EFFECT OF SCHEMA BASED INSTRUCTION ON SOLVING STORY PROBLEMS IN PHYSICS AMONG HIGHER SECONDARY SCHOOL STUDENTS

Thesis

Submitted for the Degree of

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by

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Certificate

This is to certify that the thesis entitled **EFFECT OF SCHEMA BASED INSTRUCTION ON SOLVING STORY PROBLEMS IN PHYSICS AMONG HIGHER SECONDARY SCHOOL STUDENTS** is an authentic record of research work carried out by **VIJESH K.,** for the degree of Doctor of Philosophy in Education, Farook Training College, Research Centre in Education, University of Calicut, under my supervision and guidance and that no part thereof has been presented before for the award of Degree, Diploma and Associateship in any University.

Place: Farook College

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DECLARATION

I **VIJESH K.**, do hereby declare that this thesis entitled as **EFFECT OF SCHEMA BASED INSTRUCTION ON SOLVING STORY PROBLEMS IN PHYSICS AMONG HIGHER SECONDARY SCHOOL STUDENTS** is a genuine record of research work done by me under the supervision of **Dr. Manoj Praveen G.,** Associate Professor, Farook Training College, Research Centre in Education, University of Calicut, and that no part of the thesis has been presented earlier for the award of any Degree, Diploma and Associateship in any University.

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Physics plays an important role in the progress of humankind. It provides an understanding of the basis of everything that we encounter in our day to day lives. It expands frontiers of our knowledge about the universe, contributes knowledge to the development of science and technology, and moreover creates a suitable environment for scientific advances and discoveries. Also, meaningful learning of Physics can influence social and economic development of the nation. So it is one of the chief responsibilities of formal education system of the nation to keep the quality of Physics education at the peak. It is generally accepted that quality of physics education depends on the quality of teaching and learning happening in the classroom. In order to ensure the quality of physics education, students have to learn subject matter in an environment that promotes the learner's mental efforts to acquire meaningful learning. It is generally accepted by teachers and researchers that the best way to enhance meaningful learning of Physics in classrooms is by providing problem situations and through problem solving procedures.

It is widely acknowledged that Physics is a problem-solving discipline. So it is the responsibility of a Physics teacher to enable students to apply concepts/principles/laws of Physics to understand and solve problems. Physics concepts are closely related to our real world. So it is meaningless to teach or learn Physics concepts merely as a textual material or definition without giving due weightage to the real world context in which these concepts are applied. Learning Physics by connecting it with real world situation empowers the conceptual knowledge of the learners. Researchers (Young, Freedman & Ford, 2012) have pointed out that "in Physics, truly understanding a concept means being able to apply it to a variety of problems. The best means to learn a concept in Science particularly in Physics is by presenting that concept as the part of a problematic situation"(p.2). Cognitive studies have reported that, for effective and meaningful learning, students must encounter various contextual problems. Contextual problems can act as a tool to activate meaningful learning in Physics. It enables students to analyze the context of a problem and interpret underlying concepts meaningfully.

The best way to measure the quality of comprehension of concepts or principles in Physics is to assess learners' problem solving skill. Problem solving is the necessary twenty-first century skill; it is the most reliable and therefore the most applicable learning activity that learners can involve in (Jonassen, 2010). Research studies have revealed that information constructed by solving contextual problems is better comprehended, retained, and therefore more transferable. In most disciplines the information that is not used for problem solving tasks is too quickly forgotten within a short time (Jonassen, 2010). Therefore the real goal of education in every educational context should be to engage and support problem solving skills.

As a cognitive process problem solving is influenced by various factors. These factors are categorized into two groups (Smith, 1991): "external factors (related to the nature of the problem as confronted in the world)" and "internal factors (related to prior experience, prior knowledge, or strategies used)". Problems and strategies adopted to solve them vary with their external characteristics such as structure; context; complexity; dynamicity and domain specificity (Jonassen, 2010).

Based on the structure, problems can be classified into two: well-structured or ill-structured (Arlin, 1989; Jonassen, 1997; Newell & Simon, 1972; Voss & Post,1988). Well-structured problems are those problems whose goals, path to solution, and obstacles to solution are clearly based on the information given (Pretz, Naples, and Sternberg, 2003).Typical textbook problems can be considered as well-structured problems because they have readymade solutions. For well-structured problems, all of the relevant information needed to solve the problem is accessible from problem scenario. They are constrained by the content domains learnt in classrooms. In addition to this, they have readymade equations, accurate answers;

and, suggested solution plans (Wood, 1983). Ill-structured problems are the types of problems that we face in our day to day lives. Unlike well-structured problems, ill-structured problems are not constrained by the content domains learnt in classrooms; so their solutions are not predictable or convergent (Jonassen, 2010).

As an item that promotes meaningful conceptual learning, problems deserve better understanding. Analyzing various well-structured and ill- structured problems, Jonassen (2010) categorized problems as "logic problems, algorithms, story problems, rule-using or rule-induction problems, decision making problems, troubleshooting, diagnosis-solution problems, strategic performance, policy-analysis problems, design problems, and dilemmas" (p.11). Among these, story problems are the most common in Physics education. In Marshall's (1995) words, "A story problem is a shorthand representation of a real world situation. Sometimes the stories are elaborate, which can run from a paragraph to several pages. More often the stories are brief with a length of a few sentences, where the students are expected to use their own prior knowledge of the world to fill in gaps about the situation depicted in the story" (p. 69).

Story problems have a key role in connecting Physics concepts/principles/ laws with the real world situations. It explicitly or implicitly presents several information including, situational elements like numerical values and conditions, core idea required for solving the problem, interrelationship between various physical quantities (also called structural relationship) in the problem and task variable(s) of the problem. Identification and interpretation of that information is needed to apply correct problem solution method. Integration of information obtained from various problem contexts foster understanding about the concepts/ principles/laws behind the problems. In the view of Information-Processing Theory, a story problem consists of sets of initial states (elements, relations, and conditions given in the problem), goals states (desired solution), and path constraints (characteristics of problem solver or the problem situation) (Wood, 1983; Davidson, Deuser, & Sternberg, 1994). This theory describes story problem solving as the process of moving from problem state to goal state along with various operations (Nowell & Simon, 1972; Jonassen, 2010). In order to move from problem state to the goal state, solver must analyze the problem context with the help of specific domain knowledge. To facilitate situational analysis, solver must have a data structure of the problem stored in memory. This data structure must contain specific details of problem.

It is clear from the Information Processing Theory that the story problem solving is not a simple cognitive process. It includes a series of complex set of cognitive, behavioral, and attitudinal components (Bautista, 2013).It is a process that comprises manipulation of, or operations on previous knowledge (Funkhouser& Dennis, 1992). Based on the comprehensive studies, researchers in the field of cognitive psychology had developed several information processing models of problem solving. Some models regard problem solving as a multi-step process including problem translation, problem integration, solution planning and monitoring and solution execution (Mayer, 1992). In a problem solving process solvers must recognize the potential problem, define and represent the problem mentally, develop a solution strategy, organize their knowledge about the problem, assign mental and physical resources for solving the problem, monitor their progress toward the goal and evaluate the solution for accuracy (Bransford & Stein, 1993; Hayes, 1989; Sternberg, 1986). General Problem Solving model (Newell & Simon, 1972), describes problem-solving processes in terms of two sets of thinking processes, understanding processes and search processes. The integrated activities of these two thinking process constitute the problem solving process. The IDEAL problem solving model (Bransford & Stein, 1984) explains problem solving as a process of Identifying the problem; defining the problem by thinking about it and sorting out the relevant information; exploring solution using possible strategies; acting on those strategies; and looking back and evaluating the effects of those activities. A simplified model formulated by Gick (1986) describes problem solving process in terms of sequential cognitive activities including, constructing a problem representation, searching for solutions, and implementing these solutions. Polya (1957) presented problem solving as a four step process involving understanding of the problem (what is being asked for &if there is enough information); making a plan (look for patterns; organize information); carrying out the plan; evaluating its effectiveness.

The foregoing models of problem solving process argue that problem solving requires integration of several cognitive processes. Story problems require careful analysis and interpretation of problem scenario. The cognitive activities i.e. understanding a problem and organizing all relevant information meaningfully have a vital role in problem solving process. Yet these cognitive activities of problem solving process have not received the deserved importance in traditional methods of problem solving. Instead of focusing on situational elements and structural relationships of a problem, traditional problem solving learning environment merely focuses on plucking data from problem scenario and plugging those data on to readymade mathematical formulae and finally finding the numerical value.

Emerging views in Psychology of problem solving points out that effective problem solving requires domain of specific knowledge that includes both conceptual and procedural knowledge. Organization of conceptual knowledge and procedural knowledge in a meaningful pattern provides mental representation of the problem. This mental representation of the problems is the basis of successful problem solving (Chi, Feltovich & Glaser, 1981; Fuch & Fuch, 2005; Jonassen, 2004).

Identification and interpretation of situational elements of the problem contributes relevant information required to develop conceptual model of the problem. Even so, often students follow the so called Direct Translation Strategy to solve problems. Direct Translation Strategy is one in which "problem solvers attempt to directly translate the key propositions in the problem statement into a set of computations" (Jonassen, 2010; p.28). This strategy often ignores the significance of problem scenario on conceptual learning. Actually, the Direct Translation Strategy is a problem avoidance strategy because this strategy regards problem solving as a "procedure to be memorized, practiced, and habituated", and that emphasizes "arriving at the solution than meaning making" (Wilson, Fernandez, & Hadaway, 1993). The learners, who solve problems through Direct Translation Strategy, mainly focus on surface characteristics of the problem or recall solution plans from previously solved problems. Often, they do not make any attempt to understand inter relationship between various physical quantities embedded in the problem scenario. Most of such learners face difficulty in transferring problem solving process to new situations (Woods, Hrymak, Marshall, Wood, Crowe, Hoffman, et al., 1997). For effective problem solving, students have to realize that solving physics problems require more than merely plucking data from problem scenario and plugging it onto the mathematical formulae.

For effective problem solving to occur, students have to construct conceptual models (or data structure) of the problem and to apply the correct problem solution plans based on those models (Jonassen, 2010). A robust conceptual model contains well organized specific knowledge about the problem environment. A conceptual model with adequate problem specific knowledge helps solvers to retrieve problem-relevant information at the time of solving a problem. The quality of conceptual models influences the ease and accuracy of problem solving (Hayes & Simon, 1976).

The conceptual model, also known as problem schema is the mental representation of patterns of all problem relevant-information (Riley & Greeno, 1988). A problem schema of a problem type comprises semantic information and situational information about that problem type. Problem schema also possess information about the process of solving problems (Jonassen, 2004). It is a vehicle of memory that allows organization of similar experiences in such a way that the individual can access a generic frame that consists of relevant information of these similar experiences and easily recognize additional information that are also similar. The solver can utilize skills, procedures or rules as required when encountered with a problem scenario for which this particular framework is relevant (Marshall, 1995).

A robust problem schema of a story problem generally consists of a "Situational Model", a "Structural Model", and an "Algorithmic Model" (Formula) of the problem from the problem text (Jonassen, 2004; Reusser, 1993). Organizing relevant details of problems including situational characteristics and structural characteristics onto the schema will facilitate retrieval of all problem relevant information. According to Jonassen (2010), "the most successful problem solvers are those who can integrate the situational and structural characteristics of the story problems " (p.247). For the meaningful integration of these characteristics, students should encounter with various story problems including structurally similar and situationally dissimilar problems and situationally similar and structurally dissimilar problems. Practicing problem solving by encountering variety of problems will facilitate cognitive processes required for the construction of situational and structural model of problem types.

Earlier works on problem solving reveals that unsuccessful problem solvers make no effort to construct any type of problem schema of the problems in their memory. As a result they often commit errors while solving problems. Researchers in cognitive psychology indicates that inadequate problem schema creates difficulty in identifying key features from problem scenario, in visualizing problem context in filtering out irrelevant data, in understanding structural relationships embedded in the problem and in recognizing correct mathematical formulae (Jonassen, 2004). Identification of relevant information presented in the problem context and correct interpretation of that information is essential to activate problem solving process. Thus meaningful problem solving requires student to identify key features of the problem scenario, recognize the relevant physical quantities required for solving the problem, visualize the problem scenario, understand the physics concepts behind the problem, identify the structural relationship of problem, and to identify the required mathematical formulae. Practicing problem solving by retrieving all relevant situational and structural information of a problem will enable students to develop deep understanding of the topic area. However, the Direct Translation Strategy of teaching problem solving, has constrained students' story problem solving into merely searching for key words; selecting algorithm (formula) based on key words; and applying the algorithm (Sherrill, 1983).

Schema-theory of problem solving points out that the problem-solving skill depends on construction and development of schema of problems. As a strategy for teaching problem solving in Physics, traditional methods are not enough to foster the construction of robust problem schema. So it is important to develop a problem solving learning environment that emphasizes schema construction in students.

As an initial step of teaching and learning, the process of memorization has a crucial role in education. It is noteworthy that if the memorized information is not meaningfully connected to the other information that the learner has, it will soon be lost from their memory (Marshall, 1995). Both direct instruction and rote memorization have significant role in learning and teaching process. But teaching learning process must ultimately go beyond this and provide the necessary links that allow meaning to be the basis of memory (Marshall, 1995). This indicates that we have to facilitate the development of schemas and we can best do so with schema based instruction.

In the present study the researcher has developed a Schema Based Instructional Strategy for solving story problems in Physics for higher secondary classes. This problem solving strategy is based on 'schema theory'. Schema-based instruction allows learners to approach Physics problems by focusing on the underlying semantic structure. It provides learners an environment for practicing problem solving using problem schema.

Need and Significance of the Study

The present study is based on four assumptions. Firstly, if students learn physics concepts for the purpose of solving problems in the real world, their conceptual learning will be more meaningful. Secondly, in traditional methods of teaching problem solving, students often solve physics problems without the support of conceptual understanding. Solving conceptual problems using correct cognitive models indicates depth of conceptual understanding. Thirdly novice-problem solver will be able to solve story problems successfully if they are taught to develop the same mental model conceived by the expert problem solver. Fourthly, identifying a problem at hand as belonging to familiar problem type that have known solution method will reduce novices' working memory load (Kirschner, Sweller, & Clark, 2006). and will help them to retrieve relevant information quickly from the memory while solving a problem.

It is generally assumed that students with higher conceptual knowledge have high ability to solve problems. But most of the students solve Physics problems by memorizing equations and problem solving procedures without the support of conceptual understanding behind the problems (Panitz, 1998). In Traditional methods of teaching problem solving, particularly in Direct Translation Strategy students solve physics problems without applying conceptual and interpretative knowledge (Lawson & McDermott, 1987; McMillan & Swadener, 1991; Pride, Vokos, & McDermott, 1998; Shaffer & McDermott, 1992). They typically use means-end analysis rather than applying general principles of physics (Jonassen, 2010). The means-end analysis strategy (or working backward strategy) focuses on memorization of mathematical sequences required for problem solving instead of focusing on situational and semantic information of problems. Memorizing only mathematical procedure of problem solution does not help the learner in understanding the relationship between the conceptual elements presented in the problem. Therefore they commit errors more frequently while solving physics problems. Learners' working backward strategy (means "precede backward from the goal to an equation to calculate that goal") is sometimes effective for solving problems, but more often it creates a heavy load on working memory of the students (National Research Council, 1999a). This may cause anxiety and fear during addressing the new problems.

Effective problem solving in Physics requires the "Understanding of relevant textual Information", the capacity to "Visualize the Data", and the capacity to "Recognize the Underlying Structure of the problem" (Lucangeli, Tressoldi, & Cendron, 1998). Physics students' problem-solving performance strongly depends on problem representation (Kohl & Finkelstein, 2006). Problem representation denotes the mode in which the information known about a problem is mentally organized. Successful problem solving can be achieved by providing quality instruction that emphasizes on both "Problem Representation" and "Problem Solution" (Fraivillig, Murphy, & Fuson, 1999; Fuson & Willis, 1989).

Unsuccessful problem solvers cannot identify the relevant information presented in problem scenario and also they fail to organize this information in a meaningful pattern. Thus, often students require help in creating a strong memory organization, preferably an organization that facilitates both the encoding and retrieval processes (Marshall, 1995). Schema Based Instruction can help facilitate the meaningful representation of relevant information in memory.

"In order to solve any problem, problem solvers must possess better-integrated conceptual frameworks for domain knowledge" (Jonassen, 2010; p.20). All relevant information associated with a problem can be accessible at the time of problem solving only if the information is adequately organized in memory by a suitable cognitive structure i.e., problem schema (Jitendra & Dipipi, & Perron-Jones, 2002). Schemas meaningfully arrange information stored in memory. They are a network of related knowledge and schema Based Instruction emphasizes directly on this connection. Thus schemas provide the required scaffold for a domain and as such, they will serve as an aid for future instruction and learning (Marshall, 1995). If the students properly integrate new knowledge with the old, they will achieve meaningful learning. If it is done inappropriately, they will develop misconceptions or simply not learn at all. In these situations, schema based instruction will have its impact, as it can offer appropriate clues on fundamental connections that must be developed (Marshall, 1995).

Early researches in cognitive and educational psychology specify that schema based learning improves the problem solving ability of learners (Fuchs, Fuchs, Prentice Finelli, &Courey, 2004; Jonassen, 2010; Jitendra et al., 2015). Problem schema could act as a facilitator for improving problem solving skill in learners. Experts solve problems successfully because they construct robust problem schema which the novices fail to do (Chi, Feltovich, & Glaser, 1981); They can retrieve information about typical problems more effectively (Chi, Glaser & Rees, 1982); If novices learn to organize all relevant information about different problem types in a meaningful and sequential pattern, information will be effectively and easily retrieved while solving problems. Problem schema will enable learner to identify a problem at hand as belonging to familiar problem type that have a known solving procedure. This may help them to reduce working memory load. So development of a problem solving learning environment that enables novices to develop the same problem schema as conceived by the expert problem solver, will enrich the quality of Physics problem solving.

Schema-Based Instruction (SBI) is an alternative for traditional instruction to improve the story problem solving performance of students. This instructional approach encourages students to look "beyond surface features" of story problems and to grasp the underlying structure of the problem (Jitendra & Star, 2011).

In the present study, the investigator has developed a schema based instructional strategy for teaching problem solving in physics. It is based on schema theory proposed by various researchers especially Minsky (1974), Marshall(1995) and Jonassen (2010). This Schema based instruction provides learners a problem solving learning environment in which they can practice problem solving by familiarizing all attributes of the robust problem schema. Thus Schema Based Instruction designed in this study provides novices an opportunity to acquire the same problem schema conceived by the experts. Also students get an opportunity to modify their primitive schema based on expert's problem schema. Through Schema Based Instruction, novices can learn to organize all relevant information about different problem types in a meaningful and sequential pattern in the memory. Organizing all problem-relevant information as a meaningful pattern in memory will facilitate easy retrieval of information.

The effectiveness of this strategy is tested against Direct Translation Strategy of teaching problem solving, using a quasi-experimental design by controlling the cognitive variables, Non Verbal Intelligence and Logical Mathematical Intelligence.

Statement of the Problem

Effect of Schema Based Instruction on Solving Story Problems in Physics among Higher Secondary School Students.

Definition of Key Terms

The key terms used in the study are defined operationally in the present context as follows.

Schema Based Instruction

Schema Based Instruction is a method of teaching problem solving that emphasizes on both the semantic and mathematical structure of the problem. It utilizes recognition of key words (does a simple key-word strategy) but goes further than simple recognition to stress understanding of the situation represented in the problem (Marshall, 2012).

In the present study Schema Based Instruction means the problem solving learning environment that emphasize the integration of situational information and structural information of the story problems in physics. This problem solving learning environment consists of the following phases: Preparation for problem solving, familiarizing with problem types, familiarizing with situationally dissimilar and structurally similar problems; familiarizing with situationally similar and structurally dissimilar problems; and practicing problem solving using problem schema. The phases of schema based instruction is designed in such a way that they enable students to classify problems based on structural similarities of problems; to construct appropriate problem schema of each problem type; to identify a problem at hand as it belong to a familiar problem type that have known solution method; and to apply correct problem solution method that matches the problem type.

Story Problems

Story problems are most common kind of problems in formal education. According to Marshall (1995) "A story problem is a shorthand representation of a real world situation. Sometimes the stories are elaborate which can run from a paragraph to several pages. More often the stories are brief with a length of a few sentences, where the students are expected to use their own prior knowledge of the world to fill in gaps about the situation depicted in the story" (p. 69).

In the present study Story problem means a well-structured Physics problem that is presented as a short hand representation of real world situation; which have a "set of variables embedded within a shallow story context" (Jonassen, 2010; p.27).

Solving story problems

Problem solving is "any goal directed sequence of cognitive operations" (Anderson, 1980, p. 257). Those operations includes integration of concepts and skills (Stones, 1994); and construction of mental representation of the problem and its context (Jonassen, 2004).

In the present study solving story problem means, comprehending the problem conceptually (denoted by the term Conceptual Understanding) as well as solving it mathematically (denoted by the term Problem Solving Ability).

Problem Solving Ability: It is the cognitive capability of the problem solver to perform physical or mental operations based upon his knowledge so as to achieve the goal of solving a problem (Praveen, 2014). Robertson (2001) describes Problem Solving as a process which starts off from an initial given situation and students have to work towards a solution based on the problem situation and their prior knowledge.

In the present study problem solving ability implies the cognitive capability to solve story problems in physics.

Conceptual Understanding: Conceptual Understanding is implicit or explicit understanding of the principles that govern a domain and of the interrelations between units of knowledge in a domain (Rittle-johnson, Seigler & Alibali, 2001).

In the present study Conceptual understanding of story problem in Physics means the capacity of students to identify the connection between the information in a problem situation or event or pattern. This is measured by evaluating students' capacity to:

- Identify a problem as belonging to a familiar problem type.
- Analyze structural relationship in the problem.
- Analyze mathematical procedure of the problem.
- Backward chaining (Create story problem when the situational and mathematical elements are given)

Higher Secondary School Students

In the present study, the term Higher Secondary School Students are used to denote students of grade eleven doing science course in any of the recognized schools of Kerala.

Variables of the Study

Dependent Variables

The dependent variables in the present study are Problem Solving Ability in Physics and Conceptual Understanding of Story Problems in Physics of higher secondary school students.

Independent Variable

The independent variable for the present study is the instructional strategy (Schema Based Instruction with homework/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving).

Controlled Variables

The controlled variables are Non-Verbal Intelligence and Logical Mathematical Intelligence.

Objectives

The objectives of the study are presented below as one general objective and a set of specific objectives.

Main Objective

To find out the effect of schema based instruction on solving story problems in Physics among higher secondary school students.

Specific Objectives

Following set of specific objectives of this study help to clarify the general objectives.

1. To find out the effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction Without Home Work/ Direct Translation Strategy of teaching problem solving) with Non Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among higher secondary school students.
2. To find out the effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of Story Problems in Physics among higher secondary school students.
3. To study the interaction effect of Instructional Strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.
4. To study the interaction effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Conceptual Understanding of Story Problems in Physics for total sample.
5. To find out the relation between Comprehension of Problem Schema and Problem Solving Ability in Physics of higher secondary school students taught through Schema Based Instruction.

Hypotheses

1. There will not be any significant effect of Instructional Strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among Higher Secondary School Students.
2. There will not be any significant effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of Story Problems in Physics among Higher Secondary School Students.
3. There will not be any significant interaction effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.
4. There will not be any significant interaction effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical mathematical Intelligence on Conceptual Understanding of Story Problems for total sample.
5. There will not be any significant relation between Comprehension of Problem Schema and Problem Solving Ability in physics of higher secondary school students taught through Schema Based Instruction.

Methodology

The present study is as a quasi- experimental one and the design applied here is pre-test-posttest non-equivalent groups design. However instead of a two group design, this study employs a multiple group design in which three intact classes are taken for the experiment. The classes selected for the study were selected on a double blind priority basis. The three groups were tested using ANCOVA for Non Verbal Intelligence and Logical Mathematical Intelligence and were found to be matching so as to be considered as homogenous groups.

Design of Research

The symbolic representation of the study is given below

$G_1O_1\ X_1\ O_2$

$G_2O_3\ X_2\ O_4$

$G_3O_5\ C\ O_6$

O_1, O_3, O_5- Pre tests

O_2, O_4, O_6 -Post tests

O_2 - O_1, O_4-O_3, O_6 - O_5 -Gain Scores

G_1- Experimental group-1

G_2-Experimental Group-2

G_3-Control Group

X_1 - Application of Experimental treatment -1

X_2 - Application of Experimental treatment -2

C - Application of Control treatment

Sample

Three intact class divisions of 166 students (60 in experimental group-1, 52 in experimental group-2 and 54 in control group respectively) of grade eleven doing science course from two government schools (GHSS Cheemeni and GHSS Vellur from Kasargod and Kannur districts respectively) of rural background following Kerala syllabus were selected as samples.

Tools used for the Study

Content analysis, Intelligence test (Non Verbal Intelligence/ Logical Mathematical Intelligence), test for assessing Problem solving ability in Physics, Test for assessing Conceptual Understanding of Story Problems in Physics and Test for assessing Comprehension of Problem Schema were used in the study. Intelligence test was used as a pretest in the study. The test for assessing Problem Solving Ability and the test for assessing Conceptual Understanding of story problems in physics were used as pretests and posttests in the study. Test for assessing Comprehension of problem Schema were used as a post test. A scale was used to evaluate Student's perception of Schema Based Instruction.

In addition to the measuring tools, lesson plans on grade 11 Physics unit 'Work Energy Power' using schema based instruction and Direct Translation Strategy of teaching problem solving were also developed. These lessons were designed to teach problem solving among higher secondary school students.

