APPENDICES

APPENDIX I

PRODUCTIVE THINKING SCALE

Class: VIII **Time: 1 hour**

Subject: Science **School:**

Instructions:

- Here you have 20 questions in this paper.
- All the questions are compulsory.
- Read and think carefully all the options of the question.
- Choose any one answer which is appropriate according to you.

Q.1: What if the earth's magnetic North Pole becomes magnetic South Pole and vice versa in a gradual process?

a. Malfunctioning in the function of magnetic compass.
b. The species relying on earth's magnetic field for getting direction like whales, sharks and migratory birds will get effected for navigation.
c. Rotation of the earth on its axis may be affected.
d. The most of the principles related to magnetism need to be changed.

Q.2: What would happen if there would be a compulsion to take only one type of food?

a. Multinutrient capsules would be taken along with food.
b. It would help to develop single type of food having all the nutrients like genetically modified grains carrying all the nutrient.
c. It will not affect to that person if the person is taking milk and its products.
d. The person will become malnutrition if the taken food is not a complete food.

Q.3: What will happen if sun will lose its energy may be after 1000 years?

a. We would develop artificial systems like sun to produce energy for our consumption.
b. More importance will be given to wool producing animals to get protection from severe cold.
c. There will be no life on the earth.
d. Human body would have adaptation as per the condition like having the visibility in the dark.

Q.4: How to satisfy a child who is crying to sit on a seesaw with/opposite to a tiger?

a. It could be feasible taking a baby tiger with a child with heavy weight.
b. In a big see saw, tiger will sit near the center point of the lever and child will seat far away from the center point.
c. We need to put so much extra weight at the side of child, then only child can sit with tiger.
d. When the tiger will sit on the seat of the seesaw the child will be thrown away from the seat.

Q.5: What would happen if the poles start melting?

a. As more land will submerge under water we should take strict action to curb the pollution.
b. Sea level will be high.
c. We need to develop strategy to use this extra water from river for water scarce areas so that water can be used effectively
d. More electricity can be produced using sea tides.

Q.6: Imagine the consequences of the following line.
The sun is losing its energy and sun light is the major source of getting vitamin-D.

a. Human being will need more efforts to strengthen their body muscles.
b. Number of rickets patients will increase.
c. We will find the other source of vitamin D including food and artificial sun.
d. Organisms will adapt themselves to survive in vitamin D deficiency.

Q.7: If sand will be the only form of soil present on the earth. Imagine the life in such conditions?

a. By adding organic matter and sufficient water to the sand we can cultivate crops in it.
b. Plants and animals will have special adaptations for the conditions.
c. We need to make improvised seed varieties that can grow in such condition.
d. Temperature of the earth will be very cold at night and very hot at days.

Q.8: Due to the high price of fossil fuel the market is moving for biofuel like ethanol, and bio-diesel. What will be the consequence of this?

a. The cost of fuel will not be very high and will be affordable.
b. As we have limited fossil fuel, one day it will be replaced by bio-fuels.

c. Genetically modified oil seeds like Jetropha will be developed having more content of oil without affecting the environment. (Jetropha is a drought and pest resistant oil seed that produce bio diesel).
d. There will be more cultivation of bio-fuel producing crops.

Q.9: What will happen if the herbivores hunting will be banned and carnivorous animals will be removed from forest?

a. Herbivores will be changed to omnivores when there will be scarcity of vegetation.
b. In a long run, herbivorous animals will be adapted to the smaller size.
c. Decrease in the number of elephants because of starvation.
d. It will disturb the balance of ecosystem.

Q.10: To increase the life of a house what should be the changes in the RCC concrete where steel is one of the ingredient of RCC?

a. Instead of iron rods, stainless steel, bamboo and plastics can be used.
b. Proportion of steel and cement will be increased.
c. Anti-corrosion compounds should be added to the concrete mixture.
d. Galvanized steels could be used to make it durable and cost effective.

Q.11: How the sea water resource could be used for daily use purpose?

a. Sea water can be changed into drinking water by using evaporation and condensation simultaneously using solar energy.
b. It can be converted into drinking water through specially designed filters.
c. Hydrogen and oxygen can be retrieved from sea water and can be used for different purposes.
d. It can be used for flushing and dish washing purpose.

Q.12: What would happen if we have to live without microbes?

a. Animals need to take stimulants for digestion in the absence of microbes.
b. There will be scarcity of natural proteins as microbes help leguminous plants to absorb atmospheric nitrogen.
c. All the diseases caused by microbes would be vanished
d. Excess of nitrogen and its oxide in the atmosphere will increase global warming.

Q.13: What would happen to human beings if the atmospheric pressure reaches to zero?

a. Specific life support system and suits will be developed to continue the life.

b. All the living beings will explode like balloons if the pressure reaches to zero immediately.
c. Blood will flow outside the body through different openings.
d. Blood pressure of living beings will also be reduced if the atmospheric pressure reduces gradually over a long period of time.

Q.14: What would happen if friction get reduced?

a. Accidents will increase due to accelerated speed in machines.
b. The efficiency of machines will be increased and use of lubricants will be less.
c. It will be difficult to walk.
d. The fuel consumption of vehicles will decrease solving the fuel crisis.

Q.15: What would happen if atmosphere on the earth would be thicker than normal?

a. Less number of meteorites will land on the earth.
b. The number of people with high blood pressure will be decreased.
c. Climatic temperature will increase.
d. Atmospheric pressure will increase.

Q.16: How a group of children can see solar eclipse?

a. They can see it through dark film which reduces the intensity of sun rays.
b. They can see the reflection of solar eclipse on a screen through a plane mirror.
c. They can go to a community science centre to see eclipse with the help of a telescope.
d. They can see eclipse through a pinhole camera.

Q.17: How hydrogen can be used as a fuel in future?

a. Hydrogen can replace fossil fuels as it is a cheap source of energy and can be produced from water (H_2O).
b. Hydrogen can be used to produce a high amount of energy which could be used in reactors.
c. Hydrogen can be used as a fuel but it will be difficult to handle.
d. Hydrogen can be used as a fuel in very low temperature area and under water.

Q.18: What would happen if there was no moon?

a. Calendar year (365 days) and time line (24 hours/day) will be changed.
b. Day-night cycle would be shorter than 24 hours because the earth would spin faster in the absence of moon’s gravitation force.

c. Due to the absence of tides, oceans will be comparatively calm which could facilitate sea transportation.
d. There will be no tide in the ocean.

Q.19: What if there were no metal on the earth?

a. Transportation will be affected by the absence of metals.
b. Wireless technology will be used more.
c. The color of blood will be different other than red.
d. The non-metallic wires like optical fibers, ceramic conductors will be used to transfer the electricity.

Q.20: As it is said that by 2050 ocean could contain more plastic than fish, how would you stop the consequence of it?

a. We will go with bio degradable material like cellulose from plants as the alternatives for plastics.
b. Instead of using plastic bags we can use paper or cloth bag.
c. Plastic items in any form should be banned.
d. Powerful microbes can be developed that can eat the plastics.

APPENDIX II

ACHIEVEMENT TEST

KENDRIYA VIDYALAYA SANGHATAN-AHMEDABAD REGION

SESSION ENDING EXAM: 2019-20

SUBJECT: SCIENCE **CLASS: VIII**

Time: 2:30 hours **Max. Marks- 80**

General instructions

- The question paper comprises of three sections A, B and C.
- All questions are compulsory. However internal choice has been given in each section. Attempt anyone out of the given alternatives.
- All questions in section A are very short answer type and carry one mark each.
- All questions in section B are short answer type and carry 3 marks each.
- All questions in section C are long answer type and carry 5 marks each.
- The question paper consist of 30 questions.

SECTION A

1. Mention anyone commercial use of yeast?
2. Mention the name of the thread like structure present in the nucleus.
3. Why is it difficult to walk on the wet floor?
4. Earthquakes happen when a plate scraps, bumps or drags along another plate. When does this happen? Constantly. About half a million quacks rock the earth every day. People don't feel most of them because the quake is too small, too far below the surface or deep in the sea. Some, however, are so powerful they can be felt thousands of miles away.

   Powerful earthquake can cause landslides, tsunamis, flooding and catastrophic events. Most damage and death happen in populated areas. That's because the shaking can cause windows to break, structures to collapse, fire and other dangers.

   Geologist cannot predict earthquakes. They hope they will in the future through continued research and improved technology.

   4.1 What causes earthquake?

4.2 Suppose you are outside your home and an earthquake strikes. What precautions would you take to protect yourself (write any two points).

4.3 Earthquake is measured on _____scale.

4.4 Name the Indian institution that has developed the technique of making of earthquake resistant houses.

Choose the Correct Option

5. Which of the following can be beaten into thin sheets?
    a) Zinc
    b) Phosphorus
    c) Sulphur
    d) Oxygen
6. Which of the following is necessary for the production of thyroxin?
    a) Calcium
    b) Iodine
    c) Iron
    d) Sodium
7. Abdul is running his toy car on different surfaces. The force of friction acting on the car on different surfaces in increasing order will be:
    a) Wet marble floor, dry marble floor, newspaper and paper.
    b) Newspaper, towel, dry marble floor, wet marble floor.
    c) Towel, newspaper, dry marble floor, wet marble floor.
    d) Wet marble floor, dry marble floor, towel, newspaper.
8. A tadpole develops into an adult frog by the process of:
    a) Fertilization
    b) Metamorphosis
    c) Embedding
    d) Budding

OR

The male gamete in humans is termed as:

a) Ovum
b) sperm
c) Ovary

d) Testis

9.

Above is a photo of statues called carrier tits that were built on the acropolis in Athens more than 2500 years? The statues are made of a type of Rock called marble. Marble is composed of calcium carbonate. In 1980, the original stretch use were transferred inside the museum of the acropolis and were replaced by replica. The original statues were eaten away by acid rain.

a) Name two gases mainly responsible for acid rain.
b) Marble chip has a mass of 2 grams before being emerged in vinegar overnight. The clip is removed and weighed the next day. What will the mass of dried marble chip be?
   i. Less than 2 grams
   ii. Exactly 2 grams
   iii. Between 2 and 2.4 grams
   iv. More than 2.4 grams
c) Which phenomena is responsible for marble cancer.
d) When a marble chip is placed in vinegar, bubble of gas form. Write the name of gas formed.

Fill In the Blanks

10. Time taken by an object to complete one oscillation is called_____

OR

Loudness is determined by the ____ of vibration.

11. The process of coating of zinc on iron is called_____

OR

The full form of LED is_____

True or False

12. Jupiter is the largest planet of solar system.
13. Stars emit light only during night.
14. The image that can be obtained on the screen is called real image.

SECTION B

15. Write any three harmful effects of microorganism.
16. Give reasons for the following:
    a) Aluminium are used to wrap food items
    b) Sodium and potassium are stored in kerosene.
    c) Copper cannot displace zinc from its salt solution.
17. Friction is both a friend in the foe. Elaborate this statement with one example in each case.

OR

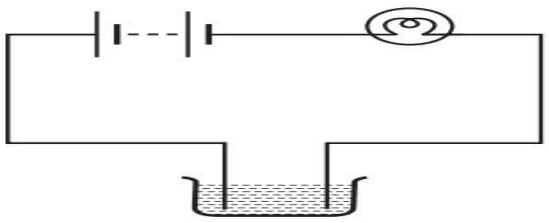
Explain why objects moving in fluids must have a special shape. What is other term given to fluid friction?

18. Give two differences between as I got and a foetus. In which female organ does the embryo get embedded?
19. Name the hormones released by testis and ovaries? State the functions of the hormones.

OR

How can sex be determined in the new born baby? Explain with diagram.

20. A pendulum oscillates 50 times in 5 seconds. Find the time period and frequency.
21. The bulb does not glow in the setup shown. List three possible reasons.



