Understanding Euler's Formula through Electrical Device

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Abstract- *ICT integration is to use ICT to introduce, reinforce, supplement and extend skills. It stimulates and motivates students, provides comfortable learning aids to understand the difficult concepts and processes It caters to different learning styles and helps students to gain knowledge of new technologies. Teaching modern techniques and technologies to the students enhances their creativity and innovation to develop tools to find solution of daily life problems. These type of activities increase the interests of the students in the class and break the monotony and boredom of the topics.*

The knowledge of robotics provides them not only a tool to give shape to their imagination but also the knowledge of advance technologies at this young age. As a part of Practical introduction to Robotics students watched some videos of robotics based equipments during Environment Awareness classes. These videos depicted the innovative methods developed by some students (other) and professionals to overcome some or the other daily life problems. Teacher found some of the students interested and enthusiastic to develop such type of instruments. That's why the basics of robotics were introduced and hands on experiences were given of bread board circuits, software, coding, AI, programming and inserting artificial minds for desired output by the devices.

A study was conducted through questionnaire to observe the learning outcome of these technical activities which showed that 70% of the students were very much enthusiastic about the techniques, out of which 60% of them were able to understand the basics of the technology and 40% were able to develop such devices which include – soil humidity testing device, smoke detector, water level indicator etc.

Key Words – Robotics, innovation, technology

Introduction

We have some set equipments also like 'Ganitmala', 'Dienes cubes', 'Fractional Kits' to perform different activities. Students use them and the concept is being understood successfully.

These kits cover the concepts like fractions, decimals, mensuration and a couple of more concepts. While doing the chapter 'Visualizing Solid Shapes', I showed them 3-D shapes like pyramids, cylinder, cone, cube, cuboids, etc. and the students recognized them. Euler's formula of polyhedron was taught in the class and I had to take an activity on this topic.

I conducted the activity in the Maths Lab asking some questions related to the faces, vertices and edges of the polyhedrons. (Questionnaire is attached) Euler's formula is a very simple formula which involves some basic mathematical operations. I was quite surprised by the result as the concept has been taught in the class and is also a simple one. I didn't have any resource or equipment in the lab to explain the topic precisely, so I decided to develop some tool so that the students can find it interesting and shall be able to understand the formula rather than cramming it. I discovered that by using a simple circuit, the equipment can be structured. By entering pre-decided values of faces, edges and vertices, the output will identify the polyhedron to be formed. It will also show whether a polyhedron will be formed or not?

I drafted a rough sketch of the circuit, placed the equipments, and analyzed its feasibility. My first experiment was done with three well-known polyhedrons – Cube, Cuboid, and Cone. As I didn't have switches, it was done by inserting wires only. Then I modified it and increased the number of entries. My student, Harshit Nayak, of Class 8, helped me to complete the complex circuit.

After testing it, I carried it to my class. It was a great excitement for all of us. I introduced the equipment to the class and depicted its working to the students. Being an electronic device, it was an attraction to all the students due to its appearance and function. Students happily tested it and tried different combinations.

Methodolgy

When it was observed in the Lab period, that almost 64% of the students are not able to answer the Euler's formula correctly, the teacher organized a written assessment.

Students of class 8, 13 years of age, tend to peep into the peer's copy to get good marks. It was discussed with the students that it is an experiment and later they will be shown an interesting equipment on this. They were thus instructed to be wise, read the question carefully and without discussing it with anyone, attempt the test.

The answer sheets were checked and it was assumed that students have attempted it wisely though there is still a 10% chance that students would have copied. After keeping the result secure, the students who had attempted the test wrong were introduced to the device. A set of questions, like the previous one, was given again to the students. The questions were based on the relation between faces, edges and vertices using mathematical operations satisfying the Euler's formula. Also to find out third dimension if the other two are given and also to identify whether the given dimensions satisfy the Euler's formula or not.

During discussion it was observed that:-

- Some students have forgotten the formula as the concept was taught a fortnight back.
- Students find the three dimensions a bit confusing.

The experiment was done with the students who were not able to give correct answers. The experiment was done on the basis of following parameters:-

- Retaining the formula
- Being able to recognize the correct mathematical operations between three parameters – faces, vertices and edges.

