection current and with the aid of the intervening medium (Fig-2).

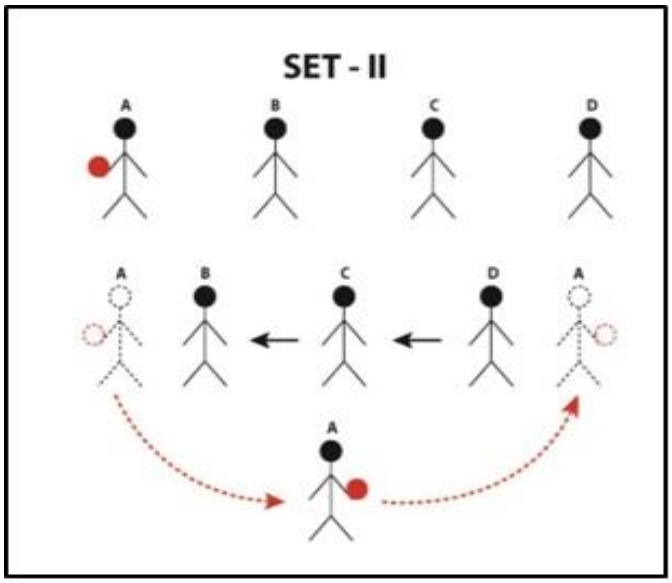


Fig 2 In this Method the First Student (Hot) with the Red Ball (Heat Energy) Reached the Last Student (Cold) with the Actual Movement of the Students from their Place Forming a flow of Current. This KLA Explained Transfer of Heat Through Convection Method using Convection Current.

In the third line the first student (Hot) threw the red ball to the last student (Cold). In this method the red ball (heat energy) reached the last student (Cold) from the first student (Hot) without the actual movement of the students from their place and also without the involvement of the intervening students. This KLA explained Transfer of heat through Radiation method where heat is transferred from the hotter region to the colder region without the actual movement of the molecules and without the aid of the intervening medium (Fig-3).

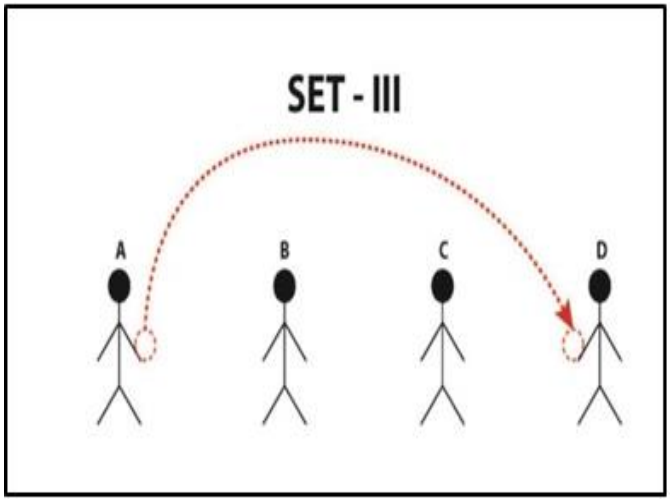


Fig 3 In this Method the Red Ball (Heat Energy) Reached the Last Student (Cold) from the First Student (Hot) without the Actual Movement of the Students from their Place and also without the Involvement of the Intervening Students by Radiation Method.

➢ *Formula in use*

For testing the difference between pre and post KLA, Paired t test which was introduced by W. S. Gosset in 1908 (Amanda Ross and Victor, 2017) is used under the Null Hypothesis, H_o: pre = post. i.e., there is no difference between the mean of pre KLA and mean of post KLA.

The appropriate formula of t in the paired t test is given by

$$t = \frac{\bar{d}\sqrt{n}}{s}$$

Where, $\bar{d}$ = mean of the differences between pre and post score and n is sample number

$$= \frac{1}{n}\sum_{i=1}^{n} di$$

n = number of observations,

s = standard deviation of the difference

$$= \sqrt{\frac{\sum_{i=1}^{n}(d_i-\bar{d})^2}{n-1}}$$

$$= \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - n(\bar{d})^2}{n-1}}$$

Standard Error (SE) = $\frac{s}{\sqrt{n}}$

Confidence Interval (CI) for the mean difference is calculated to know within what limits the true value is likely to lie. The formula at 95% CI is given by

$$\bar{d} \pm t_{5\%}\ \mathrm{SE}(\bar{d}) \text{ for (n-1) df}$$

Where, df is the degree of freedom.