22. Explain why a charged balloon is repelled by another charged balloon whereas an uncharged balloon is attracted by another charged balloon?
23. What is a constellation? Name any two constellations and draw their diagrams.

OR

The radius of Jupiter is 11 times the radius of Earth. Calculate the ratio the volume of Jupiter and the earth. How many hours can Jupiter accommodate?

24. State the laws of reflection with the help of diagram.

SECTION C

25. a) Briefly describe the displacement reaction with the help of an example.
    b) Differentiate between metals and nonmetals (any three points).
26. Draw labelled diagram of a plant cell. How does it differ from animal cell? (any three points)

OR

a) Write short notes on the following-
b) Cytoplasm
c) Nucleus of the cell
d) State three differences between eukaryotes and prokaryotes.

27. a) Define asexual reproduction. Describe two methods of a sexual reproduction in animals.
    b) Differentiate between oviparous and Viviparous animals. Give one example in each case.
28. a) Sketch the larynx and explain its function in your words.
    b) Your parents are going to buy a house. They have been offered one of the roadside and another three lens away from the roadside. Which house would you suggest your parents should buy? Explain.
29. What do you mean by electroplating? How does it take place? Explain with the diagram.

OR

a) Does pure water conduct electricity? If not, what can we do to make it conducting?
b) In case of a fire, before the Fireman use the water hoses, they shut up the main electrical supply from the area. Explain why they do this?

30. Draw a well labelled diagram of human eye and write the functions of its any three parts.

OR

a) What is the angle of incidence of a Ray if the reflected ray is at an angle of 90 degree to the incident ray?
b) Mention any three ways you follow to take care of your eyes.

APPENDIX III

REACTION SCALE

Dear student,

This is a reaction scale for integrated strategy through which you were taught science. Here, few statements related to the strategy are given to you and you have to put a tick mark on the suitable place in 5 point ratings against each statement to show your reflection for the particular statement. Your reflection will be helpful for the improvement of this strategy in future. Feel free to give your responses as your responses will be kept confidential and will be used for research purpose only.

Abbreviation used: SA-strongly Agree, A-Agree, UD- Undecided, DA-disagree and SDA-strongly Disagree.

No.	Statements	SA	A	UD	DA	SDA
1	I liked teaching of science through the productive thinking model.					
2	Teaching through this model is quite interesting than regular classroom teaching.					
3	Teaching through this model helped me to understand science better.					
4	Working in group during brainstorming was interesting.					
5	SCAMPER questions helped me a lot to think out of the box.					
6	I liked the videos used to make better understanding of science concept.					
7	Evaluation of generated ideas was good to test feasibility of the ideas.					
8	We can have variety of ideas for a problem when we work in the group					
9	I liked the way in which we relate creative ideas to solve real life problems.					

10	Presentation of ideas in front of the class improved my communication skill.					
11	I liked the way in which text-book is connecting to the real-life problems in this model.					
12	In this model all the generated ideas are welcomed by the teacher without criticism.					
13	This model helped us to be cooperative while working in the group.					
14	This model helped us to think creatively.					
15	We are encouraged to share our experience related to concerned topic in the classroom.					
16	Concept mapping is a good way to summarize and conclude the concept.					
17	Sufficient time was provided to think in the group.					
18	I am now able to think productively whenever I have to solve a problem.					
19	Teachers should use this model while teaching other subjects.					
20	I liked the teaching of science through activities in the classroom					
21	I liked the discussion to choose one productive idea from the list of generated ideas.					
22	This model help me to think differently while solving a problem.					
23	We were always encouraged to think beyond the text-book while teaching through this model.					
24	Evaluative discussion after each brainstorming was good to enhance critical thinking.					
25	It created a creative environment in the class.					

APPENDIX IV

PRODUCTIVE THINKING MODEL (FIESI MODEL)

In cognitive learning theories learning means "to think using the brain". It never mean to reproduce the similar information. The goal of cognitive learning theory is to make students think and develop abilities to apply logic, creativity, and critically analyse the situation. By 2020, critical thinking, complex problem-solving and creativity will be the three most important skills for a student to possess (World Economic Forum, 2018). Productive thinking is an attempt towards achieving this goal. It encourages students to learn, think and produce novices. Jerome Bruner who is the proponent of cognitive psychology gave learning objectives where analysis, synthesis and evaluation are the components of higher order thinking and productive thinking also involves these components. It never rely on the stimulus-response theory as David Ausubel gave emphasis on meaningful learning which is the result of the consciousness rather than the result of behaviour (stimulus-response, trial and error). It is a step towards meaningful learning because learning becomes meaningful when it is connected to what student already know.

Productive thinking is the cognitive ability to plan, reason logically, analyse, synthesize, evaluate, and make decision to reach at the solution of the problem. Hurson (2011) described it as a process of generating creative ideas. Productive thinking is the combination of critical and creative thinking and it provides separate places to both the thinking (Rusbult, 1997). It is characterized by shifts in perspective which allow the problem solver to consider new, sometimes transformational approaches (Cunningham & Villaseñor, 2016). Newton, (2017**)** made a difference between productive and reproductive thought and said "Productive thought covers a variety of forms of cognitive activity: deduction; understanding and causal reasoning; creative thinking and problem solving; evaluative or critical thinking; and decision making and wise thinking".

Hence, productive thinking involves transforming the representation of the problem from a vague, fuzzy, incomplete and confused representation that is blind to essential structural feature of the problem, into a representation that is clear, has no gaps in it, make sense and views each part of the problem in terms of its place, role and function with the problem. It is believed that creative thinking and critical thinking are two opposite concepts and both do not occur simultaneously. It is also believed that persons who are creative will be comparatively less critical or vice-versa. But it is not true in case of productive thinking. It is the combination of

creative thinking with critical thinking in such a synchronized manner having a wonderful product called productive thinking.

It involves activities in which students analyse the problem and imagine as many ideas as possible in order to see every aspect of the problem. But these ideas may be wild which may not work. To make these ideas real we need critical judgment or evaluation over each idea to make them feasible. So, it involves higher order thinking components like, analysis, synthesis and evaluation along with the lower order thinking like, knowledge, understanding and application which helps in the conception of ideas. The process starts from critical thinking (analysing a problem) and then shift to the creative thinking (imagining solutions). To plan a solution requires more critical thinking, while applying the solution is a creative process by shifting back and forth between the two types of thinking, students arrive at a solution.

FIESI: PORODUCTIVE THINKING MODEL

This model is prepared by considering the other existing model of productive thinking, creative thinking and critical thinking. It can be integrated with the subject matter to teach in the class and to develop productive thinking indirectly. This model is generic in nature and can be used in all the disciplines. FIESI is a teaching model which has its own focus, syntax, principle of reaction, social system, support system and application. The components of productive thinking model are discussed as follows:

Focus

The present model is developed with objective to develop productive thinking in the students. The model is focused around the fact that creative and critical thinking are two opposite sides of a coin. This model provides a platform for merging creative and critical thinking where both the thinking go hand in hand in a synchronized manner to give a wonderful product productive thinking. Here critical thinking is used to evaluate the creativity and thereby providing value and strength to the creativity.

Syntax

The productive thinking model has following five phases through which the model progresses. The syntax of the model is presented in the following figure.

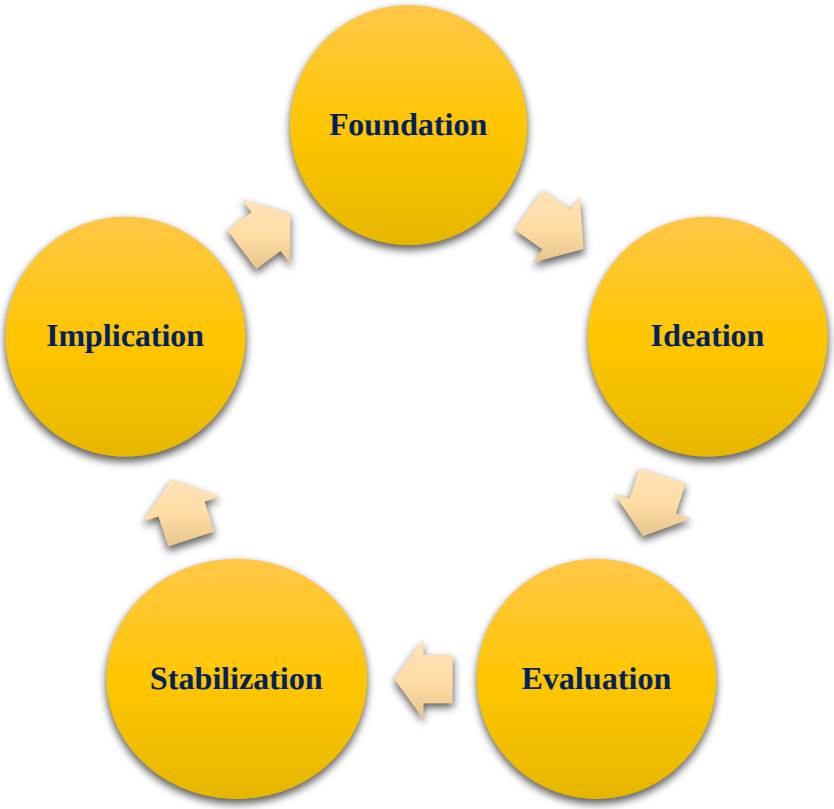


Figure: Syntax of Productive Thinking Model (FIESI)

Phase-1 Foundation

This step is to equip students with a knowledge base upon which creativity can be drawn. For this, teacher sets specific objectives to be achieved before the teaching of the lesson. For this teacher prepare cognitive lesson plan. Teacher starts a lesson with an activity or question meant to engage students, develop their interest, and provide the opportunities to share what they already know about the subject because learners are much more adept at the transfer of learning than novices and that practice in the transfer of learning is required in the good instruction. After knowing the level of previous knowledge teacher explain the content with the help of technology, activities, demonstration and discussion as they address the needs of different students. After explaining the concept by using child centric techniques teacher initiate the discussion about the topic in order to clarify the concept to the students.

Phase-2 Ideation

This phase is the creative aspect of productive thinking where ideational fluency is emphasized. This is the step where teacher asks some questions which seems to disturb the equilibrium. For maintaining the equilibrium students need to analyze the question or problem thoroughly. It is

very important to look at the problem from different perceptive in order to uncover the hidden aspect of the problem. For drawing the creativity following techniques can be used.

a. **Brainstorming:** In the classroom, teacher forms groups of 6-7 students and presents a problem in front of them to brainstorm. In this process students cooperatively generate novel ideas on the given problem.
b. **SCAMPER**: SCAMPER is an acronym of *Substitute, Combine, Adapt, Modify/magnify/minimize, Put to another use, Eliminate and Rearrange.* In order to draw the creativity from students, teacher asks a set of questions corresponding to the each of the letter of the SCAMPER.
c. **Creative free writing**

   Creative free writing is the process in which teacher set a time limit (5 or 7 minute) and ask students to write whatever comes to their mind about the given task without giving much emphasis on spelling or punctuation by keeping in mind that writing is legible and interpretable.
d. **Cognitive questioning**

   Cognitive questioning is a disciplined questioning that can be used to pursue thought in many directions. It is a systematic, deep and usually focuses on fundamental concepts, principles, theories, issues or problems.
e. **Forced connection:**

   Forced connection is the creative process which proceeds in two steps. In the first step teacher brainstorms the students about the characteristics of the object, image or some mental representation. The second step is to challenge each of the characteristic to make them think creatively.

By using any one of these strategies or a combination of more than one strategy a long list of ideas will be produced that may or may not be implemented. So, we need to introduce critical thinking elements in order to add value to the creatively generated ideas. So, that the ideas may result in useful ways to resolve the issue and to make the ideas feasible also.

