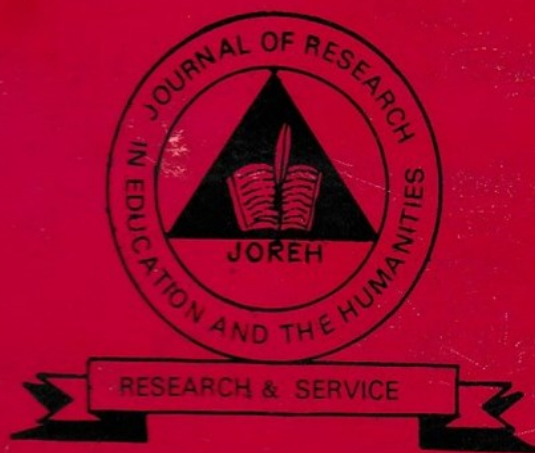


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# The Development and Use of Laboratory Problem-Solving Model (LAPSOM) in School Physics

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## Abstract:

*The work aims at constructing a problem-solving model for practical physics in school. The rationale has been that the cookbook-type practical work widely used in our schools has failed to inculcate appropriate laboratory skills expected in students, due to its lack of provision for creative and reflective thinking. For a direction in the 90's, the author proposes and constructs a model termed "Laboratory problem-solving Model (LAPSOM)" for use in solving practical physics problems. LAPSOM has five stages each of which requires the problem-solver to carry out certain actions in order to solve the problem. The use of the model is illustrated briefly with a practical problem in mechanics. Some basic precautions to be taken during practical work in physics are also given. It is finally emphasized that meaningful and successful use of LAPSOM requires mastery of all the stages involved, among other things.*

## Introduction:

**M**ODELS that have direct bearing on the teaching and learning of physics are of varied nature. They may be mechanistic, mathematical or heuristic, but must each function as analogy in either the hypothetical or real world. For instance, the kinetic Energy kit is mechanistic model that is used in illustrating the collision of molecules of a gas with each other and with the walls of the container. This, at the microscopic level, shows how pressure is exerted by the gas molecules.

Mathematical models include mathematical expressions and exerted by exerted by the gas molecules. Mathematical models include mathematical expressions and Mathematical symbolisms; for example, Maxwell — Boltzmann expression for molecular velocity and energy distribution, equations of state, etc. The use of heuristic models in the teaching of physics basically applies to the use of problem-solving models.

It is worthwhile to note that while mechanistic models aid a proper conceptualization of physics concepts, mathematical models help in the quantification of concepts. Heuristic models however help in provoking relevant actions that could be harnessed into solving problems in physics.

Moreover, it should also be noted that while the three types of models could be used in solving theoretical physics problems (problems that do not necessarily require laboratory experimentation), only the heuristic model could be applied in a practical laboratory context. It is indeed on this area that this paper is centred. This involves the use of a concrete example in mechanics.

It is necessary to report here an observation that, the use of models in solving practical physics problems in schools is yet to be fully applied and appreciated. The traditional trend has been that of providing detailed instructions and/or demonstrating the experiment required of the students, without taking readings. The adverse effect of this practice has resulted in poor development of laboratory skills in students (Raghubir, 1979; Menzie, 1979; WAEC, 1982 — 1986; Onwioduokit, 1989).

### *Importance of Heuristic Model in Practical Physics*

Generally, according to Asmore et al (1979), problem situations encountered in science range from scientific puzzles, where a unique answer could be arrived at using the information given in the problem statement, through empirical research work where information given in the problem statement is inadequate for arriving at the solution. In such cases, information needed to solve the problem must be generated by the solver's observation and/or experimentation.

The importance of the heuristic model therefore includes:

- (i) avoidance of giving too detailed instructions and hence depriving students of creative and reflective thinking;
- (ii) presentation of a situation closely analogous to the real-life situation in problem-solving among physicists;
- (iii) provision of a form of guidance as against an open laboratory condition.

It is revealing to note that although there exists no rigid way of thinking common to all, there however, exists a more or less general pattern of thought in trying to solve practical physics problems.

### *Problem-Solving Models in Physics*

Compared to other areas of science, not much has been done on the use of models in solving practical physics problems. Some studies in this area (Larking, 1980; Weeren, 1980; and Reif, 1981) have focussed on the content and processes of solving theoretical problems with the aim of developing process skills in physics. The use of problem-solving models in solving practical physics problems, has not been common. It is therefore the position of this paper, in view of the reported adverse effects of the cookbook-type physics practicals, that the use of problem-solving models in solving practical physics problems as well as problems in other areas of science, should form a distinct new direction for science in the 90's.

