Conceptualization, Theory and Practice of Marzano's Taxonomy in Science Teaching: An Objective Portrayal by the Investigator

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Abstract: *Education is centred on goals, specified by educational objectives, which are focused on the realisation of learning. Instructors target the improvement of miscellaneous personality attributes in students, which are productively realised through educational taxonomies. Taxonomies are cataloguing organisations based on a structural pattern, which signify a collection of sensibly expressed and well-organized terms. Several educational taxonomies have been developed to enhance teacher-pupil interaction. This paper is an upshot of the intense analysis of the major educational taxonomies developed by renowned educators. Among these, the 'Marzano's Taxonomy' developed by Robert Marzano in 2000, based on students' thinking skills, was studied, and an infographics on the Marzano's Taxonomy was created. The investigator framed phases and constructed lesson templates for the Marzano's Taxonomy, to make it appropriate for classroom instruction. Also, the practical problems in the application of Marzano's Taxonomy in actual classroom situations were identified through a Frequently Asked Question (FAQ) Generation Session.*

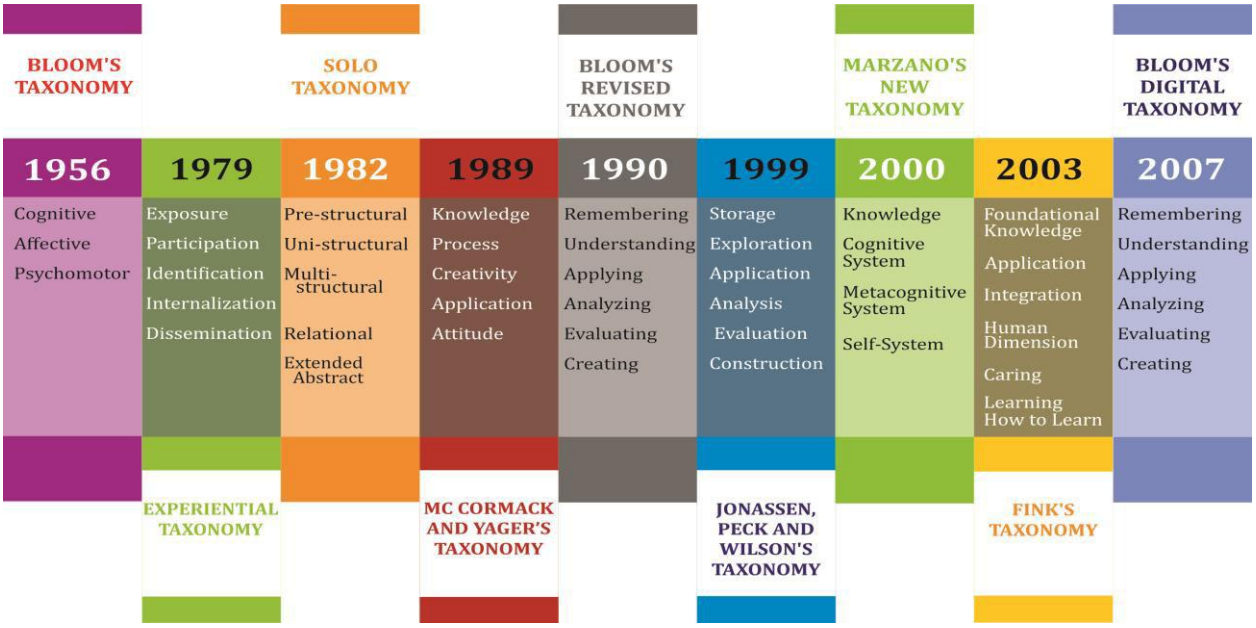
Key Words: *Educational Objectives, Educational Taxonomy, Marzano's Taxonomy, Thinking skills, Lesson Template, Infographics, Frequently Asked Question (FAQ) Generation Session.*

1. INTRODUCTION:

There are numerous distinct educational taxonomies proposed by prominent educationalists, each of which is complete in itself. Among them, Bloom's taxonomy has created a remarkable impact in the entire educational practices. But Bloom's Taxonomy had often been misapplied and misinterpreted by educators. It failed to acknowledge that learners might perform at varying levels of proficiency within each type of higher order thinking skill. In practical contexts, it gave emphasis to the attainment of the cognitive domain objectives alone. These are all the problems with the implementation of Bloom's taxonomy in actual classroom situations and not the theory itself. Plenteous educational taxonomies evolved subsequent to Bloom's taxonomy with the intention of thrusting the classroom instruction beyond rote learning. Each one of them was outstanding with regard to its spotted traits. They provide a transparent depiction of the fashioning of the classroom instruction to gratify the requisites of the existent generation. Also, each of these taxonomies has a strong theoretical backup and is relevant.