Phase-3 Evaluation

This step involves evaluation of creative thinking through critical thinking to modify the ideas to make them feasible. After generating a list of ideas students need to evaluate the potential of these ideas to see whether the generated ideas are appropriate for the problem at hand or not. For this, students have to compare the generated ideas with the criteria. Group discussion,

presentation, peer evaluation and evaluation matrix are some of the strategies that can be used to evaluate the creative ideas.

Phase- 4 Stabilization

This phase is to make the concept stable. This can be done by following strategies.

a. Drawing Conclusion

   At this stage students have to draw conclusion of the whole idea by writing or by presenting it in the class. By this teacher can have a chance to assess the students whether the concept is stabilized or not.

b. Concept mapping

   It is a hierarchical map, with the subordinate concepts stemming from the main concept. By this students are allowed to communicate ideas, thought and information. It helps students to integrate new concept into the existing concept. As students prepare concept map, they represent the concept and the information.

Phase-5 Implication

Usefulness is the necessary requirement for any idea to be considered as productive idea. Success of the productive thinking process depends upon the link between creativity and implementation of the generated ideas. Generation of ideas are more prevalent than its implementation part in creative thinking. But usefulness is necessary requirement for ideas to be considered as productive. Thus, this step is to satisfy the usefulness criteria for the productive thinking. At this step students are allowed to imply the generated ideas in some situation or to imply it logically in different situation through foresight.

Principle of the reaction

The teachers' reaction towards the students' generated creative responses are guided by the following principles:

1. Quantity precedes over quality
2. Functional fixedness should be avoided
3. Avoid criticism as it inhibits creativity

Teacher give positive reinforcement for the novice ideas generated by the students. In the second phase teacher needs to accept all the responses of the students to ensure that students feel no external criticism about their creative expression. In the first phase, the teacher need not to provide all the information about the concept directly rather respect the students' previous experiences to construct the knowledge by them. As we know criticism hinders

creativity so, students should not be criticized by the teacher rather they should be motivated for free flow of ideas.

Social system

In this model students are at the center of teaching learning process. Teacher helps students to understand how new material is related to previously learned material and help students to construct new knowledge and understanding. In the second phase, learning is collaborative and creative in nature where teacher needs to motivate the students by minimizing the criticism and help students to overcome functional fixedness. Teachers' role in this model is like a constant motivator and catalyzer who catalyze the generation of the novice ideas and channelize the process.

Support system

For the process of this model, a class require a work space of its own kind and an environment in which productivity will be prized and utilized. We need seating arrangement for groups as the whole process will be performed in the group. This model demands a good knowledge of the respected discipline in the teachers and skills to imbibe their knowledge with the skills to make it productive. If it is necessary then teachers can have training from experts. This programme would be best with technology support in the classroom as teaching by using technology addresses the need of all the students.

Application

This model is applicable for the classroom instruction in school education as well as in higher education. By the components of this model teacher can inculcate productive thinking in the students. As we know productive thinking is the combination of following components: creative thinking critical thinking, decision making, logical reasoning and problem solving, this model is also beneficial for inculcation of the above discussed components.

1. Creative thinking

   Strategies of this model can be useful to make students creative as well as critical thinkers. Students can learn how to think out of the box and applying multiple perspective to examine a phenomenon or situation.
2. Critical thinking

   By this model critical thinking can also be developed in the students. In the second phase students need to analyse the situation carefully and in the third phase students need to

critically evaluate the generated ideas to give value and strength to the immature ideas. In the fifth phase of implication students imply the novice ideas. In these steps critical thinking of the students developed.

3. Problem solving

   This model is also useful for problem solving where students need to analyse the problem, find solution of the problem and apply it to solve the problem.

APPENDIX V

UNIT PLAN-1

FORCE AND PRESSURE

PRIMARY INFORMATION:

Name of the Teacher	Kamakshi Raipure
Name of the school	Kendriya Vidyalaya, ONGC, Vadodara
Class	VIII
Subject	Science
Unit	Force and pressure
Lesson	1. Force 2. Contact force 3. Non-contact force 4. Pressure
Date	
Entry Behaviour	Students have the prior knowledge about the Motion, Speed and pressure.
General Objective	1. Students will be able to think creatively. 2. Students will be able to think critically. 3. Students will be able to think productively. 4. Students will be able to understand force and pressure
Method	1. Lecture 2. Cooperative learning
Media	Black board Power point Presentation
Approach	Integrated approach

INTRODUCTION:

Teacher will start the class by initiating a discussion on how did force help you in the past to save your life or others?

Students: Students will share their experiences like:

1. I saved someone's life by pulling the chain in the train.
2. I saved someone by giving my hand to hold.
3. I helped my father in pulling our car which was not working.
4. I helped a patient to move his wheel chair and many more……..

Teacher: By having this wonderful discussion one thing we came to know that *force is very important for life.*

So, in this chapter we are going to discuss and learn about force and pressure, types of forces, and how different forces are important for our life. Along with this we will be creatively engaged into some activities related to force and pressure.

TRANSACTION OF THE LESSON:

Name of the Unit: Force

Lesson no.: 1 (Force)

Teaching points	Specific objectives	Teacher's activity	Students' expected activity	Evaluation
Force	Students will be able to define force.	A player of the football hit the ball to make a goal but goal keeper does not allow him to get success. In this process forces are applied how many times? And how? Yes, ball starts moving by player and stop	Player apply force two times: To hit the ball and goal keeper stop the ball using force in the opposite direction.	

		by goal keeper using force. Have you ever seen push or pull written over the glass doors in the showrooms? How many of you get confused while entering or closing the door? Yes, it happens. We know that to open or close the door we need to push or pull the door. But by pushing or pulling what we are applying? Yes, therefore we can say that *a push or pull on an object is called force.* Can you give me some of the	Yes, we have seen. Some students are confused because of similar words. We are applying force. Students will give examples	What is force? Give examples.
	Students will be able to give			

	examples of forces from daily life. Students will be able to understand balanced and unbalanced force.	examples where do you pull or push an object? What would happen if two persons of equal strength push an object from opposite sides? But why? Yes, this type of force is called as balanced force and will result into no change in the position of the object. Can you give examples of balanced force from your daily life? Then, how the object move? Yes, this type of force is termed as unbalanced	of forces on object as pull or push. The object will not move at all. Because both the forces are equal. Tug of war game. When two forces are not of equal strength.	What is the difference

Effects of force	Students will be able to know the effects of force on objects.	force and result into the movement of the object in the opposite direction of the large strength force. Have you ever seen the change in the current position and appearance of the objects because of force?	Students will give examples of unbalanced force. Yes, my mother prepare dough to make chapatti with wheat flour. Another student said when I paddle my bicycle it moves. When we apply the break in the bicycle it stop moving. And when we push the moving bicycle it starts moving with greater speed.	between balanced and unbalanced force?

		Yes. So by having these examples we can say that, force can change the shape of the object, it can change the state of motion of the object also.		

RECAPITULATION:

1. We have discussed about the force.
2. We have discussed about balanced and unbalanced force.
3. We have discussed about the effects of force**.**

HOME ASSIGNMENT:

1. Give two examples each of situations in which you push or pull to change the state of motion of objects.
2. Give two examples of situations in which applied force causes a change in the shape of an object.

BLACK BOARD SUMMARY:

We have learnt force and its effect.

TRANSACTION OF THE LESSON:

Name of the Unit: Force

Lesson no.: 2 (Contact Force)

Teaching points	Specific objectives	Teacher's activity	Students' expected activity	Evaluation
Contact force	Students will be able to understand contact force.	If you want to close this door then what would you do? Similarly if I want to open this book, I have to open it with my hands. It means in order to apply force on an object we need to come in contact with the object first. So, we have some forces that are contact force. Can you give some examples of contact forces?	I will go there and close the door with my hands. Muscular force	What is muscular force give its examples?

	Students will be able to explain muscular force and its examples. Students will be able to explain frictional force and its examples.	Yes. It is a contact force. From where do we apply this force? Yes. As its name indicates muscular force is because of muscles. Give some of the examples of muscular force from your daily routine. Yes. All these are examples of muscular force. What is the importance of friction in your life? Yes. When we switch off the engine of the car, it comes into rest slowly. Why?	Through muscles. We bring our book from bag. We brush our teeth. We paddle cycle to come to school. Horses pull the cart. By frictional force we can walk, write, and vehicles can run on rod. Because frictional force make it stop.	

		Yes. Friction is a force acting between two surfaces in the opposite direction of the motion. *Now imagine what would happen if friction disappears from earth.* *Teacher will ask each of the group to present their work in front of the class.* *Teacher will ask all the groups to modify the uses and bring out one effective use that will solve*	 *Students will be engaged into creating the consequences of absence of friction. (Ideation)* *Students of one group will present the consequences and rest of the students will analyse and evaluate the effect to check the feasibility criteria. (Evaluation)* *Students will improve effects to reach out one productive consequence that can be logically*	What is friction? How would you explain it as positive or negative force?

		the problems of mankind. *Teacher asks the students to prepare a concept map to summarize the contact forces.*	*implied to solve the problem of the mankind. (implication)* *Students will prepare concept map to stabilize the concept of contact forces.*	

RECAPITULATION:

1. We have discussed about the contact forces.
2. We have discussed about the muscular force and its examples.
3. We have discussed about the friction?
4. We have also discussed about our life without friction.

HOME ASSIGNMENT:

1. A blacksmith hammers a hot piece of iron while making a tool. How does the force due to hammering affect the piece of iron?

BLACK BOARD SUMMARY:

We have learnt about contact forces.

TRANSACTION OF THE LESSON:

Name of the Unit: Force

Lesson no.: 3 (Non-Contact Force)

Teaching points	Specific objectives	Teacher's activity	Students' expected activity	Evaluation
Non-Contact force	Students will be able to understand non-contact force. Students will be able to explain magnetic force and its examples.	Imagine, you have a box in which powder of iron is mixed with sand and you have to separate the two. How would you separate iron dust from sand? Yes. But, earlier we have learnt about contact forces. So do we have to make contact of magnet and mixture? Yes, therefore we can say that magnetic force is a non-contact force.	Using magnet we can separate iron dust from sand. No, as magnet can work from some distance also. We need not to make a contact between two.	Define magnetic force and its importance in your life.

	Students will be able to explain electrostatic force and its examples.	Have you ever experience that your hair on your hands get attracted towards the blanket in the winter? Now, teacher ask the students to make pieces of paper and ask to rub their pen or pencil in their hair. After doing this teacher tell them to bring that pen near the pieces of paper. Teacher ask them to observe it and explain it? In this case also pen attracts the paper come in contact and this force is termed as electrostatic force. It is force that acts between	Yes. Students do the activity and explain their observation that pieces of paper get attracted towards the pen.	What is electrostatic force of attraction and its examples?

		two charged bodies.		
	Students will be able to explain gravitation force and its examples.	Teacher drops a piece of chalk on the ground and ask the students that why did this chalk piece come on the ground?	It is because of gravitation force acting on chalk by earth.	
		In which category would keep this force contact or non-contact?	Non-contact force.	Define gravitation force.
	Students will be able to imagine the consequences of alteration in force of gravity.	*Now imagine what would happen if force of gravity become half?*	*Students will be engaged into creating the consequences of alteration in force of gravity. (Ideation)*	
		Teacher will ask each of the group to present their work in front of the class.	*Students of one group will present the consequences and rest of the students will analyse and evaluate the*	

			effect to check the feasibility criteria. (Evaluation)	
		Teacher will ask all the groups to modify the uses and bring out one effective use that will solve the problems of mankind.	*Students will improve effects to reach out one productive consequence that can be logically implied to solve the problem of the mankind. (implication)*	
		Teacher asks the students to prepare a concept map to summarize the non-contact forces.	*Students will prepare concept map to stabilize the concept of non-contact forces.*	

RECAPITULATION:

1. We have discussed about the non-contact forces.
2. We have discussed about magnetic force and examples.
3. We have discussed about electrostatic force and examples.
4. We have discussed about gravitation force and examples.
5. We have also discussed about the effect of change in the magnitude of gravitation force.