Correlation between pre (x) and post (y) score is given by

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2 \sum_{i=1}^{n}(y_i-\bar{y})^2}}$$

To know the distinct number of sectors, pie diagram is used. The formula to get the angle is

$$\text{Angle} = \frac{Actual\ value}{Total\ of actual\ value} X360^0$$

III. RESULT AND DISCUSSION

Inferring to the literature review, feedback from teachers, focusing into the resources available in the School in India and reflecting on the topics identified in Physics to be dealt with, the Kinesthetic Learning Activity teaching methodology was identified for the topics 'Transfer of Heat' in Physics to a sample of 39 students from different schools in the Higher secondary sections.

➢ *Paired T Test Analysis*

Table 1 Paired Sample Statistics between Pre KLA and Post KLA Marks Obtained by the Students in Transfer of Heat

	Mean	N	Std. Deviation	Std. Error Mean
Post KLA	21.21	39	1.592	0.255
Pre KLA	9.15	39	5.724	0.917

Table 2 Paired Samples Correlation Statistics between Pre KLA and Post KLA Marks Obtained by the Students in Transfer of Heat

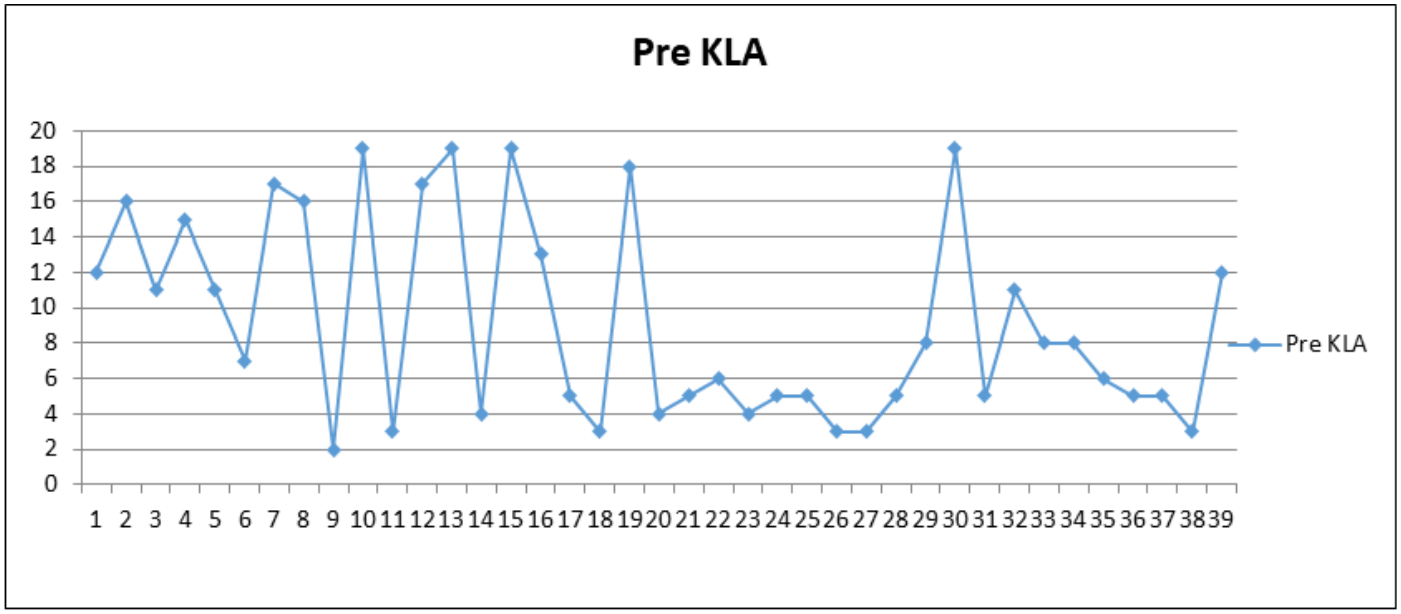
	N	Correlation	Sig.
Post & Pre KLA	39	0.577	0.000