Statistical Techniques used in the Study

In addition to the basic descriptive statistics, the following statistical techniques were used for analysis of data.

1) Basic descriptive statistics
2) Analysis of variance (ANOVA)
3) Analysis of Covariance(ANCOVA)
4) Test of correlation

Scope of the Study

1. Through this study, the academic community becomes aware of the fact that it is important to teach problem solving by focusing on conceptual understanding.
2. This study may encourage the learners to sort the problems based on their similarities into different types, and to express different problem solving strategies appropriate to each problem type with the help of schema instead of considering the problems in physics independently.
3. This study would play a significant role in creating the awareness among teaching community that it is the duty of the teacher to teach the students that problem solving in physics is not limited to memorizing equations and mathematical procedures of previously solved problems, instead it is important for them to understand the situational features and structural relationships within it.
4. The investigator expects that, this study will throw light on aspects like the influence of home works on problem solving ability and what the learning environment that influences the transfer value of problem solving be like.

Delimitations

The following are the delimitations of the study

1. This study intended to find out the effect of Schema based instruction on solving story problems in physics among higher secondary school students. Conceptualization of the study is done by keeping in mind the higher secondary school student population in government, government aided and private sectors in Kerala. However, for practical reasons the sample of the study was restricted to teaching Physics for 11^{th} grade only. The study was delimited to students of grade 11 doing Science course in

higher secondary school of Cheemeni in Kasargod district, and Vellore in Kannur district.

2. Based on the structuredness, problems are broadly classified into well-structured and ill-structured. Most of the text book problems in Physics are well-structured in nature. Analyzing various well-structured and ill-structured problems, researchers further classified problems as "Logic problems, Algorithms, Story problems, Rule-using or Rule-induction problems, Decision making problems, Troubleshooting, Diagnosis-solution problems, Strategic performance, Policy-analysis problems, Design problems, and Dilemmas" (Jonassen, 2010; p.11). Among these, story problems are the most common in Physics education. Since they are more academic oriented and convenient to discuss in classrooms, researcher selected only well-structured story problems in Physics.
3. The study was confined to a few selected topics of 11^{th} grade Physics in Kerala state syllabus. The problem types considered for this study are Work, Kinetic Energy, Potential Energy, Work-Kinetic Energy theorem, Conservation of Linear Momentum, Kinetic Energy and Linear momentum Conservation, Conservation of Mechanical Energy and Power. The range of problems addressed in the problem type -conservation of momentum was delimited to problem situations in one dimensional motion.
4. Only Non Verbal intelligence and logical Mathematical Intelligence were used as controlled variables.

Organization of Report

There are five chapters included in this thesis. Chapter I details on need and significance of the study, statement of the problem, definition of the key terms, objectives of the study, hypotheses of the study, Design of research, samples, tools used for the study, statistical techniques, scope of the study, delimitation of the study and the organization of the report.

Chapter II presents the theoretical overview of schema theory along with review of related studies in the field of Schema Based instructional Strategy.

Chapter III describes the methodology, which details the variables of the study, design of the study sample, data collection procedure and statistical techniques used in the study.

Chapter IV gives an analysis of the data along with its interpretation.

Chapter V elaborates upon the findings, conclusions, educational implications based on the inferences.

Chapter 2

Review of Related Literature

- *Theoretical Overview of Schema Based Instruction*
- *Problem Solving function of Schema*
- *Process of Solving the Story Problems*
- *Studies on Schema Based Instruction*

Theoretical Overview of Schema Based Instruction

The word schema is credited with an immense rich history. Ancient Greek philosophers had used the term schema in different texts of theirs in the context of form, shape, and figure. Researches in the early periods of psychology had also given much importance to the concept of schema. The concept of schema presented through the view of early philosophers and psychologists has a crucial role today in the teaching-learning process. Researches in psychology and cognitive science have helped to portray schema as a more vivid concept. The search for how we understand, what we see has led the philosophers and researchers to the concept of schema. The understanding that the basis of effective learning is a robust schema has made the schema research more popular. Therefore the concept schema has much relevance in the field of cognitive science. Though philosophers and psychologists have employed the term schema in different occasions, they have not been able to convey an accurate meaning for the concept of schema. Piaget (1952), Bartlett (1932) and Kant (1787/1999) introduced schema as a basic construct of understanding. Their studies have made schema a more significant and transparent concept.

The Greek philosophers viewed schema as a vehicle for describing a concept. Schema was an important term in the philosophical wittings of both Aristotle and Plato. The term schema was used in Plato's Dialogues to indicate the 'essential commonality' of a broad category (Plato, trans. 1876). Aristotle (trans. 1984) in his metaphysics used the concept of schema which was similar to that used by Plato. Both Aristotle and Plato had the opinion that the things or facts we see are perceived through schema. According to Aristotle, the 'schemas' or categories help us to identify and recognize the basic properties whereas Plato had the opinion that in individuals schema existed as general frame work or basic outline.

Kant in his 'critique of pure reason' (1787/1999) has explained schema as pure concepts or categories of understanding that exist as 'priori in the mind'. In the view of

Kant (1787/1999) schema is a link which connects the perceived phenomenon with innate understanding. Kant (1787/1999) put forth the existence of three things: "the priori categories or pure concepts of understanding, the empirical information derived through sensory perception and the schema which links sensibility and understanding" (p.B176-180). Marshal (1995) has reported that the concept of the origin of 'priori categories' by Kant has its origin from the ideas of Plato. Though it is hard to get an accurate or consistent description of schema from the writings of Kant, he has been able to give an explanation of the important features of schema. Some of the following are depicted below.

1. "The Schema is void of all experiential content"
2. "The schema is in itself always a product of imagination…"
3. "The schema has to be distinguished from the image…"
4. "the schema of the triangle can exist nowhere but in thought"

The present day researches have adopted Kant's concept that schema is a link between the concept and percept. According to Marshall (1995) the modern usage of schema draws upon the application of knowledge found in memory to make sense of some experience or event taking place in his or her world.

For a long time, the study of schema had been within the limits of philosophy. But with time psychologists also started indulging in the study of schema. The studies of British psychologist Frederic Bartlett and Swiss biologist &generic epistemologist, Jean Piaget elevated schema to the mainstream of psychology. Bartlett's (1932) study was related to a theory of remembering. He treated schema as an active organization of past experience. In his view, memory is organized around schema containing summaries of familiar stories or scenarios. Schema is activated when an individual tries to comprehend a new story. Abnormal or strange elements of a new story that do not fit the schema are changed and adapted so that the story confirms more closely to an existing schema (Marshall, 1995). Bartlett's key contribution to the study of schema is his emphasis on organization. His theory suggests a highly specific and selective memory structure. Bartlett (1932) has done his research focused on "How individual remember and what they remember". Whereas, Piaget's (1952) was about "development of scientific reasoning" in the individual. Though they had two approaches, the central theme which is 'schema' remained the same for both of them. Studies made by Piaget' (1952) emphasizing 'how schema develop and change' has brightened the schema theory. A strong influence of his studies in cognitive development was visible in cognitive science models of learning. According to Piaget's (1952) schemas govern action as well as cognition and consequently are tied to behavior. His theory reveals that repeated occurrence of the same situation or event or pattern is required for the development of a schema in individual. He explains that Schema development takes place through the assimilation and accommodation process. His theory considers schema as the result of three important aspects of assimilation: repetition, recognition and generalization (Piaget, 1952, p. 241). Piaget's views about cognition were related to the concept "Individuals actively construct their world". But, his studies were limited to the children in the sensory motor stage. Piaget tried to explain schema, based on motor skill and behavior than the cognitive skill.

The idea of schema introduced by Bartlett (1932) and Piaget (1952) is entirely different from the one called "Priori Schema" which is put forth by Kant and Plato. The former has given a new definition for schema as opposed to the already existing notion that the development of priori schema does not depend on an individual's past experience. A schema, as they state, is "the product of interaction with the environment in which similarities in the experiences are generalized and retained in memory". In agreement with their theories, a schema can also be considered as the Key Memory Structure developed out of an individual's experience and which guides his/her response to a particular environment. It is indeed the studies conducted by Bartlett

(1932) and Piaget (1952) which helped in providing a strong foundation for schema theory and making the concept more transparent.

From Plato, Aristotle, Kant, Bartlett and Piaget, we have a conceptual outline of schema. It is a mental structure centered on an event, situation, experience or object. Schema organizes past experience in such a way that their features are noted and retrieved to interpret a current instance (Marshall, 1995).

An important contribution to the development of schema theory as we perceive it today is Minsky's (1975) "Frame theory". Combining number of classical and modern views of thinking from psychology and linguistics, Minsky (1975) developed frame theory about data structure that could be used to represent knowledge in human memory. He used the terminology 'frame' to represent these data structure. The core of frame theory is that when a person encounters a new situation he/she selects from memory a structure called a frame ("a remembered framework to be adopted to fit reality by changing details as necessary"). Frames are data structures for storing large interrelated pieces of information. Each frame represents a stereotyped situation. "Attached to each frame are several kinds of information. Some of this information is about how to use the frame. Some is about what one can expect to happen next. Some is about what to do if these expectations are not confirmed"(Minsky, 1975; p 212). Minsky's (1975) frame theory has some relations with schema theory. He himself acknowledged that the concept frames were originated in Bartlett's notion of Schema. Frame theory describes the important attributes of a frame. A frame contains knowledge dealing with anticipation (Anticipatory Knowledge) and knowledge about how to take action. Another important attributes of a frame is its fixed and variable content. Some information related to a frame is fixed; and some other information is inconstant. The frame normally has a number of default characteristics in place. When details from the current situation are observed, they replace the defaults (Minsky, 1975). Minsky denotes these chunks of the frame as slots. Most theories related to artificial intelligence usually use the term data structure to represent information about a situation or object perceived in human memory. Frame theory meaningfully described these data structure.

Schank(1975) used the terminology “script” to represent the data structure in memory. It is not a general knowledge structure, but a special data structure containing a specific details about specific events. Scripts like frame consist of variables. It controls inferences about the specific scenario. One of the attribute of Schank’s (1975) scripts is that they have very similar structure from person to person.

The modeling of Schema started off with the research of Rumelhart. Rumelhart and Ortony (1977) introduced the concept of schema as a form of “data structure” used to identify the type of problem being solved. Their study about what constitute a schema outlined four essential characteristics of a schema. They are, “schemas are data structure for representing the generic concepts stored in memory; they exist for generalized concepts underlying objects, situations, events sequences actions and sequences of actions; schemas are not atomic. A schema contains as part of its specification, the network of interrelations that is believed to generally hold among the constituents of the concepts in questions; schemas in some sense represent stereotypes of these concepts” (Rumelhart & Ortony,1977, p.101). A schema is not simply a list of attributes but rather is a collection whose parts are linked together (Rumelhart & Ortony, 1977). The characteristics related to the structure of a schema states that schema has variables and resembles directly to Minsky’s concept of the slots of a frame (Minsky,1975), that is, certain elements of schema for an event or object or a problem varies from instance to instance.

Like Rumelhart and Ortony (1977), Winograd (1977) also made some contribution into the structure of the schema. He differentiates between declarative and procedural knowledge. According to him schema is composed primarily of declarative knowledge but also serves as a guide for procedural knowledge. A schema is not just a static collection of facts about a concept. It is an active structure that has procedural components. According to Gick and Holyoak (1980), a schema is “a general description of two or more problems, which students use to group problems into types that require similar solution methods" (p. 307).

Compared to the researches carried out in learning very few studies have been conducted upon the area of Schema theory. Researches done by Anderson (1984) and his Associates proved to be pertinent among them. In his work he mentions about the importance of the materials that helps in activating the relevant prior knowledge of the learner. It is the duty of the teacher to help the learner acquire the prior knowledge in case he lacks it. The new knowledge is to be constructed connecting it to what that he knows already. The learner should be motivated to activate the schema which is suitable to the problem that he is encountering. Schema helps text comprehension, memory encoding and recall (Bartlett 1932; Bransford and Johnson 1972; Anderson and Pearson 1984). Anderson(1984) argues that it is the possible outcomes from such schemas that are to be made subject to assessment.

Skemp (1987), in his "Psychology of Learning Mathematics" talks about the following three major functions of Schema: "Schema serves to integrate what is already known ; It provides the frame work for further learning; and It is the basis for understanding.". In his words "to understand something means to assimilate it in to an appropriate schema"(p.29). Skemp (1987) argues that instruction is possible targeting the specific schema and that it is appropriate as well. He also points out that one of the major responsibilities of the instructor is to help develop proper schema among the learners. The instructor should be well aware of the kind or level of schema to be formed in the learners. The analysis of the comprehensiveness of the schema developed in the learner promotes meaningful learning.

The idea put forth by Rumelhart, McClelland and PDP Research group (1986) openly contradicted the view of Skemp (1987) on the possibility of instruction based on the schema to be acquired by the learner. In the view of Rumelhart, McClelland and PDP Research group (1986), "There is no point at which it must be decided to create this or that schema; Learning simply proceeds by 'connection strength adjustment', according to some simple scheme" (p.21). Marshall's (1995) view was a combination of the two views mentioned above. According to Marshall it is true that every individual creates a unique schema for himself. Likewise, the possibility of people having similar experiences is important as well. Some common attributes can also be observed in the case of a similar schema found in different individuals. This commonality of experience allows us to have common scripts for something. Marshall (1995) has also remarked that "there is no need for all inputs to be the same in every person's schema"(p.34).

In the primary stage the studies conducted upon schema theory had some limitations. The modern researchers of schema theory argue that the information gathered by the studies conducted in the olden days related to it was not applicable to the real world. The traditional schema theory couldn't explain precisely what a schema is constituted of or how different components of a schema interact with each other. Moreover, the conventional schema theory was a failure in giving a proper explanation on different types of schema knowledge and schema functioning.

Marshall reformed the idea of schema, based on the analysis of the works written in the past of various philosophers and psychologists upon schema theory. Her reformation was based on two predominant perspectives. The first perspective was how to explain important psychological issues surrounding schema formation and Content with primary emphasis on how Individuals create and use schema and second perspective addresses the issue of memory storage, shape and form of the schema and its role in Cognition (Marshall, 1995).

The studies of Marshall (1995) played a significant role in providing a working definition for schema. It is almost impossible to completely understand how the human memory operates. Nevertheless, she was able to come up with a clear notion regarding schema formation. She had suggested that schema is the basis of comprehension. She conceptualized schema as a basic storage device having a network structure. It has no fixed size; its strength and accessibility is related to the degree of connectivity among the schema's components. Marshall (1995) considered schema as a vehicle of memory, in which individual's similar experiences are organized.

Conclusion

It can be understood from the studies done by various researchers on schema that it has certain common features as follows: Schema have common structure or form; Schema consists of specific and interrelated information; schema is formed in an individual through experiences. The details of a particular experience could either be or not be a part of the schema knowledge. The essence of concepts or experiences are usually the constituents of a schema. Researches related to schema play a significant role in giving a satisfactory explanation to some pertinent questions such as "how we know what we know".

Problem Solving function of Schema

Many of the ideas put forth by Polya, (1945) regarding problem solving teaching were connected to the principles of Schema theory. In his opinion, "solving problems is a fundamental human activity". According to his studies, the fundamental difference between an expert problem solver and a novice was found to be the fact that the former were capable of utilizing the information they had in a productive way and not necessarily because they acquired more information than the latter. If this view of Polya (1957) is interpreted through the viewpoint of schema theory it could be understood thus: though the chunks of information present in the memory of the expert problem solver and those of a novice is of the same level, the information present in the memory of the expert is organized more effectively; that is, expert might have developed a quality problem schema, whereas the information is not as organized in the case of a novice.

Polya (1957) has put forth four basic steps for problem solving. They are as follows: 1. Understand the problem 2. Device a plan 3. Carry out the plan 4. Reflect on the solution (p.56). Polya's study suggests that the formation of a broad image of the entire problem in the mind of the solver would result in effective problem solving. Polya (1957) also mentions the importance of a connected network of knowledge in his studies. His theory of problem solving focused upon example based learning. Polya (1957) elucidates that, individuals are capable of learning from examples as well as can make sense of new problems with the help of examples. It is obvious that Polya has tried to explain the fundamentals of Schema based instruction through his research.

Nowell and Simon (1972) conducted a detailed study about the integrated activities that constitute problem solving. They used the term ‘problem space’ which was equivalent to problem schema. The problem space is "the fundamental organizational unit of all human goal-oriented activity" (Newell, 1980, p. 696). They were of the view that problem solving process was dependent on the nature of problem environment and problem space. They considered problem space as a major invariant of human problem solving. The place where problem-solving takes place is termed as problem space. They viewed problem environment as the determinant of problem space. Nowell and Simon (1972) came up with the view that the problem space should possess adequate knowledge regarding the problem environment for effective problem solving. The problem space contains not only the actual solution of the problem but also all the possible solutions to the problem. Likewise, the problem space reflects elements relevant to task environment. Thus, the problem solving could be made productive only if the significant information regarding the problem environment is encoded in the problem space.

Research on schema is mostly concentrated upon the studies related to how schema influences memory recall; the specialities of the models representing the schema; how schema develops and change in an individual etc. Hinsley, Hayes and Simon (1977) states that, if we give enough priority for schema in problem solving, the learners would be able to categorize problems based on schema knowledge and store the relevant information regarding each problem type in their memory. In their opinion, the most important speciality of Schema knowledge is problem recognition. Schema knowledge is capable of differentiating similar problems based on their common features.

According to Cooper and Sweller (1987) the major variables that play an important role in the transfer of problem solving are as follows: 1. Mastering rules for problem solution 2. Classifying problems based on the similarities of solutions and 3. Recognizing connections between novel problems and previously solved problems. Among these, problem classification and recognizing connections between novel problems and previously solved problems are closely related to the concept of Schema. For a problem to be solved it is important that the relevant information related to the problem type containing the problem be retrieved from the memory. However, the relevant information related to the problem type could only be accessed during problem solving when it is stored in the memory in the form of meaningful patterns. In the field of knowledge structure the role of knowledge organization is performed by schema (Jitendra, DiPipi, & Perron-Jones, 2002).

Marshall (1995) considered Schema as an effective mechanism for problem solving. Marshall's research on schema formation and schema assessment has provided evidences for the following four knowledge types that individuals have and use in the problem solving environment:

1. Identification knowledge:- to solve well-structured problems using a schema, a solver must first recognize relevant information from the problem scenario. Activation of a Schema is dependent on this information. Thus Marshall (1995) described identification knowledge as the knowledge that contributes to the initial recognition of a problem situation. Its principal function is pattern recognition that occurs as a result of the simultaneous cognitive processing of many features.

2. Elaboration knowledge:- It includes explanation about the main features of the problem situation around which the schema has developed. Creation of a mental model about the current problem is associated with the elaboration knowledge. Marshall's research indicates that both verbal and visual information is recollected in elaboration knowledge as sensory information. "Once the general situation or experience has been recognized by means of the identification knowledge, the details from the current experience will be fit on to a template about the situation" (Marshall, 1995, p.40). Marshall considered this as an interpretive step in using schema knowledge. When the details from a current situation has matched with schema template, the individual's understanding of that situation takes place. Both identification and elaboration knowledge creates a frame work that lets the individual to form a tentative hypothesis about a scenario and then to test it (Marshall, 1995).

3. Planning knowledge:- it is related to the 'schema using' process for making plans, creating expectations, and set up goals and sub goals. Individuals acquire planning knowledge from their experience of using each schema. According to Marshall (1995) the evaluation of planning knowledge helps to determine whether or not an individual has a schema.

4. Execution knowledge:- execution knowledge is related to the execution of the steps of the plans. It includes performing skill or following an algorithm.

As reported by different research studies, there are many aspects to problem solving and these include identifying the problem, making a mental model that fits the problem to some internal representation, forming plans for solving the problem and carrying out the solution. These aspects correspond to the Marshall's four components of schema knowledge. Comprehension of a problem is realized through identification and elaboration knowledge (Marshall, 1995).

Cosgrove's (1995) study on science-in-the-making as students generate an analogy for electricity, reported that schema-induced analogy could be used to "facilitate the meaningful association between new content and prior knowledge, which would result in a perceived improvement in learning as measured by concept recall and knowledge transfer" (p. 296).

The research done by Jitendra & Xin (1997) suggests that the conceptual understanding of the learner is enhanced through schema based problem solving instruction. The research conducted in this field elucidates that, for students with learning disability and those at the risk of failing in Math, the schema based representational strategy is very useful (Hutchinson, 1993; Jitendra & Hoff, 1996; Jitendra et al., 1999; Jitendra et al., 1998; Zawaiza & Gerber, 1993). Jitendra, Deatline-Buchman, Sczesniak (2007), in the light of their studies, claims that through SBI, students will be able to move beyond simple rote memorization and apply concepts in order to improve understanding.

Futch and Futch (2005) was used schema construction theory to conceptualize a framework for how a student solved a mathematical problem. The schema construction theory puts forth the view that problem solving is effective when the students differentiate problems into different types that use similar problem solution methods and develops schema based on it for each problem type (Chi, Feltovich & Glaser, 1981; Gick & Holyake, 1983; Mayer, 1992; Quilici & Mayer, 1996).

According to Jonassen (2010) problem solving is a schema-based activity. In his view, constructing quality problem schema is essential to learning to solve problems in any domain. "Constructing and Applying problem schema is also known as problem finding, problem definition, and problem sensing" (Jonassen, 2010; p.255). So constructing and applying problem schema are crucial part of solving well-structured problems. A robust Problem schema consists of situational and structural information of problems. Problem schema also possess knowledge about the process of solving problems (Jonassen, 2004). Jonassen's studies about how to learn to solve different kind of problems, point out the importance of structure map and classification of problems in the problem solving learning environment. Structure map helps learner to analyze problems. According to Gentner, Loewenstein, and Thompson (2003), "Learning by drawing structural comparisons" across two examples (analogical encoding) has been shown to be the most effective method for reasoning by analogy. Structure map shows functional relationships among the "conceptual elements" for a specific type of problem (Jonassen, 2010). Classifying story problems in to problem types assist students to construct robust problem schema. Addressing situationally dissimilar and structurally similar problems and situationally similar and structurally dissimilar problems increases the depth of conceptual understanding.

The role of Schema in studies related to problem solving is much accepted as well as encouraged at present. One of the most important peculiarities of problem schema is that when a part of the information related to the problem, during problem solving is retrieved from the schema, other pieces of information connected to the problem are also activated. In a problem solving environment, using schema: "Individual can easily identify additional experiences that are also similar, discriminating between these and ones that are dissimilar; Individual can access a generic frame work that contains the important elements of all of these similar experiences including verbal and nonverbal components; Individual can draw inferences, make estimates, create goals and develop plans using the framework; Individual can utilize skills, procedures, or rules as needed when faced with a problem for which this particular framework is relevant" (Marshall, 1995; p.39).

Process of Solving the Story problems

Story problems are the most commonly found problems in school and college level text books, which use a "shallow story context" to represent a problem. The process of Story problem solving have "comprehension phase" and "solution phase" (Cumminse, Kintsch, Reusser, & Weimer, 1998; Hall, Kibler, Weiger, & Truxaw, 1989; Lewis & Mayer, 1987; Mayer, 1982). In the comprehension phase, problem solvers process the text of the story problem and create corresponding internal representation of the quantitative and situation based relationship expressed in the text (Nathan, Kintsch & Young, 1992). In the solution phase problem solver use or transform the quantitative relationships that are represented both internally and externally to arrive at solution. Equation solving involves only a solution phase; in other words that the comprehension is not necessary (Koedinger & Nathan, 2004). Success in calculating "correct numerical answers" did not necessarily imply that corresponding level of "conceptual understanding" was reached (Mc-Dermott, 1991). Integration of comprehension and solution phases are required to solve story problems meaningfully (Koedinger & MacLaren, 2002).

Every story problem has an initial state, a goal state and path constraints (Wood, 1983). According to the information processing theory the movement from the "initial state" to the "goal state" of a problem is termed as the problem solving process. Thus problem-solving can be considered as a "goal oriented process". It depends upon the problem solver's "understanding and representation" of the problem type, including an understanding of the problem state and goal state (Wood, 1983).

Story problem solving is a domain dependent process and tied to instruction. Story problem requires data sets and an algorithm to solve it. The crucial way of solving such problems include identifying numerical values in the problem scenario, selecting required mathematical formulae, applying values onto the formulae to generate a quantitative answer of the target variable in the problem (Sherill, 1983). Rich (1960) expanded that process: represent the unknown physical quantities with letters, translate relationship between unknown physical quantities in to equations, solve equations to find the value of unknown physical quantity. Jonassen (2004) considered this way of solving story problems as "problem avoidance strategy because successful problem solving requires conceptual understanding of the story problem before attempting any solution" (p.28). Lucangeli, Tressoldi, & Cendron (1998) points out that successful problem solving requires five things: "comprehension of relevant textual information, capacity to visualize the data, capacity to categorize the problem, that is capacity to recognize the deep structure of the problem, the capacity to correctly sequence their solution activities, and the capacity and willingness to evaluate the procedure used to solve the problem" (p.259).

Conceptual understanding of the problem is the crucial component of problem solving. For acquiring conceptual understanding, the problem solver has to construct conceptual model (problem schema) that consists of situational model of the problem, structural model of the problem and an algorithmic model (equation) (Reusser, 1993, Jonassen, 2010). For solving story problems, Solvers have to incorporate "situational aspects" described in the problem scenario with the "structural aspects" of a problem contained in solvers' conceptual models of story problems (Kintsch & vanDijk, 1978). The application of a proper strategy based on knowledge and skill is essential for solving a story problem. A quality problem schema should be developed in the learner for the transfer of problem solving skills. The transfer of problem solving skill is very difficult in the case of the learner who has not acquired a robust problem schema. In order to ensure the transfer of problem solving skill students have to develop adequate conceptual understanding of the problem. So novices require conceptually oriented approach in learning to solve the story problems.