HOME ASSIGNMENT:

1. A rocket had been fired upwards to launch a satellite in its orbit. Name the two forces acting on the rocket after immediately leaving the launching pad.

2. Name the forces acting on a plastic bucket containing water held above ground level in your hand. Discuss why the forces acting on the bucket do not bring a change in its state of motion.

BLACK BOARD SUMMARY:

We have learnt about non-contact forces

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TRANSACTION OF THE LESSON:

Name of the Unit: Force

Lesson no.: 4 (Pressure)

Teaching points	Specific objectives	Teacher's activity	Students' expected activity	Evaluation
Pressure	Students will be able to define pressure.	Have you ever experienced that a roof of a house blown away with air. Why? Yes. It is because of the pressure difference that you have learnt in your previous class. Similarly we have number of examples by which we can say importance of pressure in our life. Ok tell me why edge of knife is too sharp? It means blunt edges make difficulty in cutting?	It is so because pressure inside the house is higher than outside during very fast wind speed or storm. To cut easily. Yes.	

	Students will be able to give application of pressure-area-force relationship.	But why is it so? We can understand it by a formula: $pressure = force/area$ This formula indicate lesser area will result into higher pressure. Now can you give applications of this formula from your daily life? Yes. Very good. Now, tell me why the wheels of military tanks are too broad? Yes. Similarly, gases and liquids also create pressure. If we go very deep into the sea we would face	No response. Point of the nail and needle is too sharp. Straps of the bags are broad to make us relax. To spread the weight and force on sand. It is because under water the	Define pressure and give its formula. Why the base of the tanks are too broad?

		the problem of low blood pressure. Do you know why? Yes.	pressure of liquid is very high.	
		And what would happen if we go to the high mountains?	Bleeding from nose and ear because of low air pressure.	What would happen to the human body when we go at the higher altitude?
		Correct. So, it indicates *air and water exerts pressure. And pressure exerted by air is known as atmospheric pressure.*		
	Students will be able to imagine creative consequences of change in the thickness of the atmosphere.	*Now imagine what would happen if the thickness of atmosphere doubled?*	*Students will be engaged into creating the consequences of alteration in atmospheric thickness. (Ideation)*	
		Teacher will ask each of the group to present their work in front of the class.	*Students of one group will present the consequences and rest of the students will*	

			analyse and evaluate the effect to check the feasibility criteria. (Evaluation)	
		Teacher will ask all the groups to modify the uses and bring out one effective use that will solve the problems of mankind.	*Students will improve effects to reach out one productive consequence that can be logically implied to solve the problem of the mankind. (implication)*	
		Teacher asks the students to prepare a concept map to summarize the pressure.	*Students will prepare concept map to stabilize the concept of pressure.*	

RECAPITULATION:

1. We have discussed about the pressure exerted by soil, liquid and gas. .
2. We have discussed about application of pressure in our daily life.
3. We have discussed the consequences of change in the air concentration in the atmosphere.

HOME ASSIGNMENT:

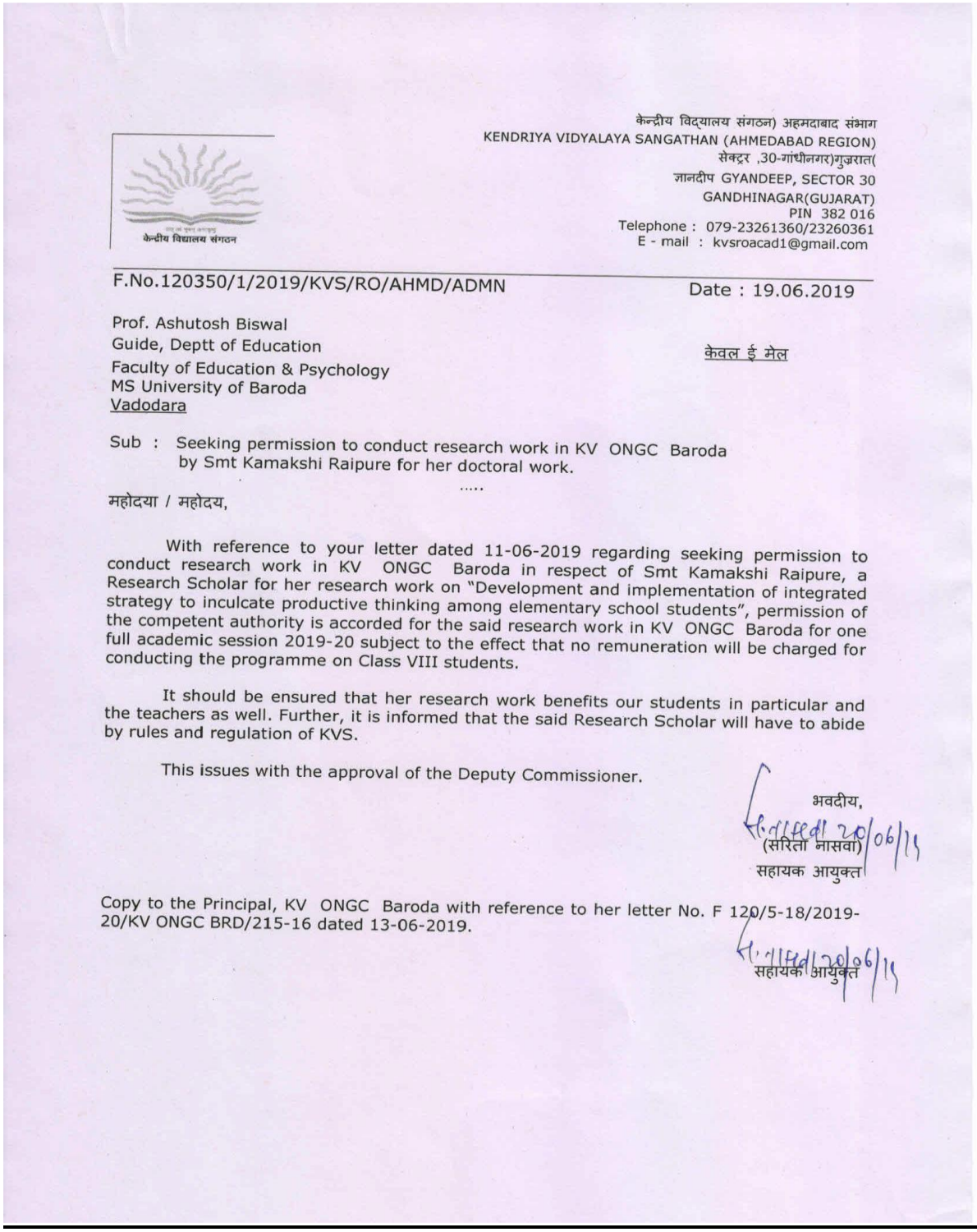
1. Write the application of force and pressure in your life**.**

BLACK BOARD SUMMARY:

We have learnt about pressure.

APPENDIX VI

Permission Letter from Regional Office of Kendriya Vidyalaya Sangathan Ahmedabad Region



केन्द्रीय विद्यालय संगठन) अहमदाबाद संभाग
KENDRIYA VIDYALAYA SANGATHAN (AHMEDABAD REGION)
सेक्टर ,30-गांधीनगर)गुजरात(
ज्ञानदीप GYANDEEP, SECTOR 30
GANDHINAGAR(GUJARAT)
PIN 382 016
Telephone : 079-23261360/23260361
E - mail : kvsroacad1@gmail.com

केन्द्रीय विद्यालय संगठन

F.No.120350/1/2019/KVS/RO/AHMD/ADMN Date : 19.06.2019

Prof. Ashutosh Biswal
Guide, Deptt of Education
Faculty of Education & Psychology
MS University of Baroda
Vadodara

केवल ई मेल

Sub : Seeking permission to conduct research work in KV ONGC Baroda by Smt Kamakshi Raipure for her doctoral work.

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महोदया / महोदय,

With reference to your letter dated 11-06-2019 regarding seeking permission to conduct research work in KV ONGC Baroda in respect of Smt Kamakshi Raipure, a Research Scholar for her research work on "Development and implementation of integrated strategy to inculcate productive thinking among elementary school students", permission of the competent authority is accorded for the said research work in KV ONGC Baroda for one full academic session 2019-20 subject to the effect that no remuneration will be charged for conducting the programme on Class VIII students.

It should be ensured that her research work benefits our students in particular and the teachers as well. Further, it is informed that the said Research Scholar will have to abide by rules and regulation of KVS.

This issues with the approval of the Deputy Commissioner.

भवदीय,
(सरिता नासवा) 20/06/19
सहायक आयुक्त

Copy to the Principal, KV ONGC Baroda with reference to her letter No. F 120/5-18/2019-20/KV ONGC BRD/215-16 dated 13-06-2019.

सहायक आयुक्त 20/06/19

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Fostering Productive Thinking Among Elementary School Students Through FIESI Model

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ABSTRACT

Productive thinking is the cognitive ability to plan, reason logically, analyse, synthesize, evaluate, and make decision to reach at the solution of the problem or we can say that it is the ability by which one can refine their creative work with critical thinking to give strength and value to it. It is a way to solve problems creatively. For this research, a model has been developed called as FIESI (Foundation, Ideation, Evaluation, Stabilization and Implication) for fostering productive thinking. Researchers conducted an experiment to foster productive thinking among VIII standard students with the help of this model as elementary level is delimited to standard VIII. Quasi-experimental pre-test post-test control group design was used. Two Kendriya Vidyalayas (Central Schools) were selected purposively for experiment purpose. One section of standard VIII from each school was selected as the sample for the experiment and control groups. Students of both the classes were made equivalent on the basis of a science achievement test. The equivalent groups consist of 26 students each. Researchers taught Science to the experimental group for one academic year (2019-2020) using FIESI model and the control group was taught by their regular teachers. Researchers developed and validated a productive thinking test for data collection. Data were analysed using chi-square. The finding revealed that FIESI model was found significant in fostering productive thinking among standard VIII students.

1. Introduction

India's primary school enrolment has come close to being universal and literacy rates have risen encouragingly in recent times. However, Indian achievements in other respects leave much to be desired. Learning achievements in both primary and secondary schooling are low, signaling poor-quality schooling (Kingdon, 2007). Majority of secondary school students were at lower order thinking level and need to improve their higher order thinking skills especially synthesis and evaluation skills required for improving students productivity (Saido et al., 2015). Students scored good marks in examinations conducted by school or affiliated board but most of the students don't get good marks at the entrance examinations based on higher order thinking. This gap in performance indicates serious deficiencies in the students' thinking and reasoning. There is a need to revamp our education system, particularly our school education to inculcate higher order thinking among the youth. The current National Education Policy (2020) rightly emphasized that one of the fundamental principles that will guide both the education system at large as well as the individual institutions within it is creative and critical thinking to encourage logical decision making and innovation. To address this gap we need to restructure our classroom atmosphere where the use of triadic dialogue in questioning has been well reported i.e. "I-R-F" (Initiation, Response and Feedback). This three step pattern as typical of traditional teaching restrict thinking and lead to rote learning (Newton, 2017). NCERT position paper (2006) reported that there is too much emphasis on drill and rote learning and too little emphasis on observation, design, analysis, and argumentation and process skills. Instead of a culture of quizzing of answering quickly and always knowing the right answer, we need to allow learners to spend time on deeper, meaningful learning (NCF, 2005). For meaningful learning in today's classroom we need two skills retention and transfer. Retention means students remember what they have learned, whereas transfer requires students not only to remember but also to make sense of and be able to use what they

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have learned (Mayer, 2002). It is evident that Bloom's taxonomy provides variety of teaching experiences ranges from lower to higher order thinking level. Most of the teaching objectives in the classroom are oriented towards knowledge level only dominated by left brain and we are not creating situations to develop the full brain potential of the child. It should be modified in such a way that there is a place for developing right brain and both hemisphere cooperate for the full potential of human brain (Gill, 1989).