As we know and would agree that hands on experience always allow the students to retain the concepts. It enhances the interest of the student. Since I have always relied upon the efficacy of 'learning by doing' approach. I employed the idea of introducing the Hands-on activities to the students. It not only makes the whole process interesting and interactive but also enhances the possibility of deeper conceptualization and longer retention. Also this cognitive learning makes it convenient for the learners to interpret and elaborate the concepts in their language in an emphatic and confident manner. Keeping this in mind, an electronic device is developed. The device contains two columns:-

- With correct mathematical operations between the three dimensions
- With incorrect mathematical operations between the three dimensions

The students had to try both the cases. A bulb attached to the circuit glowed when correct formula was applied. The students tried it and were able to understand the relation. Also the devices were developed for different values of faces, vertices and edges to give practice to the students.

This method was selected due to the following reasons:-

- Hands-on impacts were seen more precisely on the students.
- Electrical circuit due to its appearance enhances the interest of the students.
- It increases creativity as students try more and more combinations to achieve the correct result.
- Glowing of bulb on correct answer, helps to interpret the correct values and mathematical operations between the three input values.

Method of Testing

The questionnaire given both, pre and post, experiment was in the form of multiple choice questions. Multiple Choice Questions provide a range of answers, which enables the students to find the correct answer with accuracy.

Result/Findings:

The experiment was conducted because the students were finding problem in understanding and retaining the mathematical operations between the three parameters – faces, vertices and edges of a polyhedron.

The problem was observed during the Maths Lab period. Euler's formula is introduced in class 8 to find whether given values of faces, edges and vertices form a polyhedron or not. It was observed that students were getting confused and were making mistakes while writing the formula.

It was observed on the basis of the analysis of students' performance in understanding Euler's formula that the very formula was not actually conceptualized by the students. It remained an abstract idea to them as they could not delve deep into the functional aspects of the very formula. They all just tried to cram it up. This rote learning never made them comfortable with Euler's formula and thus all mistakes were being made by the students.

The first written test containing three multiple choice questions was conducted and the result was:-

- 64% students were not able to identify the correct formula.
- 30% students could not solve the simple algebraic equation.
- 6% students did not attempt.

Knowing the correct formula was a problem for the students. To overcome this challenge the focus was shifted from theoretical learning to practical learning. The cognitive activities were invited and involved in the process of thinking about making a device which could assist in understanding the Euler's formula. It was collectively decided that something can be and should be worked around electronics, the wires, the LED lights, simple circuits – boards etc. That's how the foundation of the discovery of the device was laid. This all brain storming and interactive discussion led to the structuring of the electronic device, which was assumed to become an effective teaching – learning tool for an in – depth learning, understanding and conceptualization of the Euler's formula.

The introduction of the self –created Electronic device changed the environment of the class in a very positive and productive manner. All the students were charged and excited about the device and it so very much made the difference. Even the students who could not understand the Euler's formula originally were equally a happy lot.

Our device, even before it was used created a positive impact upon the students by enhancing their interest in understanding Euler's formula in a different light. The students of the class were distributed in small groups and each group was allowed hands on exposure to the device. It all was so exciting to them. A modus – operandi was discussed with the students and they were instructed to input different readings and analyse the output. The device was found quite successful as it called for participation from each and every student and the euphoria around the device extracted better focus and consequently better results in terms of the understanding and conceptualization of the Euler's formula.

The 64% students were exposed to the electronic circuit device. They tried and checked their answers by putting the values and obtaining the output. It was observed that the concept was taught around a fortnight before; the post-experiment test was conducted around 10 days after.

The result was

- 34 out of 64 answered the correct option and put the correct values.
- 15 solved correctly with correct formula.
- 19 chose the correct option of the formula but solved wrong.
- 30 students needed more practice.

Around 40% of the students succeeded in the test.

The graphs are plotted between:-

- Percentage of success in retaining the formula
- Percentage of success in writing the correct formula and solving the formula correctly to solve identification.
- Percentage of writing correct formula and solving wrong

Here the result shows that hands-on activities enhance the learning process and help the students to understand the concepts in a better way. It increases the interest of the students in the subject. As the device is not that complicated and is developed using the simple concept of electric circuit, students were able to do it easily.

In the beginning the device was given two options of the formula but after observing the interest of the students, modifications were done and other small components were developed to check different values of the parameters of the polyhedron.

Discussion/Analysis

The basic objective of postulating this novel way of teaching Euler's formula through this electronic device is to ensure that students should develop a firm grasp of the concept of the Euler's formula in such a way which is deep and lasting. The concept is assimilated in the students' mind to that extent that there remains no need to categorically learn it.