The story problem learning environment should be corresponding to the nature of the conceptual structure of the problem to be solved, to make the process of problem solving meaningful. The components which are part of the conceptual structure of story problems should be used judiciously in order to construct a learning environment that provide practice and exposure in solving story problems. Thus it would contain the text of the problem in the verbal form. Each type of problem will have a different structure; therefore the problem solving learning environment should contain a problem schema that act as template which could address the structure of the problem.

For a learner to solve a new problem, he/she should know the similarities of a new problem with the situational and structural information of a problem that he solved before. The appropriate problem schema of various problem types should be constructed within the learner for him to understand the connection between the novice problems and previously solved problems. In order to find a suitable solution for a story problem, one should recognise the pattern of associations and relationships within the problem. Marshall presented schema as a mechanism within the memory that can understand the pattern of relationships and linkage to operations.

Conclusion

Students usually see story problem solving as a difficult task. The difficulty level of a story problem is related to the relational and situational details within it. Unsuccessful problem solvers are those who fail to recognize the relationships embedded in a story problem. The inability to retrieve relevant information from the memory during problem solving is because the relevant information related to the problem type is not meaningfully organized in the memory. Studies related to schema theory assert that the formation of Schema of different problem types would help in effective problem solving. Schema organizes information collected in the memory into meaningful patterns (Marshall, 1995). It enables schema in providing proper scaffolding for a domain. Thus, schema works in such a way that it promotes future instruction and learning.

Studies on Schema Based Instruction

This section presents a brief review of studies conducted on Schema Based Instructional strategy for solving well-structured problems. Since the strategy is not an old one, there is not a wide spread research findings on the topic. Almost all results of the studies conducted on schema based problem solving have positive opinion about it. Most of these studies are focused on either elementary or middle school students with learning disabilities. Some studies also discussed the effect of schema based instruction on high school students. Most of studies related to Schema Based Instruction were concerned with the problem solving in Mathematics.

Powell and Fuchs (2018) investigated the use of schema in facilitating mathematical reasoning. Two instructional strategies-Attack Strategies and Schema Instruction- that are effective for word-problem instruction were used in the study. The learning environment in the Attack Strategies provided students with a general plan for processing and solving word problems. While in the schema based instruction, students were taught to categorize word problems within problem types. Additive and Multiplicative category schemas were included in the study. The study result demonstrates that Schema Based Instruction “facilitates mathematical reasoning by helping students understand the underlying structures within word problems”. This study suggests not teach students to solve word problems by isolating key words and linking them with operations. It is noteworthy for the students to understand the conceptual schema of the word problem.

Root, Browder, Saunders and Lo (2017) investigated the relationship between “modified Schema-Based Instruction” (SBI) and the “Mathematical word problem solving skills”. The study samples were three elementary students with autism spectrum disorders and moderate intellectual disability. In order to evaluate the effect of modified SBI, “compare” type word problems with themes related to participants interests and daily experiences were used. The study also compared the effects of concrete and virtual manipulative within the treatment package. Multiple probes across participants with an embedded alternating treatment design were used. Results of the study indicate a functional relation between modified schema-based instruction and word problem solving. This study suggests modified SBI is one of the best methods to teach Mathematical problem solving to students with autism spectrum disorders and moderate intellectual disability.

Jitendra, Harwell, Karl, Simonson and Slater, (2017) investigated the efficacy of Schema-Based Instruction among the students with and without Mathematics difficulties (MD). This randomized controlled study designed to help MD students to develop proportional reasoning. The sample included 373 students, among whom 253 demonstrated MD. The study had evaluated Participants performance on proportional problem solving (PPS) and general mathematical problem-solving before and after the treatment. The study result reveals that the participants who received Schema Based Instruction showed comparatively better performance for all measures. The findings of the research indicates that the students with MD, when taught through schema based instruction showed improvement in their achievement in both PPS and PPS Delayed Test but not in General Problem Solving Test.

Mitsugi (2017) investigated the effectiveness of two instruction methods (Schema Based Instruction (SBI) and “Translation Based Instruction” (TBI)) for teaching “polysemous English prepositions” (at, in, on) and explored learners’ perception on learning tools used in the instruction when learning polysemous words. In the study SBI was employed as a form of instruction based on the insights of Cognitive Linguistics and also as a way of teaching, which offers learners with the schematic core meaning; while that of TBI was employed as one of the conventional ways of teaching prepositions as polysemous words, which provides learners a list of several meanings of each preposition. Findings of the study showed that the core-schema approach to teaching English propositions is more effective than the conventional approach. The study also points out that administering core schema approach in learners is practical; but, it was revealed that learners perceived both benefits and disadvantages in the two instruction methods and suggested the necessity of separate-use depending on the learning situation.

Elahi, Sepahmansour, Golshani, and Emamipour (2016) compared the effectiveness of "Schema-Based Education" and "Social Problem Solving Training" on social competence of high school female students studying in the academic year 2015-2016 in the city of Arak. The multi-stage cluster sampling method was used. In the sample, 25 students were received Schema-based training and 25 were received social problem solving training. The findings of the study reveal that Schema-based training has a significant and positive effect on social competence of adolescents.

In the study "Teaching Problem Solving to Students Receiving Tiered Interventions using the Concrete-Representational-Abstract Sequence and Schema-Based Instruction", Flores, Hinton & Burton (2016), highlighted the importance of both the "Concrete-representational-abstract" (CRA) sequence with "Explicit instruction" and "schema based instruction" on problem solving. CRA instruction improves students' computational skills and the schema-based instruction increases students' problem-solving performance. So in their study they combined CRA and schema-based instruction for three students receiving tertiary interventions for mathematics instruction. A functional relation was found for the three students' problem-solving performance.

To investigate student difficulties in solving word problems in algebra, Jupri and Drijvers (2016) carried out a teaching experiment with fifty one 13 year old Indonesian students. The learning environment that the researcher designed encompasses student activities including digital tasks within applets embedded in a digital environment; intermediate formative paper-and-pencil assessment tasks; a final written test; and a teacher guide. The findings were backed up by an interview study, in which eighteen students (13/14 year-old) were involved. The perspective of Mathematization, (the activity to transform a problem into a symbolic mathematical problem and to identify the mathematical system) was used to recognize students' difficulties on solving mathematical word problems. The two frequent difficulties identified include (i) understanding words, phrases, sentences; and (ii) formulating equations, schemas, or diagrams. From the perspective of Mathematization, the first one is related to understanding the problems, and the second to formulating mathematical models.

The research of Mudrikah (2016) has revealed a model of learning activities that can be used to stimulate reflective abstraction in students. The theory puts forth reflective abstraction as a way to construct information in the Action-Process-Object-Schema theory. This will be able to encourage students to make the process of formation of new mental objects, new processes and new schemes through the construction process in the form of generalization, interiorization, encapsulation, coordination and reversal.

Peltier and vannest(2016) studied the effect of Schema Based Instruction on the mathematical problem solving of students with emotional or behavioral disorders. The study result demonstrated that Schema Based Instruction improves ability to solve words problems in mathematics of students with emotional or behavioral disorders. The students and special education teacher participated in the study reported that schema Based Instruction was a socially valid intervention.

Study of Root (2016) evaluated the effects of modified Schema based Instruction on the algebra problem solving skills of three middle school students with autism spectrum disorder and moderate intellectual disability. In the study participants were taught key mathematics vocabulary terms related to "missing -whole and missing –part" type of word problems. The study result showed a "functional relation between modified Schema Based Instruction and Mathematical Problem solving".

Using a pretest –intervention-posttest–retension design, Jitendra, Star, Dupuis, & Rodriguez, (2013), studied the effect of Schema Based Instruction on Mathematical problem solving performance of seventh grade students. In the study they administered Schema based Instruction as an intervention that emphasizes "the role of mathematical structure in word problems" and also provides participants with a "heuristic to self –monitor and aid problem solving". The study compared the learning outcomes for 1,163 seventh grade students in 42 classrooms. The study result demonstrate that Schema Based Instruction was more effective than students' regular mathematics problem solving instruction.

In an experimental study "Enhancing Transfer by Learning Generalized Domain Knowledge Structures" Kalyuga (2013) compared the effectiveness of two types of instruction: Schema Based Instruction and Non Schema based Instruction in facilitating transfer of knowledge. The sample of the study was Forty-nine undergraduate university students with low or no prior knowledge in the domain. Study results showed that "(a) transfer within a domain could be facilitated by explicitly instructing learners in generalized domain schemas; (b) general-to-specific approach could possibly be used as a preferred instructional sequence for enhancing transfer; and (c) cognitive load perspective could add some valid arguments to explain the role of generalized domain knowledge in transfer."

Fang (2012) considered Schema Based Instruction as one of the most supported strategy for teaching word problem solving. Schema Based Instruction generally consist of four steps: "identifying the problem type", "applying corresponding method", "determining an operation", and "solving the problem". Categorizing problems in to types is a complicated cognitive process for elementary students to learn and identify the problem types (Fang, 2012). Therefore researchers simplified Schema Based Instruction and referred it to "Simplified Schema Based Instruction" (SSBI). In Simplified Schema Based Instruction students did not need to identify problem type. Fang (2012) evaluated the effectiveness of this strategy with second grade students. The study results showed that word problem solving skills were improved by Simplified Schema Based instruction. The study also revealed that students not only mastered SSBI but also maintained the skills.

Khodadady and Elahi, (2012) evaluated the effect of schema-Based Instruction (SBI) and Translation-Based Instruction (TBI) on the 'structure and vocabulary knowledge and reading comprehension ability' of sixty undergraduate students studying general English. The experimental and control groups were taught through Schema Based Instruction and the Translation Based Instruction, respectively. Study result showed that the learners taught through the Schema Based Instruction performed significantly better than those taught through the Translation Based Instruction.

In the article "Meeting the needs of students with learning disabilities in inclusive mathematics classrooms: The role of the schema-based instruction on mathematical problem-solving", Jitendra & Star (2011) claims schema-based instruction (SBI) as "an alternative to traditional instruction for improving the mathematical problem solving performance of students with learning disabilities (LD)". Based on research and developmental efforts, they designed SBI to meet the needs of middle school students with LD in inclusive mathematics classrooms. They argue that SBI introduces students to multiple strategies for solving ratio and proportion problems and encourages students to look beyond surface features of word problems to grasp the underlying mathematical structure.

The study "Schema-Based Strategy Instruction in Mathematics and the Word Problem-Solving Performance of a Student With Autism" by Rockwell, Griffin, & Jones (2011) had discussed the use of schema-based strategy instruction in teaching addition and subtraction word problem solving to a fourth grade student with autism. The multiple probes across behaviors single-case experimental design was used. The participant was trained to use schematic diagrams to solve three types of addition and subtraction word problems. Study results indicated that the participant's ability to solve all types of one-step addition and subtraction word problems improved following instruction over time.

Jitendra et al. (2009) examined the effectiveness of an instructional intervention (schema-based instruction, SBI) on learning to solve ratio and proportion word problems. One hundred forty eight seventh-grade students and their teachers were participated in the study. The study points out that SBI can highlight the importance of the mathematical structure of the word problems and also offer students with a heuristic to aid and self-monitor problem solving. SBI have well-articulated problem solving strategies and supports flexible use of the strategies based on the problem situation. Findings of the study demonstrated that students in SBI treatment classes outperformed students in control classes on a problem solving measure, both at posttest and on a delayed posttest administered 4 months later.

In the study by Xin, (2008) he investigated the effects of a schema-based instructional strategy that gave emphasis to pre-algebraic conceptualization of multiplicative relations on solving arithmetic word problems for elementary students with learning disabilities or problems (LP). Samples were 4 fifth graders with LP in a Midwestern urban public elementary school. In order to find the functional relation between the schema-based instructional strategy and students' performance on word problems, the researcher had used an adapted multiple-probe-across-participants design. The results of the study favored the effect of the schema based instructional strategy with elementary students with LP.

Through a quasi-experimental study, Morimoto and Loewen (2007) compared the effectiveness of two types of vocabulary instruction: "Image- Schema Based Instruction" (ISBI) and "Translation–Based Instruction" (TBI) on the acquisition of English language polysemous words. The sample of the study were fifty eight Japanese high school learners of English. The study result showed that Image Schema Based Instruction is more effective than Translation Based Instruction. The study also suggests that Image–schema from the field of cognitive semantics can serve as a pedagogical devise in teaching English language polysemous words.

In the study “Enhancing mathematical problem solving among third-grade students with schema-based instruction”, Fuchs, Fuchs, Prentice, et al., (2004) studied the effects of schema-based instruction (SBI) in promoting mathematical problem solving and investigated schema induction as a mechanism in the development of mathematical problem solving. The sample of the study comprised Twenty-four 3rd-grade teachers, with 366 students. They were assigned randomly to conditions that provided instruction on 4 types of word problems. Conditions applied in the study were contrast, SBI, and SBI with practice in sorting word problems into schemas. Findings of the study supports the effect of schema based instruction (with and without sorting practice) on the improvement of mathematical problem solving. This points out that schema development of schema based instructional group exceeded that of the contrast group.

Fuchs, Fuchs, Finelli, Courey and Hamlett, (2004) came up with a study in which they investigated the effects of an expanded version of “Schema Based Transfer Instruction” (SBTI) including more challenging transfer features for broadening schemas and helping children identify real-life math problems as solvable. Teachers were assigned randomly to 16-week control, SBTI, or expanded SBTI conditions. Before and after intervention Students were assessed focusing on increasing transfer distances. On a measure approximating real-life problem solving, the expanded SBTI group outperformed the SBTI group, which in turn outperformed the control group.

Jitendra; DiPipi; Perron-Jones (2002) conducted an exploratory study in which they investigated the effect of schema-based strategy instruction on the mathematical problem solving. The sample of their study was 4 middle school students with learning disabilities who performed low in mathematics. A multiple-probe-across-participants design was used to examine the effect of schema strategy on word problem solving performance. It included baseline, treatment, generalization, and maintenance. Participants received schema strategy training in problem schemata (conceptual understanding) and problem solution (procedural understanding). The study result indicates that schema strategy is seen as a practical approach for training students with learning disabilities in solving word problems. This strategy was also effective in significantly improving the number of correctly solved multiplication and division word problems for all 4 participants. The researcher found that maintenance of strategy effects was evident for 10 weeks after the termination of instruction.

Using an adapted multiple-probe-across-students design of instructional research, Jitendra and Hoff (1996) investigated the effects of a schema-based direct instruction strategy on the word-problem-solving performance of three third and fourth-grade students (2 girls, 1 boy) with learning disabilities. Result of their investigation showed that schema based instruction was successful in increasing the word- problem solving performance for the participants. It is noteworthy that retention of word-problem solving was seen 2 to 3 weeks after the study. After the intervention, the investigator had conducted student interview. The student responded as the strategy was beneficial for them.

The study by Zawaiza and Gerber (1993) has investigated the effectiveness of the schema strategy in solving "multiplicative comparison" type word problems among post-secondary students with learning disabilities. The study theorized that poor problem solving performance of post-secondary students with learning disability is a function of faulty cognitive representation process. The study result also emphases the importance of instruction in representation related process; especially translation and schema formation which meaningfully enhances L D students' performance. This research points out that instruction of declarative or procedural information in isolation may lead to fragmented and limited problem understanding and stunt schema development while comprehensive instruction on the other hand enhances elaborations of schema.

Jong and Hessler (1986), conducted a study on students with high and low success in solving physics problems. The study investigated the ways for the student to organize knowledge for problem solving. The study reported that the students with high problem-solving ability in physics are more successful in organizing knowledge than those with low problem solving ability.

Conclusion

Review of earlier works on Schema Based Instruction discloses that "Schema Based Instructional Strategy" is an effective instructional strategy for promoting problem solving skill. Schema Based instruction (SBI) is a well-received effort to teaching problem solving, that emphasizes the "construction and expansion" of learners schema for the domain in which instruction occurs. An important characteristic that distinguishes the Schema Based Instruction from other approaches of problem solving is the "use of schema diagrams to map key information and highlight semantic relations in the problem to facilitate problem translation and solution" (Jitendra, DiPipi, & Perron-Jones, 2002; p. 24).

The review of related studies reflects a wide prospective of the topic under investigation. The schema Based instruction is seen as a workable approach for teaching elementary and middle school students (especially with learning disabilities) to solve well-structured problems. However, research on teaching grade 11 students to solve story problems in Physics using Schema-Based Instruction is lacking. Therefore, the purpose of this study was to examine the effect of the schema Based Instruction on solving Story problems in Physics.

Summary

Table 1 gives reference to some structural characteristics of the problem schema. These characteristics of schema suggested by the various researchers were considered to design schema diagram in the study.

Table 1

Structural Characteristics of Problem Schema Suggested by Researchers

Researcher	Structural Characteristics of Schema
Minsky (1974)	Schema consist fixed and variable content.
Schank (1975)	It is a special data structure containing specific details about specific events
Rumelhart & Ortony(1977)	Schema contains specifications and the network of interrelations of constituents of the concepts in the problem
Winograd(1977)	Schema consist of Declarative and procedural knowledge
Marshall(1995)	Schema has no fixed size; its strength and accessibility is related to the degree of connectivity among the schema's components. Schema formation require integration of four knowledge type: 1. Identification knowledge 2. Elaboration knowledge 3. Planning knowledge 4. Executing knowledge
Jonassen (2010)	A robust schema consist 1. Situational model 2. Structural model 3. Algorithmic model

The key components of the Schema Based problem solving have been identified from the theoretical overview. They are summarized in the Table 2.

Table 2

Key Components of Schema Based Problem Solving

Components	Theoretical Basis
Classification of Problems	Classifying problems based on the similarities of solutions play an important role in the transfer of problem solving (Cooper and Sweller 1987). Problem solving is effective when the students differentiate problems into different types that use similar problem solution methods and develops schema based on it for each problem type(Chi, Feltovich & Glaser, 1981; Gick& Holyake, 1983; Mayer, 1992; Quilici & Mayer, 1996).
Structure map	Learning by drawing structural comparisons across two examples (analogical encoding) is an effective method for reasoning by analogy (Gentner, Loewenstein, & Thompson 2003). Structure map shows functional relationships among the conceptual elements for a specific type of problem (Jonassen, 2010)
Construction of Conceptual model (Problem Schema) including Situational & structural information	The formation of a broad image of the entire problem in the mind of the solver would result in effective problem solving (Polya 1957) Problem solving could be made productive only if the significant information regarding the problem environment is encoded in the problem space (Nowell and Simon 1972) Activation of a Schema is dependent on the identification of relevant information from the problem scenario(Marshall 1995) A robust Problem schema consists of situational and structural information of problems (Jonassen, 2010)

Major findings of studies on Schema Based Instruction conducted by various researchers is summarised in Table 3.

Table 3

Major Findings of Studies on Schema Based Instruction Conducted by Various Researchers

Researcher(s)	Major Findings
Powell and Fuchs (2018)	Schema Based Instruction “facilitates mathematical reasoning by helping students understand the underlying structures within word problems
Root, Browder, Saunders & Lo (2017)	Modified Schema Based Instruction is one of the best methods to teach Mathematical problem solving to students with autism spectrum disorders and moderate intellectual disability.
Jitendra, Harwell, Karl, Simonson and Slater, (2017)	The students with Mathematics difficulties, when taught through schema based instruction showed improvement in their achievement in both proportional problem solving (PPS) and PPS Delayed Test but not in General Problem Solving Test.
Mitsugi (2017)	The core-schema approach to teaching English propositions is more effective than the conventional approach
Elachi (2016)	Schema-based training has a significant and positive effect on social competence of adolescents
Jupri and Drijvers (2016)	The two frequent difficulties identified in students include (i) understanding words, phrases, sentences(is related to understanding the problems); and (ii) formulating equations, schemas, or diagrams(related to formulating mathematical models).
Mudrikah (2016)	Schema based learning encourage students to make the process of formation of new mental objects, new processes and new schemes through the construction process in the form of generalization, interiorization, encapsulation, coordination and reversal.
Peltier & Vannest(2016)	Schema Based Instruction improves ability to solve words problems in mathematics of students with emotional or behavioral disorders.
Root (2016)	Functional relation between modified Schema Based Instruction and Mathematical Problem solving
Jitendra, et al. (2013)	Schema Based Instruction was more effective than seventh grade students' regular mathematics problem solving instruction
Kalyuga (2013)	Transfer within a domain could be facilitated by explicitly instructing learners in generalized domain schemas; General-to-specific approach could possibly be used as a preferred instructional sequence for enhancing transfer;

Researcher(s)	Major Findings
Fang (2012)	Word problem solving skills were improved by Simplified Schema Based instruction (SSBI).
Khodadady & Elahi, (2012)	The learners taught through the Schema Based Instruction performed significantly better than those taught through the Translation Based Instruction.
Jitendra & Star (2011)	Schema Based Instruction encourages students to look beyond surface features of word problems to grasp the underlying mathematical structure
Rockwell, Griffin, & Jones (2011)	The student's ability to solve all types of one-step addition and subtraction word problems improved following schema based instruction over time.
Jitendra et al. (2009)	Students in SBI treatment classes outperformed ,students in control classes on a problem solving
Xin, (2008)	Schema based instructional strategy was effective for elementary students with Learning Problems.
Morimoto and Loewen (2007)	Schema Based Instruction is more effective than Translation Based Instruction
Fuchs et al., (2004)	Schema development of schema based instructional group exceeded that of the contrast group
Fuchs, Fuchs, Finelli, Courey & Hamlett, (2004)	On a measure approximating real-life problem solving, the expanded Schema Based Transfer Instruction" (SBTI) group outperformed the SBTI group, which in turn outperformed the control group.
Jitendra; DiPipi; Perron-Jones (2002)	Schema strategy is seen as a practical approach for training students with learning disabilities in solving word problems
Jitendra & Hoff (1996)	Schema based instruction was successful in increasing the word-problem solving performance for the third and fourth-grade students
Zawaiza & Gerber (1993)	Instruction of declarative or procedural information in isolation may lead to fragmented and limited problem understanding and stunt schema development while comprehensive instruction on the other hand enhances elaborations of schema.
Jong and Hessler (1986)	The students with high problem-solving ability in physics are more successful in organizing knowledge than those with low problem solving ability

Chapter 3

Methodology

- *Variables of the Study*
- *Objectives*
- *Hypotheses*
- *Design of the Study*
- *Tools used for Collection of Data*
- *Description of Tools*
- *Design of the Experimental Phase of the Study*
- *Sample*
- *Data Collection Procedure*
- *Scoring and Consolidation of Data*
- *Statistical Techniques*

The present study is intended to find out the effect of Schema Based Instruction on solving story problems in Physics among Higher Secondary School Students. The variables of the study, objectives, hypotheses, tools used for data collection, sample of the study, data collection procedures and statistical techniques used in this study are detailed in this chapter.

Variables of the Study

The independent variables, dependent variables and the controlled variables of the present study are detailed below.

Dependent Variables

The dependent variables in the present study are Problem Solving Ability and Conceptual Understanding of Story Problems in Physics of Higher Secondary School Students.

Independent Variable

The independent variable in the present study is the instructional strategy(Schema Based Instruction with Homework/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving)

Controlled Variables

The controlled variables are Non-Verbal Intelligence and Logical Mathematical Intelligence.

Objectives

The objectives of the study are presented below as one main objective and a set of specific objectives.

Main Objective

To find out the effect of Schema Based Instruction on solving story problems in Physics among Higher Secondary School Students.

Specific Objectives

Following set of specific objectives of this study help to clarify the main objective.

1. To find out the effect of Instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among Higher Secondary School Students.

2. To find out the effect of Instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of story problems in Physics among Higher Secondary School Students.

3. To study the Interaction effect of Instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.

4. To study the Interaction effect of Instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Homework/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Conceptual Understanding of story problems in Physics for total sample.

5. To find out the relation between Comprehension of Problem Schema and Problem Solving Ability in Physics among Higher Secondary School Students taught with Schema Based Instruction.

Hypotheses

1. There will not be any significant effect of Instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among Higher Secondary School Students.
2. There will not be any significant effect of Instructional strategy (Schema Based Instruction with Home Work/ Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of story problems in Physics among Higher Secondary School Students.
3. There will not be any significant Interaction effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.
4. There will not be any significant interaction effect of Instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Conceptual Understanding of story problems in Physics for total sample.
5. There will not be any significant relation between Comprehension of Problem Schema and Problem Solving Ability in Physics among Higher Secondary School Students taught with Schema Based Instruction.

Design of the Study

In the present study, Experimental method was employed to test the effect of Schema based Instruction, on solving story problems in Physics among Higher Secondary School Students. The study was done in three Phases namely Exploratory phase, Developmental phase and Experimental phase. The layout of the design is illustrated in Figure 1.