Table 3 Paired Samples Correlations Statistics between Pre KLA and Post KLA Marks Obtained by the Students in Transfer of Heat Paired Differences

	Mean	Std. Deviation	Std. Error Mean	95% C.I. of the difference		t	d. f.	Sig. (2-tailed)
				Lower	Upper			
Post–Pre KLA	12.051	4.979	0.797	10.437	13.665	15.117	38	0.000

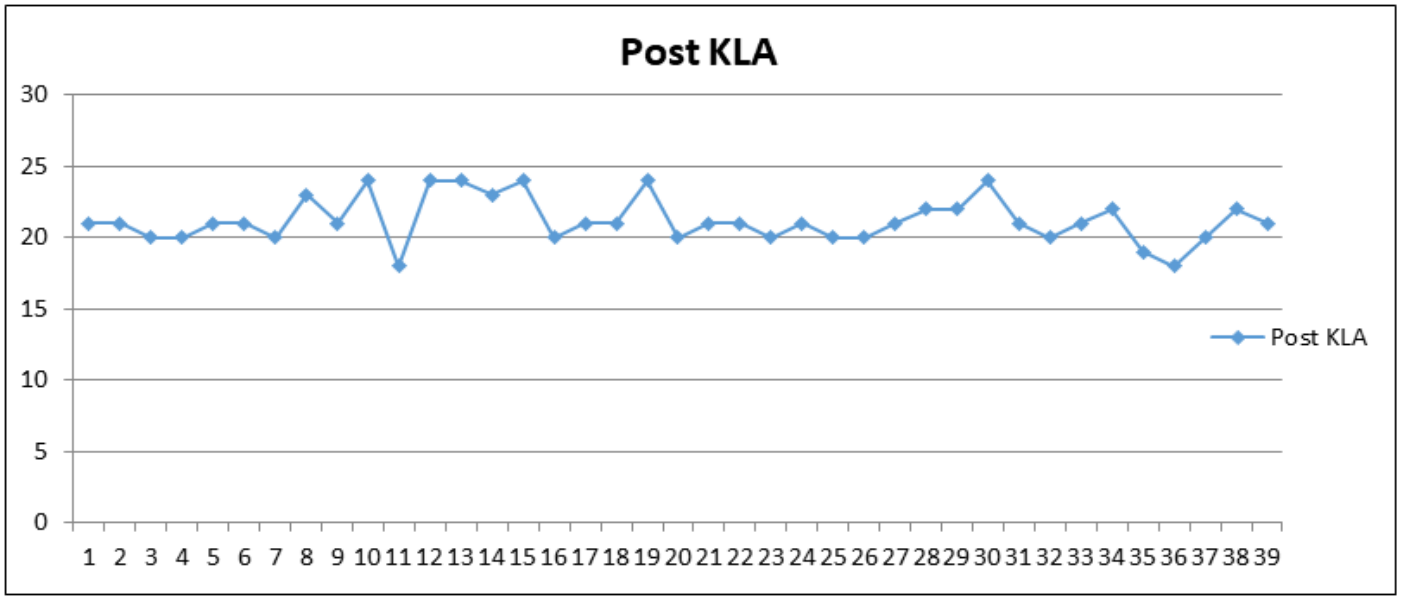
The average paired difference sample is 12.051 and S. D. is 4.979. By comparing between the pre Kinesthetic and post Kinesthetic Learning Activities while dealing with the topic 'Transfer of heat', the value of t is 15.117 which is highly significant at 1 per cent level of significance.

➢ *Graphical Analysis of Score for 39 Respondents*
Two line graphs were drawn based on the data:



Graph 1: Independent axis of Pre KLA: Number of Respondent

➢ *Dependent axis : Total score of Respondents Pre KLA*



Graph 2: Independent axis of Post KLA : Number of Respondent

➢ *Dependent axis : Total Score of Respondents Post KLA*

Since the experiment was performed in the same class which consisted of 39 students, the number of respondents were the same Pre KLA and Post KLA. It is observed that Pre KLA scores varied from two out of twenty four to nineteen out of twenty four. However, Post KLA scores varied from eighteen out of twenty four to twenty four out of twenty four. This proved that the KLA method of treating the topic was highly effective.