Classroom environment and teaching strategy dominated by rote learning and authoritative discourse which lead to reproductive thinking (rote learning) will not train our students for 21st century challenges. It is rightly stressed in the World Economic Forum report, *The Future of Jobs* (2016). Out of the 10 skills identified for the youth for the present fourth industrial revolution according to this report, five skills are directly related to thinking, i.e. Complex Problem Solving, Critical Thinking, Creativity, Emotional Intelligence and Judgement and Decision Making. It shows the importance of incorporating thinking in the process of education. It is the time to revamp our classroom environment and teaching learning process for thinking particularly by harnessing productive thinking on the base of reproductive thinking as productive thinking includes most of the types of thinking. Birch and Rabinowitz (1951) described reproductive thinking as solving a novel problem using previously mastered skills or by the use of chained behavior, whereas, productive thinking is solving problem by restructuring or changing the patterns of past experience to meet the current demands. Further, productive thinking can be defined as *the cognitive ability to plan, reason logically, analyse, synthesize, evaluate, and make decision to reach at the solution of the problem.* In the present research, researchers made an attempt to develop a thinking model called FIESI (Foundation, Ideation, Evaluation, Stabilization and Implication) model for fostering productive thinking among school students through teaching of different subjects as this is the right age where foundation for the secondary and higher secondary schooling is made and students are also ready for abstract thinking according to Piaget cognitive development model. Researchers experimented this model in the teaching of Science subject as Saido et al. (2015) suggested that in science education, students should have the opportunity to begin thinking like scientists by engaging them in the process of thinking instead of merely ingesting the product of the scientists' discipline. So, this model provides a scope to foster a range of higher cognitive abilities among students through science education.

2. FIESI Model

The FIESI model was developed with the objective to foster productive thinking among elementary school students with its appropriate syntax, social system and the support system. This model provides a platform for merging process of creative and critical thinking where both the thinking process go hand in hand in a synchronized manner where critical thinking is used to evaluate the creative thinking and thereby providing value and strength to the creative thinking. The model has following five phases to progress viz. Foundation, Ideation, Evaluation, Stabilization and Implication. At the first phase, a knowledge foundation is prepared by the teacher using student centered strategies, then some situations are provided to the students to draw their creative potentials through generating different creative ideas, in the third phase, students evaluate the generated creative ideas to make the ideas feasible through critical thinking, then students try to stabilize the generated ideas and finally imply these stabilized ideas in real life situations. This FIESI model was integrated with the content of science subject. The process of productive thinking can be understood by Figure 1:

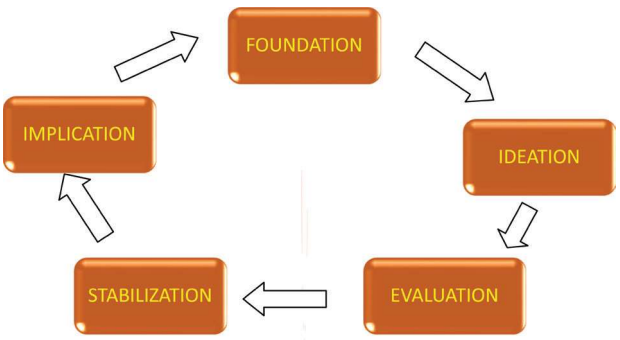

Figure 1: Model of Productive thinking (FIESI).

3. Objectives

1. Development of a model for fostering productive thinking among school students.

2. Implementation of the proposed model for fostering productive thinking among standard VIII students of Kendriya Vidyalayas through the teaching of Science.
3. Studying effectiveness of the proposed model for fostering productive thinking among standard VIII students of Kendriya Vidyalayas through the teaching of Science.

4. Hypotheses

11 null hypotheses were formulated.

H_o (1-10): There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 1. (Likewise there were 10 null hypothesis for 10 thinking tasks)

Ho11: There is no significant difference between the thinking pattern of students belonging to experiment group and control group considering the average frequency for all the 10 thinking tasks.

5. Methodology

Quasi experimental design was used in the present study. Pre-test post-test non equivalent groups design was used for the experimentation. Researchers developed and validated a FIESI model for fostering productive thinking among students with its appropriate syntax, social system and the support system. The developed model was experimented following the said research design.

6. Population and Sample

All the students studying in standard VIII of KendriyaVidyalayas in Gujarat, India constituted as the population for the present study. Two Kendriya Vidyalayas were selected purposively from Vadodara City. One school was assigned as the school for experimental group and other school as the school for control group. One section of standard VIII from each school was selected as the class for the sample for the experimental and control group. Students of both the sample classes were made equivalent on the basis of their science achievement (pre-test). The equivalent group consisting of 26 students each for experimental and control group and those 52 students constituted as the sample for the present study.

7. Tools for Data Collection

For the present study, researchers developed a productive thinking test based on the content of science subject with the assumption that productive thinking is the last stage of thinking process in a continuous process of thinking starting from reproductive thinking passing through critical and creative thinking through learning, experience and maturation. The test consist of 10 situation specific tasks and was validated by the experts. Each task/item of the test has 4 different alternative responses representing different types of thinking i.e. reproductive thinking, critical thinking, creative thinking and productive thinking in a sequence. The alternatives are arranging in the test on a random manner. The respondents were asked to choose one or more appropriate alternatives for each items as the response. The thinking ability of the respondents for the specific items would be considered having the highest order of thinking from his/her responses. A science achievement was also developed on the basis of the science content of the previous year i.e. standard VII which was used as the pre-test for the purpose of making the experiment and control group equivalent. The test was also validated by the subject experts.

8. Experiment

The experiment group was taught science for one academic year, integrating FIESI model with the science content for the purpose of fostering productive thinking along with the knowledge of science. Lesson plans were developed for all the chapters of science keeping in mind the steps of FIESI model and the group was taught by the researchers. During the same period, the control group was taught science through the traditional method of teaching by their subject teachers. At the end of the session, productive thinking test was administered on both the experiment and control groups as post-test.

9. Analysis of Data

Collected data were analyzed using Chi-square test as it is a useful method of comparing experimentally obtained result with those to be expected theoretically on some hypothesis (Garrett and Woodworth, 2008). In the present study, the assumption is that the

results of the experiment group is expected like that of the control group if there is no experiment and hence the result of the control group is considered as the expected frequency (fe) and the result of the experiment group is considered as the observed frequency (fo). Item wise detailed analysis is given in tables 1 to 11, where reproductive thinking is considered as the lowest order of thinking and productive thinking is considered as the highest order of thinking passing through critical and creative thinking in an increasing order.

From Table 1, the chi-square value for the frequency observed and frequency expected was found to be 28.84 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o1}$ i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 1" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 1.

From Table 2, the chi-square value for the frequency observed and frequency expected was found to be 8.64 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o2}$ i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 2" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 2.

From Table 3, the chi-square value for the frequency observed and frequency expected was found to be 8.02 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o3}$ i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 3" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 3.

Table 1: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 1.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	1	11	6	8	26	28.84
Control (fe)	11	6	7	2	26	

Table 2: Frequency wise distribution of students in Experiment group(fo) and Control group (fe) in different pattern of thinking for thinking task 2.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	7	2	3	14	26	8.64
Control (fe)	7	2	9	8	26	

Table 3: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 3.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	6	3	2	15	26	8.02
Control (fe)	13	3	1	9	26	

From Table 4, the chi-square value for the frequency observed and frequency expected was found to be 17.46 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the **H_o4** i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 4" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 4.

From Table 5, the chi-square value for the frequency observed and frequency expected was found to be 49.29 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the **H_o5** i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 5" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 5.

From Table 6, the chi-square value for the frequency observed and frequency expected was found to be 20.31 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the **H_o6** i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 6" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 6.

From Table 7, the chi-square value for the frequency observed and frequency expected was found to be 60.73 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the **H_o7** i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 7" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 7.

Table 4: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 4.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	3	3	8	12	26	17.46
Control (fe)	11	5	3	7	26	

Table 5: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 5.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	5	1	9	11	26	49.29
Control (fe)	12	7	5	2	26	

Table 6: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 6.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	3	7	7	9	26	20.31
Control (fe)	7	3	13	3	26	

Table 7: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 7.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	5	6	6	9	26	60.73
Control (fe)	11	7	7	1	26	

From Table 8, the chi-square value for the frequency observed and frequency expected was found to be 17.44 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o 8}$ i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 8" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 8.

From Table 9, the chi-square value for the frequency observed and frequency expected was found to be 33.7 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o 9}$ i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 9" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 9.

From Table 10, the chi-square value for the frequency observed and frequency expected was found to be 16.14 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o 10}$ i.e."There is no significant difference between the thinking pattern of students belonging to experiment group and control group for thinking task 10" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of thinking task 10.

Table 8: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 8.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	2	7	12	5	26	17.44
Control (fe)	11	7	5	3	26	

Table 9: Frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for thinking task 9.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	3	10	6	7	26	33.7
Control (fe)	7	12	6	1	26	

Table 10: Frequency wise distribution of students in Experiment group(fo) and Control group (fe) in different pattern of thinking for thinking task 10.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	2	7	12	5	26	16.14
Control (fe)	9	9	5	3	26	

Table 11: Average frequency wise distribution of students in Experiment group (fo) and Control group (fe) in different pattern of thinking for average of all thinking tasks.

Thinking Pattern ⇨ Groups ⇩	Reproductive Thinking	Critical Thinking	Creative Thinking	Productive Thinking	Total	Chi-Square Value
Experiment (fo)	3.7	5.7	8.2	8.4	26	8.95
Control (fe)	9.9	6.1	6	4	26	

From Table 11, the chi-square value for the frequency observed and frequency expected was found to be 8.95 which was found to be greater than the table value for chi-square i.e. 7.815 at 0.05 level of significance with df of 3. Hence, the $\mathbf{H_o11}$ i.e. "There is no significant difference between the average thinking pattern of students belonging to experiment group and control group considering the average frequency for all the 10 thinking tasks" is rejected and it can be said that there is a true difference in the thinking pattern of experiment and control group in terms of the average frequency taking all the items together.

Further, analyzing the frequency distribution of experiment and the control group students across different thinking patterns from all the tables 1 to 11, it can be inferred that more students are there in the experiment group towards higher order productive thinking, whereas, there are more students towards lower order reproductive thinking and less students towards productive thinking in the control group, which may be due to the influence of FIESI model that promotes more students towards productive thinking through critical and creative thinking.

10. Major Findings and Discussion

Significant differences were observed in the thinking pattern of students in experiment and control groups in all the 10 thinking tasks individually and as a whole. More number of students were found in the experiment group towards higher order productive thinking through critical and creative thinking, whereas, more number of students were observed in the control group towards the lower order reproductive thinking. Hence, teaching science through FIESI model was found effective in fostering productive thinking of standard VIII students of Kendriya Vidyalaya in comparison to the traditional method of teaching. Along with these major findings, it was also observed that quite a good number of students showed their critical and creative thinking pattern in comparison to their control group counterpart.

The findings of the present study revealed that teaching through FIESI model will lead students towards higher order thinking like critical, creative and productive thinking which is also supported by the studies conducted by Kumari (2014) and Sridevi (2016) where six thinking hats technique was used for enhancing problem solving abilities, lateral thinking and general creativity of students. Studies conducted by Patel (1988) and Schuler (1974) also supported the findings of the present study. In their studies, productive thinking programmes were found effective in developing creativity of students. The findings of the present study is also supported by the studies of Reema (2016) and Kachhia (1990) where the researchers found CoRT thinking programme effective in developing creativity in elementary school students. The study conducted by Chin (2006) is directly related to the present study where the researcher proved the effectiveness of questioning in promoting productive thinking. In the present study, the researchers also used a lot of questioning strategy in the FIESI model to develop creativity among students. From the findings and discussion of the present study, it can be said that strategies, models, programmes designed and implemented in a planned way can help student to develop higher order thinking. In the present study, the developed FIESI model was proved to foster higher order thinking skills like critical, creative and productive thinking among elementary students by integrating it with the content of science and further researches are needed to integrate this model with other subjects and in higher classes to foster higher order thinking skills among students.

