

# A Logical way of Solving Story Problems in Physics

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**Abstract**— The best way to teach and learn a concept in Physics is to embed it in a problem situation. Unfortunately teachers and learners ignore the importance of problem solving process in education. Traditional approach to solve typical text book problems in physics does not support conceptual understanding. Effective problem solving demands proper conceptual understanding. If the novice problem solver is provided suitable problem solving learning environment he will successfully transfer his problem solving ability to novel situation. Solving problems logically requires a systematic approach. For this the investigator designed a problem schema that explains the conceptual model of the problems. This design is based on the model suggested by Jonassen. Solving problems using problem schema elucidate the relationship between the situational elements and structural elements embedded in the problem. Investigator constructed problem schema for story problems in the chapter 'Electricity' of 10th standard. To be systematic, a wholistic structural map (semantic network) of the chapter 'Electricity' was prepared and the major problem types associated with the chapter 'Electricity' were identified.

**Index Terms**— Problem solving, Story problem, Problem Schema, Well structured problem, Schema Based Learning, Physics education, Problem type, Structural map

## 1 INTRODUCTION

Facing problems and solving problems are quite natural in human life. So the learning of how to solve problems has a key function in human lifespan. In the field of formal education problem solving based on conceptual understanding is the symbol of constructive learning. The best way to teach and learn a concept in Physics is to embed it in a problem situation. According to Jonassen [7] "content, the coin of the educational realm is relatively meaningless outside the context of a problem". So the logical end of education and breeding should be problem solving. Unfortunately teachers and learners ignore the importance of problem solving process in education.

Traditional approach to solve typical text book problems in physics involve identifying the physical quantities given in the problem and merely applying these quantities into mathematical equations, to generate a required numerical value for the unknown physical quantity. This procedure does not support conceptual understanding. Effective problem solving demands proper conceptual understanding. If the novice problem solver is provided suitable problem solving learning environment he will successfully transfer his problem solving ability to novel situation. Solving physics problems require a coherent path that would integrate situational (story) content and semantic structure of the problem.

## 2 PROBLEM SOLVING

The word 'Problem' derives from the Greek problema, meaning obstacle. Problem solving process is the careful analysis of details of a problem to reach a solution. Crebert, Patrick, Cragnoliniet.al [1] asserted that solving problems effectively requires students to identify, define and solve problems using logic, as well as lateral and creative thinking. In the process, students arrive at a deep understanding of the topic area and construct new knowledge and understanding on which they are able to make decisions.

A problem consists of sets of initial states, goals states, and path constraints [13]. According to Davidson, Deuser, and Sternberg [2], the elements, relations, and conditions that is given in the problem represents the initial state of the problem (problem state), desired solution represents goal state of the problem and characteristics of the problem solver or the problem situation that make it difficult to transform initial state into goal state represents obstacles. So problem solving is the process of moving from problem state to goal state (problem space) along with various operations (see fig1.). This problem space also known as problem schema.

## 3 DIFFERENT TYPE OF PROBLEMS

On the basis of structuredness we can classify problems into two. Well structured problems (problems encountered in formal education that is typical text book problems) and ill structured problems (problems that occur in our everyday and professional lives). Solutions of ill structured

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problems are not predictable or convergent[4]. Well-structured problems on the other hand present all of the information needed to solve the problems in the problem representation; they require the application of a limited number of rules and principles; they possess correct, convergent answers[4]; and have a preferred, prescribed solution process [13]. It is also known as transformation problems[3], that consist of a well-defined initial state (problem state), a known goal state, and a constrained set of logical operators [5]. Analysing different type of well-structured and ill structured problems Jonassen[6], identified eleven kinds of problems: logic problems, algorithms, story problems, rule-using/rule-induction problems, decision making, troubleshooting, diagnosis-solution problems, strategic performance, policy-analysis problems, design problems and dilemmas. Among them story problems play important role in formal education.