➢ *Analysis of Question for all 6 Bloom's Taxonomy Levels*

All the 24 questions were analyzed further and the percentages of students responding correctly were found and a pie chart to analyze the number of respondents answering different questions was drawn Pre KLA and Post KLA (Table 4).

The following observations were highly significant based on the 6 levels of Bloom's Taxonomy: Remember, Understand, Apply, Analyze, Evaluate and Create.

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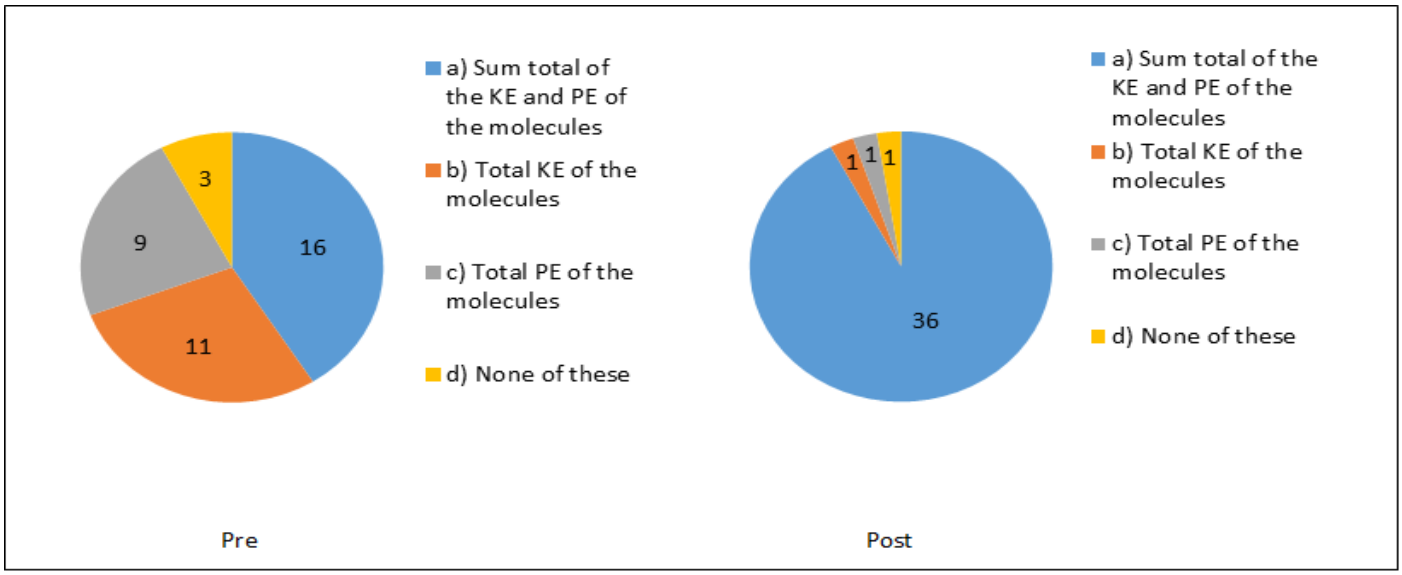
Table 4 Analysis of Questions based on 6 Levels of Bloom's Taxonomy