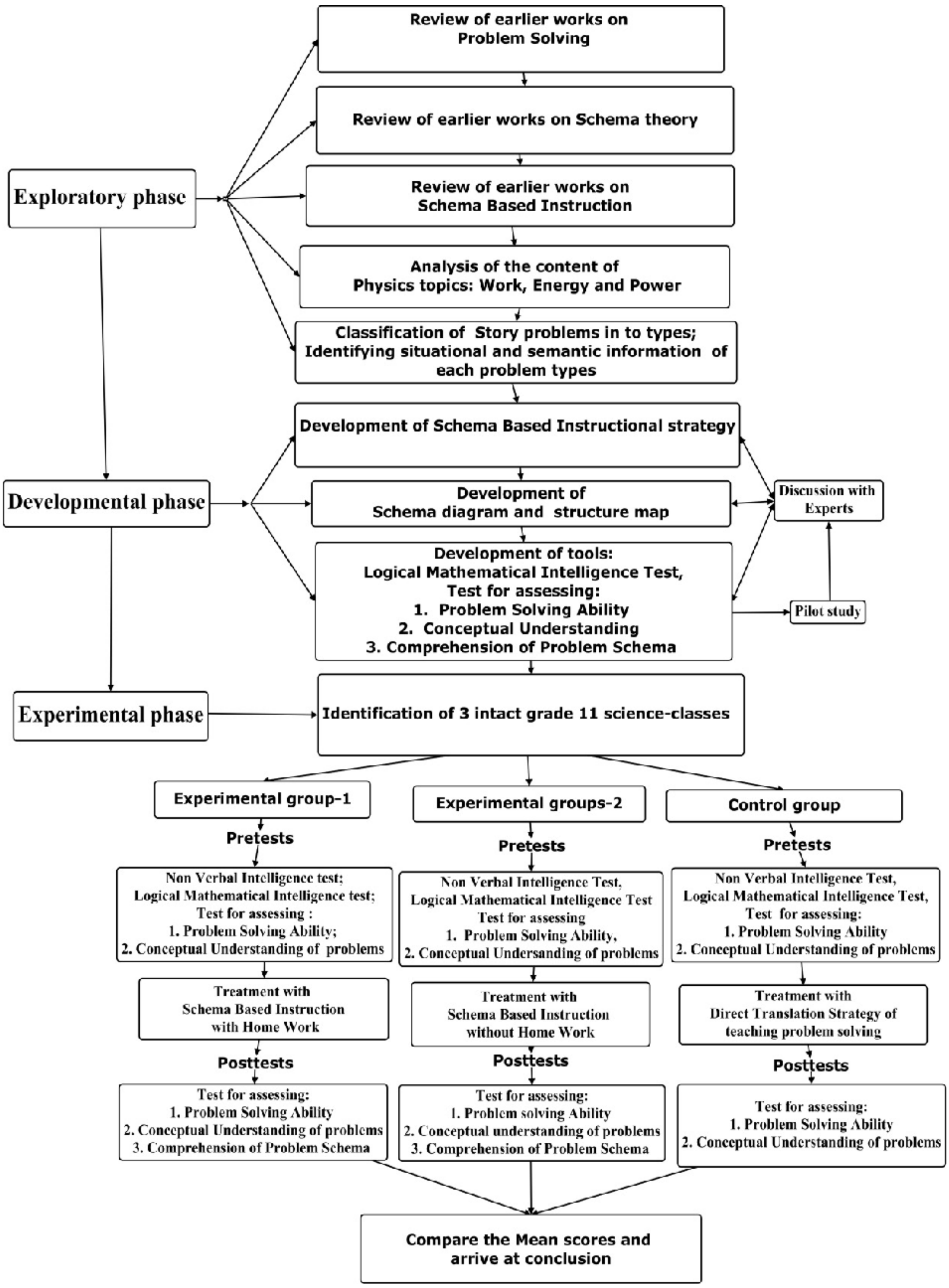


Figure 1. Layout of the design of study

Phase I: Exploratory Phase

In the exploratory phase, initially, review of literature on problem solving was done to understand various problem solving strategies. This helped to recognize the limitations of traditional approach (for example: Direct Translation Strategy) in solving well-structured problems in Physics and Mathematics. A detailed analysis of the different problem solving learning environment was done to know problem solving learning strategies that support conceptual understanding of the problems. Consequently, Schema Based Learning was identified as one of the best strategies to practice problem-solving with the support of conceptual understanding. Hence the focus of the study was limited to the schema based learning for solving well-structured problems. In order to identify the nature of schema and to recognize the essential cognitive requirements of schema construction, review of earlier works on schema theory was performed. Following that, review of earlier works on Schema Based Instruction was done to know the influence of that on solving story problems.

Discussion with Physics teachers working in higher secondary schools of Kerala was conducted to identify topics containing variety of story problems. The topics: Work, Energy and Power were identified consequently. The content analysis of the topics was done. The topics are included in the chapter ‘Work, Energy and Power’ presented in the NCERT physics text book prescribed for grade 11 in India. The result of content analysis is given in Table 4.

Table 4

Summary of Content Analysis of the Chapter: Work, Energy and Power

Terms with Symbols, formula, Major concepts, definitions and principles in the chapter 'Work Energy and Power'	
	Key Terms with symbols
	Work –W, Force- F, Displacement-d Kinetic energy-K, Potential energy-V, Potential Energy of Spring- V_S, Spring force-F_S, spring constant – k, Energy – E, momentum – p, initial velocity-v_i, final velocity-v_f
	Key formulae
	W =f.d , $K=\frac{1}{2}mv^2$, U=mgh.F_s = -kx, $V_S=\frac{1}{2}kx^2$, $P=\frac{W}{t}$, $E=mc^2$, p=mv , $v_{1f}=\left(\frac{m_1-m_2}{m_1+m_2}\right)v_{1i}$, $v_{2f}=\left(\frac{2m_1}{m_1+m_2}\right)v_{1i}$
	Major concepts
1	Work 1. Work done by a constant force 2. Work done by a variable force
2	Energy
3	Kinetic Energy
4	Potential Energy 1. Gravitational Potential Energy 2. Elastic Potential Energy(Potential energy of spring) 3. Spring force 4. Spring constant
5	Mechanical Energy
6	Conservative force and Non conservative force
7	Various forms of energy 1. Heat 2. Electrical energy 3. Chemical energy 4. Nuclear energy
8	Mechanical power
9	Momentum

10	Collision 1. Elastic collision 2. Inelastic collision 3. Collision in one dimension, 4. Collision in two dimension
	Definitions
10	1. The work done by the force is defined to be the product of component of the force in the direction of the displacement and the magnitude of this displacement. 2. The energy possessed by a body by virtue of its motion is called kinetic energy. 3. Potential energy is the energy possessed by a body by virtue of its position or state of strain. 4. The sum total of potential and kinetic energy of an object is called mechanical energy. 5. A force is said to be conservative if the work done by the force is independent of the path but depends only on the initial and final positions. 6. A force is said to be non-conservative if the work done by or against the force depends on the path followed by the object. 7. Power is defined as work done per unit time or energy dissipated per unit time. 8. Elastic collision is one in which both momentum and kinetic energy is conserved. 9. Inelastic collision is one in which the momentum is conserved, but KE is not conserved.
	Principles
	1. Work energy theorem:- According to work energy theorem, the change in kinetic energy of a particle is equal to the work done on it by the net force. 2. Principle of conservation of mechanical energy:- it states that the total mechanical energy in a system remains constant as long as the only force acting are conservative forces. 3. Principle of conservation of energy:- According to principle of conservation of energy, energy can neither be created nor destroyed. It can be changed from one form to another. 4. Principle of conservation of linear momentum:- it states that the total linear momentum of a system is constant if there are no external force acting on the system.

On the basis of content analysis the story problems in the select topics were classified in to eight types namely Work, Kinetic Energy, Potential Energy, Work-Energy theorem (also known as Work-Kinetic Energy theorem), Conservation of Mechanical Energy, Mechanical Power, Conservation of Linear Momentum, and Kinetic Energy and Linear Momentum conservation. Review of various text books of fundamental physics was done to collect the examples of story problems of each problem types. Afterwards, in order to design structure map and problem schema, situational characteristics and structural information of each problem types were analyzed.

Phase II: Developmental Phase

In this phase, Schema Based Instructional strategy based on schema theory was developed. After the detailed analysis of situational characteristics and structural relationships in the problem, structure map illustrating inter-relationships between various physical quantities in the problem and problem schema of each problem type were developed. After designing the phases of Schema Based Instruction, the lesson transcripts were prepared for the select topics. Lesson transcripts for Direct Translation Strategy of teaching problem solving in physics were also prepared in this phase. Then, Logical Mathematical Intelligence test was prepared to measure students' Logical Mathematical Intelligence. Three tools were prepared to assess students Problem Solving Ability, conceptual understanding of story problems and comprehension of problem schema. A pilot study was conducted in this phase.

Schema Based Problem Solving Learning Environment.

The effectiveness of a problem solving process depends on the nature of problem solving learning environment. The Direct Translation Strategy of teaching problem solving in physics give over emphasis on memorization of equations and mimic of mathematical procedures of the previously solved problems. In such problem solving learning environment, students do not learn to organize information relevant to the problem in the form of a conceptual model. Neglection of the situational and semantic information of the story problem often creates cognitive difficulties in the learner.

To develop effective problem solving skills, the learner must practice problem solving in a logical way that would help the learner to overcome cognitive difficulties in problem solving. Jonassen (2004) argues that 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. Thus teaching of solving story problems must be designed as to promote the ability to construct conceptual model (or problem schema) of a problem type in the memory of learner.

A schema is a useful and efficient mechanism for solving story problems. It is a framework, outline, or plan for solving a problem (Marshall, 1995). Most structural representation of schema shows them as networks of related elements. Rumelhart and Ortony (1977) introduced problem schema as a sort of knowledge structure used to identify the type of problems being solved. Minsky (1975) used the term ‘frame’ to represent the data structure of the information in human memory. Marshall (1995) described schema as a ‘vehicle of memory’, allowing organization of an individual’s similar experiences. Thus ‘it can be thought of as a storage mechanism’.

Jonassen (2004) found that problem schema consist situational information and semantic information about the problem. In order to activate schema based problem solving, solver must possess sufficient domain-specific knowledge including both conceptual and procedural knowledge. The acquisition and use of schema knowledge does not occur in a simple cognitive process. it requires the following cognitive processes: Categorizing problems in to problem types, constructing problem schema of the problem being solved, retrieving the mathematical equations and processing operations required to solve the problem, mapping data onto the formula, remembering the problem information and the structure of the problem entities and file according to problem type (Jonassen, 2010).

A Schema Based Instructional environment for problem solving is a structured environment to practice solving story problems with scaffolds and procedure sequences. This environment of learning problem solving mainly focus on solving story problems by understanding the inter relationship between various conceptual elements embedded in the problem scenario. As earlier studies on schema based problem solving prove that schema is effective in modeling story problems, they become the essential component for designing story problem solving learning environment.

Story problems in physics demand conceptual understanding of the problem rather than memorizing ready-made equations without understanding causal relationship. In Solving a story problem with the help of conceptual understanding, students require the comprehension of textual information, the capacity to visualize a problem scenario, the capacity to identify relevant data, the capacity to recognize the semantic structure of a problem, the capacity to sequence their solution activity correctly and the capacity and willingness to evaluate the procedure that they use to solve the problem (Lucangelli, Tressoldi & Cendron, 1998). This implies that rather than providing merely an environment for mathematical calculations by collecting numerical data from a problem and plugging it into readymade equations, the design of Schema Based Instructional environment for solving story problems should include means to view the problem holistically to identify and elaborate situational information in the problem, to construct situational model of the problem by integrating situational elements and ‘ their interpretations, to causally relate the data sets with structural configuration of the problem, to map the structure with the arithmetic formulae, and to reflect upon the result of applying the algorithm on the basic premise of the problem.

Frame work for Schema Based Instruction for solving story problems in physics.

Problem solving in physics is not merely a process of transformation of values in to formulae. Solving story problems based on conceptual understanding requires integration of situational and structural information of the problem in the form of a schema. Thus the Schema Based Instruction for problem solving is mainly focused on the construction of schema of each kind of problems. It provides learners a problem solving learning environment in which students can practice problem solving using problem schema. Problem schema enables learners to acquire adequate conceptual understanding of the problem. The schema based problem solving learning environment has five basic components: problem type, problem schema, structure map, worked examples and practice problems. The frame work of Schema based problem solving learning environment is illustrated in Figure 2.

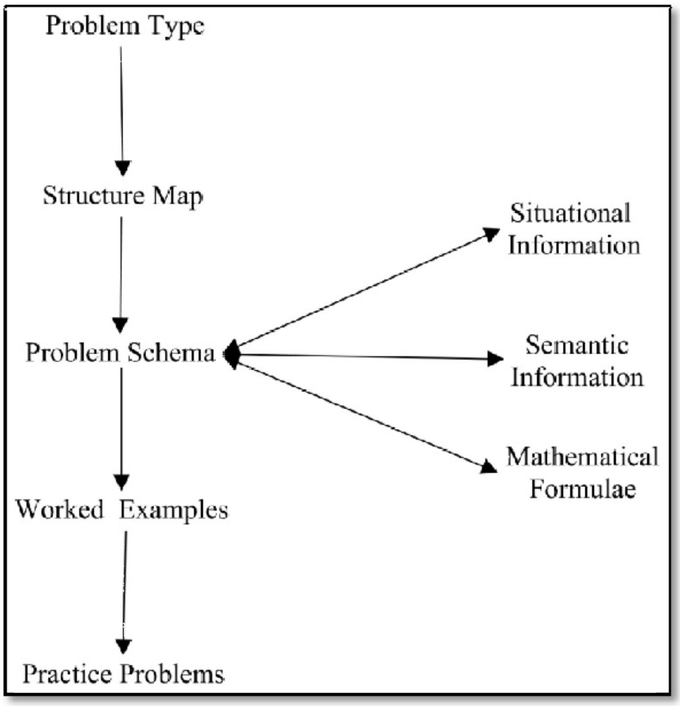


Figure 2. Frame work of Schema based problem solving learning environment

Problem type.

Usually it is the teachers and students who undertake the process of problem classification, which is mainly of two types as follows: Based on situational characteristics of problem scenario and based on causal relationship (or structural relationship). Jonassen (2010) is of the opinion that the classification based on situational characteristics can lead to misclassification. Such a classification can also increase the cognitive load of the problem solver. For instance, teachers and students, most often, place the problem known as Conservation of Linear Momentum under the category of Collision problems. This classification is purely on the basis of situational characteristics. The story problems which come under elastic or inelastic collisions are called collision problems whereas to solve collision problems in physics prescribed for Grade 11, the principle of the conservation of linear momentum is used. The same principle is used in cases of explosion, recoiling, rocket propulsion, disintegration of stationary nucleus, so on and so forth. When the problems involving the application of conservation of momentum principle are classified into collision problems, explosion problems, and recoiling problems based on their situational characteristics, it creates working memory load in learners. Therefore studies show that an effective problem solving involves classification rooted upon structural relationship and not merely on surface level characteristics.

In this study, problem type refers to the classification of problems based on the structural relationship in the problems. Identifying a problem as it belongs to a familiar problem type that has already a known solution plan makes the task of problem solving an easier one. Therefore, the problems dealt in the selected chapter, 'Work, Energy, and Power' are indeed categorized as problem types. The classification is made based on the structural relationships (or causal relationships) in the problems and not merely on the surface level features of a problem situation. Hence the problems which can be grouped under a particular problem type are identified and their situational characteristics are analyzed so as to recognize the situational elements that lead to the solution of a specific problem. On the basis of this situational information, situational model was also developed for each problem types selected for the study.

Structure map.

The structure-mapping theory (Gentner, 1983) describes the implicit interpretation rules of analogy. Analogical encoding is a crucial process in problem solving. It involves the comparison of two analogues for structural alignment

(Catrambone & Holyoak, 1989). Analogical encoding of problems is not an automatic process. Research studies reported that structure map can provide scaffold to analogical encoding of problems.

The structure-map is defined as the meaningful network of the interrelationships between the different physical quantities in the problems (Gentner, 1983). The purpose of structure maps in this study is to provide a tool for enabling students to analyze problems. Fig 3 illustrates the structure map of the problem type 'work'. Students have used this structure map to analyze structural relationships of 'Work' problems. All 'Work' problems contain some combination of the predicates in Figure 3, so students have to analyze the situation of the problem to see which conceptual elements are included. In the present study structure map of all problem types identified in the selected topics were constructed. Structure map of problem types: Work Kinetic Energy theorem and Conservation of Mechanical Energy are given as Appendix A.

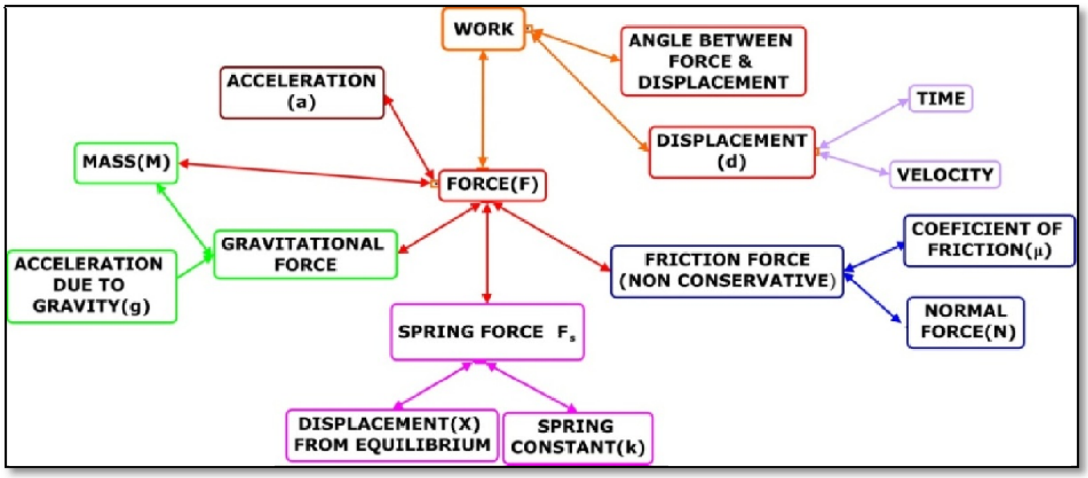


Figure 3. Structure map of problem type 'Work'

Problem Schema.

The most difficult task in physics problem solving that a student faces is perhaps, finding out the underlying physics concepts/principles/laws in a given problem. Problem solving becomes an easy task when they are able to recognize the structural information in the problem and classify the problems accordingly. They should be able to decode in their memory both the situational information and structural information along with the algorithmic formula of each problem type. Once these are organized, it is in turn helpful to retrieve from memory all relevant information regarding the problem. So it is crucial for a problem solver to construct a conceptual model or a problem schema of each problem type that is indicative of the interrelationship between the entities stated in the problem. And hence it is necessary that the students must be aware of the structural information of a problem type for which they are trying to find a solution. An effective problem solving is often the result of a better conceptual understanding and therefore creating a problem schema becomes very important in this process.

Different researchers have explained the concept of schema differently. Though it helped to form a definition for schema, it almost failed in elucidating its practical application. Modern researchers in schema theory like Minsky (1975), Marshall(1995), and Jonassen (2010) had succeeded in giving a working definition for the concept.

A Schema have fixed and variable content. Some information associated with a schema (or frame) is fixed and others may change with context. The variable part of the schema consists of slots that must be filled by elements of specific instances or data; that may change with situation (Minsky, 1975).At the same time, Marshall's theory (1995) identifies schema formation as the result of the integration of problem knowledge, as she puts it, which is of four types namely, identification knowledge, elaboration knowledge, planning knowledge and execution knowledge. Identification knowledge is the one that helps to identify the situational elements that lead to the solution. Its main function is pattern recognition. It acts, moreover, as a doorway to schema activation. However, it is not a mere list of situational features. It is rather loaded with the relevant structural information. On the other hand, elaboration knowledge is the detailed information about the main features of the situation. Elaboration knowledge enables students to construct mental models of the current problem. Planning knowledge denotes the method in which the schema can be used to make plans and set up goals and sub goals. Execution knowledge is the knowledge that lets the learner carry out the steps of the plans. It includes the ways that lead to action such as following an algorithm. Researchers argue that the problem schema thus produced must also incorporate the structural and the situational information. In Jonassen's (2010) view, an effective problem schema contains certain components, a fruitful integration of which helps the solver in retrieving the necessary information regarding a specific problem and thereby solving it. He identifies the components as follows: Situational model, Structural model, and Arithmetic model.

Designing problem schema

This study merges the structural characteristics of schema as put forth by the theorists: Minsky (1975), Marshall(1995), and Jonassen (2010) and by which the investigator has designed a problem schema of select problem types. Each problem schema consists of the following three crucial components: situational model, structural model and arithmetic model (or algorithmic model). Suggestions from experts in physics were taken into consideration while designing the problem schema. The first stage of the design, involved collection of maximum number of problems which can be included in a select problem type to analyse the situational features, structural relationships, arithmetic formula and mathematical operations of each of them. Around forty problems of different types were analysed after which the situational model, the structural model, and the arithmetic model were constructed.

*Situational model:-*Situational characteristics of a problem is most common gateway to schema activation. It is important that a solver has to recognize the causal relationship embedded in a given problem for which solver has to identify the problem type and also differentiate the relevant situational elements. Marshall calls this situational information that contributes to the identification of problem type as identification knowledge. A novice problem solver often finds it difficult to identify the relevant situational elements from a problem context. The investigator has thus developed a situational model for each problem type.Situational model consists of key features of a problem scenario and its interpretation. It is important to note that the proper interpretation of situational features that is explicitly given in the problem context is required to make inferences about the major concepts/ principles/laws that are embedded in the problem scenario. So it is important for a learner to incorporate a situational model in their problem schema. It is through situational elements that a schema is initially activated. Hence the purpose of situational model in the study is to provide a gateway for activating students' problem schema. Fig 4, illustrates the situational model of the problem type "Work-Kinetic Energy theorem". Students have to use this situational model to identify the relevant situational elements from the problem. Usually, the situations of all Work-Kinetic Energy theorem problems mainly contain the following category of physical conditions: state/position of the object, nature of motion, kind of force, and direction of force (given in Figure 4); so students have to analyze the situation of the problem to identify which situational elements are relevant. In the study Situational model of problem types identified in the topics "Work, Energy, and Power were deigned. Situational model of problem type "Work" is given as Appendix B1.

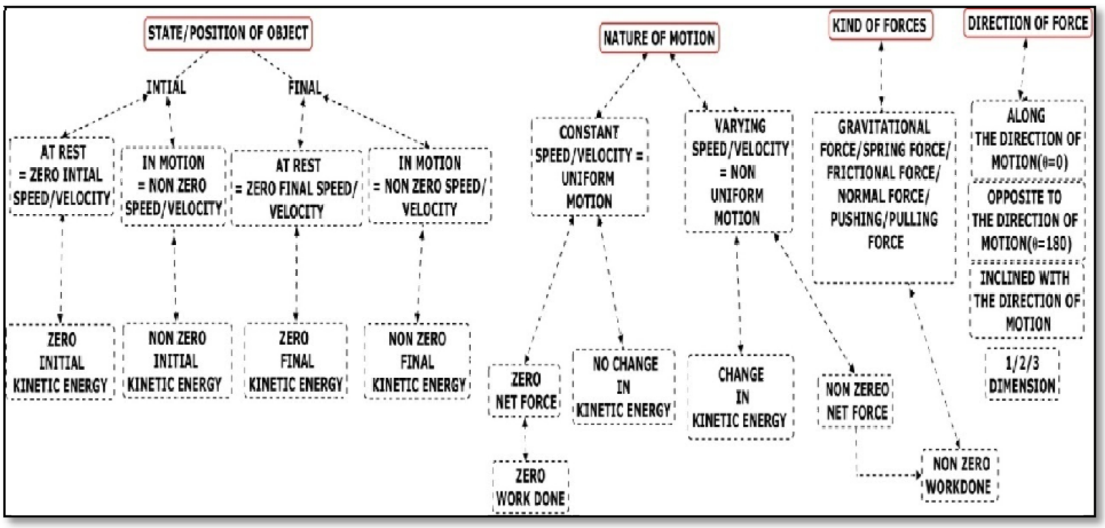


Figure 4. Situational model of 'Work- Kinetic Energy theorem' problems

Structural model:-each problem type in Physics consists of a different structural model. Structural model defines the structural and causal components of the problem (Jonassen, 2004). A solver has to recognize the causal relationship embedded in a given problem. Identification of the structural relationship in the problem is crucial for the activation of planning and execution of the solution in the schema. Retrieval of correct arithmetic model is dependent on the structural information of the problem.

According to Jonassen (2004) "allowing the student to compare and contrast the situational and structural models which will provide for a richer model of the problem type" (p.45). For solving story problems successfully, students have to integrate the situational and structural models of the story problems. Therefore both situational and structural information of story problems are important in problem solving.

*Arithmetic model (or Algorithmic model):-*Arithmetic model represents required mathematical formula which describes how one physical quantity depends upon another. The physical quantities in an equation could be thought of as being either directly proportional or inversely proportional.

Usually a problem scenario contains both relevant and irrelevant situational elements. A solver's search for relevant elements should be on the grounds of structural information embedded in the problem, and, therefore the solver has to plan the situational analysis on that basis. Physical conditions stated in the problem scenario assist students to decide which situational elements are relevant from a problem context. Therefore the investigator has tried to categorize the physical conditions stated in each type of the problem. Situational analysis will become an easy task for novice if the situational model in their problem schema includes information about the physical conditions stated in the situations of each problem type. Students must plan situational analysis on the basis of these physical conditions stated in the problem. This will help them to find out the relevant information from a problem scenario. Hence they can also interpret the elements in the right way which helps them to understand the causal relationship in the best possible manner

The selected topics: ‘Work, Energy and Power’ consists of different problem types like Work, Kinetic Energy, Potential Energy, Work-Kinetic energy (or Work-Energy) theorem, conservation of Mechanical Energy, Conservation of Linear Momentum, Kinetic Energy and Linear momentum conservation and mechanical power. Each problem type shares a set of common associated problem elements and interlinking set of structural relationship in the form of equations. Figure 5, shows the schema of a “Work-Kinetic Energy theorem” problem. It is a schematic diagram which represents the type of problem with situational information and semantic information associated with the content portion- Work- Energy theorem. It helps students to retrieve the associated concepts along with their relationships to select and execute the appropriate algorithm to solve the given problem. Investigator has categorized the physical conditions commonly presented in the problem type Work-Kinetic Energy theorem in to four labels namely State of the object, Nature of motion, Kind of Force and Direction of Force. Along with these four labels of physical conditions, the situational model of the schema of Work-Kinetic Energy theorem consists of slots for mapping situational information and their interpretations. Learners have to identify those elements in the problem scenario which assists them in making inference about the causal relationships embedded in the problem.