The reasons of the study conducted include the following points:-

Practical relevance of the formula

Euler's formula is an important formula in geometry which describes whether the formation of a polyhedron is possible or not. It is introduced in class 8 in the chapter 'Visualizing Solid Shapes' to understand 3-D shapes and its formation. It is very important for a child to understand the formula to know the formation of 3-D shapes. This formula also helps in forming nets to make a 3-D shape. Nets comprise the number of parameters such as faces, edges and vertices. If the

values are not taken correctly, a correct net will not be formed hence the 3-D shape of polyhedron will not be constructed.

Problems faced by the students

It was observed that students got confused in applying mathematical operations between three parameters. Due to this they were not able to write the correct formula. Also some students faced problems when it took the form of simple integer problem.

Losing Interest

It's very common that if students are not able to solve any problem they lose interest due to failure. Some interesting activity is always required in the class to bring the interest of the students back and to increase their concentration. Experiments and hands on activities break the monotony of the class and keep the students away from boredom.

Solutions of the problems of the students

To draw the student's interest and to make the concept clear, some attraction was required and this gave birth to the idea of developing this device. The idea of making device was discussed with the senior Maths teacher in the school. She agreed with the idea of making and using the device. The reason behind selecting an electrical circuit is that it is very easy to operate as students are very familiar to it. Also when bulbs glow in the circuit for a correct answer, students remember it. Students were very excited while using the device, even the students those who were least interested in the topic earlier, seemed to be excited and eager to do the task. During verbal discussion about the impact of the device, students gave the positive response and showed their excitement by using it more than one time. It is clearly evident from pre and post written tests that the device has helped the students to retain the correct formula. 40% students showed that they have answered correctly which is a significantly positive outcome.

In the beginning the device was constructed for two options of the formula only. Observing the interest, curiosity excitement and success in the result, it is developed to identify the values of edges, faces and vertices for a particular polyhedron.

Pre experiment data collection

Three multiple choice questions were given to the students to choose the correct option. Multiple options were given to widen the range of choosing the answer. 64 out of 95 of the students attempted the wrong option for the question no-1 where they had to choose the correct formula. Because of wrong selection of the answer they could not attempt the other questions correctly as they were based on the formula only. After discussing with the students it was noted that there were main two reasons of attempting the wrong answer-

- As the formula involves three variables – faces, vertices and edges and two mathematical operations which confuse the students and make it difficult for them to remember it.
- Students could not revise as test was not declared earlier.

The latter reason listed above can be solved but for the first reason it is required to have some effective method. According to frame work -2005 hands- on activities improve the interest of the students and help them to understand the concept/topic easily. It is evident during maths lab period and by using ready-made maths equipment that students remember the concept for longer duration when they are taught in this way.

Construction of device

When no readymade device was found to teach Euler's Formula and to check the answer, concept of simple circuit was used to develop the device. This simple device contains two parts, one has the correct formula - F+V–E = 2 and the other one is F-V+E =2. Six push buttons are there, three for each equation. A bulb is connected as output .Bulb glows for the correct option only.

Effectiveness of the device

The electronic device was a basic assembly of those components which were pretty known to the students in advance. The device consisted of LED bulbs, switches, battery, wires and the bread board. So despite the device, which was structured anew, the students were not totally clueless about its functioning because the components of the device were known to them. It was the application of the Euler's formula which they wanted to witness through the device. The 'Look and feel' of the device was well – taken by the students and they took turns to put their hands upon the device.

Every student was allowed to insert their input values for both the options and check the output in the form of glowing or not glowing of the bulb. Overall it was a highly charged up practical session where students successfully learned the Euler's formula.

Students inserted their inputs for both the options and received the answers. They enjoyed the class.

Post experiment result

The test was again conducted after 10 days. The questionnaire for this part contained three multiple choice questions. It was observed that there is 40% accuracy was there this time.

Modifications

It was observed that the use of device made the class lively and students were happy and stress free. They received the instant output for their input values. They enjoyed the hands on experience. The learning atmosphere of the class helped them to retain the formula and did not allow the confusion to get into their minds. Other devices were also developed after this due to curiosity and excitement of the students. These devices includes-

- Checking with values of the parameters in the formula whether it is possible to form a polyhedron or not.