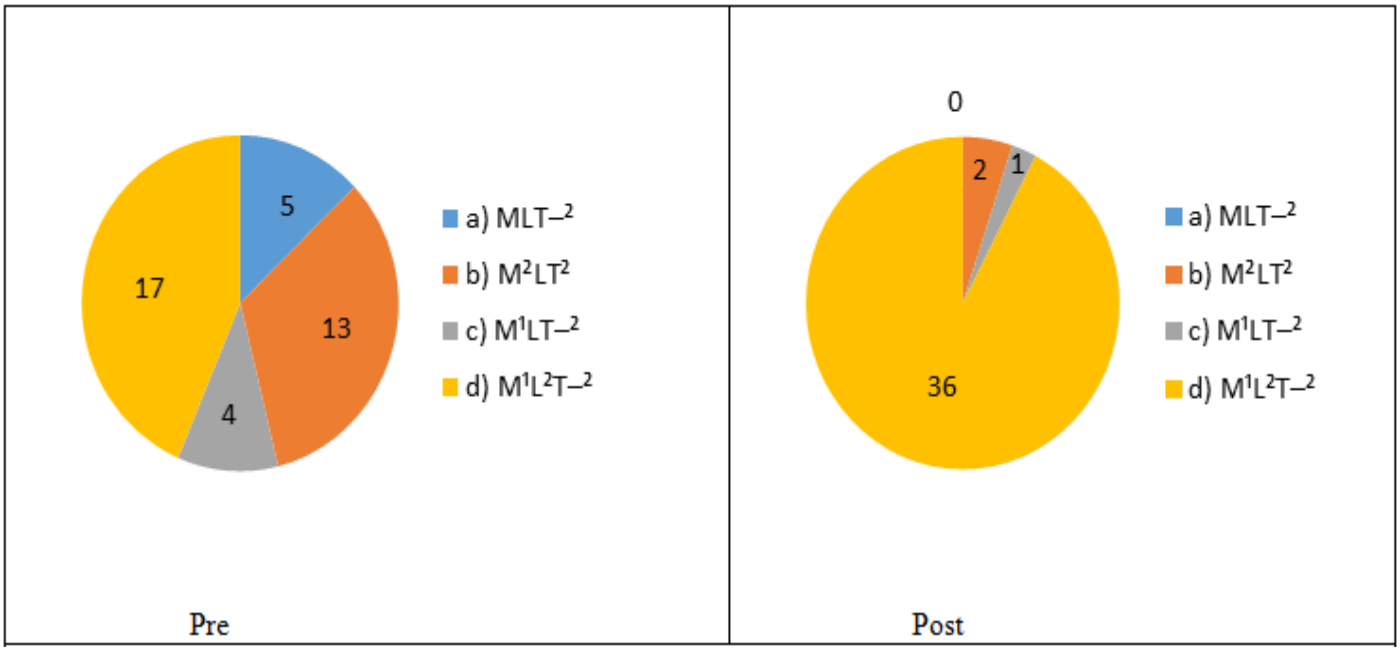
Serial no.	Level of Taxonomy	Q. no.	Question	No. of respondents answering correctly Pre KLA	No. of respondents answering correctly Post KLA	Analysis remarks
1	Remember	3	What is the definition of Heat?	16	36	Even the knowledge based question could be recalled post KLA by more students
	Understand	1	Derive the dimension of Heat from its definition.	17	36	Based on the understanding of the knowledge developed about Heat, the dimension could be derived.
	Apply	6	Heat transfer takes place according to which of the following law?	17	34	The respondents could apply the previous knowledge of the Law of Thermodynamics to the transfer of heat post KLA better.
	Analyse	8	Which of the following is an example of steady-state heat transfer?	17	37	Of the given examples analysing the steady state example was better done post KLA
	Evaluate	7	Which of the following is the rate of heat transfer unit?	19	34	Using the understanding from point.2 evaluating the rate of heat transfer was easier post KLA.
	Create	16	Why are fins provided on a heat transfer surface?	8	35	Respondents worked on the design of the fins and could relate to it better post KLA

Based on the base level of 'Bloom's taxonomy', REMEMBER, the question 'What is the definition of Heat?' was asked. Among the 39 respondents in Pre KLA sixteen students answered option (a), eleven students answered option (b), nine students answered option (c), three students answered option (d). Of these options, option (a) was correct. Post KLA thirty six out of thirty nine students answered the correct option (a). The findings are shown in the pie diagram [Graph 3].