Conclusion

Productive thinking is the ability to be both creative and critical while solving a problem creatively. It

provides a platform to be away from the reproductive thinking or rote learning as we know it is the prevalent condition of our classroom today. The process of productive thinking in the FIESI model starts from foundation to implication through ideation, evaluation and stabilization. Through this cycle, students learn higher order thinking skills like analysis, synthesis, evaluation, decision making and implementing. The result of the study shows that teaching science through the integration of FIESI model is effective in fostering productive thinking among standard VIII students of Kendriya Vidyalayas. This model may be useful for teaching other school subjects at different levels. This need lots of efforts by research taking different subjects at different levels of the school education for the enhancement of higher order thinking among students.

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Productive Thinking Model (Fiesi): To Make Science Education More Scientific And Innovative

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ABSTRACT

Science is not a set of facts and vocabulary to memorize rather it is an ongoing journey and a quest for knowledge about the natural world (Custraro, 2012). Science is a discipline that provide a lot of scope for analysis, synthesis, evaluation, decision making, critical thinking, creative thinking and logical reasoning. But a mismatch between curriculum objective and its transaction is observed (Sreehari, 2011). As emphasized by the National Policy on Education (1986) "Education should be visualized as the vehicle to train the child to think, analyze, reason and articulate logically". Putting light on recommendation given by advisory body we need to think of new ways to approach problems in science rather than relying on single correct answer. In this direction productive thinking is the construct which is the combination of higher order thinking components and it can be defined as "Productive thinking is a process involving in the creation of something new by applying higher order thinking skills". For this productive thinking model (FIESI) can be used in science teaching-learning process to make science education more scientific and innovative. It is a way by which students can think out of the box to strengthen body of knowledge of science. It is based on the principle of evaluating creative thinking by critical thinking to make it productive. This model consist of five steps: Foundation, Ideation, Evaluation, Stabilization and Implication. This paper will put light on this model, how it can be integrated in classroom instruction to teach science in innovative way, how to avoid functional fixedness and how to give emphasis on ideational fluency. This is the area which need to be introduced in teacher training programme also so that teachers can use it efficiently in the classroom instruction.

Keywords: *Productive thinking, creative thinking, critical thinking, functional fixedness, ideational fluency*

Introduction :

Growth of science and technology supported by innovation decides growth of a nation therefore education is one of the focus of government from the independence. India's development can be better met by our scientists and this can be done by introduction of work experience as an integral part in science teaching (Kothari commission, 1964-68). Local knowledge

and children's experiences are essential components that can be used in the classroom for better learning of science (NCF, 2005). We are in 21st century and we have so much challenges in the field of science education. It demands reform in curriculum and examination system by moving away from lower order thinking components to the critical understanding by inculcating higher order thinking components (National Knowledge Commission, 2009). It laid stress on the need for a radical construction of the education system to improve its quality at all stages and gave much greater attention to science and technology (NPE, 1968). Quality is one of the major issue facing our country today. Quality in science education can be met by changing teachers' attitude towards science, changing school and classroom environment, by using child centered and activity centered teaching methodology (NPE, 1986).

In this direction, thinking is the major concern which is lack in the classroom. It is the concept without which progress in science and technology or in any subject cannot be imagined. It cannot be done by simply reproducing already existing facts. We need to train our children to think divergently, consider multiple perspective and generate something new which will be beneficial for the society.

In Vision 2020, J.S. Rajput reported that there is a wide spread decline in demand for higher education in basic sciences. This may affect the scientific advancement in this field. This low demand is due to either curriculum and teaching-learning processes or the attraction towards professional courses. In order to attract and retain the bright minds in basic sciences we need to improve our instructional strategies at school level. Having achieved near universal access at the primary level (by SSA), the focus is now on quality improvement and enhancing student learning (World Bank, 2014). For qualitative change from the present situation, science education in India must undergo a paradigm shift where rote learning will be discouraged and schools will give greater emphasis on co-curricular and extracurricular elements aimed at stimulating *investigative ability, inventiveness and creativity* (position paper NCERT, 2006). Similarly, according to OECD, we should improve our practices of teaching science, that lead to foster creativity and thinking skills because thinking is an integral part of the teaching-learning process. NCF (2005) who is the operational guide of the school education provides the direction for the teachers to choose the content and methods of education to teach in the school.

Present instructional strategy for knowledge management in India must be

examined for its adequacy to develop thinking skills required for higher education. In the higher secondary examination questions are knowledge oriented whereas in the admission tests more weightage is given to the cognitive skills (Sreehari, 2011). Many students fail to secure ranks in admission tests conducted for professional courses, arts and sciences. It indicates we need to introduce pedagogy that gives emphasis over cognitive abilities of the students and to change their level of the learner from knowledge level to that of knowledge generating. As we have entered in the new millennium we cannot neglect the need of the hour i.e. individual must gain the capacity to be creative, having ability for critical thinking, reflective thinking, logical thinking and producing knowledge rather than receiving and reproducing it. The problem which we are facing today is "how to make students capable of generating new knowledge or ideas, planning and problem solving." It can be done by inculcation of productive thinking among students. Gini-Newman and Case (2015) emphasized inappropriate use of Bloom's taxonomy of the cognitive domain in the classroom. The proposed model is an attempt to give emphasis over the higher levels of Bloom's taxonomy along with the lower levels. As Tsai, Chen, Chang & Chang (2013) emphasized that critical thinking in science classes make instruction fruitful. Chine (2006) and Wardrop et al (1969) developed productive thinking by self-instructional lesson and found positive result in elementary school. Present model is beneficial for the students to learn science through developing productive thinking.

Productive Thinking :

Gestalt psychologists were the first to provide a description of productive thinking. They identified two processes: reproductive thinking and productive thinking. **Reproductive thinking** is consisting of a mechanical application of chains of associations which have already been learned and reinforced by experience and habits. It is associated with repetition, conditioning, habits or familiar intellectual territory. **Productive thinking** is a process involving in the creation of something new by applying higher order thinking skills. Productive thought covers a variety of forms of cognitive activity: deduction; understanding and causal reasoning; creative thinking and problem solving; evaluative or critical thinking; and decision making and wise thinking (Newton, L., 2013). Higher order thinking, through the combination and integration of information, enables the construction of meaningful and more comprehensive ideas that go beyond the information presented. The practice of productive thinking in academic contexts is often directed at

reasoning, understanding, creative thinking, evaluative thinking and decision making. Romiszowski (1981) also applied the term productive thinking to Bloom's (1956) higher level thinking – the analysis, synthesis and evaluation processes. According to him productive thinking is what can successfully generate ideas, develop plans, guide decision making and problem solving, and lead to actions. It is a valuable asset for people setting out to engage with and survive in the world and is the kind of thinking that has the potential to generate actions that can change minds and lives.

Considering the definitions given by the researchers, productive thinking can be define as "*the cognitive ability to plan, reason logically, analyze, synthesize, evaluate, and make decision to reach at the solution of the problem"* where newton (2013) focused on deduction, understanding, reasoning; creative thinking, problem solving, evaluative thinking, decision making and wise thinking, Cunningham & Macgregor (2014) consider Productive thinking as mechanism of shifts in perspective to solve a problem, Craig Rusbult (1997) describe it as combination of critical and creative thinking , Tim Hurson (2007) define it as problem solving approach.

Conceptualizations Of Productive Thinking In Science Teaching :

Productive thinking is not a new concept in the teaching-learning process rather it is an indispensable part of it as it combines higher order thinking components. In science teaching our prime focus is to develop analysis, synthesis and evaluation capacity in the students because science provides tremendous scope for these elements. In science teaching, productive thinking is the area which provides a balance between these elements to have something new rather than relying on drill and practice. As fig I showing opposite nature of creative thinking and critical thinking and it is also believed that persons who are creative will be comparatively less critical or vice-versa. In science we require both the skills. As fig I showing, it is the combination of creative thinking with critical thinking in such a synchronized manner having a wonderful product called productive thinking.

In science we need higher order thinking components and these components are integral part of the research and technology. Science is dead without creative and critical thinking. Productive thinking is an element where all the higher order thinking components can be enriched in the students in specifically science subject. It is the combination of creative thinking with critical thinking in a synchronized manner to make creativity wonderful and to make something new and valuable also.

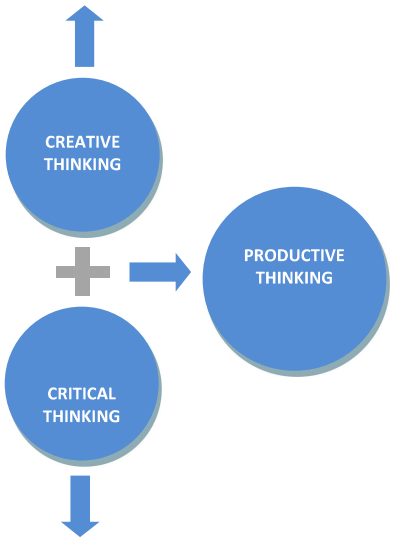

Fig I showing combination of creative and critical thinking (opposite nature) to result productive thinking

SCOPE FOR FIESI MODEL

Development of productive thinking among students through science teaching is very important aspect. It is the way by which we can achieve the expected objectives. It has its scope in the following area :

- Productive thinking give value to the creative thinking by evaluating through critical thinking.
- It provides a platform upon which creative thinking and critical thinking go hand in hand.
- It enhances scientific temper among students and develop the tendency of inquiry based learning.
- It is the foundation of science as it require the critical use of reason in experimentation and theory configuration.
- Students with productive thinking never rely on teachers and classroom time for instruction and guidance rather they are more independent and self-directed learners.
- Analytical reasoning, logical reasoning and ability to think critically are the basic component of today's entrance examination and productive thinking make them prepare for these type of examination.
- Productive thinking is the important component of research and development in science and technology.
- It provides scope to the students to develop research aptitude.

FIESI Model

The proposed model is developed by considering the other existing models of productive thinking, creative thinking and critical thinking. Rusbult (1997) gave emphasis on the implementation of the ideas in the model given by him but in the classroom it is not possible to implement all the ideas therefore in FIESI model emphasis is given over implication of the ideas. Similarly, Hurson (2007) also gave model ThinkX for productive thinking but it is for management studies. Therefore, presenter has developed model for productive thinking (FIESI) by considering the available models and adding the needed component.

This model can be integrated with the syllabus to teach the content of science. The productive thinking model (FIESI) is having the following steps as mentioned in the fig II :

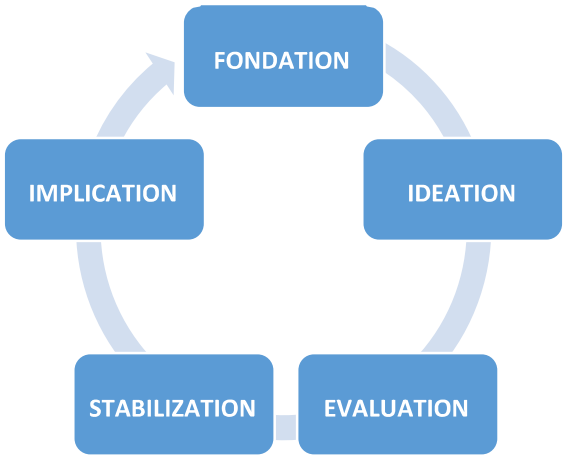

Fig. II Model of productive thinking (FIESI).