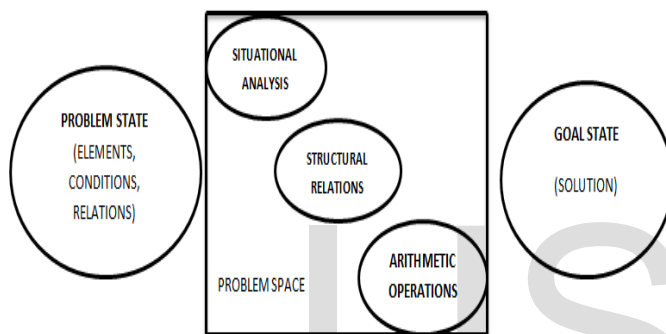


Fig 1: The Process of story problem solving

#### 4 STORY PROBLEMS

Story problem represents typical textbook problems that are shown as a piece of shallow story context (Eg: A car moving with a speed of 10m/s is brought to rest in 10 second by applying brakes. find the retardation produced ? ). Students solve numerical problems (Eg:  $5-2=?$  ) very easily. But most of them face difficulty to solve the same problem in story context (Eg: Ram has 5 balls and Sitha has 2 balls. How many balls does Sitha have less than Ram). Often students' performance on story problems was worse than the performance on numerical problems.

Sherrill [12], asserts that story problems are normally solved by identifying key values in the situation, selecting the appropriate algorithm and applying the algorithm to generate a quantitative answer. This direct translation strategy focuses only on quantitative representation of problem. Often students face cognitive difficulty while solving story problems. Some cognitive barriers of novice solver are inability to identify key features of problem situation; inability to visualise problem situation; inability to classify the problem; inability to identify and use key concepts and procedures in analogous but new situations. Jonassen [5] argues that direct translation strategy is actually problem avoiding strategy and successful problem

solving requires the construction of a conceptual model of the problem and the application of solution plans that are based on those models. So Story problem solving requires a logical representation of the problem.

Generally story problems particularly in Physics would have a situational part and a structural part. Wood [13] states that the context in which problems are embedded become a significant part of the problem and necessarily part of its solution. Story problem solving calls for not only calculation accuracy, but also the comprehension of textual information, the capacity to visualize the data, the capacity to recognize the semantic structure of the problem, the capacity to sequence their solution activities correctly, and the capacity and willingness to evaluate the procedure that they used to solve the problem [8]. The learner's ability to construct a conceptual model of problem will promote transfer of problem solving skill in a different problem situation. Problem solving strategy varies according to problem type. The article here, illustrates the logical way of solving Physics problems at Secondary School level. This logical way of solving problems is based on the concept of 'Problem schema', the mental representation of a problem.

#### 5 PROBLEM SCHEMA

Solving of story problems in secondary level physics education strongly demands conceptual understanding of the problem. Problem solving in semi-structured and unstructured domains often involves the transfer of knowledge and skills from a structured (classroom) domain to the semi-structured or unstructured domain[10]. But traditional approach in the form of direct translation strategy to story problem solving do not support conceptual understanding and often fails to foster transfer of problem solving ability. Inability to reach satisfactory level of proficiency in problem solving quite often creates fear and anxiety in learner at the time of facing problems in novel situations.

To develop effective problem solving skill, the learner must practice problem solving process using a logical way that would help the learner overcome cognitive difficulty in problem solving. Thus teaching for problem solving must be designed as to promote the ability to construct mental representation of a particular problem in the minds of learners. This mental representation is called *problem schema*. According to Riely and Greeno[11] problem schema is the mental representation of the pattern of information that is represented in the problem. This Problem schema (conceptual model) is necessary for developing meaningful solution to the problem. Jonassen [5] studied about the role of problem schema on solving story problems. He says that problem schema includes semantic information and situational information about the problem. Problem schemas also possess knowledge about the process of solving problem. Jonassen [5] also argues that the most successful problem solvers are those who can integrate the situational and structural characteristics of the story problems.

## 6 FEATURES OF PROBLEM SCHEMA

According to Jonassen[5], understanding a problem includes two process-representing pattern of information in the meaning of terms in the text and constructing a conceptual model that represent the situation in the text. A robust problem schema takes account of the following features.

### 1. Problem Type(Problem classification):

According to Mayer, Larkin and Kadane[9]classifying problem type is essential to an understanding of the problem and transfer of problem solving skills.Classification of problem should be based on relationships embedded in the principles contained in the problem.

### 2. Structural Model

It represents structural relationship between problem elements.Problem elements refer to the relevant physical quantities mentioned in the problem. The model describes the structural and causal components of the problem. Learning about the structure of each type of problem will help to construct robust problem schema.

### 3. Situation Model

The situational characteristics represent the contextual story elementsin the problem. Situational content is also valuable because it affects access to internal, mental problem schemas.