For identifying key features of problem situation, students have to plan the story context analysis. The categorization of physical conditions given in the situational model can assist novices to plan the analysis. For example, in the problem, given in Example 1 (problem type: Work-Kinetic energy theorem), with a view to identify key elements in the situation, students can plan the situational analysis by dividing problem situation into following four parts addressing different physical conditions: 1. Identifying *state of object*(identifying initial state and final state of object) 2. Identifying *nature of motion* (whether motion is in uniform velocity or in non-uniform velocity; whether it is one dimensional/two dimensional/ three dimensional) 3. Identifying *kind of forces* applied on the object (whether it is conservative or non-conservative) 4. Identifying *direction of applied force* (whether it is along/normal to /inclined to the direction of force). This information constitutes situational model. On the basis of conceptual knowledge, students must interpret this situational information to make inference about the major concepts embedded in the problem. This assists them to retrieve structural information from the schema of that problem type.

Example 1.

A 1200kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?

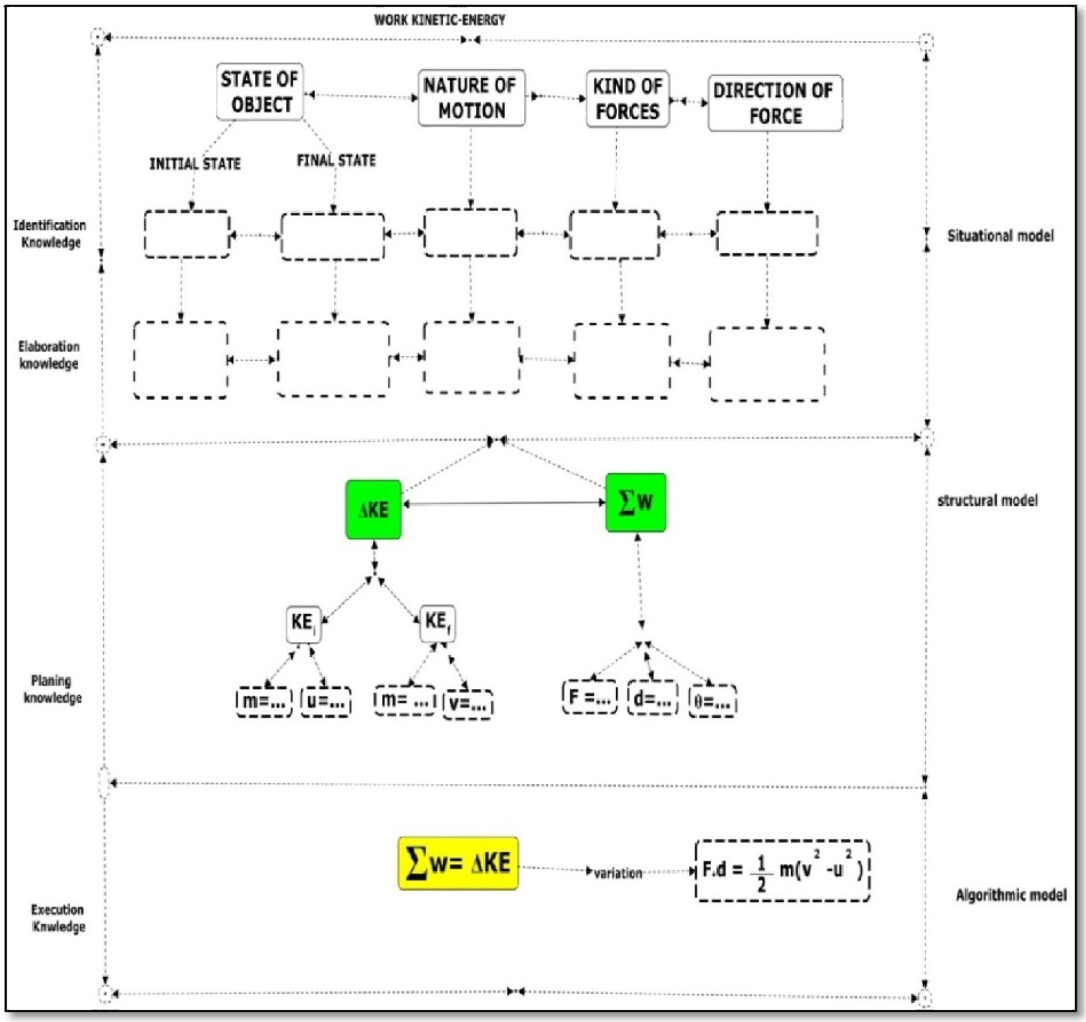


Figure 5. Problem schema of 'Work- Kinetic Energy Theorem'

Schema diagram of all the problem types in the selected topics, Work, Energy and Power were designed. Problem Schema of "Work" type problems is given as Appendix B2.

Worked examples

A worked example is a "step-by step demonstration of how to solve a problem" (Clark, Nguyen, Sweller, 2006, p.190). Worked examples are designed to support initial acquisition of cognitive skills through introducing a formulated problem, solution steps and the final solution (Renkl, 2005) "Worked examples of problem solution that precede practice improve practice- based problem solving by reducing the cognitive load and helping learners to construct problem solving schemas"(Cooper & Sweller, 1987; Sweller & Cooper, 1985). When learner compares two examples they can identify structural similarities presented in the problems. Moreover, worked examples improve performance on similar problems because of schema acquisition. In the present study, worked examples are included as one of the basic components of the Schema based learning environment. Three problems for each problem type were presented as worked examples. Worked examples were used to demonstrate how to solve problems by constructing conceptual model. Schema based problem solving procedure including mathematical operations were illustrated before allowing students to practice problem solving. It was engaged as teacher-led demonstration along with frequent student exchanges to identify situational information and map them onto the problem schema.

Practice problems

Another crucial component of Schema Based Instruction is the opportunity to practice the problem solving skill acquired from the instruction. Worked examples of similar problems may not lead to formation of required problem schema. It may lead to over generalization of the procedure. Hence for constructing robust problem schema of each problem types, students have to practice problem solving in a systematic way. Students must practice problem solving by perceiving the attributes of each kind of problems. In the study, Practice problems are presented to students in the form that was illustrated in the worked examples. Students were requested to practice problem solving by, identifying given problem as belong to a problem type that have known solution plan.

Phases of Schema Based Instruction.

Schema based learning refers to the method of successfully and effectively solving a problem by designing a problem schema or the mental representation of each problem type which includes all the information like situational features, relevant data, structural relationship, problem type and mathematical formula concerned to that particular problem. The phases of Schema Based Instruction is designed as to provide a learning environment for novice problem solvers to practice story problem solving by getting familiarized with various problem types, comprehending appropriate problem schema of each problem type, identifying problems as they belong to a familiar problem type that have known solution plan, encountering situationally similar and structurally dissimilar problems, encountering situationally dissimilar and structurally similar problems, and making arguments for the solution. The phases of this strategy give more emphasis on problem solving with the support of schema. Phases of this instructional strategy are developed on the basis of schema theory suggested by various researchers.

Schema Based Instruction start with familiarizing the concepts related to chapter 'Work, Energy and Power. Students were taught key concepts and their explanations before attempting the problems. Then to understand the structural relationship between various physical quantities the students are requested to construct a structure map connecting the important physical quantities. In order to add missing information, and remove irrelevant information, structure map constructed by them were compared with those constructed by the instructor. The instructional phases then familiarize students with eight problem types in the chapter ‘Work, Energy and Power’. Schema Based Instruction employed teacher-led demonstration and modeling, along with frequent student exchanges, to identify problem-relevant information, and map them onto the relevant schema diagrams. Each student worked independently in Schema Based Instruction.

In this study, Schema Based Instructional strategy is designed by including the following five phases:

1. Preparation for problem solving
2. Familiarizing with the problem type
3. Familiarizing with Situationally dissimilar and Structurally similar Problems
4. Familiarizing with Situationally similar and Structurally dissimilar problems
5. Practicing problem solving using problem schema

Schema Based Instruction was performed by strictly following these phases.

The framework of the design is illustrated in Figure 6.

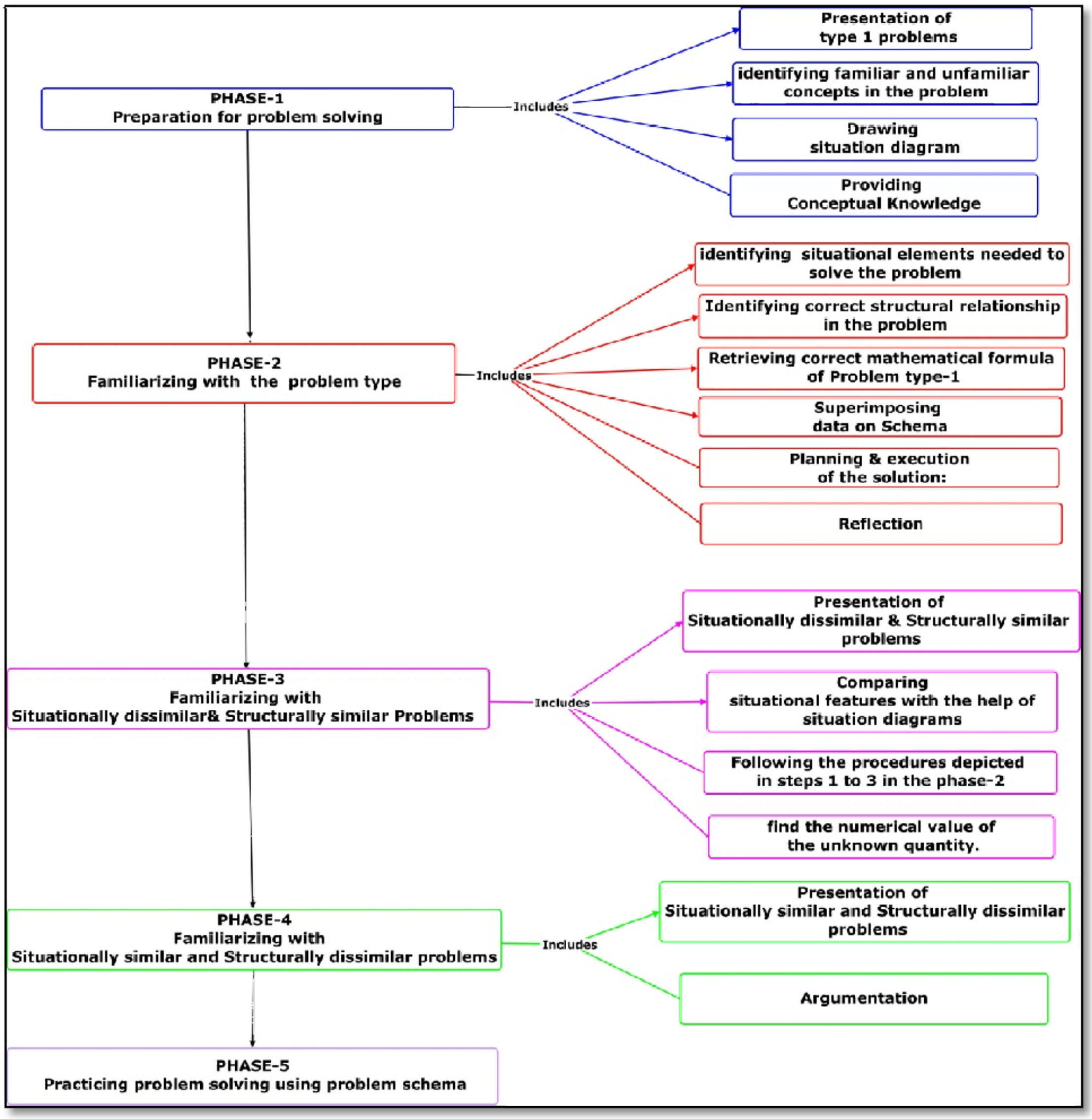


Figure 6. Frame work of the Schema Based Instructional Strategy

Phase 1: Preparation for problem solving:

The intention of this phase is to prepare the learner to solve story problems of each problem type with the support of problem schema. The students evaluate their pre requisites for the problem and collect all the relevant information required to solve the problem. This stage is beneficial in such a way that it prepares the learner to collect and integrate all the information needed and to develop a problem schema with the help of which they can solve the problem. The different steps in the preparation phase are listed below:

Step 1 Presentation of type 1 problems:- Teacher presents a story problem of particular problem type before the students.

Step 2 identifying familiar and unfamiliar concepts in the problem:- Teacher makes an effort to evaluate students' prerequisites onthe given problem situation based on the physical quantities, conceptual elements and target variables. Students are asked to list out familiar and unfamiliar concepts embedded in the problem scenarios.

Step 3 Drawing situation diagram: This step aims at designing 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. Symbols to represent quantities (eg: Force- F; work-W), arrows for directions (←, ↑, →, ↓) and small circles, squares, triangles etc. to represent objects can be used to draw the thumb nail sketch. Conceptual elements can also be incorporated in the sketch. Based on the schematic sketch developed by the learner, the teacher can assess whether the salient features of the problem situation and the relevant physical quantities has been correctly identified by the learner.

The diagram learner tries to represent could possibly be incomplete. Salient features may be excluded and irrelevant data may come into the picture. When going through the forthcoming phases, the learners will get more acquainted with the problem type and can make the necessary modifications in the thumbnail sketch. The learner should be able to narrate the problem situation based on the thumbnail sketch developed and the schematic sketch developed should be able to support this.

Step 4. Providing Conceptual Knowledge

Teacher evaluates learners' prerequisites and based on them provides content knowledge about the unfamiliar concepts/ principles embedded in the problem scenario.

Phase 2. Familiarizing with the problem type 1.

The development of the situational and semantic information of problem type-1 and mapping all problem relevant information on to the problem schema of problem type-1 are the part of this phase. Schema diagram of each problem type aims at helping the novice problem solver in developing problem schema having situational and semantic information for each problem type.

Six steps have been incorporated in this phase for familiarizing the problem type-1 and its schema diagram.

Step 1- Identifying situational elements needed to solve the problem: -

One of the methods for helping learners to construct problem schema is to provide situational model for each problem type. In this step teacher provides students a 'situational model' diagram consisting different situational elements of problem type-1 and a worksheet consisting of different physical conditions and several slots (A copy of Work sheet is provided as Appendix B3). The category of physical conditions presented in the situational model guides learner to plan situational analysis for identifying crucial elements in the problem scenario. This situational model is an essential component of the problem schema that has to be developed by the students in the forthcoming steps.

In this step, students are asked to plan situational analysis on the basis of physical conditions given and identify the key elements in the problem situation. Situational model presented by the teacher is used for this purpose. Teacher uses the following question to prompt student attention to relevant situational elements in the problem.

- What part(s) of the situational model is/are best representative of the given problem situation?

Step 2- Identifying correct structural relationship in the problem:-

In this step students are asked to identify the correct structural relationship embedded in the problem. Structure map constructed by them are used for this purpose. Teacher uses the following question to prompt student attention to those elements and relationships.

- What part(s) of the structure map is/are best representative of the structural relationship in the given problem?

The goal is for students to identify appropriate structural relationships from the structure map and map them on to the problem schema of type-1 problem.

Step 3- Retrieving correct mathematical formula of Problem type-1

Based on the structural relationship embedded in the problem, students are asked to retrieve correct mathematical formulae. And map them onto the algorithmic model of the problem schema of problem type-1.

Step 4- Super imposing data on Schema

Find out the correct numerical values of the conceptual elements and superimpose them on the appropriate schema elements.

Step 5- Planning and execution of the solution:

This step in the Schema Based Instruction assists the learner in developing solution plan. Instructor demonstrates them how to plan and execute the solution by dividing problem in to sub problems. Given the presence of more than one unknown quantity in a single problem, the student must acquire the knowledge for selecting which one to calculate first. Structural information presented in the problem schema will help them to plan the solution. In order to find the numerical value of target variable with unit consistency, students are asked to substitute the values, and solve the equation.

Step 6- Reflection

Attribute the values and conceptual elements on the visual diagram to get a holistic picture.

Phase 3- Familiarizing with Situationally dissimilar and Structurally similar Problems.

The problem schema becomes more robust when interacting with structurally related and situationally different problems. Situationally dissimilar problems aid in recognizing the conceptual elements and in integrating it with the problem schema of the problem type. The following steps have been incorporated in this phase for improving quality of a problem schema of a problem type

Step 1- Presentation of situationally dissimilar and structurally similar problems:

At this step the teacher presents the type 1 problems which must be situationally different and structurally related. (Irrelevant data is also incorporated along with the relevant information in the problem situations.)

Step 2- Comparing situational features with the help of situation diagrams:

Teacher presents simple sketches of the problem scenario. One of them almost correctly represents the problem scenario by including the relevant data and situational features of the problem. Teacher requests students to identify the diagram which correctly represent the problem scenario. Students are also requested to compare situational features of the problem with the earlier problem that is presented in phase 1. The following prompting questions are used.

- Which of the diagrams correctly represent the situation of the problem?
- Compare this diagram with the earlier one (situation diagram in phase 1)

Step 3- Following the procedures depicted in steps 1 to 3 in the phase-2,

Students identify situational elements, structural relationships and algorithmic information of the problem given to solve. Following this, students are asked to match their schema knowledge of type-1 problem acquired from previous problem context (that is presented in phase 1). Students are asked to recognize similarities and differences in the situational information and semantic information.

On the basis of that, they are requested to elaborate situational model by mapping new situational features on it; and also if there is any variation from basic formulae, they should map them with basic formulae on to the algorithmic model of the problem schema.

Step 4- Following the procedures of the step 4 to 6 in phase 1 students find the numerical value of the unknown quantity.

Repeat the steps (1 to 4) for each situationally dissimilar and structurally similar problems. Three problems of this kind were used in this phase.

Phase 4. Familiarizing with situationally similar and structurally dissimilar problems.

Interaction with different problem types facilitate in boosting the conceptual understanding. Incorporation of different types of problems will encourage the learners to focus on the structural relationship and situational features of the given problem and also help them to eliminate the blind replication of mathematical procedures. The following steps have been incorporated in this phase.

Step 1- Presentation of situationally similar and structurally dissimilar problems:

Teacher presents different type of story problems. The problems must be situationally similar and structurally dissimilar. Irrelevant data should also be included along with relevant data. Students are requested to select problems that can be solved with schema-1(of type -1 problem). The following prompting questions are used.

- ❖ Select the problems that can be solved with schema 1.
- ❖ What element(s) of the situational model of the problem schema-1 is/are best representative of the context of given problems?
- ❖ Identify the problem having structural relationships similar to type-1 problems

Step 2- Argumentation.

Teacher asks students to formulate arguments for their selection of problems. Arguments should be based on concepts and principles in Physics. The following prompting question is used.

- Explain your reason for your selection?

Phase 5. Practicing problem solving using problem schema.

During this phase different types of problems are solved. The problem solving practice should not only focus on the numerical results. The learner should give attention to go through the different steps stated in the phase 1, 2, 3 and 4. This will foster the problem solving in such a way that it supports the conceptual understanding. So in this phase students are asked to practice story problem solving by answering the following subquestions that are presented as part of each story problem.

1. What are the key features of the given problem situations?
2. What are the relevant data given in the problem?
3. Draw the diagram that correctly represents the situation of the problem?
4. What quantities are directly given/stated in the problem?
5. Identify what kind of problem it is?
6. Identify the core idea embedded in the problem scenario
7. What is the inter relationship between various physical quantities embedded in the problem
8. What equation is needed to solve the given problem?
9. Find the numerical value of target variable

Following the phases of the Schema Based Instruction, Lesson transcripts were prepared on the select topics and a sample is given as Appendix H

Direct Translation Strategy of teaching problem solving

Direct Translation strategy is one of the commonly used strategies for teaching problem solving in Physics among Higher Secondary School Students. According to Jonassen (2010), Direct Translation Strategy is a “form of problem solving that typically involves reading a well-structured story problem, attempting to identify the correct equation, inserting values from the problem statement into formula and solving for the unknown value,”(p.308). In this strategy students learn to “directly translate the key propositions in the problem statement into a set of computations” (Jonassen, 2010, p.28).

Usually the story problems in learning environments like these are solved through procedures like identifying key values in the short scenario, selecting the appropriate algorithm and applying the algorithm to generate quantitative answer (Sherill, 1983). This strategy regards problem solving as a procedure to be memorized, practiced, and habituated and that emphasizes answer getting, not meaning making (Wilson, Fernandez, & Hadaway, 1993).The learners, who solve problems through Direct Translation Strategy, focus too closely on surface features or recall familiar solutions from previously solved problems. In the present study, the control group was taught problem solving using Direct Translation Strategy. The following steps were used for this purpose.

Step 1: Reading the problem

Step 2: Represent the unknowns with letters

Step 3: Identifying key values in the problem scenario

Step 4: Identifying the correct equation

Step 5: Inserting values into formula

Step 6: Solving equations to find the values of the unknowns

(Jonassen, 2010., Sherill, 1983., Rich, 1960)

Following these steps Lesson transcripts were prepared on the select topics for teaching control group (Sample of lesson transcript is given as Appendix H).

Tools Used for Collection of Data

Tools used to explore the effect of Schema Based Instruction on solving story problems in physics among Higher Secondary School Students are listed in Table 5.

Table 5
Tools Used in the Study

Sl. No.	Variables	Tools
1	Non-Verbal Intelligence	Standard Progressive Matrices (1996 Edition) prepared by Raven, Court and Raven published by Oxford Psychologists Press, Lambowne House, Oxford, UK
2	Logical Mathematical Intelligence	Logical Mathematical Intelligence test prepared by the investigator along with supervising teacher
3	Problem Solving Ability in Physics	Test for assessing Problem Solving Ability in Physics prepared by the investigator along with his supervising teacher
4	Conceptual Understanding of Story Problems in Physics	Test for assessing Conceptual Understanding of Story Problems in Physics prepared by investigator along with his supervising teacher
5	Comprehension of Problem Schema	Test for assessing Comprehension of Problem Schema, prepared by the investigator along with supervising teacher.

In addition to this, a strategy questionnaire was used to evaluate student's perception of Schema Based Instruction.

Description of Tools

Four tools were prepared as a part of the study which comprises Logical Mathematical Intelligence test, Test for assessing Problem Solving Ability in Physics, Test for assessing Conceptual Understanding of Story Problems in Physics and Test for assessing Comprehension of Problem Schema. The tests except Intelligence tests were based on the topics selected for the experimentation, i.e., Work, Energy and Power.

The sample used for standardization of tools, general structure, the scoring procedure and the psychometric properties of tools employed in this study are detailed below.

Sample used for Standardization of Tools

Higher Secondary School Students of grade 11 doing science course in Kerala constitute the population of the study. Three higher secondary schools with students of comparable socio economic background and educational background were chosen from Kasargod, Kannur and Kozhikode districts for the standardization of Test for assessing Problem Solving Ability in Physics, Test for assessing Conceptual understanding of story problems in Physics and Test for assessing Comprehension of Problem Schema. Among these, Government Higher Secondary School, Cheemeni is located in Kasargod district, Government Higher Secondary School, Vellore is located in Kannur district and Al-Farook residential senior secondary school, Farook College is in Kozhikode district. One class from each school was randomly selected as standardization sample. Draft test of the tools were administered in these classes. Out of the 118 students, 100 students gave data complete in all respects. Therefore, these 100 students were selected as the sample for standardization of the tools.

Try Out of the Tools

Proper instructions were given at the starting of the execution of each tool. Response sheets provided space for personal information like name of the student, gender, division and name of school. The responses of each item by the students were scored and were subjected to item analysis.

Raven's Standard Progressive Matrices (SPM).

Standard Progressive Matrices (1996 Edition) prepared by Raven, Court and Raven published by Oxford Psychologists Press, Lambowne House, Oxford, UK were used to test the Non-Verbal Intelligence of the subjects. The test is a popular measure of abstract reasoning ability and general intelligence (Spearman's 'g' factor of Intelligence). This test is designed to measure the general intelligence of literate as well as illiterate individuals. This nonverbal test is intended to measure the subject's ability to discern and utilize a logical relationship presented by nonverbal materials.

The test booklet consists of 60 multiple choice items (5 sets of 12 items each), arranged in their increasing order of difficulty. In each item, a part of the geometrical design is missing. Below each item six alternative answers with numbers are given for each design. All of these fit the missing part, but only one logically belongs to it. The test takers are required to identify the right answer and record it in a separate answer sheet provided for this purpose. The scoring procedure of the test is to give one score for each correct answer and zero score for each incorrect ones. The test takers responses can be scored with the help of the scoring key given in the manual. Reliability and Validity of the test has been studied in a variety of usual ways.

(a) Reliability: Test – Retest reliabilities reported by Raven vary from 0.80 to 0.93.
(b) Validity (Concurrent validity): When Stanford-Binet test was used as the criterion, correlation varied from 0.54 to 0 86.

Logical Mathematical Intelligence Test

To measure the Logical Mathematical Intelligence of the subjects a paper-pencil test was developed based on Logical Mathematical component of the theory of the multiple intelligence proposed by Gardner (1983). The test was developed by the investigator along with his supervising teacher.

The items were intended to measure the following 13 components of the construct- logical Mathematical Intelligence. 1. Classification 2. Logical pattern recognition 3. Logical diagram analysis 4. Coding and Decoding 5. Ordering 6. Direction sense 7. Information analysis 8. Drawing logical assumptions 9. Understanding relationship between cause and effect 10. Analogy 11. Syllogism 12. Symbol manipulation 13. Computing ability.