The timeline of the various taxonomies of educational objectives evolved is shown in Figure 1.

Figure 1: Timeline of major Educational Taxonomies



2. MARZANO'S TAXONOMY (2000):

Robert J. Marzano, an esteemed educationalist, has propositioned a New Taxonomy of Educational Objectives in 2000. This taxonomy was developed to deal with the inadequacies of the extensively used Bloom's Taxonomy and the existing background of instruction based on curriculum standards. Marzano's taxonomy of thinking skills encompasses a broader collection of aspects that influence students' thought processes and offers a more inquiry-based theory to assist teachers so as to enhance the thinking of students.

The biography of Robert J. Marzano is shown in Figure 2.

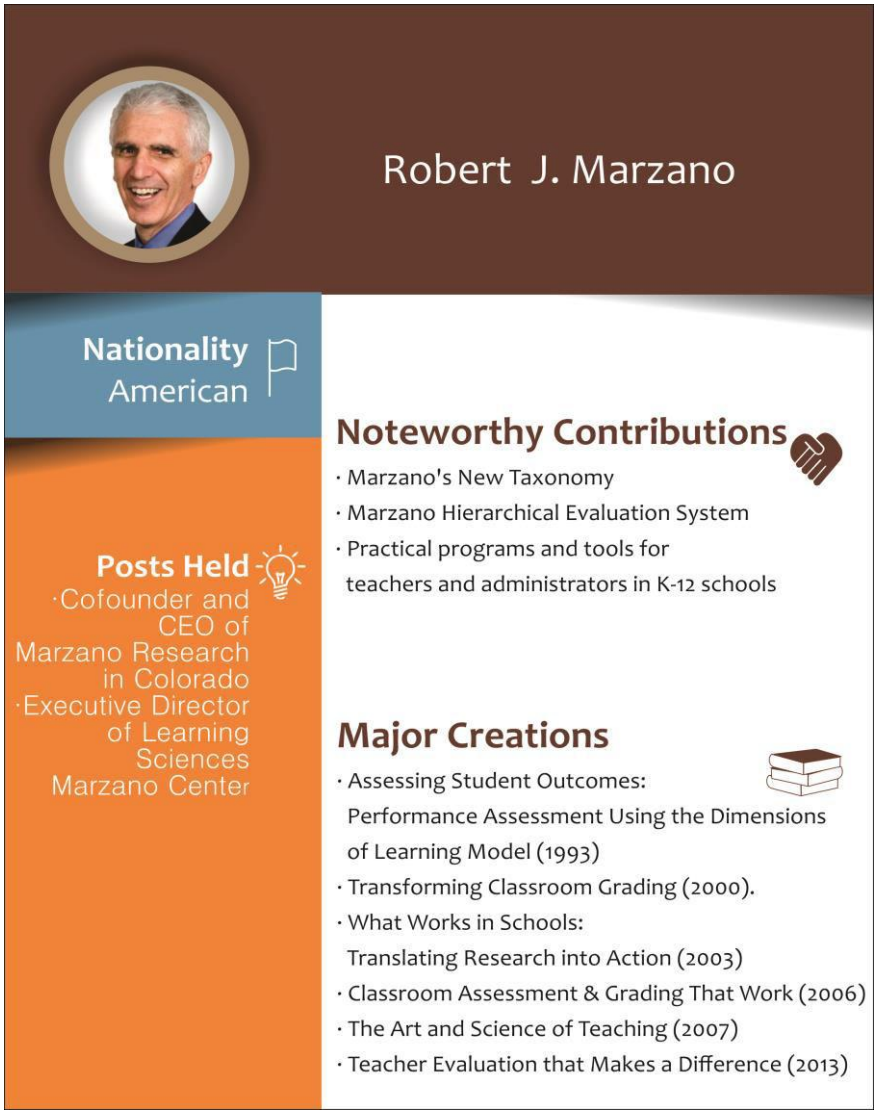


Figure 2: Biography of Robert J. Marzano

Marzano's New Taxonomy comprises the Knowledge Domain and three systems namely the Self-System, the Metacognitive System, and the Cognitive System, all of which are significant for learning and thinking. When confronted with the choice of commencing a fresh task, the Knowledge Domain delivers the content, the Cognitive System processes all the essential information, the Metacognitive System establishes goals and records how well they are being accomplished; and the Self- System determines whether to resume the current behaviour or involve in the new activity. The categories in the Marzano's taxonomy are described as follows:

a) Knowledge domain

Conventionally, the element of knowledge has been the emphasis of most instruction. It is a decisive factor in thinking too. Devoid of adequate knowledge or information about the topic being studied, the other systems do not have much to perform and are incapable of affecting the learning process efficaciously. Thus the thinking process is fuelled by knowledge.