- If two values are given, can they find the third one?

Overall it was a nice experience and a perfect method for making the class lively and stress free.

Conclusion

The basic objective of this whole exercise was to maximize the learning outcome by overcoming the abstractions which are, at times there in several key concepts of mathematics. The natural revulsion towards these relatively complex topics reduces the interest towards the subject among the students.

The development of 'Electronic Device' in understanding the Euler's formula countered both the aforementioned challenges in a very effective and result-oriented manner. Firstly, the complexity due to the abstraction was simplified in a manner that it attracted an eager and enthusiastic participation from all the students and especially from those who found Euler's formula as a boring, difficult and 'avoidable' topic. Secondly, the employment of this Audio-Visual teaching aid brought back the excitement part in teaching-learning process which successfully yielded the desired results.

Summing it up, it was a hugely satisfying and motivating experience for me in taking my teaching to a next-level solely by virtue of a terrific team effort. I do foresee the need of coming up with similar solutions as there are problems which are observed among students in understanding topics like 'Linear Equations in One Variable' and 'Integers'.

Looking forward! Thank you all.

Euler's Formula
Assessment (Pre Assessment)
Class VIII

1 Identify the Euler's Formula.

a) F + V – E = 2 b) F + E – V = 2 C) V – F+ E= 2 d) F – V – E =2

2 Complete the Table:- (Identify whether a polyhedron will form or not)

F	V	E	YES/NO
6	10	8	
20	12	30	
4	4	2	
4	8	4	

3 Complete the Table :- (Find the Missing Values)

F	V	E
6	8	
	4	12
8		6
4	12	

Euler's Formula

Assessment (Post Assessment)

Class VIII

1. Tick the correct one:-

a) F - V + E = 2 b) F + V – E = 2

2. Fill in the blank:-

- F = 4, E = _____ , V = 6
- E = 24, F = _____ , V= 16
- V = _____, E = 8 , F = 4
- V = 12 , F = _____, E = 8

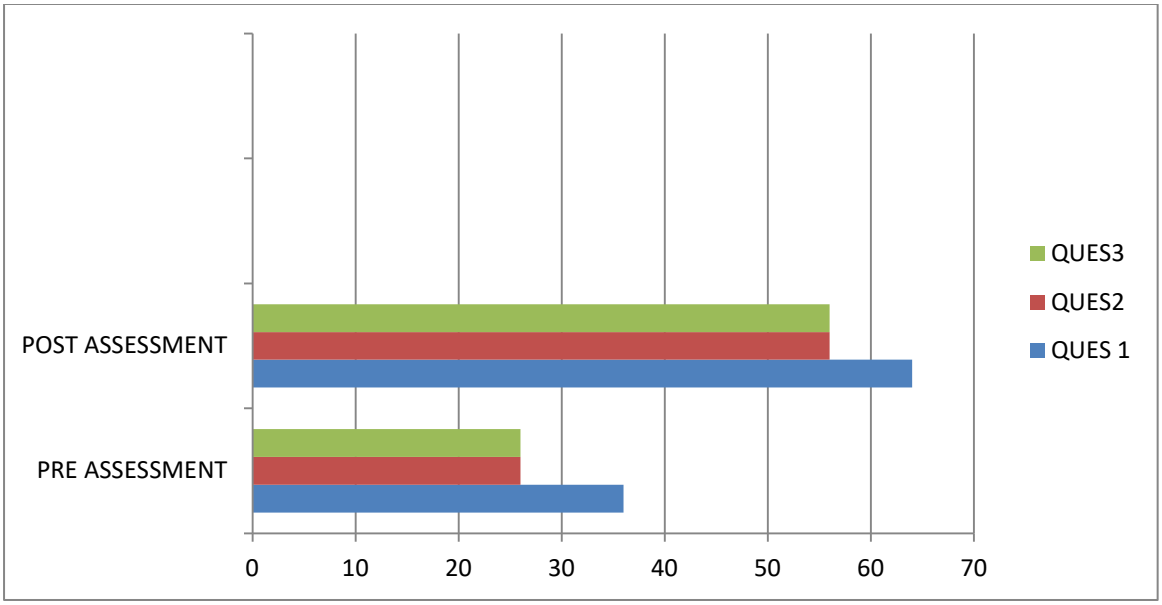
3. Answer these

- Is it possible to make a polyhedron with 12 faces, 16 edges and 4 vertices?
- During maths lab activity Ravi is trying to form a polyhedron with 5 faces, 9 edges and 5 vertices. He could'nt form despite of trying so hard. Please find the error and correct it.
- What should be the correct combination for making a perfect polyhedron?