# LABORATORY PROBLEM—SOLVING MODEL (LAPSOM)

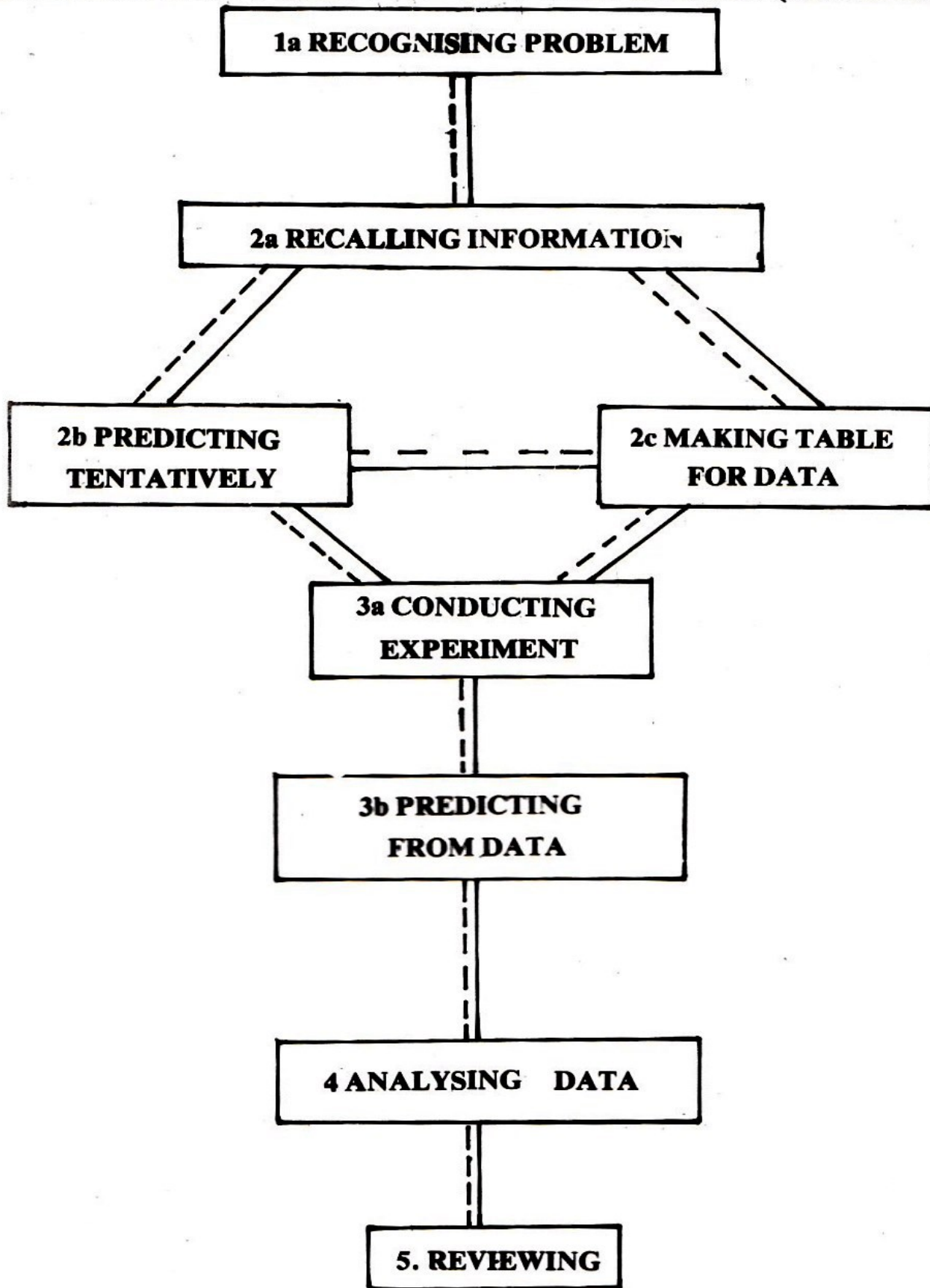


Figure 1: Laboratory Problem-Solving Model (LAPSOM)

### ***Theoretical Background of Lapsom***

The Laboratory problem-solving model (LAPSOM) as shown in Figure 1 has its root in the process approach of science and in philosophy of Instrumentalism derived from John Dewey's pragmatic view of education (Berstein, 1967).

Dewey's five steps of pragmatic problem-solving are as follows:

1. Sensing the problem;
2. Locating it and delimiting it, precisely;
3. Collecting possible data, that is, thinking of possible solutions;
4. Sifting data, that is, weighing merits and the demerits of the possible solutions; and
5. Selecting one solution for verifying and accepting or rejecting it according to the outcome of the experiment.

Although there is no stereotype way of solving a problem that is common to all problem-solvers, due to individual differences, there are, however, certain things they share in problem-solving. Generally, in problem solving, be it numerical, theoretical or practical, three essential elements are:

1. identification of problem;
2. a search for solution; and
3. evaluation of solution.