Marzano recognises three classifications of knowledge: information, mental procedures, and physical procedures.

- **Information**: Information involves coordinating ideas, such as principles and generalizations, which permit us to stock more information with reduced effort by putting concepts into classes.
- **Mental Procedures:** This can extent from complex processes to simpler tasks.
- **Physical Procedures**: The range to which physical procedures fit into learning differs significantly by subject areas like reading, playing and other activities.

b) Cognitive system

The mental processes in the Cognitive System start from the knowledge domain. These mental processes help people gain access to the information and procedures in their memory and help them handle this knowledge. The Cognitive System is divided into four constituents: knowledge retrieval, comprehension, analysis, and knowledge utilization, where each process is comprised of all the preceding processes.

- **Knowledge Retrieval:** Knowledge Retrieval includes recollecting information from permanent memory by simply retrieving facts, series, or processes precisely as they have been stored.
- **Comprehension:** At a higher level, Comprehension involves recognising what is important to remember and putting that information into suitable categories.
- **Analysis:** By involving in the five cognitive processes in Analysis like matching, classifying, error analysis, generalizing, and specifying, learners can use their learning to create new visions and invent means of using them in new circumstances.
- **Knowledge Utilization:** The final level of cognitive processes namely Knowledge Utilization adopts the use of knowledge. It comprises the processes used by people when they want to achieve a definite task. Knowledge Utilization includes Decision-making, Problem-solving, Experimental inquiry and Investigation.

c) Metacognitive system

The metacognitive system deals with our thinking about our learning. It regulates our approach to learning in the cognitive system. Metacognition assists us recognise the best strategies to be able to learn and comprehend new information. It includes stating learning goals and then examining the execution of knowledge, accuracy, and clarity.

Being the 'mission control' of the thinking process, the metacognitive system controls all the other systems by setting goals and making decisions about which information is needed and which cognitive processes best fit the goal. It then examines the processes and makes the required changes. Research on metacognition, chiefly in literacy and mathematics reveals that instruction and support in the control and regulation of thinking processes can have a solid influence on achievement.

d) Self-system

In addition to offering students with instruction in cognitive strategies, even with metacognitive skills, for them to achieve the tasks that they believed to be very hard, it is inevitable that they possess the Self-System. This system consists of the attitudes, beliefs and feelings that govern a person's drive to finish a task. The factors that impact motivation are importance, efficacy, and emotions.

Importance: When a student is faced with a learning task, one of his primary responses is to decide how important the task is to him, whether he wants to learn it or whether the learning helps him achieve a pre-determined goal.

Efficacy: Efficacy denotes the student's views about his capacity to realise a task effectively. He becomes intensely involved in these tasks, continue working on the task, and overcome the trials.

Emotions: Emotions have a massive effect on motivation, though students cannot control their emotions associated with learning experiences. Successful learners use their metacognitive skills to help them make use of positive responses and cope with negative emotional responses.

3. STATEMENT OF THE PROBLEM:

Conceptualization, Theory and Practice of Marzano's Taxonomy in Science Teaching: An Objective Portrayal by the Investigator

4. OBJECTIVES OF THE STUDY:

- To create and develop a fundamental structure in the form of phases for the Marzano's Taxonomy, so as to make it compatible for classroom instruction.
- To create an infographics based on Marzano's Taxonomy.
- To develop a lesson template on the Marzano's Taxonomy, based on the phases developed.
- To identify the difficulties in the implementation of the Marzano's Taxonomy in classroom situations.

5. METHODOLOGY:

The concept of Marzano's Taxonomy has been theorized since 2000. But the practical application of this concept in actual classroom situations it rarely tracked. Through this study, the investigator attempts to create and develop a fundamental structure for the Marzano's Taxonomy in the form of phases, which facilitates its implementation in the real classroom settings. Also, an infographics based on Marzano's Taxonomy is created. Besides this, a sample lesson template on the Marzano's is constructed to illustrate the model, on the topic 'Gravitation' in Science.