### 4. Set Identifier

Set identifier refers to the relevant values given in the problem for solving it. Identifying key values in the problem isan important process in solving story problems.

### 5. Arithmetic Model( Equation Builder)

Arithmetic model refers to the actual mathematical expression connecting the known and unknown quantities mentioned in the problem. The problem solver assigns values from the structural model into the equation to solve it.Fig2 shows the structure of story problem solving environment.

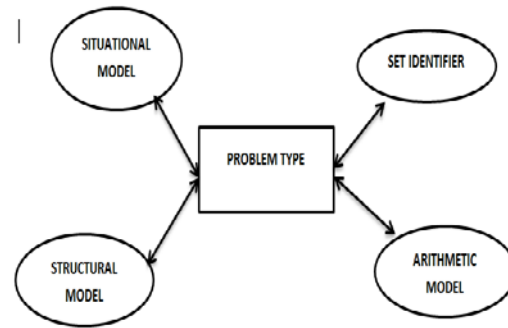


Fig 2: Structure of the Problem solving learning environment for story problems

## Logical way of solving story problems

Solving problems logically requires a systematic approach. For this a problem schema that explains the conceptual model of the problems is designed. This design is based on the model suggested by Jonassen[5]. Solving problems using problem schema elucidate the relationship between the situational elements and structural elements embedded in the problem. From personal experience of teaching Physics at higher secondary school, the investigator is convinced about the effect of using problem schema to impart the logical skills of problem solving to students. In the light of this experience the investigator constructed problem schema for story problems in the chapter 'Electricity' of 10th standard. To be systematic, a wholistic structural map (semantic network) of the chapter 'Electricity' was prepared and the major problem types associated with the chapter 'Electricity' were identified. The major problem types presented in the chapter 'Electricity' are (1) Equivalent Resistance (2) Ohm's law (3) Joules law of Heating (4) Electric Power.

The structural map for the chapter 'Electricity' is given as fig 3.

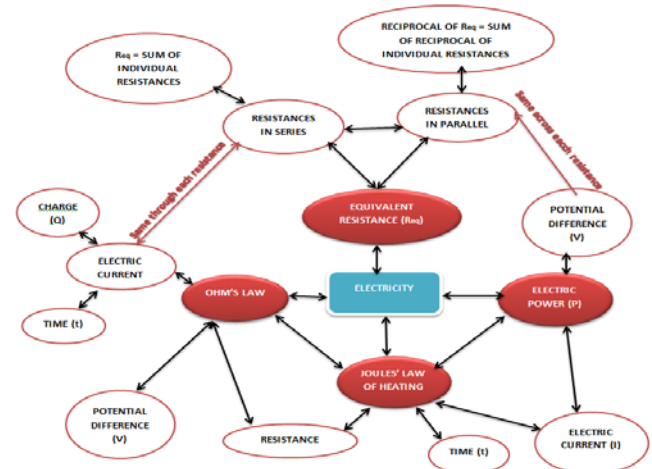


Fig 3: structural map for the Chapter 'Electricity'

The problem schema for the two major problem type in the chapter is illustrated below.

Consider the story problem associated with the problem type -Equivalent Resistance, the structural and situationalelements along with the relationship is

represented in the problem schema given as fig4.

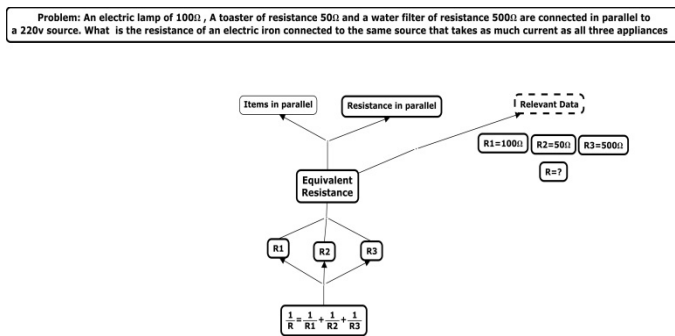


Fig4. Problem schema of the problem type 'Equivalent Resistance'

Consider the story problem associated with the problem-type 'Joule's law', the structural and situational elements along with the relationship is represented in the problem schema given as fig:4