A.Foundation

This step is based on the principle that *creativity never comes in vacuum,* for this we need to provide a knowledge foundation upon which productivity can be drawn. As productive thinking is the combination of motivation, memory, creative thinking and critical thinking, a foundation stage is necessary in which teacher motivate students to get engaged in the content by manipulating their prior understanding and teach them with the help of student centric strategies like: activities, demonstration and teaching with technology.

B.Ideation

This step emphasizes over creative aspect of productive thinking where ideational fluency is emphasized. Ideation is based on the following principles:

- Quantity precedes over quality.
- Functional fixedness inhibits novelty.
- Criticism is the barrier in the way of creativity.

By keeping in mind above discussed principles, students are allowed to think out of the box by considering multiple perspectives. Here the role of a teacher is to present a problem in such a challenging way that disturb the equilibrium and engage students in idea generation. For this we need to minimize criticism i.e. self-criticism or criticism by others as it hinders creativity and avoid giving emphasis on drill, skill and rote learning. In science teaching using this model SCAMPER, forced connection, brainstorming, creative free writing and cognitive questioning can be used in this step.

C.Evaluation

This step is the critical thinking aspect of the productive thinking. It involves evaluation of the creative thinking through critical thinking to modify the concept to make it feasible. As critical thinking provides value, strength, potential, usefulness and appropriateness to the embryonic ideas by considering the criteria of domain. In classroom science teaching peer evaluation and presentation are the strategies that can be used to evaluate the immature ideas.

D.Stabilization

This phase is to stabilize the concept. Students may have developed some doubts on their developed ideas. This step will allow them to clear all the doubts related to their creative ideas and taught content to make it stabilize.

In classroom science teaching concept map and conclusion writing are two strategies can be used.

E.Implication of the concept:

Success of the productive thinking process depends upon the link between creativity and implication of the creative ideas. In creative thinking generation of ideas are more prevalent than its implication whereas in this, usefulness is necessary criteria for ideas to be considered as productive. Thus, this step is to satisfy the usefulness criteria for the productive thinking. At this step students are allowed to imply the generated ideas logically. In this component concept map and foresight can be used in the classroom science teaching.

Conclusion:

Knowledge of science and scientific ways of thinking both are necessary for the students to contribute to nation's growth. This start from the school science education. Today there is a mismatch between the curriculum objectives and curriculum transaction. This results in the disparity between the standard of the science education achieved by the students and the expected one. To achieve the expected objectives and draw our students' attention towards research we need to introduce productive thinking in the classroom instruction. Productive thinking allow the students to think creatively and at the same platform critically evaluate it to provide value and strength to the creative idea. This is the component which is to be included in teacher training programme, as teachers use this component in the classroom to make it feasible.

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2. Integrated Strategy to Foster Productive Thinking among Elementary School Students

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Abstract

Productive thinking is a cognitive ability to solve problems creatively. It is a way of thinking that combines creative thinking and critical thinking in an integrated manner.The present study aimed at fosteringproductive thinking among elementary school students through an integrated strategy. This integrated strategy is the integration of different techniques like brainstorming, concept map, videos and activities with a five step FIESI (Foundation, Ideation, Evaluation, Stabilization, and Implication) model at different phases of this model.Quasi experimental pretest posttest non-equivalent control group design was used. The study was delimited to teaching of Science to standard VIII students of CBSE School in Vadodara city. All the students studying in standard VIII in CBSE School in Gujarat constituted as the population of the present study. Two KendriyaVidyalayas were selected conveniently from Vadodara city. Students of one section of standard VIII from each of the selected schools were selected as the sample for experimental and control groups. Experimental group was taught science by the researchers through the developed integrated strategy for one academic session (2019-20,) while the control group was taught through their regular science teachers using traditional method of teaching during the same period. Both the groups were made equivalent through a science achievement test. Productive thinking was measured through a productive thinking scale that was prepared by the researchers. Mann Whitney U-test was used to analyze the data. Findings revealed the effectiveness of integrated strategy in fostering productive thinking among elementary school students.

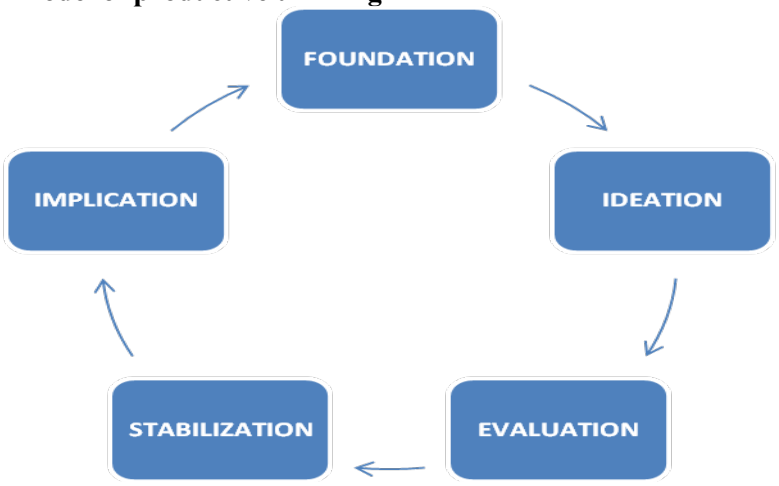
Key words-Productive thinking, creative thinking, critical thinking, FIESI model and integrated strategy

Introduction

The purpose of education in general is to help children in developing the needed skills, the knowledge, and the dispositions that will allow them to be responsible and contributing members of their democratically informed community. It would help children to contribute for the well-being of the community. But, it is not happening proportionately as Education times highlighted that "the good marks do not necessary equate to effective learning and the onus of education is being defeated in this competitive mad race for high marks" (December 30, 2020). It is really happening in this examination oriented teaching learning environment. Children think at the early ages, but as they go through the education system their thinking power deteriorates because of the environment. The ready-made answers for each and every questions asked in the examination hinders their thinking power and they start thinking in most acceptable way. This is not going to achieve the purpose of education. It is not fulfilling the aspiration of the nation builders as the Education Commission (1966) began its document with the sentence "the destiny of India will be shaped in her classroom".There seems no change in the system of education even after 55 years. There is a need to change our classroom scenario as the future job will demand cognitive abilities (creativity and mathematical reasoning) as well as process skills (listening and critical thinking) along with mastery over the subject (World Economic Forum, 2016). Today, we need to impart education which also give emphasis on decision-making, problem solving creative thinking, critical thinking, and self-awareness (World Health Organization, 1999) and (UNESCO, 2019). Cognitive skills that help an individual to adapt in a new situation and prepare to face challenges by making use of experiences and reason are the need of the hour (World Bank, 2021).Our students do not perform well specially on creative and critical thinking skill and they face problem in thinking (Velayati, N., Muslem, A., Fitriani, S., & Samad, I., 2017 and Flores, K. L., Matkin, G. S., Burbach, M. E., QuinnC. E. &Harding H., 2012). One of the reason for this is the chalk and talk method of teaching used by our

teachersbased on rote learning which is not effective enough to develop these skills in the students (Pany, 2014).Even teachers face problem in creative and critical thinking based instruction (Afifah and Retnawati, 2019). Now, it is the right time that educators and curriculum developers need to rethink curriculum by which equal importance could be given to essential thinking skills (World Economic Forum, 2016). This can be done by open-ended questioning and a supportive environment that motivate students to think freely and flexibly, consider ambiguity and also encourage students to take risk (Walsh, J. A. & Sattes, B. D., 2012and Molina, E., Adelle, P., Sara, R., Wong, &Ka-Yee, 2018). This learning gap that need to be filled by designing a strategy that equally focus on content of specific class along with the thinking skills like creative thinking and critical thinking. This needs integrated strategy where 'learners get opportunity to learn specific thinking skill through the subject content'. The National Education Policy (2020) also give emphasis on creative and critical thinking development at school.The present study is an attempt in this direction to develop an integrated strategy using FIESI model for productive thinking that will create foundation for learning productive thinking through creative and critical thinking at one place. Productive thinking is a dynamic process of four components viz. memory, convergent thinking, divergent thinking and evaluative thinking (Gallagher and Aschner, 1963 cited in Aranda, M. L., Lie, R., & Guzey, S. S., 2019).It is a process of combining memorization, understanding and causal reasoning, creative thinking and problem solving, evaluative and critical thinking, and decision making and wise thinking. It can be said that productive thinking is the ability to solve problem creatively by using creative and critical thinking simultaneously (Raipure, 2020) and (Biswal&Raipure, 2020).To train students to think productively we need a plan which provide separate place to different thinking skills so that critical thinking can never hinders creative process rather it would add on to the creativity to make it productive. For this, FIESI Productive thinking model is used in the present research. It is a 5 step model developed by (Biswal&Raipure, 2020). The productive thinking process can be represented as follows:

Figure 1: FIESI model of productive thinking



The FIESI model was developed with the objective to foster productive thinking among elementary school students with its appropriate syntax, social system and the support system. This model provides a platform for merging process of creative and critical thinking where both the thinking process go hand in hand in a synchronized manner where critical thinking is used to evaluate the creative thinking and thereby providing value and strength to the creative thinking. The model has following five phases to progress viz. Foundation,Ideation,Evaluation, Stabilization and Implication. Atthe first phase, a knowledge foundation is prepared by the teacher using student centered strategies, then some situations are provided to the students to draw their creative potentials through generating different creative ideas, in the third phase, students evaluate the generated creative ideas to make the ideas feasible through critical thinking, then students try to stabilize the generated ideas and finally imply these stabilized ideas in real life situations.

As we know that biological maturation cannot suffice for the development of higher order thinking, role of environment is equally important during this process. So, to create a motivating environment where students feel free to think differently is also needed. The integrated strategy will create an encouraging environment to think in a productive manner.Though the developed strategy will be generic in nature, science is selected as the subject of teaching because science process skills open the doors for productive thinking. Therefore, science is selected as the subject to integrate strategy while teaching.

Review of related literature

To develop an insight about the area of present research, researchersreviewed the studies related to productive thinking, creative thinking, critical thinking and higher order thinking abilities.Productive thinking needs a threshold level of knowledge but to know whether this knowledge acts as barrier in thinking differently, Birch and Rabinowitz (1951) studied the negative effects of previous experience on productive thinking and found that prior experience may act as hindering effect in problem solving.To avoid this it is necessary to ask question or create situation that may trigger students' imagination. It can be done by powerful questioning techniques such as interactive dialogues as the experimental work of Chin, C. (2007) on grade VII science class showed the impact of interactive dialogue strategy on developing productive thinking among students. Wardrop, J. L., Goodwin, W. L., Klausmeier, H. J., Olton, R. M., Covington, M. V., Crutchfield, R. S. & Ronda, T. (1969) found a productive thinking programme effective in increasing the level of productive thinking skill among VI grade students.The experiment of Patel (1988) to teach Geographythrough a productive thinking programme found it effective in developing creativity among IX standard students. Krishnan (2011)found blended learning strategy on higher order thinking effective in enhancing critical thinking, problem solving and science process skillsamong secondary school students.Patel, R. (2010) and Ramesh, K. (2015) used some standardized programme like CoRTas a strategy to develop creative and critical thinking skills and also found it effective in developing both the thinking skills. George (2016) studied the impact of play, brainstorming and storyline on creativity among middle school children and found all the interventions equally effective in enhancing creativity. Aranda, M. L., Lie, R., & Guzey, S. S. (2019) studied productive thinking among VI grade students by engaging them in designing tasks related to science and found cognitive memory, divergent thinking, and evaluative thinking among students in the earlier phases of design task.Hidayati, N., Zubaidah, S., Suarsini, E. &Praherdhiono, H. (2019) found it effective for developing creative thinking and critical thinking by using integrated problem based learning (PBL) and digital mind map as strategy. They also found significant correlation between creative thinking and critical thinking.