It was against such background that LAPSOM was developed for solving practical physics problems.

### ***Structure of Laboratory Problem-Solving Model (LAPSOM):***

As shown in Figure 1 above, LAPSOM is a five-stage model, designed to operationalize the teaching and learning of problem-solving in physics. At each stage, the problem solver is required to undertake some desirable actions geared towards solving the problem. These actions and step are as follows:

#### ***Stage 1***

##### ***1. Recognizing the problem:***

- Actions: (a) Reading carefully the laboratory problem(s) posed and thinking reflectively on it/them; recognizing and checking the soundness of apparatus.
- (b) Writing down the problems and sub-problems that require solution (a problem may be in the form of a statement or a question).
- (c) Reading the question again; sketching a diagram of how one intends to arrange the apparatus to enable one solve the problem(s) (if a diagram has not been provided).

## **Stage 2:**

### **2A. Recalling Background Information:**

- Actions* (a) Writing known general principles and mathematical expressions that are necessary for solving the problem.
- (b) Listing possible sources of error likely to be encountered in solving the problem.
- (c) Recognizing independent and dependent variables in the problem and relationship between them.
- (d) Re-arranging the mathematical model or expression in a simple form, making the required quantity the subject of the expression.

### **2B Predicting Tentatively:**

- Actions:* (a) Predicting the relationship between variables, the nature of the graph and the intercept (if any).
- (b) Predicting the solution to the problem.

### **(2C) Drawing up a Table for Data:**

*Action:* In view of the anticipated solution to the problem and the knowledge of variables to be manipulated to obtain the solution, drawing up a table for data, providing appropriate units.

## **Stage 3:**

### **3A Experimenting:**

- Actions:* (a) Reading the question carefully again, together with the sketch diagram, setting up the apparatus.
- (b) Taking precautions on the basis of the supposed errors.
- (c) Manipulating the independent variable to obtain the corresponding values of the dependent variable (all linear measurements and measurement of angles being made to at least one decimal place; quantities read from tables (e.g. reciprocals, logarithms, squared values, trigonometrical identities etc) being recorded to three places of decimal; all calculated values being recorded to at least two decimal places).
- (d) Writing the values straight into the table already drawn (at least five values should be obtained).

### **3B. Predicting From Data:**

- Actions:* Inspecting the data obtained and making more realistic predictions based on the data to include:
- (a) the nature of the graph
- (b) the position and nature of intercept (when the independent variable is zero, the dependent variable could have a value other than zero).
- (c) solution to all the problems.

## **Stage 1: Analysis the data**

### **4.A Graph:**

- Actions:** (a) Noting the smallest and the largest values of the independent and dependent variables to be used in plotting the graph.
- (b) Choosing a scale such that the graph will occupy at least two-thirds of the graph paper (unless otherwise instructed, the origin of the axes may not necessarily start from zero). Avoiding a scale that is a multiple or sub-multiple of odd numbers like 3, 7, 9 etc.
  - (c) plotting the points correctly by using conspicuous marks (preferably, x, at corresponding points).
  - (d) Drawing the line of best fit through the points.

### **4B. Calculating:**

- Action:** (a) Finding the slope and the intercept from the graph and relating them to the mathematical expression given or derived (the right — angled triangle drawn in attempting to find the slope should occupy at least one-third of the graph plotted).
- (b) Calculating all required values using mathematical expressions given or derived, adding appropriate units.

## **Stage 5: Reviewing: This involves evaluation**

### **5A Evaluating solutions**

- Actions:** (a) Checking the graph, all calculations and units.
- (b) Finding the average values of both independent and dependent variables.
  - (c) Substituting these values and those obtained from the graph into the mathematical expression used.
  - (d) Solving the equation to see whether or not the two sides will be equal.

### **5B. Evaluating Experiment:**

- Actions:** In order to evaluate the experiment, answering the following questions:
- (a) is your equation balanced? Why?
  - (b) What is the importance of the problem solved?
  - (c) What can you conclude from the experiment?
  - (d) what do you think should be done to improve upon the result you obtained?

**Summary:**

*It should be noted that the stages involved in the use of LAPSOM are not independent of one another. For instance, in recognizing a problem, background information plays a key role. Even the ability to make useful predictions is somehow tied to the quantity and quality of information already known by the problem-solver. In the prediction too, the clear concept of the problem is crucial. In the figure shown, this inter-relationship in stages is depicted by the use of broken arrows.*

**Solving a Practical Physics Problem Using LAPSOM:**

**Example — Mechanics**

Suppose that a student is provided with a spiral spring, metre rule, stop watch, set of weights, a weight hanger and a clampstand, and is asked to determine the value of acceleration due to gravity,  $g$ , as a novel problem.