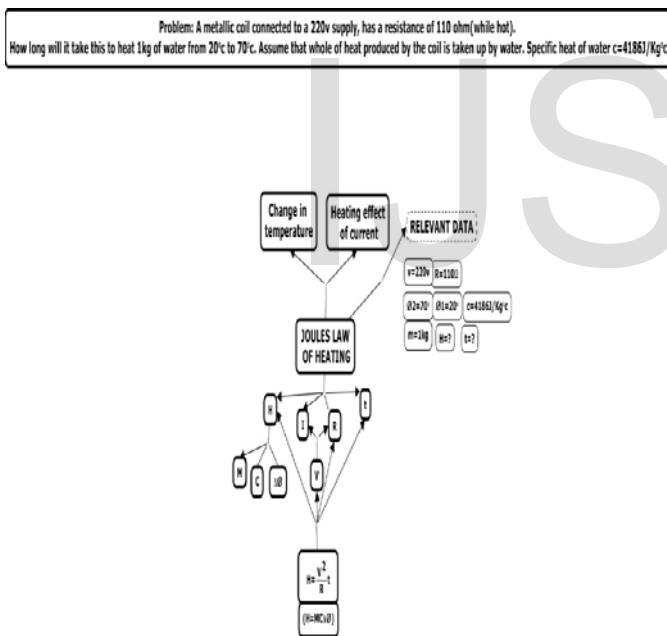


Fig.4: Problem schema of the problem type 'Joule's law'

### How to construct Problem schema.

Worked examples of similar problems may not lead to formation of required problem schema. Construction of robust problem schema for solving different types of story problems demands systematic

training. After reviewing various studies on solving of story problems, the investigator designed logical steps for training students to construct problem schema.

#### Step1: Presentation of Story problems: A

teacher can present story problems in different way such as in the form of an interesting story, or written description, simulation, pictures or videos.

#### Step2: Visualization of the problem scenario:

Draw a simple sketch or outline of the problem scenario by including the relevant data and situational features of the problem. The thumb nail sketch should be a reflection of how the learner has perceived the problem situation.

#### Step3: Analysis of problem scenario:

In this step the learner analyses all the elements embedded in the problem conceptually. The learner can put forth the following questions and find information.

1. What are the key features of problem situation?
  2. What are the target variables in the problem?
  3. What are the relevant data embedded in the problem?
  4. What are the irrelevant data given in the problem?
- What are the Inter relationship between the target variable and other variables in the problem.

Problem-solvers are instructed to identify relevant and irrelevant physical quantities from the given story context. This filtration must be based on structural relationship between various physical quantities embedded in problem situation.

#### Step4: problem classification

This is the very crucial stage of story problem solving process. Problem classification should be done on the basis of information gathered from contextual analysis. Miss-categorization of 'Problem type' causes suggestion of unfavorable solution. To foster problem classification, The learner can put forth the following questions

"What is the critical problem to be solved in given context. What ideas/principles/laws are needed to solve this problem?

What kind of problem it is?

Which is the equation required to solve the problem?

On the basis of conceptual elements and core idea embedded in the problem context, the learner classifies the problem. The mentor can guide the learner to classify the problem properly

#### Step5. Argumentation:

In this stage solver make arguments for their

classification of problem. Solver must justify their classification with accurate reasons.

#### **Step6. Finding numerical Value of target variable:**

Learner finds numerical result of target variable by applying the relevant physical quantities on to the mathematical formula.

#### **Step 7. Reflection:**

In this stage solver think about what he have learnt by solving the problem. The learner can express relevant information of particular problem type in the form of problem Schema. Solver organizes key factors in the problem context, problem type, structural relationship, relevant physical quantities and mathematical formula in the problem schema. Thus learner would construct a mental representation of each kind of problems in the form of a meaningful patterns illustrated in figures. This mental representation would have key attributes (semantic and structural attributes) of problems.

Different types of problems require different types of problem schema. Construction of different types of problem schema would help the learner to compare situational and structural characteristics of each kind of problems. Learner will be able to recognise situationally similar and structurally dissimilar problem; situationally dissimilar and structurally similar problems. Solver can assimilate novel problem situation with existing problem schema. And also can retrieve more information about the problem from existing problem schema. This type of problem solving promotes transfer of problem solving skill and minimises the number of wrong attempts. This problem schema promotes the ability of learner to filter relevant and irrelevant physical quantities given in the problem, to visualise the problem situation, to retrieve the inter relationship between the physical quantities. Robust schema is the symbol of conceptual understanding. Schema based instruction on solving problems can promote the integration of creative thinking, critical thinking and reflective thinking in problem solving process.

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