6. CONSTRUCTION OF PHASES FOR MARZANO'S TAXONOMY:

The phases constructed by the investigator for the Marzano's Taxonomy of educational objectives are described below:

Phase 1: Encounter with Knowledge Strands

The teacher shows a video or powerpoint presentation, or conducts a speech about a task. He/ she then raises questions, cues or advance organizers based on this. The students utilize their background knowledge to make sense of the information and show willingness to receive the knowledge necessary to think intensely about the task.

Phase 2: Cognitive Manipulation

In this phase, the students process the information, and manipulate and use the knowledge acquired to accomplish the task. The teacher divides the students into task groups and asks them to conduct experiments relevant to the task. He/ she asks them to explore the task bringing about its causes and effects, its disparity from a related one, make predictions and suggest the best alternative. The students summarize the investigation through pictures, maps or flowcharts.

Phase 3: Trajectory Tracking

Here, the students monitor the entire process, sort out the available information and make changes if needed. The teacher schedules small task group reflection sessions at critical points in the project and asks the students to go through and reflect on the whole course of action, identify the essential elements and express them in their own words.

Phase 4: Valuing/ Credibility Building

The students identify the factors that motivate them to learn and acquire the skill of looking things in new ways and to take up tasks with confidence, and verbalize these in the form of a slogan, verse, resolution or caption.

7. INFOGRAPHICS CREATION ON MARZANO'S TAXONOMY:

The infographics of the Marzano's Taxonomy created by the investigator is shown in Figure 3.

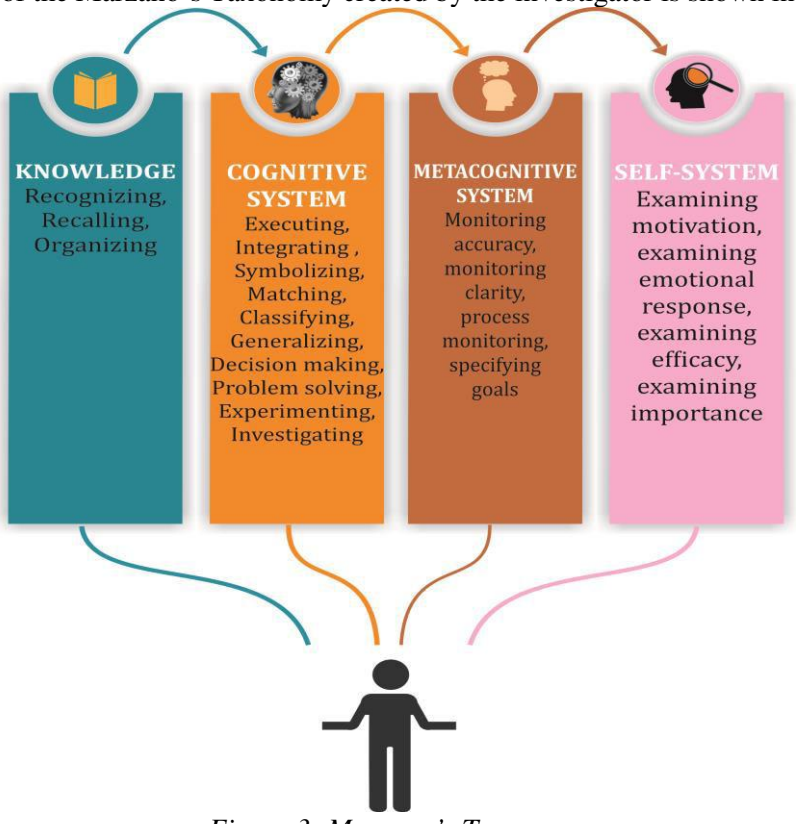


Figure 3: Marzano's Taxonomy

8. LESSON TEMPLATE CREATION ON MARZANO'S TAXONOMY:

A sample lesson template on the Marzano's Taxonomy is constructed on the topic 'Gravitation' in Science, based on the phases developed. This is attached as APPENDIX.

9. IMPLEMENTATION OF THE FREQUENTLY ASKED QUESTION (FAQ) GENERATION SESSION:

A Frequently Asked Question (FAQ) Generation Session was conducted to identify the practical difficulties in the implementation of the existing major educational taxonomies. The session aimed at creating awareness about different educational taxonomies among the student- teachers and to extract maximum genuine doubts in the form of Frequently Asked Questions (FAQs). It was conducted among the student- teachers of Department of Teacher Education, Government College of Teacher Education and Mar Theophilus Training College.