Graph 3: Graph of Bloom Taxonomy of REMEMBER

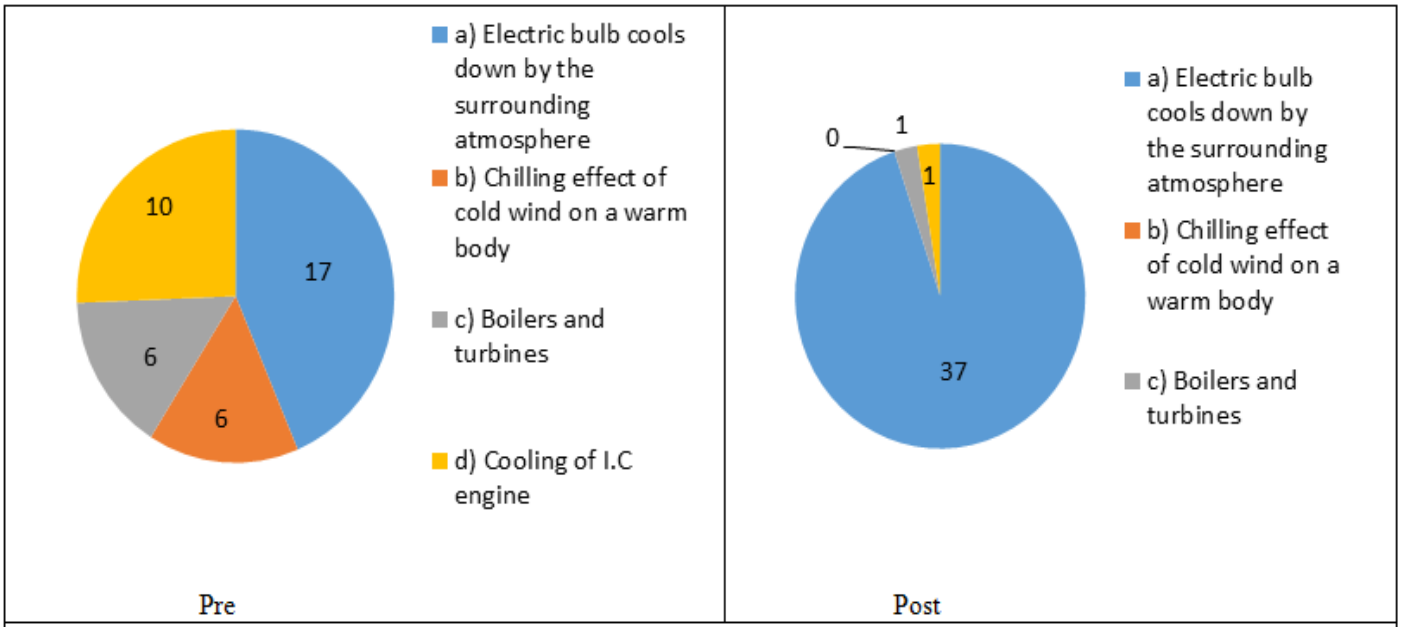
The second level of 'Bloom's taxonomy' is based on UNDERSTANDING, the question 'Derive the dimension of Heat from its definition.' was asked. Among the 39 respondents in Pre KLA, five students answered option (a), thirteen students answered option (b), four students answered option (c), and seventeen students answered option (d). Of these options, option (d) was correct. Post KLA thirty six out of thirty nine students answered the correct option (d). It is shown in Graph number 4.



Graph 4: Graph of Bloom Taxonomy of Understanding

Graph 5 is based on the third level of 'Bloom's taxonomy', APPLY, the question does Heat transfer take place according to which of the following law?' was asked. Among the 39 respondents in Pre KLA three students answered option (a), eleven students answered option (b), eight students nswered option (c), and seventeen students answered option (d). Of these options, option (d) was correct. Post KLA thirty four out of thirty nine students answered the correct option (d).

On the fourth level of 'Bloom's taxonomy', ANALYZE, the question 'Which of the following is an example of steady-state heat transfer? ' was asked. Among the 39 respondents in Pre KLA seventeen students answered option (a), six students answered option (b), six students answered option (c), and ten students answered option (d). Of these options, option (a) was correct. Post KLA thirty seven out of thirty nine students answered the correct option (a) which is shown in graph 6.



Graph 6: Graph of Bloom Taxonomy of Analyze

Graph 7 shows the fifth level of 'Bloom's taxonomy', EVALUATE, the question 'Which of the following is the rate of heat transfer unit? ' was asked. Among the 39 respondents in Pre KLA eight students answered option (a), six students answered option (b), nineteen students answered option (c), and six students answered option (d). Of these options, option (a) was correct. Post KLA thirty four out of thirty nine students answered the correct option (a).