Comparative Study						
	Pre Assessment			Post Assessment		
Name Of The Student	Question 1	Question 2	Question 3	Question 1	Question 2	Question 3
Reshma	No	No	Na	Yes	Yes	Yes
Samvrita	No	Na	No	Yes	Yes	Yes
Sumit	Yes	Na	Yes	Yes	Yes	Yes

Aman	Yes	Na	Yes	Yes	Yes	Yes
Shivani	No	No	No	Yes	Yes	Yes
Kritika	No	No	No	Yes	Yes	No
Adarsh Sh.	Yes	Yes	Na	Yes	Yes	Yes
Dheeraj	Na	Na	Na	Yes	Yes	Yes
Arnav	No	Na	Na	Yes	Yes	Yes
Piyush	Na	Na	Na	Yes	Yes	Yes
Priyanshi	No	No	No	Yes	Yes	Yes
Bhoomika	No	No	No	Yes	Yes	Yes
Lokesh	Yes	Yes	Na	Yes	Yes	No
Arsh	Na	Na	Na	Yes	Yes	Yes
Shreya	No	No	Na	Yes	Yes	Yes
Daksh	Yes	Na	Na	No	No	No
Pardeep	Na	Yes	Yes	Na	Yes	Yes
Himanshu Yadav	Yes	Yes	Yes	Yes	Yes	Yes
Navneet	No	No	No	Yes	Yes	Yes
Sayed	No	Na	Na	No	No	No
Yogita	No	No	No	Yes	Yes	Yes
Zaib	No	No	No	Yes	Yes	Yes
Ravi	Yes	Yes	Yes	Yes	Yes	Yes
Pranay	Yes	Yes	Yes	Yes	Yes	Yes
Chirag	No	No	Yes	Yes	Yes	Yes
Kashish	No	No	No	Yes	Yes	Yes
Yatin	No	No	No	Yes	Yes	Yes
Jishan	No	No	No	Yes	Yes	Yes
Priya	No	No	No	Yes	Yes	Yes
Lalit	Yes	Yes	Yes	Yes	Yes	Yes
Affan	Yes	Yes	Yes	Yes	Yes	Yes
Taran	No	No	No	No	No	No
Akshika	No	No	No	No	No	No
Sanyam	No	Yes	Yes	Yes	Yes	Yes
Ayush K	Yes	Yes	Yes	No	No	No
Kabir	Na	Yes	Yes	Yes	Yes	Yes
Nikhil	No	No	No	Yes	Yes	Yes
Divyanshu	No	No	No	Yes	Yes	Yes
Ayush Kushwaha	No	Yes and No	No	Yes	Yes	Yes
Yogita	No	No	Yes	Yes	Yes	Yes
Pratha	No	No	Yes	Yes	Yes	Yes
Aditya T	No	No	No	Yes	Yes	Yes
Nadeem	No	No	No	Yes	Yes	Yes
Anirudh	No	No	No	Yes	Yes	Yes
Ravi	No	Yes	Yes	Yes	Yes	Yes
Shubham S	No	No	Yes	Yes	Yes	Yes