**Guideline to solution:**

**Stage 1:**

**Recognizing the problem:**

The main problem, as stated in the a question, is to determine the acceleration due to gravity,  $g$ . But from previous knowledge, the student will probably recall that 'period' and 'length' are required for determining the acceleration due to gravity. From the set of apparatus provided the student will likely know that the extension of the spring will constitute the 'length'. Then he is likely to reason this way: "the period is determined by the length used. Weight attached to the spring causes extension of the spring, so weight determine period."

From this reasoning, the student is likely to recognize two sub-problems:

- (i) variation of period with mass
- (ii) the value  $n = \frac{\text{mean extension}}{\text{mean mass}}$

**Stage 2A:**

The background reasoning required in the first part of Stage Two, started in the process of recognizing the problem. Here, mathematical expressions having bearing on the problem are written and simplified:

$$n = \frac{\text{mean extension}}{\text{Mean mass}} = \frac{x}{m}$$

$$x = Mn$$

$$\text{period, } T \propto x \quad T = 2\pi\sqrt{\frac{(M + m)n}{g}} \dots \dots \dots (1)$$



where  $m$  is effective mass of the spring.

Squaring both sides of (1)

$$T^2 = 4\pi^2 \frac{(M+m)n}{g} = \frac{4\pi^2 Mn}{g} + \frac{4\pi^2 mn}{g}$$

Thus the plot of  $T^2$  against  $M$  gives a slope of

$$\frac{4\pi^2 n}{g} \dots (2), \text{ and an intercept of}$$

$$\frac{4\pi^2 Mn}{g}$$

$$\text{Hence, from (2), } g = \frac{4\pi^2 m}{\text{slope}}$$

2B. From the expression, the student is probably going to predict a straight line graph with an intercept of  $4\pi^2 mn$  on  $M$  axis.

2C From the main problem and sub-problems recognized, coupled with a knowledge of dependent and independent variables identified, the student will probably draw up a table as follows:

Mass (g)	Extension (Cm)	Time taken for 20 oscillations (Sec)	T (Sec)	T <sup>2</sup> (sec <sup>2</sup> )

### Stage 3: — Experimenting:

Knowing that extension is required and that it is the mass that will cause extension, the student is likely to attach a weight hanger to the spring to help him apply the mass. He will then set up the experiment accordingly. In order to determine the period, the student is likely to first of all displace the spring with the mass, horizontally. Since this will not work, he is likely to try it vertically. As this will give smooth oscillation, he is likely to start timing. He could make some more reliable prediction from his data.

### Stage 4: Analysis of Data:

#### 4A Graph

The graph of  $T^2$  on the vertical axis will be plotted against  $M$  on horizontal axis from the table; slope from the graph, and finally,  $g$ . will be calculated.

### **Stage 5:**

The student will then evaluate his solution and experiment.

## **SOME COMMON PRECAUTIONS TO BE TAKEN WHILE SOLVING PRACTICAL PHYSICS PROBLEMS.**

### ***Mechanics:***

1. Looking directly when taking readings with any measuring instruments (this precaution is common to all areas of physics practicals).  
The aim is to reduce error due to parallax in reading the scale.
2. Ensuring correct bearing of apparatus. That is, apparatus should be correctly placed and inclined to required angles. A metre rule, for instance, should make either  $90^\circ$  or zero degree with either the vertical or horizontal when in use.
3. Reducing damping effects associated with experiments involving simple harmonic motion by using small angle of displacement.
4. Repeating the readings (common to all areas). This is to reduce random errors in readings and therefore ensure accuracy.

### ***Optics:***

1. Placing pins vertically erect
2. Closing one eye during viewing.
3. Using a sharp pencil
4. Having reasonable spacing between pins
5. Having good illumination

### ***Electricity:***

1. Ensuring tight connections
2. Ensuring that there is no zero error in the measuring instrument; or adjust for it (Zero error) if it occurs.
3. Keeping the key open when readings are not being taken.
4. Not dragging the jockey on potentiometer wire.

### ***Heat:***

1. Ensuring that the thermometer does not touch the bottom of a beaker of boiling water.
2. Ensuring a quick transfer of objects to the calorimeter.
3. Stirring the content of the calorimeter continuously.
4. Except for cooling curve, ensuring a minimum loss of heat by a proper shielding of the calorimeter.

### **Conclusion:**

Although practical physics problems differ contextually, their levels of complexity are almost the same in school physics. The heuristic model (LAPSOM) used here for solving practical problems in mechanics is also used for other areas of physics. For good performance, LAPSOM requires the mastery of the heuristics involved as well as the possession of appropriate background information. It could be observed that LAPSOM requires greater time in the laboratory than the conventional cook-book type practical approaches. This seeming weakness of the model is made up for by the fact that it promotes reflective thinking and creativity in problem-solvers.

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