

# Empirical Analysis of Exploratory Question Formulation

-- The Example of Newton's First Law

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**Abstract:** Investigative questions are an extremely important part of the teaching of the secondary science curriculum. The design of the investigative questions and activities in Newton's First Law by this famous teacher is a good example of how students can ask investigative questions, design experimental procedures and produce experimental results on their own, under the correct guidance of the teacher, in line with the principles of investigative questions. The article uses this as an example to analyse and gain inspiration from.

**Keywords:** Effective probing questions, Analysis of Newton's First Law, Reflections and inspiration.

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## 1. Introduction

In the process of teaching science in secondary schools, the teacher acts as a guide, according to objective reality, by designing interlocking and progressive effective investigative questions, allowing students to practice hands-on experiments, on the one hand, to enhance students' classroom participation, on the other hand, to make students experience Designing experimental content, observing experimental phenomena, analysing experimental data and results, analogizing related experiments, summarizing, reasoning and guessing and other thinking activities, so as to solve problems and enhance students' ability level.

## 2. Effective Probing Questions

### 2.1. The Concept of Effective Probing Questions

The concept of an effective inquiry question is one that both broadly encompasses the learning content and clearly specifies the thinking procedures necessary to achieve the curriculum objectives. It is only through effective inquiry-based questions that students can think actively, develop and enlighten their ways of thinking, develop their intellectual abilities and develop their general skills, and stimulate a great interest in scientific inquiry, thus improving their cognitive level.

### 2.2. Characteristics of Effective Inquiry-based Questions

#### 2.2.1. Student Perspective

When asking an effective inquiry question, teachers should consider the students' learning situation, i.e. their existing knowledge and abilities. The inquiry question should be relevant and appropriate to the students' learning situation and knowledge level at this stage. Students can explore the questions based on their own knowledge and through the teacher's guidance, so that they can practice what they know and improve their abilities. At the same time, teachers should also pay attention to students' interests in learning, as Professor Bruner of Harvard University points out in The

Educational Process, which describes 'cognitive-discovery learning' for teaching science, including physics, chemistry and biology; asking questions, providing helpful materials, and proposing questions based on actual students' interests. Problems, helpful materials, possible hypotheses, comparative examination of hypotheses to solve problems.

#### 2.2.2. The Problem Itself Perspective

An effective investigative question should have a clear purpose, be question directed, challenging and process-oriented, and teachers should ensure that the question is detail-investigable rather than generalised, and that students can experiment and derive a final conclusion based on the investigative question, which can be based on multiple hypothetical experiments, based on multiple experimental investigations, rather than a simple and easy to know solution to a problem.

#### 2.2.3. Teacher's Perspective

Teachers should guide students to draw analogies to operational definitions, for example, to design an investigative experiment based on a life phenomenon, i.e. the original question, to design the dependent and independent variables, and then generalise and infer the results based on the experimental phenomenon. In this way, the development of higher-order thinking in students is an important element of inquiry-based problem design, and students are encouraged to develop the ability to think in diverse ways.

## 3. Levels of Inquiry Activities

The elements of an inquiry activity grade classification are: 1. who asked the question; 2. who designed the process; and 3. the outcome. Depending on the subject giving the content, the level of that inquiry activity varies. If the question, process and outcome are given by the teacher, then the inquiry is not challenging and the level is 0. If the question, process and outcome are given by the students based on actual phenomena, then the inquiry is challenging and more difficult. The higher the level the more you can develop your students' subject skills and cognitive abilities.

**Table 1.** Exploratory Activity Level

Levels	Questions	The Process	Results
0	Teacher	Teacher	Teacher
1	Teacher	Teacher	Student
2	Teacher	Student	Student
3	Student	Student	Student

## 4. Inquiry-based activities in Newton's First Law

### 4.1. Simple Inquiry-based Activities

The teacher follows a certain classroom structure, creating a small activity of shooting a balloon to introduce the question of Newton's First Law. Firstly, from 3:57 - 4:30, the teacher designs the first investigative question by giving the question "Can a force change the motion of an object" and asks students to design their own experiments with objects around them to test the hypothesis. The students share their experiments with the teacher after practice and give their results. This is a very simple, investigative experiment and falls under Level 1.