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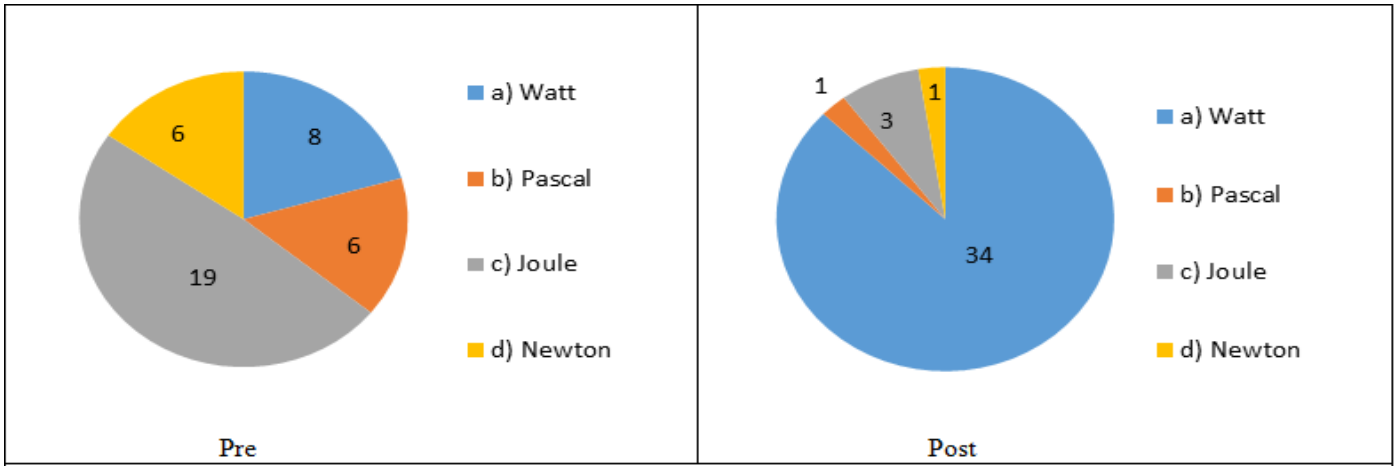
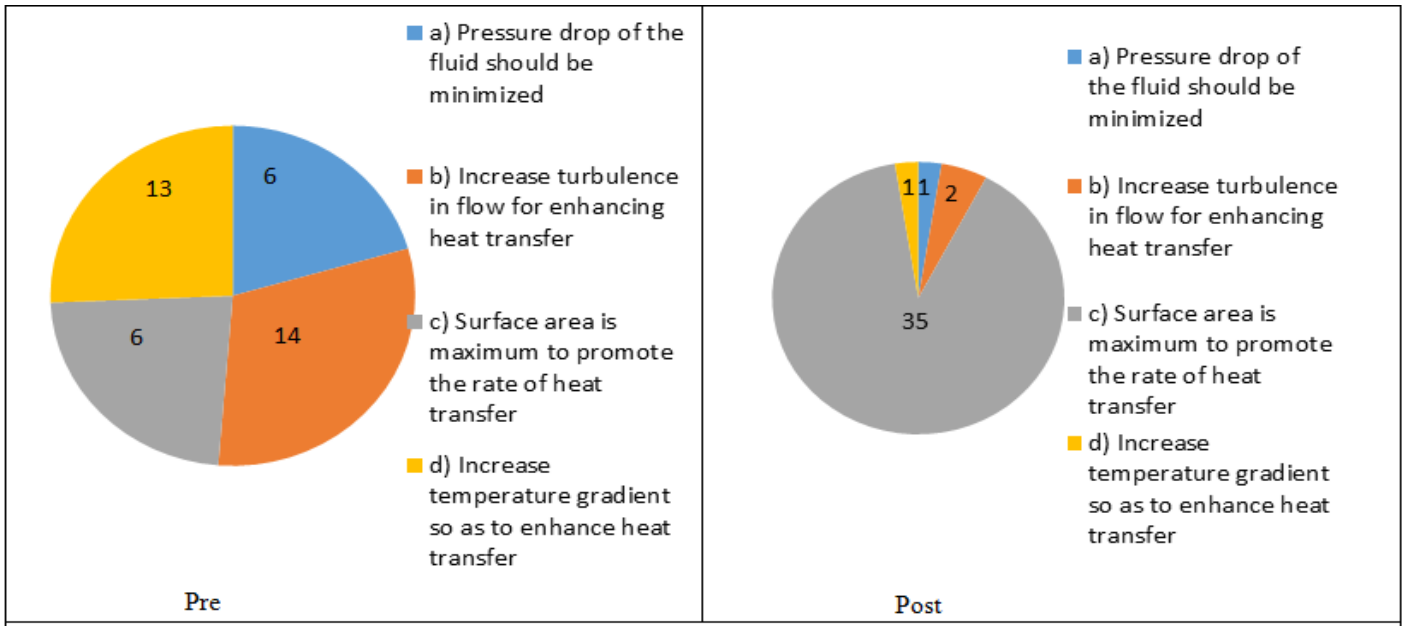