Vaibhav R	No	Yes	Yes	Yes	Yes	Yes
Ayush K	No	Yes	Yes	Yes	Yes	Yes
Srishti	No	No	Yes	No	No	No
Ashish Omm	No	Yes	Yes	No	No	No
Gaurav	No	No	No	No	No	No
Angith	No	Yes	Yes	No	No	No
Masoom	Yes	Na	Yes	No	No	No
Mridul	Yes	Yes	Yes	Yes	Yes	Yes
Khushi	No	No	No	Yes	Yes	Yes
Anshika	No	No	No	No	No	No
Anvi	Yes	No	No	No	No	No
Mohit M	No	No	No	Yes	Yes	Yes
Devansh T	No	No	No	No	No	No
Khushi	No	No	No	No	No	No
Srivasu	Yes	Yes	Yes	Yes	Yes	Yes
Suraj	Yes	No	No	Yes	Yes	Yes
Kiran	Yes	No	No	No	No	No
Himanshu S	Yes	Yes	Yes	Yes	Yes	Yes
Abhinav	Yes	Yes	Na	Yes	Yes	Yes
Ayush D	Yes	Yes	Yes	Yes	Yes	Yes
Divyam	No	No	No	Yes	Yes	Yes
Ritesh	No	No	Na	No	No	No
Kripa	Yes	No	No	Yes	Yes	Yes
Ritik	No	No	No	Yes	Yes	Yes
Shivam	No	No	Yes	Yes	Yes	Yes
Piyush	No	No	No	Yes	Yes	Yes
Daksh	No	No	No	No	No	No
Kunal	No	No	No	Yes	Yes	Yes
Saurabh	No	No	No	No	No	No
Yashu	Yes	No	No	Yes	Yes	Yes
Sika Bhati	No	No	No	No	No	No
Iqra	No	Yes	Yes	Yes	Yes	Yes
Anubhav	No	No	No	Yes	Yes	Yes
Sahaj	Yes	No	No	No	No	No
Harsh	No	No	Yes	No	No	No
Kushal	No	No	No	No	No	No
Anushka	No	No	No	No	No	No
Sneha	No	No	No	Yes	Yes	Yes
Tanishq	No	No	No	Yes	Yes	Yes
Krish	No	No	No	Yes	Yes	Yes
Vaibhav	No	Yes	Yes	No	No	No
Aditya	No	Yes and No	Yes	Yes	Yes	Yes
Riyanshu	No	No	Yes	Yes	Yes	Yes



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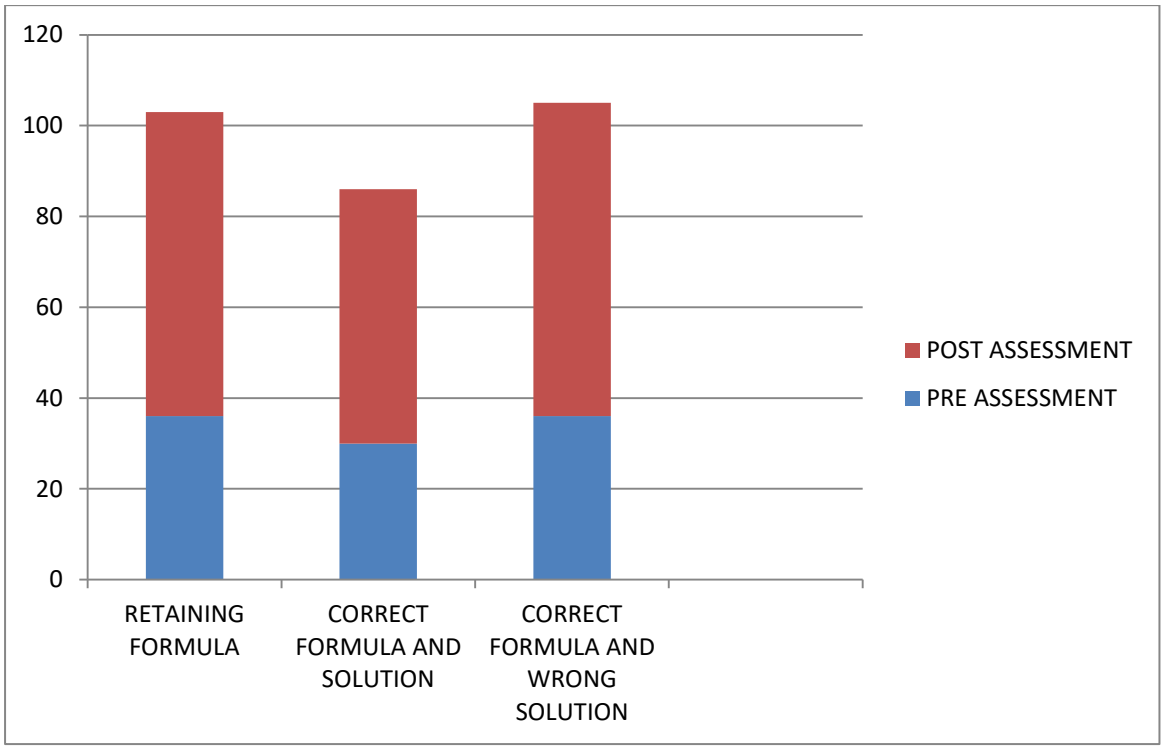

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