A draft test consisting of 62 multiple choice items with 62 marks were prepared. The scoring procedure of the test is to give one score for each correct answer and zero score for each incorrect ones. The investigator chose 415 grade 11 students in the higher secondary schools of Kasargod, Kannur and Kozhikode districts of Kerala for the standardization of the test. During item analysis, question with difficulty index in the range 0.3 to 0.75 were selected for the final test. Also those items with discriminating index lesser than 0.3 were weeded out. The final draft of the test had 36 items.

Reliability of the test was established by the test retest method, on 31 grade 11 students doing science course. 33 days after the first test, the same test was administered on the same students. The test-retest reliability coefficient was 0.74. The validity of the test was estimated empirically by comparing the scores of the test with Raven's standard progressive Matrices on a group of 48 grade 11 science students. The coefficient of correlation so obtained was 0.59, indicating that the test had concurrent validity. The above evidences suggest that the test is reliable and valid to measure logical mathematical intelligence of Higher Secondary School Students. A copy of the Logical mathematical Intelligence Test along with the response sheets and scoring keys are provided as Appendix C1 to C3.

Test for Assessing Problem Solving Ability in Physics

A Problem Solving Ability test with story problems in Physics was constructed and was administered as pretest and posttest to measure the Problem Solving Ability of Higher Secondary School Students in Physics. The final test contains 14 story problems from the topics work, energy and power. The story problems were selected so as to represent the 8 problem types identified within the content portion of chapter 'Work, Energy and Power' presented in the NCERT text book prescribed for grade 11 students in India. The story context of the problems selected for the test consisted of situational information and semantic information. Each of the story problem required mathematical model for solving it. The problem solving process will hence require analyzing situational characteristics of problem, identifying relevant physical quantities, recognizing inter relationship between various physical quantities (structural relationship) embedded in the problem scenario along with the mathematical part of selecting the correct arithmetic formulae, substituting and solving it. Consistency in units is also important as the final part of problem solving.

Planning

The initial step in developing this tool was a detailed content analysis on the chapter work energy and power presented in the NCERT physics text book of grade 11. Based on this investigator identified various problem types included in the chapter as identified in Table 6. In the second step, in order to gather more information about the situational and structural attributes of identified problem types, comprehensive review of authentic Physics text books and question banks of various competitive exams in physics of grade 11 were done. This helped in designing the tool and a preliminary pool of items. All items were then reviewed in relation to their meaningfulness and appropriateness for the target problem types and target group through a widespread consultation process with experts in physics. This consultation network was utilized during all stages of the tool development. Certificates of consultations with experts are provided as Appendix J.

Item writing

A draft of 20 story problems was prepared giving due representation to the problem types listed in Table 6. While preparing the draft test, care was taken regarding the rules for item construction such as clarity, precision, and relevance of items. Based on the difficulty level, the items in the test were categorized into easy, medium difficulty, and difficult items. Appropriate weightage was given to each difficulty level. The detailed content analysis and comprehensive review done in the preliminary stage helped to allocate proper weightage to problem types.

Table 6

Problem Type-wise Distribution of Items in Draft of Test for Assessing Problems Solving Ability in Physics

Sl. No.	Problem type	Item No.	Total
1	Work	1,2	2
2	Kinetic energy	11,12,13,18	4
3	Potential energy	14,15,16	3
4	Work-Kinetic Energy theorem	3,4,19	3
5	Conservation of Mechanical energy	7,8,20	3
6	Conservation of Linear momentum	5,17	2
7	Mechanical power	6, 9	2
8	Kinetic Energy &Linear Momentum conservation	10	1
	Total		20

As 20 problems at one stretch would be tiresome to attempt, the tool was divided in two part (part-1 and part-2) containing 10 problem each. The first section was administered to the students (N=100) selected for standardization of tool. Second section was also administered to the same students on the very next day. Total marks and adequate time to finish the test were also decided. The time allotted for completion of each part was 60 minutes. While administering the test students were instructed to inscribe the logical steps and mathematical calculations they used to solve the problem. This was necessary to evaluate the story problems. Each story problem had 4 value points of half a score each. Thus each story problem had a maximum score of two and the test had a maximum score of 40. The scores so obtained were subjected to item analysis. Sample of an item included in the draft test is given in Example 2.

Example 2

A 62.1-kg male ice skater is facing a 42.8-kg female ice skater (figure. A). They are at rest on the ice. They push off each other and move in opposite directions. The female skater moves backwards with a speed of 3.11 m/s. Determine the final speed of the male skater?

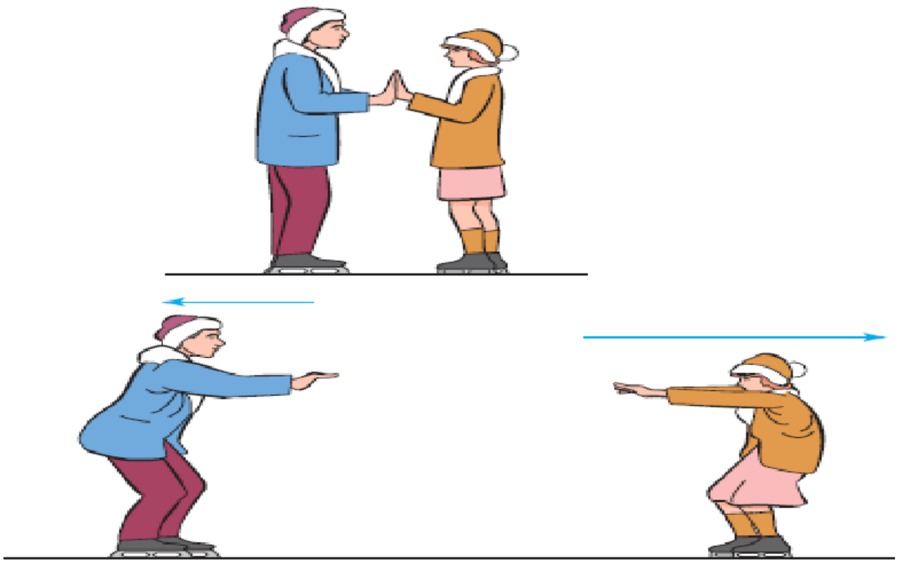


Figure A.

A copy of draft of Test for assessing Problem Solving Ability in Physics is given as Appendix D1.

Item analysis

Item analysis is the systematic estimation of the effectiveness of the individual items on a test (Brown, 1996). Based on item analysis investigator determined Item Facility (IF) value (also called item difficulty index) and item discrimination index of each item in the Problem Solving Ability test. This test consists of the items that have weighed scores. In such cases of partial credit, item facility is the average proportion of correctness for a particular item (Brown, 2000). Item facility and item discrimination statistic of each item having weighted scores were calculated following the item analysis procedures advocated by Brown (2000).

For calculating item facility value, investigator first converted each student's answer to each item on a proportion score scale from 0 to 1. The conversion to a 0 to 1 scale was done by dividing each student's item score by the total possible score for that item. Then the Item Facility (IF) value (item difficulty) was calculated using the formula:

IF= Average of the proportion scores

$$= \frac{\text{sum of the proportional scores of 100 students in an item}}{100}$$

For measuring Item Discrimination statistic(ID)of each item, investigator arranged the total scores of responses collected from 100 students in the descending order. The lower 33 percent and upper 33 percent of students' response sheets were taken. Thus, the number of students in lower and upper group constituted 33 each. The responses for each item in both groups were scored and subjected to item analysis. The item discrimination statistic (ID) was measured as the average proportion score for the upper group minus the average for the lower group(Brown, 2000). Thus ID can be written as:

$$ID=IF_{Upper}-IF_{Lower}$$

$$= \frac{sum of Proportional scores of Upper\ 33\%}{33} - \frac{sum of Proportional scores of Lower\ 33\%}{33}$$

The item facility (IF) and item discrimination statistic (DP) of each item in the Problem Solving Ability test with story problem in Physics is shown in Table 7.

Table 7

Data and Results of Item Analysis of Test for Assessing Problem Solving Ability in Physics

Item No	U	L	ID	IF	Selected or not
1	31.00	7.75	0.70*	0.69*	✓
2	28.75	10.00	0.57*	0.69*	✓
3	29.5	15.50	0.42*	0.69*	✓
4	12.5	6.25	0.19	0.32	
5	32.5	14.00	0.56*	0.69*	✓
6	28.75	8.25	0.62*	0.57*	✓
7	28.00	6.50	0.65*	0.58*	✓
8	10.00	3.75	0.19	0.19	
9	29.25	11.50	0.54*	0.59*	✓
10	26.50	8.75	0.54*	0.54*	✓
11	28.75	12.00	0.51*	0.56*	✓
12	13.75	10.00	0.11	0.32	
13	13.25	3.75	0.29	0.24	
14	25.25	12.50	0.40*	0.48*	✓
15	24.75	4.50	0.61*	0.40*	✓
16	28.75	16.50	0.40*	0.61*	✓
17	10.75	2.50	0.25	0.15	
18	26.75	10.00	0.51*	0.45*	✓
19	28.25	5.25	0.69*	0.40*	✓
20	12.50	2.25	0.31	0.17	

Note. The asterisk mark indicates that the value agrees with the criterion for selection.

Those items having IF value between .30 and .70 (Brown, 1996) and ID statistic of 0.4 and above are good items (Ebel 1979, p. 267; Nunnally and Jum, 1978) and are usually considered acceptable. Thus on the basis of item analysis, 14 items with IF value in the range 0.3 - 0.70 and ID statistic of 0.4 and more were accepted as good items. Six items with discriminating index lesser than 0.4 were weeded out. The final test thus contains 14 items, in the manner, easy items: 4 (28.5%), medium difficult: 6 (43%), difficulty items: 4 (28.5%).

Reliability

Reliability of the test was established by the test-retest method on 54 grade 11 students doing science course. After four weeks of first test, the same test was administered on the same students. The correlation between students' scores on the first and second test was calculated. The test-retest reliability coefficient was found to be 0.77. Hence the test can be considered reliable.

Validity

Content validity

Content validity of Problem Solving Ability Test in Physics with story problems was ensured by obtaining the judgment of four experienced higher secondary school physics teachers and three physics teachers in collegiate education from Kasargod and Kannur districts of government and aided sector. Their opinion was taken into consideration while preparing the test. With the help of experts, the content validity of the test was ensured as the items were made from the subject content of grade eleven physics text book giving due representation to the problem types within the content.

Concurrent validity

Concurrent validity of Problem Solving Ability test in Physics with story problems was estimated empirically by correlating the test scores of 54 grade 11 science students with their scores of Problem Solving Ability test developed by Praveen (2017). The coefficient of correlation so obtained was 0.64 (N=54) indicating that the test has concurrent validity.

Construct validity

The test has construct validity because it is prepared based on the following three process of problem solving suggested by Young, Freedman and Ford (2012) identify the relevant conceptual elements from the problem scenario, Set Up the problem; Execute the solution. The items were scored with proper indicators and scoring key elements.

Intervention study was performed to confirm construct validity (Brown, 1996) of Problem Solving Ability test with story problems. Construct validity was estimated empirically by comparing the mean of pretest and post-test scores of Problem Solving Ability for a group of 54 grade 11 students doing science course. In order to do intervention study for Problem Solving Ability test, the test was administered (pretest) before implementing instructional intervention. The instructional intervention was based on information processing theory of problem solving process. The test was Re-administered (post-test) at the end of the period of intervention. Paired sample t test was performed to compare the mean scores of pretest and posttest. The result of the paired sample t test showed significant difference between pretest scores and posttest scores of Problem Solving Ability($p < 0.05$). Descriptive statistics of the scores of both tests showed that the students performed much better on the second administration (M=11.70) than on the first (M=3.77).This increased score indicates that the test has indeed measured that learning construct which was accrued by the instruction for problem solving. This supports the argument for the construct validity of the test (that is the test measures the construct adequately).The logic of the decision to execute an intervention study is based on the assumption that students actually do learn something (Brown, 1996).

The above evidences suggest that the test is reliable and valid to measure Problem Solving Ability of Higher Secondary School Students. A copy of Test for assessing Problem Solving Ability in Physics (final) along with response sheet and scoring key are given as Appendix D2 to D4.

Test for assessing conceptual understanding of story problems in physics

Constructing recall test items to assess problem solving in physics assess student's ability to memorize mathematical formulae and mathematical procedure required to generate numerical value for the unknown physical quantity. This type of assessment does not support to assess learner's conceptual understanding on problems. Moreover merely assessing quantization procedure of unknown physical quantity gives no much information about learner's Problem Solving Ability.

Understanding of the concepts that are embedded in the problem scenario, have crucial role in determine the success of problem solving in physics. Conceptual understanding of the problems is the basis of transfer of Problem Solving Ability to new problems. So it is generally accepted by teachers and researchers that the main purpose of story problem solving is to enhance students' deeper understanding of a specified subject matter domain. Therefore the purpose of problem solving-assessment is also to promote students' conceptual understanding rather than training in arithmetic procedures needed to solve the problem. Assessment of the current level of understanding about specific knowledge of the domain is required to ensure students ability to find acceptable solution to the problem as well as their ability to recognize similar problems in future.

The conventional way of story problem solving assessment, merely assess solvers ability to substitute relevant data given in a problem at hand into a mathematical formula; to perform appropriate arithmetic procedures, and to calculate numerical value of unknown quantity in the problem. This way of assessment does not assess students understanding about the causal relationship in the problem, whether students perceive physics concepts embedded in the problem scenario, whether student identify a problem at hand as it is similar to earlier solved problems, their ability to visualize problem scenario and even their ability to identify similar problems in future. Teachers teach students how to solve problems using a variety of strategies; but they only assess student's ability to recall what they have memorized for a test. Consequently students will not invest any mental effort in learning to solve problems (Jonassen, 2010).

According to Jonassen (2004), assessing problem solving based on only one form of assessment (limited to assessment of knowledge and ability) neglects the richness and complexity of problem solving. He also argued that the ability to solve story problems and to transfer problem-solving knowledge and abilities to new problems cannot be effectively evaluated using any single form of assessment. Therefore multiple forms of assessment are required to know whether learners are able to transfer problem-solving knowledge and skills. Jonassen (2010) describes four different ways to assess problem solving including:

1. Assess problem schemas associated with different problem types.
2. Assess students' problem-solving performance
3. Assess the component-cognitive skills required to solve problems (e. g. understanding of domain concepts and causal reasoning).
4. Assess students' ability to construct arguments in support of their solutions to problems.

Jonassen (2010) further argues that at least one form of all four ways be used to ensure adequacy in assessing. A problem schema is a data structure containing specific knowledge about a problem at hand. It is the basis of human understanding and reasoning and it represents interpretation of things. Therefore constructing and developing schema of problems is an important learning outcome (Jonassen, 2010). In Skemp's (1987) words "to understand something means to assimilate it into an appropriate schema"(p.29).

Problem Schema is a form of conceptual understanding of the problem in the form of a structured imagery (Praveen, 2017). So assessment of problem solving in schema based learning would assess the quality of the problem schema the learner has constructed. The meaningful integration of situational and semantic information into the problem schema determines the depth of conceptual understanding of the problem. There are several cognitive processes in problem solving for supporting conceptual understanding. They are, classifying problems, understanding causal relationship in the problem, analogically comparing similar problems and metacognitive regulation of problem solving. The assessment of the conceptual understanding of the problem would thus consist of items that test students' capacity to:

- Identify a problem as belonging to a familiar problem type.
- Analyze structural relationship in the problem.
- Analyze mathematical procedure of the problem.
- Backward chaining (Create story problem when the situational and mathematical elements are given)

The manner in which the problems are represented to the learners plays an important role in developing conceptual understanding. For recognizing the structure of the problem quickly, the solvers have to identify the attributes of external problem representation and they must be mapped onto the learner's mental representation (Jonassen, 2004). The form of the external representation of problem affects the cognitive process of problem solving. Therefore, in order to develop adequate conceptual understanding of the class of problems, learner must perceive the form, organization and sequence of problem representation.

Planning

A standardized test for assessing conceptual understanding of story problems in physics was prepared. The same test was administered as pretest and posttest. The story problems were selected so as to represent the 8 problem types(i.e., Work, Kinetic Energy, Potential Energy, Work-Kinetic Energy theorem, Conservation of mechanical Energy, Mechanical Power, Conservation of Linear Momentum, Kinetic Energy and linear momentum conservation) identified within the content portion of chapter 'Work, Energy and Power' presented in the NCERT physics text book prescribed for grade 11 in India. Based on the difficulty level, the items in the test were categorized into easy, average and difficult. Appropriate weightage was given to each difficulty level. The test was designed as a mixed-format test having multiple-choice and constructed response item types. Investigator used a combination of these two item formats to take advantage of the benefits of each item type while compensating for their weaknesses (Reshetar & Melican, 2010). Constructed response is often used to measure complex skills, and the use of such items helps avoid random guessing (Livingston, 2009). All items except the last four (item No. 11, 12, 13 and 14) in the draft test were objective type.

Item writing

The test contained 10 items from the topics 'Work, Energy and Power'. Items for the test was prepared considering the following cognitive processes (suggested by Jonassen, 2010) that are identified as the requirements for solving story problems with the support of conceptual understanding.

- Categorizing problems into problem types by comparing the situational characteristics of the problem and structural relationship described in the problem to previously solved problems or to problem class descriptions.
- Identifying problem entities (sets) from the surface content; mapping those sets onto the structural model of the problem.
- Retrieving the mathematical equations and processing operations required to solve the problem.
- Remembering the problem information and the structure of the problem entities and filing according to problem type.

The draft of the test contained 14 items. The categories of items included in the test were text editing problems, Jeopardy problems, problem classification and problem posing. The items in each category were designed to test learners understanding about the situational and structural information of the problem types and understanding about the physics concepts or principles or laws embedded in the problem scenario. Category wise distribution of the items in the draft test is given in Table 8.

Table 8

Category wise Distribution of Items in Draft Test for Assessing Conceptual Understanding of Story Problems in Physics

Sl. No.	Category	Item no	No of items
1	Text editing problems	1,2,3	3
2	Jeopardy problems	5,6,7	3
3	Problem classification	8,9,10	3
4	Problem posing	4,11,12,13,14	5

Text editing problems

Text editing questions assess quality of learners' problem schema (Jonassen, 2010). In the present test, Text editing items presented in the form of a story problem contain sufficient, irrelevant or missing information (Low & Over, 1990; Low, Over, Doolan, & Michell, 1994; Ngu, Lowe, & Sweller, 2002, Jonassen, 2010). Instead of asking students to solve the given problem, the text editing problems ask them to identify whether the problem scenario contains sufficient, missing or irrelevant information for solving the problem. These questions appear fairly simple, but it is extremely demanding of proper conceptual understanding about structure of the problem. In the draft test, out of 14, three items (Item No. 1, 2 and 3) were presented as text editing problems. Text editing questions were included in this test to assess students' understanding of the nature of problem schema, not the process for calculating a correct response. For answering such questions, students must understand what kind of problem it is and what elements are appropriate for that kind of problem. Example of the Text Editing Problems is given as Example 3.

Example 3

Problem:-*Consider a car initially at rest and out of fuel. A group of people get behind the car and push on its rear bumper with net force of 560 N in the forward direction for a distance of 15.0 m displacement. Predict the final speed of the car after the 15.0m displacement?*

For this problem I think,

A. There is sufficient data presented to solve the problem.
(If so, what are those data, needed to solve the given problem?)

B. There is insufficient data presented to solve the problem
(If so, what additional data do I need to solve the given problem?)

C. There is more data presented than needed to solve the problem.
(If so, what are the irrelevant data presented in the problem?)

Jeopardy problems

Physics jeopardy items were first designed by Van Heuvelen and Maloney (1999).The name 'Jeopardy' was adopted after the popular television quiz show of the same name. For solving Jeopardy problem students must work backward. Instead of giving students a story problem to solve, they are given a worked out solution to the problem and are asked to determine the correct story problem that can be solved by using the given solution. In the test, item-No 5,6 and 7 represents Jeopardy problems. In example-2 a few steps of the solution of conservation of linear momentum problem is presented as a jeopardy problem.

Example: 4

You are given below a worked out solution to a problem.

Solution:

$$m_1u_1+m_2u_2=m_1v_1+m_2v_2$$

$$0 = m_1v_1+m_2v_2$$

$$m_1v_1=(-m_2v_2)$$

$$v_1= (-0.3)m/s$$

I think the correct story problem that can be solved by using the solution given above is ……….

A. A girl on a swing is 2.5m above the ground at the maximum height and at 1.5 m above the ground at the lowest point. Calculate her maximum velocity on the swing(g=10m/s2)

B. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to ground ,then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. Calculate the velocity attained by the ball

C. A Sky Lab astronaut of mass 70 kg discovered that while concentrating on writing some notes, he had gradually floated to the middle of an open area in the spacecraft. Not wanting to wait until he floated to the opposite side, he asked his colleagues for a push. But his colleagues decided not to help him, and so he had to take off his uniform of mass 1kg and throw it at a speed of 20m/s in one direction so that he would be propelled in the opposite direction. Estimate his resulting velocity.

D. A toy car of mass of 2kg starts from rest. A spring performs 196 joules of work on the car. What is the toy car's final velocity?

Jeopardy problems demand a serious effort to represent a physical process in different ways (VanHeuvelen & Maloney, 1999). In order to recognize the correct story problem of the given solution, students must relate information given in the mathematical and symbolic representation to the structural characteristics of the problem scenario.

Problem classification items

Story problem solving requires adequate conceptual understanding of problem types. Student's ability to classify problems by comparing situational attributes and structural relationship in the problem indicate that they have robust problem schema in the form of conceptual understanding.

Problem classification items were included in this test for assessing how students generalize problem schemas. It tests whether the students' classification is based on surface level similarity among problems or on the similarity of Physics concepts or principles embedded in the problems. In this test, problem classification items are simply presented as set of different kind of problems which are in the form of situationally similar & structurally dissimilar and situationally dissimilar & structurally similar types. Instead of asking students to solve the given set of problems, they are asked to group the problems based on the core idea or concepts or principles embedded in the problem scenario.

Example: 5

Group the given problems together based on the major concepts/ principles/laws needed to solve the problems. Write the name of the concepts/ principles/laws behind your grouping?

(A) A football of mass 0.43 kg travelling with a velocity of 5 m/s hits another ball of the same mass, which is stationary. The collision is head on and elastic. Find the final velocities of both balls.

(B) Two blocks of masses 5kg and 7 kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. The blocks collide and stick together. The velocity of blocks after collision is (-0.1m/s) .Find the loss in kinetic energy during the collision

(C) Two blocks of masses 5kg and 7kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. Find the final velocity of each block, if the collision is completely elastic.

(D) A bullet of mass 20g is found to pass two points 30m apart in a time interval of 4 second. Calculate the kinetic energy of the bullet if it moves with constant speed?

In order to classify problems properly, student have to construct robust problem schema. Students must generalize their problem schemas based on the physics principles used by experts rather than surface-level similarities among problems (Chi et al., 1981; Dufresne, Gerace, Hardiman, & Mestre, 1992; Hardiman, Dufresne, & Mestre, 1989).

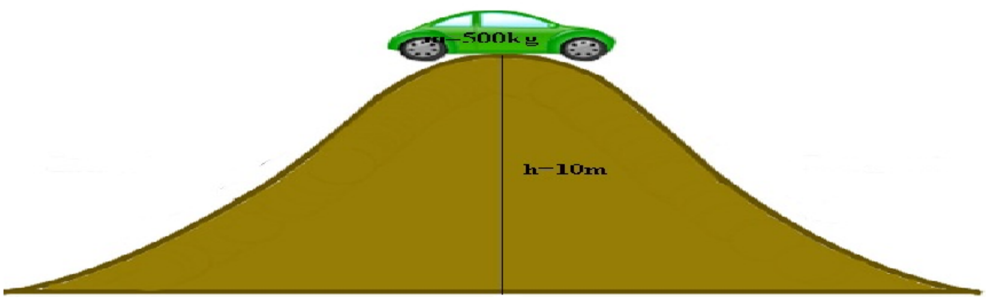
Problem posing questions

Mestre and others (Mestre, 2002) used problem posing question to test conceptual knowledge of students in the context of physics problems. Instead of asking students to solve the problem, problem posing questions ask them to create their own story problem based on the given situation.

Problem posing items were included in this test for testing students' ability to integrate their conceptual knowledge to a context. In the test students are given a context from their day to day life, in the form of a picture, and are asked to create a story problem around the context that must be based on certain physical concepts or principles from the chapter 'work energy and power' (item No. 11,12,13 and 14). This type of problem posing items is open-ended with multiple possible answers.

Example: 6

Direction: *The following figures represent the situations of different types of Story problems in physics. Based on the situations of each figure create suitable Story Problem that can be solved using familiar ideas/concepts/laws/principles which you have studied in the chapter 'Work, Energy and Power'.*



A. Create story problem based on the situation.

B. Write the name of concepts/laws/principles which are applicable to solve the problem you have created?

C. Which equation(s) can be used for solving the problem you have created?

Alternative problem-posing item (as suggested by Jonassen, 2010) was also included in the draft (item no:4) which is presented in example 7. Here students are given a statement describing a context and are asked to add a question that would turn it into a problem that uses specified principles or equations. This type of alternative problem posing has a unique correct answer.

Example: 7

You are given the situation of a problem below

A child of mass 20kg rides on an irregularly curved slide of height h=2m. The child starts from rest at the top. Assuming no friction is present

Which question, when added to the situation above, will make a solvable problem, that requires all of the following equations to solve?

$$\mathbf{KE=\frac{1}{2}MV^2}$$

$$\mathbf{PE=M\ g\ h}$$

$$\mathbf{E=KE+PE}$$

A. Determine the work done by frictional force on the child
B. How much time does the child take to reach the bottom of the slide?
C. What is the average force of air resistance acting on the child?
D. Determine child's speed at the bottom of the slide?