Graph 7: Graph of Bloom Taxonomy of Evaluate

Graph 8 is the sixth level of 'Bloom's taxonomy', CREATE, the question 'Why are fins provided on a heat transfer surface?' was asked. Among the 39 respondents in Pre KLA six students answered option (a) i.e., pressure drop of the fluid should be minimized, fourteen students answered option (b), increase turbulence in flow for enhancing heat transfer, six students answered option (c), i.e., surface area is maximum to promote the rate of heat transfer and thirteen students answered option (d) i.e., increase temperature gradient so as to enhance heat transfer. Of these options, option (c) was correct.



Graph 8: Graph of Bloom Taxonomy of Create

IV. CONCLUSIONS

Statistical analysis while teaching the Transfer of Heat through KLA method gave the following result.

The average mean of the Post and Pre KLA score are 21.21and 9.15 with their respective standard deviations 1.592 and 5.724. Pre and post KLA score is correlated which is proved by correlation value $r=0.577$, $p<0.01$. The average paired difference sample is 12.051 and S. D. is 4.979. By comparing between the pre kinesthetic and post Kinesthetic learning activities for the topic Transfer heat, the value of t is 15.117 which is highly significant at 1 per cent level of significance. All six levels of Blooms Taxonomy received a higher score, hence a higher understanding is observed by introducing the Kinesthetic Learning Activity method in teaching Physics. The number of respondents accepting the question based on 6 taxonomy level also improved largely with 'Remember', taxonomy hitting a high of 36 from 16, understanding reached 36 from 17, Application reached 34 from 17, Analyses reached 37 from 17, Evaluation reached 34 from 19 & Creation reached a high of 35 from 8.

From the above discussions we can say that kinesthetic learning activity (KLA) is highly effective in teaching Transfer of heat, which has been identified as the very abstract concept in Physics in School curriculum. This research has shown that the effect of KLA makes a significant contribution to general and conceptual understanding of the concepts of Physics based on the Transfer of heat.

It is further observed that by incorporating experiential learning activities into the lesson plans, students found it easier to recognize concepts being taught and remained focused longer by switching class activities from regular instruction to experiential learning. And finally, these activities induce great deal of excitement and enthusiasm into the classroom and the topics dealt are etched in the memory with clarity and depth.

As is seen in the present study and some other studies as well, though not much work has been done in India as yet on this concept, Kinesthetic learning methodology can be revolutionary, when it comes to creating interest and scholarship amongst students who are not natural high scorers, who avoid engagement due to a variety of reasons, most prominent of them being the fear of rejection and ridicule. Particularly notable is the fact that these are senior secondary school students who are learning topics in Physics considered rather difficult to grasp. This kind of learning takes them very close to everyday life experiences, thus making them want to get involved, be proactive in class activities and conceptualize even abstract topics with a permanent mind mapping.

- *Scope For Further Research*

This interactive nature of KLAs makes it is a valuable tool for "content-related" exercises and understanding ambiguous topics in a play way method. The KLA method of teaching can also be used to address social challenges faced by any classroom or society. Thus we can further research with topics like Thermodynamics and Waves in Physics to be introduced to students in School curriculum.Further problems identified while conducting the KLA method of teaching in Physics can be researched and statistically analysed.

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