### 4.2. Complex Inquiry-based Activities

#### 4.2.1. Presentation of the Problem

From 6:30 onwards, the teacher says "What questions can you think of about forces and motion", which guides the students to ask a scientific question based on their own knowledge and phenomena. Do forces necessarily change the state of motion of an object?" and "Does the state of motion change when no force is applied?". At 9:37 the teacher again uses language to guide students to think about the methods they should use to investigate the question 'Does an object change its state of motion when no force is applied': 25, the teacher uses an analogy to show that observation and experimentation can be used to investigate the question and to introduce the next more complex investigative experiment - the effect of resistance on the motion of an object. Through a series of questions between 11:10 and 15:25, the teacher points out that the existence of resistance should be addressed, so that the question 'The effect of resistance on the motion of an object' is posed as a result of the students' participation and the teacher's summary, which helps to develop the students' Higher order thinking.

#### 4.2.2. Design of the Experimental Process

15:30 - 21:00, are the teacher and students in the design of the experimental process, the teacher did not follow the textbook directly give a table, but to ask some detailed questions, mentioned how to keep the initial velocity equal, how to make the friction force different and so on, and students in the answer to these questions, the teacher through the details of the follow-up questions The teacher then summarised the experiment by giving a table using towels, cotton cloths and wooden boards to represent different frictional forces, thus exploring the effect of the amount of resistance on the movement of the object.

#### 4.2.3. Derivation of Experimental Results

21:00 - 26:00 Teachers provide students with sufficient learning resources, provide each student with a copy of the experiment materials, let students organise their own investigations based on the experiment materials, most students determine the amount of resistance based on the distance the car slides down from a certain same height on different friction surfaces, and based on the experimental

phenomenon The results of the experiment were entered into a table and each group reported that the greater the resistance, the shorter the distance the object would travel. The problem formulation, experimental process design and generalisation of the results of this investigative experiment are all guided by the teacher and designed by the students themselves, rather than being mechanically imitated by the teacher and students, so this more complex investigative activity is graded 3.

### 4.3. Summary

In this course, whether it is the simple inquiry experiment 'Can force change the motion of an object' or the more complex inquiry experiment 'The effect of resistance on the motion of an object', the teacher takes into account the characteristics of effective inquiry questions in designing the latter. In the latter case, the teacher's approach is based on the characteristics of effective inquiry questions, which are designed by the teacher with the students in mind, and is progressive, moving from Galileo to Descartes to Newton, rather than in one step, and the inquiry into the effect of resistance on the motion of an object is well directed, with the teacher asking detailed questions to help the students design the experimental process. This is an example of a more successful inquiry-based course.

## 5. Reflection and Inspiration

### 5.1. Classroom Dark Lines Bright Lines

The first is the dark line of the journey of scientific enquiry and methodology from ancient times to the present day, which runs unnoticed throughout the classroom, allowing students to get a sense of the results and methods of enquiry of their ancestors and how they questioned and conducted investigative experiments based on their predecessors' research. The bright line is 'Can forces change the motion of an object' to 'Factors affecting resistance', with a chain of progressive questions leading to investigative questions. Not every teacher can design a classroom where these two strands work together, but we should learn from this thinking and consider whether we can create another strand that integrates with history, so that students can grasp existing knowledge as well as certain historical facts and methodologies.

### 5.2. Inquiry-based Question Formulation and Guidance in Designing Solutions

One of the most important factors in determining the level of an investigative activity is who asks the questions and who designs the experimental procedure. However, the master teacher tried to get the students to generate their own questions through observation of phenomena, and through constant questioning and correction, to arrive at the investigative questions that the classroom objective was to investigate. The experimental process was also designed through a series of questions for students to answer and solve, and in the process some experimental considerations and experimental design methods were naturally explained, with the teacher guiding the students to complete them on their own. This is an inspiration to us, how to ask a series of detailed questions, without running away from the students to guide the students to generate their own questions, and the teacher through a certain questioning skills to allow students to design their own experimental solutions in the process of answering questions, this is a we should exercise thinking.

### 5.3. Science Experiments in The Classroom

A successful science lesson is inseparable from the science experiment link, through experimental activities, not only can well stimulate students' interest in learning science, cultivate students' practical and analytical skills, but also teach students the methods of scientific research, the formation of a rigorous scientific world view. Letting students experiment on their own, thinking while doing so, stimulates their thinking and curiosity. In the Newton's First Law classroom, the master teacher starts with the creation of the context, and continues with small scientific experiments throughout, and works to get students to experiment on their own, through solo and group learning. It is clear from this that teachers should make experimentation an important part of their science lesson planning in order to stimulate students' enthusiasm for discovery, rather than an indoctrination classroom.

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