This way of problem posing presents students with the initial part of a problem statement that obviously describes a story context. Students are then asked to select from a list of choices (A-D), a question, which when added to the statement will create a solvable problem that requires the use of a set of given equations. For answering such question students must require knowledge of specific conceptual knowledge, represented in the form of formulae (Jonassen, 2010).Moreover, Problem-posing items assess students' understanding of concepts as well as their ability to transfer their understanding to a new context (Mestre, 2002).

A copy of draft Test for assessing Conceptual Understanding of story problems in Physics is given as Appendix E1.

Item analysis

Item analysis was performed to estimate item facility index and item discrimination index of the test items. This was done by conventional item analysis procedure with only slight variations from the usual calculations. As the test consist dichotomously scored multiple-choice, partial credit multiple choice and partial credit constructed response item types, Brown's (2000) procedures were used to calculate item facility and item discrimination. The item facility is measured as the average proportion of Correctness for a particular item.

For calculating item facility value, investigator first converted each student's answer to each item (except dichotomously scored item) on a proportion score scale from 0 to 1. The conversion to a 0 to 1 scale was done by dividing each student's item score by the total possible score for that item. Then the Item Facility (IF) value (item difficulty) was calculated using the formula:

IF= Average of the proportion scores

$$= \frac{\text{sum of the proportional scores of 100 students in an item}}{100}$$

For measuring Item Discrimination statistic (ID) of each item, investigator arranged the total scores of responses collected from 100 students in descending order. The lower 33 percent and upper 33 percent of students' response sheets were taken. Thus, the number of students in lower and upper group constituted 33 each. The responses for each item in lower and upper groups were scored and subjected to item analysis. The item discrimination statistic (ID) was measured as, the average proportion score for the upper group minus the average for the lower group(Brown, 2000). Thus ID can be written as:

$$ID=IF^{Upper}-IF_{Lower}=$$

$$\frac{sum of Proportional scores of Upper(U)\ 33\%}{33}-\frac{sum of Proportional scores of Lower(L)\ 33\%}{33}$$

The item facility (IF) and item discrimination statistic (DP) of each item in the conceptual understanding test of story problems in physics is shown in Table 9.

Table 9

Data and Results of Item Analysis of Test for Assessing Conceptual Understanding of Story Problems in Physics

Item No	U	L	ID	IF	Selected or not
1	29.00	8.00	0.64*	0.52*	✓
2	28.00	8.00	0.61*	0.49*	✓
3	30.00	23.00	0.22	0.77	
4	23.00	9.00	0.43*	0.44*	✓
5	29.00	18.00	0.33	0.74	
6	28.00	13.00	0.46*	0.65*	✓
7	31.00	11.00	0.61*	0.67*	✓
8	28.33	14.77	0.41*	0.64*	✓
9	16.67	4.32	0.37	0.32	
10	26.65	10.98	0.48*	0.54*	✓
11	20.99	7.33	0.42*	0.44*	✓
12	26.36	3.83	0.66*	0.41*	✓
13	24.35	4.66	0.60*	0.41*	✓
14	15.36	2.64	0.38	0.25	

Note. The asterisk mark indicates that the value agrees with the criterion for selection.

On the basis of item analysis, 10 items with item facility value in the range 0.38 to 0.68 and ID statistic of 0.4 and more were accepted as good items. Four items with discriminating index lesser than 0.4 were weeded out. The final test thus contains ten items in the manner, easy items: 2 (20%), medium difficult items: 6 (60%), difficult items: 2 (20%).

Reliability

Reliability of the test was established by the test retest method on 64 grade 11 students doing science course. After five weeks of first test, the same test was administered on the same students. The correlation between students' scores on the first test and second test was calculated. The test-retest reliability coefficient was found to be 0.70. Hence the test can be considered to be reliable.

Validity

Content validity

Content validity of Problem Solving Ability Test in Physics with story problems was ensured by obtaining the judgment of four experienced higher secondary school physics teachers and three physics teachers in collegiate education from Kasargod and Kannur districts of government and aided sector. Their opinion was taken into consideration while preparing the test. With the help of experts, the content validity of the test is ensured as the items were made from the subject content of grade eleven physics text book giving due representation to the problem types within the content.

Concurrent validity

Concurrent validity of conceptual understanding test in Physics with story problems was estimated empirically by correlating the test scores of the 60 grade 11 science students with their scores of conceptual understanding test developed by Praveen (2017). The coefficient of correlation so obtained was 0.61 (N=60) indicating that the test has concurrent validity.

Construct validity

The test has construct validity because it is prepared based on the following cognitive processes required for solving story problems with the support of conceptual understanding (suggested by Jonassen, 2010): identify a problem as belonging to a familiar problem type, analyze structural relationship in the problem, analyze mathematical procedure of the problem and backward chaining (create story problems when the situational and mathematical elements are given). The items were developed from these indicators. Hence this established the concurrent validity of the tests.

Scoring procedure

The scoring was done with the scoring key prepared by the investigator. The test contains dichotomously-scored multiple-choice items, partial credit multiple choice items and partial credit constructed-response items. In the case of dichotomously-scored multiple choice items single score was given for each correct answer and zero for every incorrect answer. Each partial credit multiple choice item had six correct answer of half a score each. Thus each such question had a score of three. The partial credit constructed response questions were given four value points with half score each. So each constructed response items had a score of two. The four value points were based on the following 4 aspects of the story problems: situational attributes, relevant physical quantities, structural elements and problem statement

A copy of the Test for assessing Conceptual Understanding of Story problems in Physics (final) along with the response sheet and scoring key are provided as Appendix E2 to E4.

Test for Assessing Comprehension of Problem Schema

From a problem solving learning environment students access a lot of information about the problem. If this information is not organized as a meaningful pattern in their memory, students will not be able to retrieve them at the time of addressing new problems. Important issue regarding schema is that “a student does not commit a schema to memory in the same way that he or she may memorize a formula or definition"(Marshall 1995; p.46). This suggests that schema formation demands a thorough understanding of it.

There have several factors that influence the ease and accuracy of problem solving in physics. The most important factor influencing learners' problem solving is the quality of their Problem schema (Hayes & Simon, 1976). Robust problem schema consist situational characteristics, structural relationships and algorithmic information (Ruesser, 1993; Jonassen, 2004). As a "mental representation" of the pattern of information presented in the problem (Riley & Greeno, 1988), schema of a problem type enable solver to retrieve situational aspects, structural aspects, and algorithmic aspects of the problem. Jonassen (2004)argue that when students conceptually comprehend the structure of the problem, they solve story problems successfully.

In order to solve story problems effectively, students have to construct quality problem schema. For constructing quality problem schema students have to acquire the basic aspects of the problem schema. Comprehension of problem schema is the measure of how much of essential aspects of a problem schema related to a particular problem type is assimilated by the learner. Hence the comprehension of a schema can be assess by assessing the following essential aspects of a schema suggested by various researchers (Minsky, 1975; Marshall, 1995; Jonassen, 2010).

1. Situational characteristics:
2. Structural relationship:
3. Algorithmic information:

The assessment of the comprehension of problem schema would thus consist of items that test various aspects of problem schema. In this study the Comprehension of problem schema was measured by evaluating students' capacity to

- Identify key features of problem situation
- Identify relevant physical quantity from the problem scenario

- identify the correct situation diagram
- Understand the structural relationship in the problem
- Understand the underlying Physics concepts in the problem scenario.
- Recognize appropriate mathematical formula
- Apply correct problem solution method

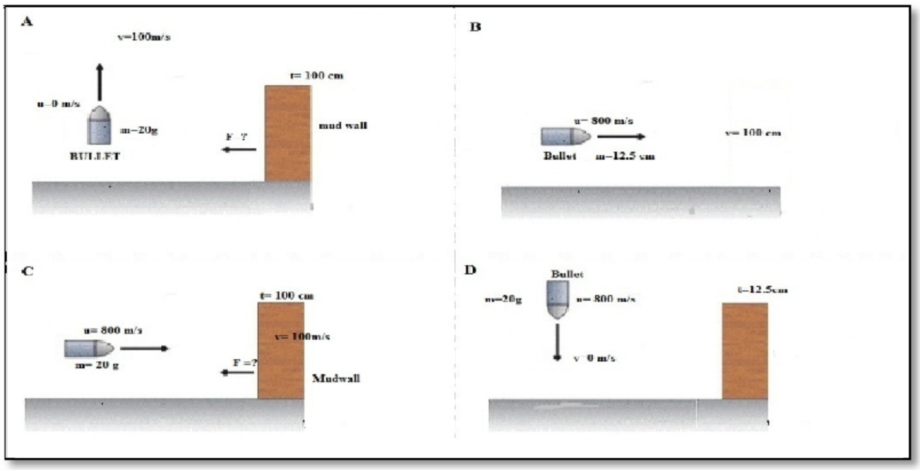
Planning and item writing

A standardized test for assessing comprehension of problem schema was prepared taking into consideration of the following aspects 1. Key features of the problem that helps to solve the problem 2. Situation diagram, 3. Major concepts underlying the problem 4. Structural relationships embedded in the problem, 5. Relevant Physical quantities presented in a problem, 6. Values assigned to the quantities, 7. Mathematical model. Instead of preparing items for each component, a set of items was prepared which will test all the seven components. Thus one story problem representing a problem type will act as a battery of items requiring students to solve seven items corresponding to the seven aspects of comprehension of problem schema before actually solving the problem per se. Hence to represent the problem schema of problem types in 'Work, Energy and power' seven sets of items were prepared. Students were also asked to calculate the final answer of the problem as the 8th item. Each item carried a score of 1 mark. All the items corresponding to the seven aspects of problem schema were multiple choice questions. However more than one response could be correct and hence students were instructed to select all those were correct. The test was administered as posttest on experimental groups. The test had a maximum score of 48 and the maximum time allotted for answering the test was 75 minutes. A pilot test was conducted on 52 students to check for ambiguity and mistakes in the test.

An example of the items used for testing Comprehension of Problem Schema is presented in Table 10.

Table 10

Example of Items Used for Testing Comprehension of Problem Schema

Problem 1	A bullet of mass 20 g is fired from a rifle of diameter 12.7cm, with a velocity of 800m/s. After passing through a mud wall 100 cm thick, velocity drops to 100 m/s. What is the average resistance of the wall neglecting friction due to air?(solve this question only after attending the sub question a, b, c, d, e, f, and g)
1a	What are the key features of the problem situation given above? (select all that apply) A. Constant velocity =Constant kinetic energy B. Increase in velocity = Increase in kinetic energy. C. Decrease in velocity= Decrease in kinetic energy D. Total work done is zero E. Total work done is positive F. Total work done is negative
1b	Identify the diagram that correctly represents the situation of the problem? 
1c	Which of the following quantities are directly given /stated in the problem?(select all that apply) A. Mass of the bullet B. Mass of the mud wall C. Initial and final velocities of bullet D. Thickness of mud wall E. Diameter of the rifle F. Resistive force of mud wall
1d	Identify what kind of problem it is? A. Work B. Work-Kinetic energy theorem

	C. Collision D. Potential energy E. Conservation of linear momentum F. Kinetic energy G. Mechanical power
1e	What laws/ideas are needed to solve this problem? A. Total linear momentum before collision =total linear momentum after collision B. Applied force=product of mass and acceleration C. Work done by net force =change in kinetic energy D. Power= rate of change of work done
1f	Which of the following quantities are not relevant for solving the problem? A). 20g B).12.7cm C).800m/s D).100cm E).100m/s F).Need all the information given to solve the problem
1g	Which of the following equation/equations are required to solve the problem?
1h	What is the average resistance of the wall neglecting friction due to air? (Apply the equation and calculate the final answer with unit consistency)

Options for 1g:

A) W= F.d	**E)** $W = \Delta KE$	**I)** $KE = {}^{1}/_{2} MV^2$
B) E= KE+PE	**F)** $P = \frac{W}{t}$	**J)** PE= Mgh
C) $V_1 = \frac{(M_1 - M_2)u_1 + 2M_2u_2}{(M_1 + M_2)}$	**G)** $V_2 = \frac{(M_2 - M_1)u_2 + 2M_1u_1}{(M_1 + M_2)}$	**K)** $f = \mu mg$
D) F=ma	**H)** $M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$	**L)** W=Fv

Table 10 shows test item to assess comprehension of problem schema. The story problem given in Table is an example of problem type 'Work-Energy theorem. Out of seven set of questions, First three (1a-1c) assess learners comprehension about the situational information in the problem schema associated with problem type. 1d-1f assesses their comprehension of semantic information presented in the problem. Item '1g' measures comprehension of required algorithmic model of a 'Work – Energy theorem' problems.

Item analysis

Based on item analysis investigator determined Item Facility (IF) value (item difficulty index) and item discrimination index of each item in the Comprehension of Problem Schema test. This test consists of the items that have weighed scores. Item facility and item discrimination statistic of each item were calculated following the item analysis procedures advocated by Brown (2000). According to him, Item facility of an item with partial credit is the average proportion of correctness for a particular item.

For calculating item facility value, investigator first converted each student's answer to each item on a proportion score scale from 0 to 1. The conversion to a 0 to 1 scale was done by dividing each student's item score by the total possible score for that item. Then the Item Facility (IF) value was calculated using the formula:

IF= Average of the proportion scores

$$= \frac{\text{sum of the proportional scores of 100 students in an item}}{100}$$

For measuring Item Discrimination statistic (ID)of each item, the total scores of responses collected from 100 students were arranged in the descending order. The lower 33 percent and upper 33 percent of students' response sheets were taken. Thus, the number of students in lower and upper group constituted 33 each. The responses for each item in both groups were scored and subjected to item analysis. The item discrimination statistic (ID) was measured as the average proportion score for the upper group minus the average for the lower group(Brown, 2000). Thus ID can be written as:

$$ID = IF^{Upper} - IF_{Lower}$$

$$= \frac{sum of Proportional scores of Upper\ 33\%}{33} - \frac{sum of Proportional scores of Lower\ 33\%}{33}$$

The item facility (IF)and item discrimination statistic (DP) of each item in the Problem Solving Ability test with story problem in physics is shown in Table 11.

Table 11

Data and Results of Item Analysis of Test for Assessing Comprehension of Problem Schema

Item No	ID	IF	Selected or not	Item No	ID	IF	Selected or not
1a	0.41	0.64	✓	3a	0.39	0.36	✓
1b	0.45	0.67	✓	3b	0.39	0.58	✓
1c	0.71	0.39	✓	3c	0.67	0.41	✓
1d	0.46	0.39	✓	3d	0.42	0.41	✓
1e	0.78	0.42	✓	3e	0.82	0.44	✓
1f	0.71	0.46	✓	3f	0.82	0.60	✓
1g	0.82	0.44	✓	3g	38	0.42	✓
1h	0.75	0.69	✓	3h	0.40	0.60	✓
2a	0.57	0.43	✓	4a	0.78	0.38	✓
2b	0.57	0.59	✓	4b	0.39	0.66	✓
2c	0.53	0.40	✓	4c	0.67	0.55	✓
2d	0.42	0.42	✓	4d	0.60	0.37	✓
2e	0.39	0.41	✓	4e	0.82	0.45	✓
2f	0.41	0.48	✓	4f	0.78	0.53	✓
2g	0.60	0.44	✓	4g	0.62	0.42	✓
2h	0.49	0.66	✓	4h	0.58	0.47	✓
5a	0.62	0.40	✓	6a	0.43	0.51	✓
5b	58	0.69	✓	6b	0.58	0.61	✓
5c	0.61	0.70	✓	6c	0.63	0.57	✓
5d	0.66	0.42	✓	6d	0. 56	0.43	✓
5e	0.56	0.46	✓	6e	0.47	0.38	✓
5f	0.61	0.64	✓	6f	0.70	0.58	✓
5g	0.47	0.39	✓	6g	0.61	0.54	✓
5h	0.65	0.59	✓	6h	054	0.59	✓

Items with IF value between .30 and .70 (Brown, 1996) and ID statistic higher than 0.3 (Nunnally & Jum, 1978) are good items and may be accepted for final tool. Thus on the basis of item analysis, all items having IF value in the range 0.3 - 0.70 and ID statistic higher than 0.3 were selected for the final test.

Reliability

Reliability of the test was established by the test retest method on 54 grade 11 students doing science course. After 35 days of first test, the same test was administered on the same students. The correlation between students' scores on the first test and second test was calculated. The test-retest reliability coefficient was found to be 0.73. Hence the test can be considered to be reliable.

Validity

Content validity

The test has content validity as it has been prepared taking into consideration the aspects of comprehension of problems schema giving due weightage to the content and problem types in the topic 'Work, Energy and Power'.

Concurrent validity

Concurrent validity of Comprehension of Problem Schema test was calculated by correlating the test scores of the 54 grade 11 science students with their scores of Problem Solving Ability test and Conceptual Understanding test developed by Praveen (2017).The coefficients of correlation so obtained were 0.68 (N=54) and 0.71 (N=54) respectively, indicating that the test has concurrent validity.

Construct validity

The test has construct validity because it is prepared based on the following characteristics of problem schema suggested by Jonassen (2010): situational model, structural model and arithmetic model. Thus the test measures the following valid features of the Problem Schema of a problem type: key features of problem situation, relevant physical quantity, situation diagram, and structural relationship in the problem, underlying Physics concepts in the problem type, appropriate mathematical formula, and problem solution procedure. These indicators established construct validity.

A copy of the Test for assessing Comprehension of problem Schema along with the response sheet and scoring key are provided as Appendix F1 to F3.

Student's Perception of Schema Based Instruction

Feedback has been generally perceived as an important component of formal Education. Feedback from instructed students in the classroom about instructional strategy helps to increase the efficiency of instruction and to improve students out comes also. Correct feedback guides the instructor to make changes or modifications in the instructional phases they developed. In order to measure students' perception of Schema Based Instruction that they received, a strategy questionnaire was prepared in the form of a scale. The scale contained both Likert-type and closed-ended statements that provided information on each student's perception of the strategy's effectiveness and his or her attitude towards it. The statements included in the questionnaire were prepared with respect to the usefulness of the strategy. This includes the following specific components: structure of the problem, integrating situation with semantics of the problem, transferability, ease of use and deal of time. The questionnaire was designed as a 5 point scale consisting total 20 (12+8=20) items. First 12 items were related to cognitive domain and 8 were related to affective domain. Items related to cognitive domain were further classified into two - Structure of the problem(item No: 1,2,4,9 and 12)and Integrating situation with semantics of the problem (item No: 3,5,7,8,10 and 11). Items related to affective domain were also classified in to three; based on Transferability (item No: 15,16,17 and 19), Ease of Use (Item No: 13,14 and 18) and time duration (item No.20). Scale points include 'totally disagree', 'disagree', 'neutral', 'agree' and 'totally agree'. Statements of the questionnaire were arranged one under the other, such that the questions form a table (or matrix) with identical response options placed on top.

An example of the items related to cognitive domain, used in the scale-students' perception of Schema Based Instruction is given in Table 12.

Table 12

Example of Items Related to Cognitive Domain, used in the Scale-Student's Perception of Schema Based Instruction

Perception Related to Cognitive Domain					
	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
Schema Based Instruction (SBI) has helped me to think and analyze the structure of the problem in a meaningful way.					
The way of classifying problems into problem types helps me to better comprehend the problem.					

An example of the items related to affective domain, used in the scale – Students' perception of Schema Based Instruction is presented in Table 13.

Table 13

Example of Items Related to Affective Domain, used in the Scale-Student's Perception of Schema Based Instruction

Perception Related to Affective Domain					
	Totally Disagree	Disagree	Neutral	Agree	Totally Agree
I feel more comfortable while using schema for doing problems.					
I enjoyed drawing the situation diagram as part of this method					

A copy of the scale- Student's perception of Schema Based Instruction is provided as Appendix G.

Phase III: Experimental Phase

This phase includes the experimental intervention using quasi-experimental pretest- posttest nonequivalent group design in a higher secondary schools. Pretest and posttest were administered, and suitable statistical procedures were employed to analyze the data.

Design of the experimental phase of the study

The present study probes the effect of Schema Based Instruction on solving story problems in Physics among higher secondary students. The symbolic representation of the study is given below

G_1O_1 X_1 O_2

G_2O_3 X_2 O_4

G_3O_5 C O_6

O_1, O_3, O_5- Pre tests

O_2, O_4, O_6-Post tests

O_2 - O_1, O_4 - O_3, O_6 - O_5 -Gain Scores

G_1- Experimental group-1

G_2-Experimental Group-2

G_3-Control Group

X_1- Application of Experimental treatment-1

X_2- Application of Experimental treatment -2

C- Application of Control treatment

Sample used in the Experiment

Three intact class divisions of 166 students (60 in experimental group-1, 52 in experimental group-2 and 54 in control group respectively) of grade eleven doing science course from two Schools- Government Higher Secondary School Cheemeni and Government Higher Secondary School Vellur from Kasargod and Kannur districts respectively- of rural background following Kerala syllabus (Prescribed by SCERT) was selected as the sample.

Data Collection Procedure

The data required for the actual study was collected during the progressive stages of the treatment itself. The Non-Verbal intelligence, Logical Mathematical Intelligence, initial Problem Solving Ability in physics and initial conceptual understanding of problems were measured right at the beginning, the first two being the variables to be treated as covariates.

Pretest

In the initial stage of the experiment, apart from measurement of Non Verbal intelligence and Logical Mathematical intelligence for ensuring the homogeneity of the group, the initial scores on the Problem Solving Ability in Physics and Conceptual Understanding Story Problems in Physics were measured in the three groups. For this, the standardized test for assessing Problem Solving Ability in Physics and standardized test for assessing conceptual understanding of problems prepared by the investigator were given as pretests.

Experimental treatment-1(The Schema Based Instruction with home work)

The investigator himself taught both the experimental groups and control group. The experimental group-1 was taught through Schema Based Instruction with

Home Work. The students were taught the content of chapter 'Work, Energy and power' in the usual expository method of teaching and the problems were dealt in the schema based method of instruction. The complete teaching was done during the usual class hours in the face to face mode. The investigator himself acquainted the students with schema based method of instruction. The way of teaching the story problems in the Schema Based Instruction followed the same phases described in the design of Schema Based Instruction. The diagrams and schemata were sketched using black board and presentation slides to practice the worked out examples. One of the crucial phases of this instruction is the opportunity to practice Problem Solving Ability learned in the instruction. As part of this students were given practice problems to review and solve them with in the usual class hours. In addition to class room practice problems, students were assigned additional three problems of each problem type to practice as Homework.

Experimental treatment-2 (The Schema Based Instruction without home work)

The experimental group-2 was taught through Schema Based Instructional without Home Work. The investigator himself taught the theory and problems of the content portion. The students were taught the content of chapter 'Work, Energy and power' in the usual expository method of teaching and the problems were dealt in the schema based method of instruction. The whole instruction was executed during the usual class hours in the face to face mode. The students were informed about the new strategy of schema based problem solving. The way of teaching problems in the Schema Based Instruction without home work followed the same phases described in the lesson transcript of Schema Based Instruction with home work. But the exception is that it was not provided students to practice story problems as home work. The very same set of problems except homework problems, given to the experimental group-1 were administered to the experimental group-2 also.

Control treatment (The Direct Translation Strategy of teaching Problem Solving)

The control group was taught using the expository method of instruction. The investigator himself taught the theory and problems of the content portion. The students were taught the content portion of the chapter Work, Energy and Power followed by the worked out of problems. The very same set of problems given to the experimental groups were administered to the control group also; but in the usual way of Direct Translation Strategy of teaching Problem Solving. The problems meant for worked out- worked out examples – and practice problems were practiced in the class and 3 problems of each problem type were assigned as home work.

This would mean that the interventions in the groups differed only in the pattern of instruction of solving problems whereas the learning experiences employed to teach the subject matter remained the same in all the three groups. Also the investigator could do justice to the experimental groups as well as the control group by teaching them the very same set of problems for work out as well as for practice. The time taken for the entire treatment session was five weeks for experimental groups and four weeks for control group.

Administration of Posttest

The standardized test for assessing Problem Solving Ability and the standardized test for assessing conceptual understanding were re-administered in all three groups after the completion of the treatment period. Similarly the standardized test for assessing comprehension of problem schema was administered in both the experimental groups as posttest after the period of treatment.

A strategy questionnaire for evaluating students' perception on Schema Based Instruction were administered after finishing all experimental procedures.

Scoring and Consolidation of Data

The Non Verbal Test, Logical Mathematical Intelligence Test, Test for assessing Problem Solving Ability, Test for assessing Conceptual Understanding of problem and Test for assessing Comprehension of Problem Schema were administered as paper-pencil test with appropriate time restriction. The difference between the post test and the pretest (the gain score) was taken as measure of the Problem Solving Ability and conceptual understanding of problems. But the measure of comprehension of problem schema would be the post test scores.

The Nonverbal Intelligence test (Standard Progressive Matrices) was administered in the initial stage of the study and was scored with the help of scoring key and guidelines given in the manual for Raven's Progressive Matrices and Vocabulary Series (1996) authored by Raven et al. Similarly the logical mathematical intelligence test was administered at the initial stage of the study. This was scored with the help of appropriate scoring key.

The Test for assessing Problem Solving Ability in Physics was scored using a suitable scoring key and marking scheme. The maximum marks for the Problem Solving Ability test was 28 and the test was to be performed in time duration of seventy five minutes.

Scoring of the Test for assessing Conceptual understanding of problem was scored appropriately using a scoring key. The maximum score of the test for assessing Conceptual Understanding of problems was 17 and the test was to be performed in time duration of one hour.