The difficulties identified in the implementation of the Marzano's Taxonomy were as follows:

- Lack of time
- Insufficiency of proper assessment techniques
- Unsuitability for language lessons
- Insufficiency of trained teachers

10. FINDINGS AND DISCUSSION:

Marzano's taxonomy of thinking skills encompasses the key aspects that influence students' thought process. It offers an explorative theory for teachers so that they could enrich the thinking of students. It aids the instructors to freely categorise the educational objectives, and support the scheming of assessments to confirm certain processes, which are used to tackle different types of knowledge. In Marzano's taxonomy, instances of tasks, educational objectives, and assessment elements are represented, which express how each processing level intermingles with the knowledge domains. This helps the instructors to achieve confidence in their capability to implement the taxonomy to support these endeavours in their practice. It serves as an excellent reference to arrange the course content meaningfully. Marzano's taxonomy also includes the addition of explicit thinking skills in the curriculum. It highlights the instructors' necessity to teach students how to involve in thought processes more effectively, and delivers general practices to assist teachers and students to develop effective mental processes.

11. CONCLUSION:

The current theoretical compulsions bring about significant changes in the students' needs. Consequently, they need to develop their knowledge and skill through need- based learning opportunities. Therefore, the taxonomies implemented today require an upgrade and facelift. As years pass by, the classroom picture transforms still more, along with the students' needs. In this context, a taxonomy based on thinking skills deserves attention. Thus Marzano's taxonomy could be effectively used in the educational system for planning and categorising educational objectives, devising assessment schemes, restructuring standards, and developing a thinking skills curriculum.

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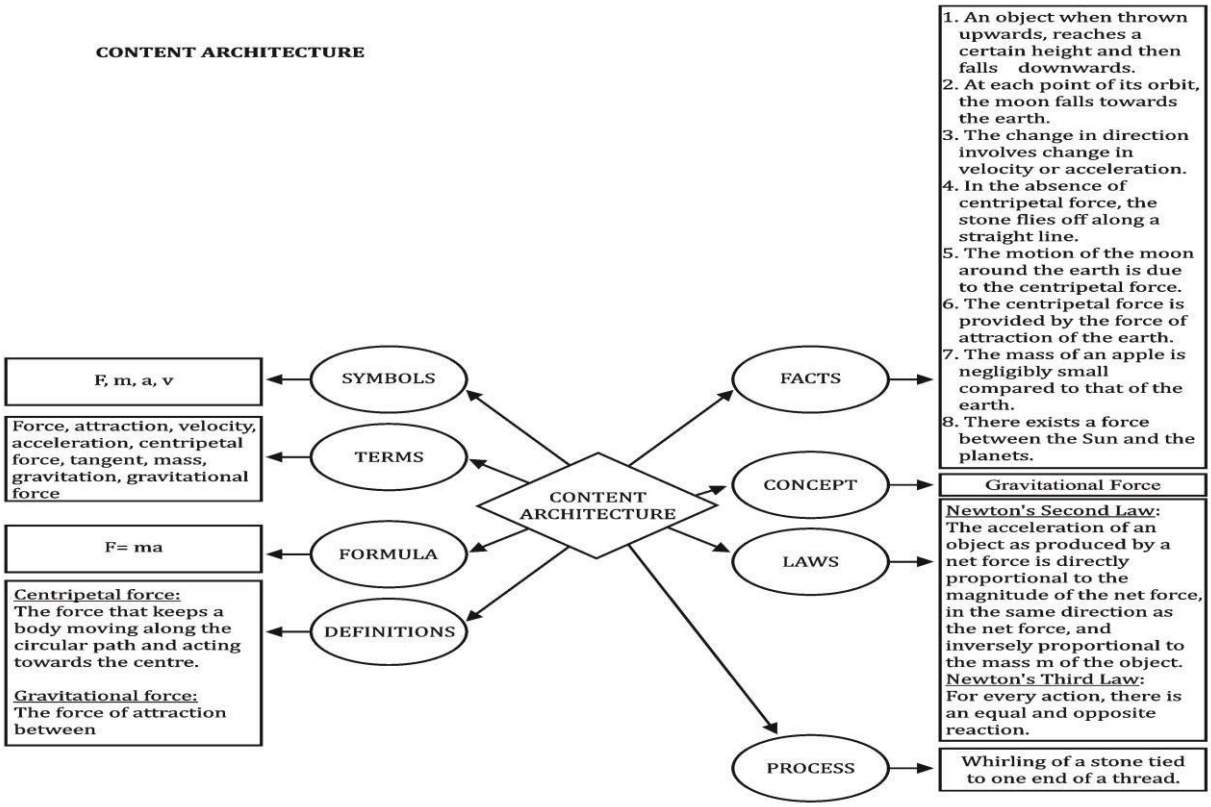
APPENDIX