It can be said that productive thinking can be considered as creative problem solving where creative and critical thinking have their own role and place. Studies showed that planned programmes can develop specific thinking skills like, creative thinking, critical thinking or productive thinking independently. In the present study, an attempt is made to develop productive thinking through reproductive, critical and creative thinking in a linear developmental problem solving approach using a tested model through a specific integrated strategy.

Objectives of the Study

The study was conducted with the following objectives.

1. To develop an integrated strategy to foster productive thinking among elementary school students.
2. To implement the developed integrated strategy to foster productive thinking among elementary school students.
3. To study the effectiveness of integrated strategy to foster productive thinking among elementary school students.

Hypothesis of the Study

Following null hypothesis was formulated and tested at the 0.05 level of significance.

H_0: There is no significant difference between mean productive thinking score of experimental and control group.

Methodology

The present study was experimental in nature. Quasi experimental design was used in the present study. Pre-test post-test non-equivalentcontrol groups design was used for theexperimentation.The present study aimed at fostering productive thinking among elementary school students through an integrated strategy.

In the present study, an integrated strategy was prepared to create scope for learning specific thinking skills through the subject content. Integrated strategy has its foundation in cooperative learningand creative problem solving where students need to work together in a heterogeneous groupfor finding the productive solution or idea. It is an operational strategy that can be directly used by the teachers to teach productive thinking skills through the subject content. Teacher presents a thought provoking situation or thinking task in front of the students and students need to work upon in the groups cooperatively to find out the productive solution of the problem. This integrated strategy was developed through the integration of different techniques like brainstorming, SCAMPER, concept map, videos and activities with a five step FIESI model. The integration of these techniques were made at different phases of this FIESI model. The present study was delimited to teaching of science to standard VIII CBSE school students.Details of the population, sample, tools of the data collection, procedures of data collection, and data analysis are discussed as follows.

Population and sample

All the students studying in standard VIII in CBSE schools in Gujarat state in the session 2019-20 constituted as the population for the present study. Non-probability sampling method was used to select the sample for the present study. Two KendriyaVidyalayas were selected conveniently from Vadodara city among the schools of Gandhinagar region of KendriyaVidyalayas. Permissions from the principals and the assistant commissioner, KendriyaVidyalayaSangathan, Gandhinagar was taken to conduct experiment at these schools. One section of standard VIII from each of the selected schools were selected as the samplefor experimental and control groups. Students of these two section were made equivalent on the basis of a science achievement test. These two equivalent groups constituted of 26 students each, constituted as the sample of the present study.

Tools for Data Collection

Researchers developed a productive thinking scaleconsisted of 20 thinking tasks. Each thinking task is having 4 options representing different type of thinking ranging from reproductive thinking, critical thinking, and creative thinking to productive thinking but not in the same order in the scale. In the scale,reproductive thinking is considered as the lowest order thinking followed by critical thinking and creative thinkingand productive thinking is considered as the highest order of thinking.The score 1, 2, 3 and 4 were assigned for reproductive thinking, critical thinking, creative thinking and productive thinking respectively. The respondents were asked to choose one option for each thinking task. Hence, the maximum score and the minimum score in the scale were 80and 20 respectively.The scale was also validated by the experts. A science achievement test was also developed on the basis of the science content of the previous year i.e. standard VII which was used as the pre-test for the purpose of making the experiment and control group equivalent. The test was also validated by the subject experts.

Procedure of the study

The present study was conducted in three phases. In phase 1, an integrated strategy was developed through the integration of different techniques like brainstorming, concept map, videos and activities with the different steps of the FIESI model to achieve objective 1 of the study. Phase 2 was the implementation phase in which researcherstaught science to the experimental group through the developed integrated strategy for one academic year to achieve objective 2 of the study, while the control group was taught by their regular subject teacher using traditional method during the same time. Phase 3 was the data collection phase. At the end of academic session, researchers administered the developed scale to measure the productive thinking of both the groups to achieve the objective 3 of the study.

Analysis and interpretation of Data

To achieve the objective 3 and to test the hypothesis of the study, the collected data were analyzed using mean, standard deviation and U-test which are given in table 1, table 2 and figure 1.

Table 1: Mean,Standard Deviation (SD) and Standard Error of Mean (SE) wise distribution of productive thinking score in experiment and control groups.

Groups	N	Mean	SD	SE
Experiment group	26	57.19	7.206	1.413
Control group	26	43.42	5.508	1.080

From Table 1, it was observed that the mean and Standard Deviation of the productive thinking score of the experiment group were found to be 57.19 and 7.206 respectively with standard error of mean of 1.413 from the total score of 80. It showed a high mean score (71.48%) of productive thinking among the experiment group with moderate standard deviation and low standard error of mean. This may be due to the impact of integrated strategy for the development of productive thinking. From the same table, it was also observed that the mean and Standard Deviation of the productive thinking score of the control group were found to be 43.42 and 5.508 respectively with standard error of mean of 1.08 from the total score of 80. It showed an average mean score (54.27%) of productive thinking among the control group with low standard deviation and low standard error of mean.

The mean score of experimental group was found to be greater thanthe mean score of the control group, which may be due to the integrated strategy. To find whether the difference in the mean scores of the experiment and control group is statistically significant or not and to test the null hypothesis, Mann-Whitney U-test was used. The summary of the U-test is given in table 2.

Table 2: Sum of the Ranks (SR) wise distribution of the developmental thinking score of the experiment and control group along with the U-Value,Z-Value and the level of significance.

Groups	N	SR	U-Value	Z-value	Significant level (α)
Experiment group	26	981.5	45.5	5.34	0.05
Control group	26	396.5			

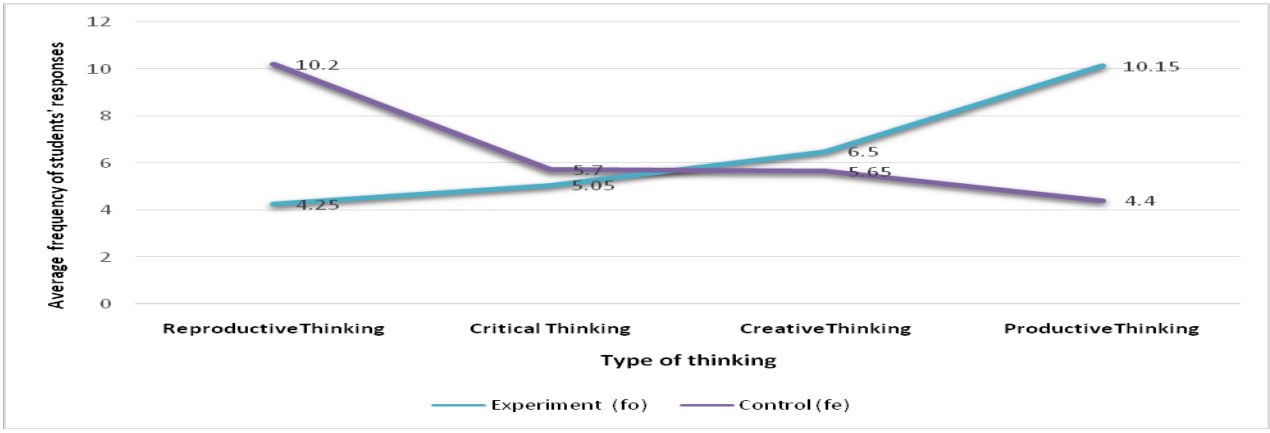
From Table 2, the Sum of ranks (SR) of the productive thinking scores ofexperiment and control group were found to be 981.5 and 396.5 respectively with the number of observations (N) 26 in each group. U-valueand Z-value were found to be 45.5 and 5.34 respectively. The Z-value was found to be significant at 0.05 level of significance. Thus the null hypothesis H_0 "There is no significant difference between mean productive thinking score of experimental and control group" is rejected and there is significant difference in the experimental group and control groupin terms of their productive thinking mean score which is due to the impact of the integrated strategy. Further, the mean score of productive thinking of experiment group was found to be greater than the mean score of productive thinking of the control group. Hence, it can be said that integrated strategy using FIESI model is effective in fostering productive thinking significantly among elementary school students through the teaching of Science.

Further, to understand the distribution of the respondents of control group and experiment group on the whole spectrum of productive thinking in all the 20 thinking tasks after the completion of the experiment, the average frequency of both the groups for different scale points are presented in table 3 and figure 1.

Table 3: Group wise distribution of average frequency of responses on the productive thinking scale.

Thinking ⟹ / Groups ⇓	Reproductive thinking	Critical thinking	Creative thinking	Productive thinking	Total
Experimental	4.25	5.05	6.5	10.15	26
Control	10.2	5.7	5.65	4.4	26

Figure 1: Average frequency distribution of responses of experimental and control group on 20 thinking tasks on the productive thinking scale.



From the table 3 and figure 1, it was observed that the average frequencies of the control group for all the 20 thinking tasks were found to be 10.2, 5.7, 5.65 and 4.4 for reproductive thinking, critical thinking, creative thinking and productive thinking respectively. On the contrary, the average frequencies of the experiment group for all the 20 thinking tasks were found to be 4.25, 5.05, 6.5 and 10.15 for reproductive thinking, critical thinking, creative thinking and productive thinking respectively. From the same table and figure, it was also found that the frequency concentration of experiment group was more towards creative thinking and productive thinking and less towards reproductive thinking. Unlikely, the frequency concentration of control groupwas more towards reproductive thinking and less towards creative thinking and productive thinking. Hence, the comparative scenario of the average frequency distribution of the experiment and control group showed a more significant concentration of experiment group towards the productive thinking in comparison to their counterpart which is due to the impact of the integrated strategy using FIESI model.

Major findings of the study

Following major findings were drawn from the analysis and interpretation of data.

1. Integrated strategy using FIESI model was found significantly effective in fostering productivethinking among elementary school students through the teaching of Science.
2. Concentration of students of the experiment group was found more towards the productivethinking and less towards the reproductive thinking in comparison to the control group which was due to the impact of the integrated strategy using FIESI model.

Discussion

Present research aimed at fostering productive thinking among elementary school students. An integrated strategy was developed and standard VIII studentswere through the developed strategy. Developed strategy was found effective in fostering productive thinking among elementary school students and the concentration of students of the experiment group was found more towards the productive thinking in comparison to the control group. The findings of the present study is supported by the previous studies like, Wardrop, J. L., Goodwin, W. L., Klausmeier, H. J., Olton, R. M., Covington, M. V., Crutchfield, R. S. & Ronda, T. (1969) , Patel, D. D. (1988), Chin, C. (2007) and Aranda, M. L., Lie, R., & Guzey, S. S.(2019). In the present research, the major component of the developed strategy is FIESI model which is mainly based on the creative and critical thinking that leads towards productive thinking which is also considered by Aranda, M. L., Lie, R., & Guzey, S. S. (2019) in their study and it showed that creative thinking and critical thinking had strong effect in arriving at the productivethinking (Hidayati, N., Zubaidah, S., Suarsini, E. &Praherdhiono, H. (2019).

Conclusion

Productive thinking is the ability to solve problems using creative thinking and critical thinking. Developed integrated strategy using FIESI model for the teaching of science was found effective in fostering productive thinking among elementary school students. Along with productive thinking the integrated strategy also creates foundation for creative and critical thinking. FIESI was a tested model for fostering productive thinking. Through the present study, a strategy was also developed and tested that can help teachers to integrate FIESI model in the Science content for fostering productive thinking strengthening both creative and critical thinking. Though the present study was delimited to science teaching for class VIII students, the developed strategy using FIESI model can be replicated in the teaching of other subjects at different standards of elementary education. Attempts are needed in this direction to have more and more research in different subjects and different standards of elementary education for fostering productive thinking along with the teaching of subject contents. This may help in developing a generic strategy for the development of higher order thinking skills among elementary school students.

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