MARZANO'S NEW TAXONOMY
(2000, Roberrt Marzano)

Name of Teacher	:	Name of School	:
Subject	: Science	Standard & Division	: IX
Unit	: Gravitation	Duration	:
Subunit	: Gravitation	Date	:

STATEMENT OF CURRICULAR APPROACH
Through pupil centered, activity thinking stimulated approach, the students investigate the importance of the concept of gravitation to them.

CONTENT ARCHITECTURE



LEARNING OBJECTIVES

Thinking Skills → / Phases ↓	Interpretation	Analysis	Inference	Evaluation	Explanation	Self- Regulation
Encounter with Knowledge Strands						
Cognitive Manipulation						
Trajectory Tracking						
Credibility Building						

(Note: The learning objectives are represented in the form of a grid with the phases of the Marzano's taxonomy along the vertical axis and thinking skills along the horizontal axis.
The thinking skills are given in the following reference:
http://www.rasmussen.edu/student-life/blogs/main/critical-thinking-skills-you-need-to-master-now/)

SUPPORTING RESOURCES
Powerpoint presentation on Newton's discovery of the universal law of gravitation, thread, stone.

ATTITUDES DEVELOPED
Curiosity, open- mindedness, honesty, creativity

SPECIFIC PROCESS SKILLS TO BE ATTAINED
Observing, communicating, using space/ time relations, predicting, formulating hypotheses, interpreting data, experimenting

THINKING SKILLS INVOLVED
Knowing, analyzing, generating, evaluating.

SUGGESTED ARTIFACT TO BE EVOLVED
Inspirational verse

PRE REQUISITES
The students already know about the motion of objects and force as the cause of the motion.

	Phases Involved and Procedural Details	*Expected Pupils' Response*
Multi- sensory Approach, Set Induction, Law of Motivation	***Phase 1*: Encounter with Knowledge Strands** The teacher shows a powerpoint presentation on the contributions of Isaac Newton, highlighting the discovery of the universal law of gravitation. He/ she then asks the students to think of the way in which Newton had found the universal law of gravitation.	The students utilize their previous knowledge and show interest and willingness to receive the knowledge necessary to think intensely about the task.

	Phases Involved and Procedural Details	*Expected Pupils' Response*
Learning by Doing, Multi- sensory Approach, Guided Discovery Learning, Co-operative Learning, Meaningful Verbal Learning	***Phase 2*: Cognitive Manipulation** The teacher divides the students into task groups. After providing the essential support materials, he/ she asks the students of each group to tie a small stone at one end of a piece of thread, hold the other end of the thread, whirl it round and note the motion of the stone, as given below: 	The students perform the experiment in groups, observe the motion of the stone and explain that the stone moves in a circular path with a certain speed and changes direction at every point.
	The teacher asks them to release the thread and note the direction of motion of the stone. He/ she then asks them to explore the task bringing about its reasons.	The students release the thread and summarize that all objects in the universe attract each other.
	The teacher also narrates the story of the falling apple and asks the students to find the reason for not seeing the earth moving towards the apple.	The students predict that the mass of an apple is negligibly small compared to that of the earth.

	Phases Involved and Procedural Details	*Expected Pupils' Response*
Co-operative Learning, Induced Thinking Principle	***Phase 3*: Trajectory Tracking** The teacher schedules small task group reflection sessions at critical points in the project and asks the students to go through and reflect on the whole course of action, identify the essential elements and express them in their own words.	The students monitor the entire process, sort out the available information and express the ideas in their own words.
Creative Construction of Knowledge	***Phase 4*: Credibility Building** The teacher asks the students to identify the factors that motivate them to learn and verbalize these in the form of a verse.	The students express their inspiration to look things in new ways and to take up tasks with confidence, in the form of a verse as 'every accomplishment starts with the decision to try'.

CLASSROOM EXTENSION
Explore and find out the way in which Newton guessed the inverse- square rule.

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