The Test for assessing comprehension of problem schema was scored using a suitable scoring key and marking scheme. The maximum marks for the test was 48 and the test was to be performed in time duration of seventy five minutes.

The subjects were students from three schools studying at grade eleven. Even though three intact divisions were taken for study some students (four from experimental group-1, eight from experimental group-2 and 4 from control group) who were not punctual in the class were avoided for the final data analysis. Table 14 shows the number of subjects in the experimental and control groups who were taken in to consideration for final data analysis.

Table 14

Actual Number of Subjects for Final Data Analysis

Name of the students	Boys	Girls	Total
Experimental group-1	20	40	60
Experimental Group-2	24	28	52
Control-Group	26	28	54
Total	70	96	166

Procedure used for Analysis of Data

The hypotheses of the present study were tested by employing appropriate statistical techniques. The major statistical processing like ANOVA and ANCOVA were done using computer facility with software IBM SPSS Statistics 21. To analyze the effects of factor like, Logical Mathematical Intelligence the subjects were classified in to two levels each with respect to the factor.

Classificatory technique

The classifications of the subjects into two groups were done with respect to Logical Mathematical Intelligence. Median was taken as the cutoff point and subjects with scores less than the median score fell into the below average category whereas, subjects with scores equal to or greater than the median score moved into the above average category.

Subjects were classified into Below Average Logical Mathematical Intelligence (BALMI) group and Above Average Logical Mathematical Intelligence (AALMI) group on the basis of Logical mathematical Intelligence test scores. Median was used as the cutoff points since the sample for experimentation was not large. In the present study, the median point for Logical Mathematical Intelligence of total sample was

17.50(N=166).Subjects who scored below the median point were classified as Below Average Logical Mathematical Intelligence (BALMI) group and those subjects who scored equal to or above than the median point were classified as the Above Average Logical Mathematical Intelligence (AALMI) group. The number of subjects who fell under each category when this classification was effected in the case of total subjects is given in Table 15.

Table 15

Classification of Subjects on the basis of Logical Mathematical Intelligence

Study groups	BALMI	AALMI
Experimental group-1	34	26
Experimental group-2	28	24
Control group	21	33
Total	83	83

Statistical Techniques used for the Study

In order to test the hypotheses stated in the present study the following statistical techniques were used for the present study.

To understand the nature of the distribution of the independent and dependent variables, the descriptive statistics such as mean, median, mode, standard deviation, skewness and kurtosis were calculated for each of the study group.

Effect of the Schema Based Instruction on solving story problems in Physics among Higher Secondary School Students was examined using one way ANCOVA. Since the experiment was conducted using intact study groups of students of grade eleven, it was suspected that differences in nonverbal intelligence and Logical Mathematical Intelligence among subjects would influence the relation between instructional strategy and Problem Solving Ability. In such situation analysis of covariance serves the purpose of statistically removing the effects of extraneous variables from the dependent variable (Ferguson, 1971). In the present study ANCOVA is used to remove statistically the effects of the extraneous cognitive variables (Non Verbal Intelligence and Logical Mathematical Intelligence) which would have an effect upon the dependent variables: the Problem Solving Ability and conceptual understanding of problems.

The use of ANCOVA increases the sensitivity of the test of main effects and interactions by reducing the error term (Huitema, 1980).There are number of specific assumptions (Ferguson, l971; Widt & Ahtola, 1978, Field, 2009) that must be tested before proceeding with the ANCOVA.Therefore the data used for analysis was subjected to a detailed inspection with a view to know whether the data is sufficient to satisfy the basic assumptions of ANCOVA procedure.The following statistical models were used to test the important assumptions of ANCOVA. The details were presented in Table 16.

Table 16

Details of Statistical Techniques used to Test the Basic Assumptions of ANCOVA

Sl. No.	Assumptions	Statistical Techniques used
1	Independence of the independent variable and covariates	One way ANOVA for comparing mean scores
2	Covariates should not be highly correlated	Pearson's Correlation
3	Residuals should be normally distributed	Histogram with normal curve, Q-Q plot, box plot, Shapiro Wilk tests of residuals
4	Homogeneity (equality) of variance	The Levene's test of Homogeneity
5	Homogeneity of regression slopes	Scatter plot, one way ANCOVA

When the covariate and independent variable are not independent the treatment effect is concealed, false treatment effects can arise and at the very least the interpretation of the ANCOVA is seriously compromised (Wildt & Ahtola, 1978). According to Cochran (1957) "it is crucial to verify that the treatments have had no effect on the covariate. Analysis of covariance is inappropriate if the covariate is not independent of the treatment" (pp. 388-389). Field (2009) argues that the assumption of independence of the independent variable and covariatescan meet by randomizing participants to experimental groups, or by matching experimental groups on the covariate. Thus before including Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates in the analysis, one way Analysis of variance (one way ANOVA) was performed to test whether the covariates are independent of the instructional strategies.

If the Homogeneity of variance assumption is broken, the SPSS offers us an alternative version of the F ratio: the Welch's F(1951).Welch's F technique controls the type -I error rate well (Field, 2009). The assumption of homogeneity of variance was not met for the scores of covariate Non Verbal intelligence. Therefore the Welch test of Analysis of Variance (Welch- ANOVA) was used to check the independency of Non Verbal Intelligence and the instructional strategy. While the Independence of covariate logical mathematical intelligence and instructional strategies were tested by using one way ANOVA.

The homogeneity of variance assumption was not met in the case of pretest scores of Problem Solving Ability. In such situation, Welch's F test (Welch-ANOVA) was done to compare the mean pretest scores of Problem Solving Ability for experimental and control groups.

In order to verify the assumption that the covariates- Non Verbal Intelligence and Logical Mathematical Intelligence-are not overly correlated with one another, Pearson product-moment correlation coefficient was used in the study.

In order to test the homogeneity of variance of distribution of independent variables and dependent variables for the study groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were used in the study.

For the confirmation of Normality assumption, the histogram of the distribution with normal curve, box plot and Q-Q plot of the residuals of independent and dependent variables for each study group were used for the data analysis.

To test the assumption homogeneity of regression slopes between dependent variable and covariate, scatter plot with regression lines for each study group were used. Further judgment of homogeneity of regression slopes between dependent variable and covariate for the study groups was performed using one way ANCOVA (customized model).

Post hoc comparison were done between pairs of groups of the selected variables wherever F ratio were found to be significant in ANCOVA. Following these analyses two-way ANOVA was performed to find out the effects and interaction effects of instructional strategy and Logical mathematical intelligence upon Problem Solving Ability. Also analysis of variance was done to find out the main effect and interaction effects of instructional strategy and Logical mathematical Intelligence upon Conceptual Understanding of Problems. In both cases ANOVA technique in the 3 x 2 factorial designs was used.

Pearson product-moment correlation coefficient was used to study the correlation between comprehension of problem schema and Problem Solving Ability in physics.

Partial eta squared (η_p) value has utilized to determine the effect size. Partial eta square can be computed using the following formula (Levine & Hulltt, 2002).

$$\eta_p = \frac{SS\ between}{SS\ between + SS\ error}$$

Partial eta squared effect size values are interpreted as .09= Small, .14= Medium, and .22 = Large (Richardson, 2011; Fay & Boyd, 2010).

Chapter 4

Analysis and Interpretation

- *Preliminary Analysis*
- *Major Analysis*
  - *Effect of Instructional Strategy on Problem Solving Ability in Physics*
  - *Effect of Instructional Strategy on Conceptual Understanding of Story Problems in Physics*
  - *Interaction Effect of Instructional Strategy and Logical Mathematical Intelligence on Problems Solving Ability in Physics*
  - *Interaction Effect of Instructional Strategy and Logical Mathematical Intelligence on Conceptual Understanding of Story Problems in Physics*
  - *Relation Between Comprehension of Problem Schema and Gain in Problem Solving Ability in Physics*

The present study focused on determining the effect of Schema Based Instruction on solving story problems in Physics among Higher Secondary School Students. The study found out the effect of Instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) on Problem Solving Ability in Physics of Higher Secondary School Students treating Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates. ANCOVA was used to make comparisons between group means after statistically removing the effect of covariates on the dependent variable. Further, analysis was conducted to test the effect of Instructional strategy on Conceptual Understanding of story problems. For this ANCOVA was performed on the total sample.

Following these analysis, two-way ANOVA was performed to find out interaction effect of instructional strategy and Logical Mathematical Intelligence upon Problem Solving Ability in Physics. Also Analysis of Variance was done to find out the interaction effect of instructional strategy and Logical Mathematical Intelligence upon Conceptual Understanding of story problems. In both the cases ANOVA technique in the 3x2 factorial designs was used.

Analysis was also done to test the relation between Comprehension of Problem Schema and Problem Solving Ability in Physics. For this, Pearson's coefficient of Correlation test was performed on the sub-sample (students taught with Schema Based Instruction.

Further, percentage analysis was performed to know students' perception of Schema Based Instruction.

The following hypotheses of the study were tested based on the result of statistical analysis of the gain scores.

1. There will not be any significant effect of Instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Home work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among Higher Secondary School Students
2. There will not be any significant effect of Instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Home work/Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of story problems in Physics among Higher Secondary School Students
3. There will not be any significant interaction effect of Instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Home work/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.
4. There will not be any significant interaction effect of Instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Conceptual Understanding of story problems for total sample.
5. There will not be any significant relation between Comprehension of Problem Schema and Problem Solving Ability in Physics of Higher Secondary School Students taught with Schema Based Instruction

Preliminary Analysis

Here an analysis of variables- Nonverbal Intelligence, Logical Mathematical Intelligence, Problem Solving Ability in Physics, Conceptual Understanding of story problems in Physics and Comprehension of problem schema was done to know the nature and characteristics of distribution.

To understand the nature of the distribution of the independent variables- Non-Verbal Intelligence and Logical Mathematical Intelligence- the descriptive statistics like sample size, mean and standard deviation are calculated for each of the study group. The statistical values are presented in Table 17.

Table 17

Distribution of Non-Verbal Intelligence and Logical Mathematical Intelligence in the Experimental and Control Groups

Study group	n	Non-Verbal Intelligence		Logical-Mathematical Intelligence	
		Mean	SD	Mean	SD
Experimental group 1	60	48.62	3.64	16.80	3.72
Experimental group 2	52	47.62	5.13	17.29	4.79
Control group	54	47.02	5.34	18.30	4.65

Experimental Group 1 : Schema Based Instruction with Homework
Experimental Group 2 : Schema Based Instruction without Homework
Control Group : Direct Translation Strategy of Teaching Problem Solving

Table 17 Shows that the mean and standard deviation of Non-Verbal Intelligence and Logical Mathematical Intelligence in three study groups does not vary too much.

Further Tables 18 & 19 give the basic properties of the dependent variables, Problem Solving Ability in Physics and Conceptual Understanding of story problems in Physics respectively for the three study groups.

Table 18

Distribution of Pretest, Posttest and Gain Scores of Problem Solving Ability in the Experimental and Control Groups

Study group	Pretest			Post test		Gain	
	n	Mean	SD	Mean	SD	Mean	SD
Experimental group 1	60	4.02	1.27	18.21	3.70	14.19	3.62
Experimental group 2	52	4.19	1.93	17.01	4.03	12.76	3.05
Control group	54	3.78	1.47	11.70	2.31	7.95	2.57

Table 18 shows that the mean and standard deviation of the pretest scores of Problem Solving Ability among the study groups does not vary too much. But the mean post test score and mean gain score of Problem Solving Ability varies among the study groups. This is due to the effect of the intervention applied in the groups.

Table 19

Distribution of Pretest, Posttest and Gain Scores of Conceptual Understanding of story problems in Physics for the Experimental and Control Groups

Study group		Pretest		Post test		Gain	
	n	Mean	SD	Mean	SD	Mean	SD
Experimental group 1	60	2.33	0.77	8.82	2.32	6.49	2.03
Experimental group 2	52	2.27	0.71	8.65	2.79	6.38	2.38
Control group	54	2.26	0.73	5.32	1.79	3.06	1.55

Table 19 shows that the mean and standard deviation of the pretest scores of Conceptual Understanding of story problems in Physics among three groups does not vary too much. Table 19 also reveals that experimental group-1 and experimental group-2 have approximately equal mean and standard deviation of Conceptual Understanding of story problems. But the control group shows different mean and standard deviation from both of the other groups. This is due to the effect of the intervention applied in the groups.

To reduce error variance due to covariates and to get a more accurate picture of the true effect of the independent variable Analysis of covariance was used.

The data used for the statistical analysis was subjected to detailed inspection with a view to know whether the data is sufficient to satisfy the basic assumptions of ANCOVA procedure. In the major analysis section, the following basic assumptions of ANCOVA were tested before proceeding with the test of ANCOVA.

- Independence of the independent variable and covariates
- Covariates should not be highly correlated
- Residuals should be normally distributed
- Homogeneity of variance
- Homogeneity of regression slopes

Major Analysis

Effect of Instructional strategy on Problem Solving Ability and Conceptual Understanding of Story Problems in Physics

The effect of instructional strategy (Schema Based Instruction with Home works/ Schema Based Instruction without Home works/ Direct Translation Strategy of teaching problem solving) with Non-Verbal intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability and Conceptual Understanding of story problems in Physics of Higher Secondary School Students was tested using ANCOVA. A one way ANCOVA was applied to detect if statistically significant difference existed between the Schema Based Instruction with Home works, Schema Based Instruction without Home works and Direct Translation Strategy of teaching problem solving, on Problem Solving Ability and Conceptual Understanding of story problems in Physics.

The investigation included analyzing the statistical constants, confirming independence of independent variable and covariates, examining correlation between the covariates, verifying the normal distribution of residuals, checking the homogeneity of the distributions, checking the homogeneity of regression slopes, testing the significance of difference between mean scores of Problem Solving Ability (in terms of gain scores) for experimental and control groups, testing the significance of difference between mean scores of Conceptual Understanding of story problems in Physics (in terms of gain scores) for experimental and control groups, and calculating the effect size.

The results of analysis on Non-Verbal Intelligence scores, Logical Mathematical Intelligence scores, pretest and gain scores of Problem Solving Ability, pretest and gain scores of Conceptual Understanding of story problems in Physics, and post test scores of Comprehension of problem schema are presented below.

Non-Verbal Intelligence and Logical Mathematical Intelligence of Experimental and Control groups

Non-Verbal Intelligence of Experimental and control groups

The statistical indices of distribution of Non-Verbal Intelligence scores obtained for experimental and control groups of Higher Secondary School Students are presented in Table 20.

Table 20

Statistical Constants of Distribution of Non-Verbal Intelligence for the Experimental and Control Groups

Study group	N	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental group-1	60	48.62	48	48	3.64	-0.17(0.31[a])	-0.42(0.61[b])
Experimental group-2	52	47.62	48	48	5.13	-0.60(0.33[a])	0.67(0.65[b])
Control group	54	47.02	48	51	5.34	-0.55(0.33[a])	0.10(0.64[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 20 shows that, mean (48.62), median (48), and mode (48) of Non-verbal Intelligence test scores are almost equal for experimental group-1. The indices of skewness (-0.17) and kurtosis (-0.42) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental group-1, the ratios between skewness and its standard error (-0.55), and that between kurtosis and its standard error (-0.69) are less than 1.96, indicating that the distribution of Non-verbal Intelligence test scores for experimental group-1 do not significantly deviate from normality.

Mean (47.62), median (48), and mode (48) of Non-verbal Intelligence test scores are almost equal for experimental group-2. The indices of skewness (-0.60) and kurtosis (0.67) indicate that the distribution is slightly negatively skewed and leptokurtic. For the experimental group-2, the ratios between skewness and its standard error (-0.18), and that between kurtosis and its standard error (1.03) are less than 1.96, indicating that the distribution of Non-verbal Intelligence test scores for experimental group-2 do not significantly deviate from normality.

Mean (47.02), median (48), and mode (51) of Non-verbal Intelligence test scores are almost equal for control group. The indices of skewness (-0.55) and kurtosis (0.10) indicate that the distribution is slightly negatively skewed and leptokurtic. For the control group, the ratios between skewness and its standard error (-1.66), and that between kurtosis and its standard error (0.16) are less than 1.96, indicating that distribution of Non-verbal Intelligence test scores for control group do not significantly deviate from normality.

In order to test the homogeneity of variance of distribution of Non-verbal Intelligence for the study groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were performed. The results are presented in Table 21.

Table 21

Result of Shapiro-Wilk Test of Normality and Leven's Test of Homogeneity of Non-Verbal Intelligence for the Experimental and Control Groups

Study groups	Shapiro-Wilk test of Normality			Levene's test of Homogeneity			
	df	statistic	Sig.	df_1	df_2	F	sig
Experimental group-1	60	0.98	.25				
Experimental group-2	52	0.96	.08	2	163	3.21	.04
Control group	54	0.96	.07				

Shapiro-Wilk statistic of normality indicates a reasonable assumption normality for the scores of Non-verbal Intelligence for both experimental groups (exp-1: S-W=0.98, df=60, p=.25; exp-2: S-W=0.96, df=52, p=.08) and control group (S-W=0.96, df=54, p=.07). Levene's test of homogeneity indicates that the variances of Non-verbal Intelligence of the experimental and control groups were not equal [F (2, 163) =3.21, p= .04]. Therefore Non-verbal Intelligence in the experimental and control groups are normal but the variances of the scores of Non-verbal Intelligence for the three groups are inhomogeneous.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, box plot and Q-Q plot of the residuals of Non-verbal Intelligence, for each study group. The results are shown in Figure 7 & Figure 8.

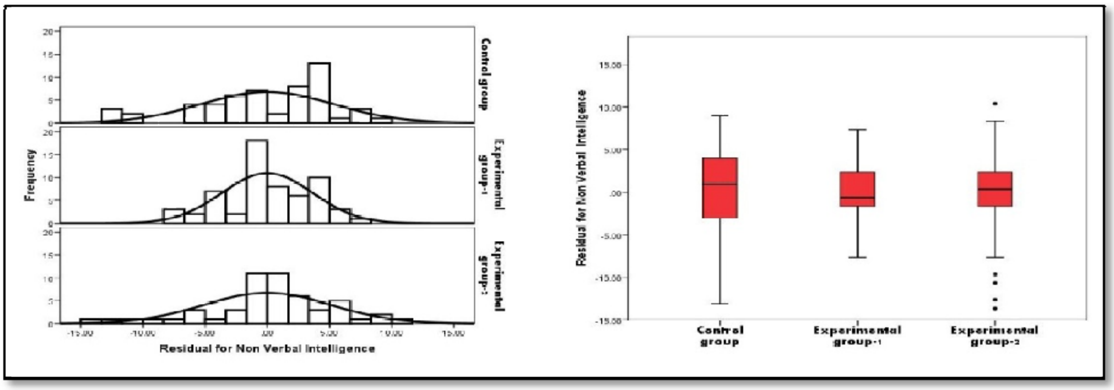


Figure 7. Histogram with normal curves and box plot of the residuals of Non-verbal Intelligence for the experimental and control groups

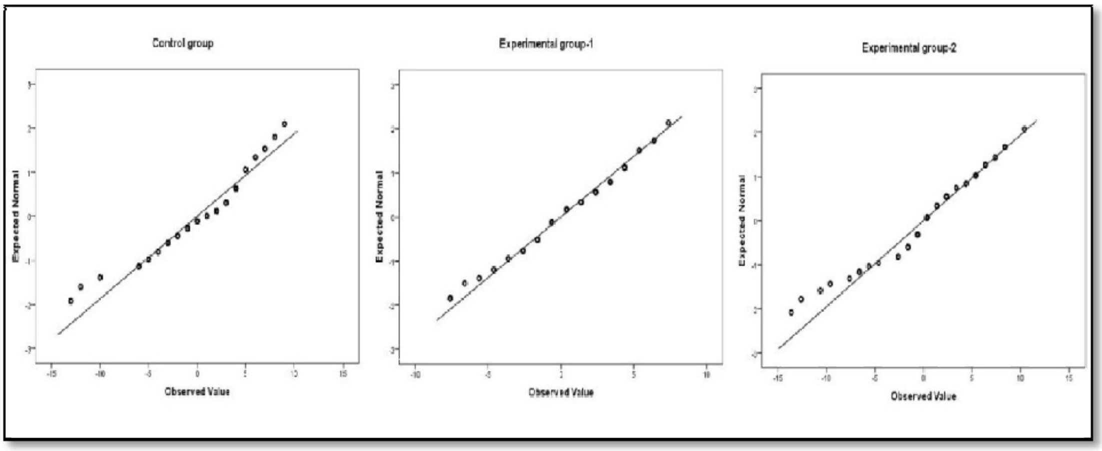


Figure 8. Q-Q plot of the residuals of Non-verbal Intelligence for the experimental and control groups

Logical Mathematical Intelligence of Experimental and control groups

The statistical indices of distribution of Logical Mathematical Intelligence scores obtained for experimental and control groups of Higher Secondary School Students are presented in Table 22.

Table 22

Statistical Constants of Distribution of Logical Mathematical Intelligence for the Experimental and Control Groups

Study group	N	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental group-1	60	16.80	17	15	3.72	-0.03(0.31[a])	-0.64(0.61[b])
Experimental group-2	52	17.29	17	15	4.79	-0.16(0.33[a])	-0.44(0.65[b])
Control group	54	18.30	18.50	19	4.65	-0.54(0.33[a])	0.30(0.64[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 22 shows that mean (16.80), median (17), and mode (15) of Logical Mathematical Intelligence test scores are almost equal for experimental group-1. The indices of skewness (-0.03) and kurtosis (-0.64) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental group-1, the ratios between skewness and its standard error (-0.09), and that between kurtosis and its standard error (-1.05) are less than 1.96, indicating that the distribution of Logical Mathematical Intelligence test scores for experimental group-1 do not significantly deviate from normality.

Mean (17.29), median (17), and mode (15) of Logical Mathematical Intelligence test scores are almost equal for experimental group-2. The indices of skewness (-0.16) and kurtosis (-0.44) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental group-2, the ratios between skewness and its standard error (-0.48), and that between kurtosis and its standard error (-0.68) are less than 1.96, indicating that the distribution of Logical Mathematical Intelligence test scores for experimental group-2 do not significantly deviate from normality.

Mean (18.30), median (18.50), and mode (19) of Logical Mathematical Intelligence test scores are almost equal for control group. The indices of skewness (-0.54) and kurtosis (0.30) indicate that the distribution is slightly negatively skewed and leptokurtic. For the control group, the ratios between skewness and its standard error (-1.64), and that between kurtosis and its standard error (0.47) are less than 1.96, indicating that distribution of Logical Mathematical Intelligence test scores for control group do not significantly deviate from normality.

In order to test the homogeneity of variance of distribution of Logical Mathematical Intelligence for the study groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were performed. The results are presented in Table 23.

Table 23

Result of Shapiro-Wilk test of Normality and Leven's Test of Homogeneity of Logical Mathematical Intelligence for the Experimental and Control Groups

Study groups	Shapiro-Wilk test of Normality			Levene's test of Homogeneity			
	df	statistic	Sig.	df_1	df_2	F	sig
Experimental group-1	60	0.98	.39				
Experimental group-2	52	0.98	.60	2	163	1.65	.20
Control group	54	0.97	.13				

Shapiro-Wilk statistic of normality indicates a reasonable assumption normality for the scores of Logical Mathematical Intelligence for both experimental groups (exp-1: S-W=0.98, df=60, p=.39; exp-2: S-W=0.98, df=52, p=.60) and control group (S-W=0.96, df=54, p=.13). Levene's test of homogeneity indicates that the variances of Non-verbal Intelligence of the experimental and control groups were equal [F (2, 163) =1.65, p= .20]. Therefore Logical Mathematical Intelligence in the experimental and control groups are normal and the variances of the scores of Logical Mathematical Intelligence for the three groups are homogeneous.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, box plot and Q-Q plot of the residuals of Logical Mathematical Intelligence, for each study group. The results are shown in Figure 9 & Figure 10.

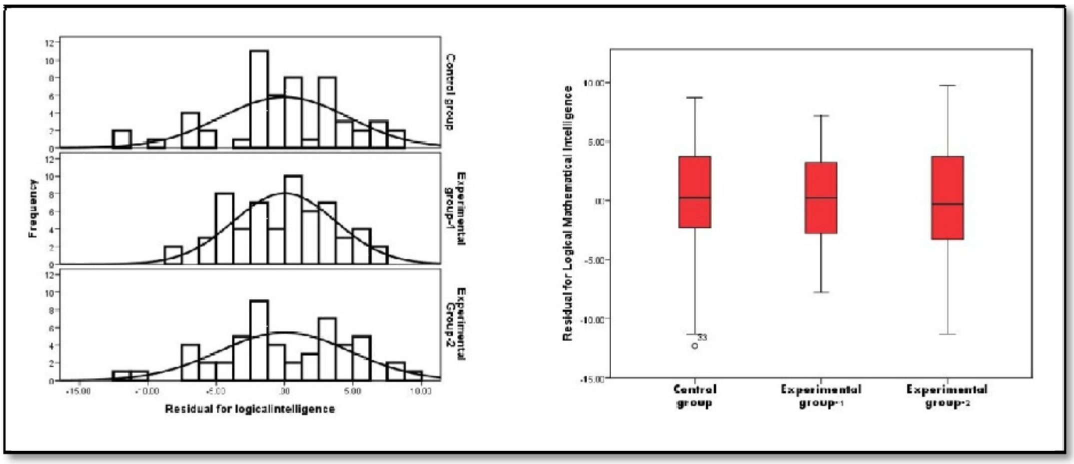


Figure 9. Histogram with normal curves and box plot of the residuals of Logical Mathematical Intelligence for the experimental and control groups

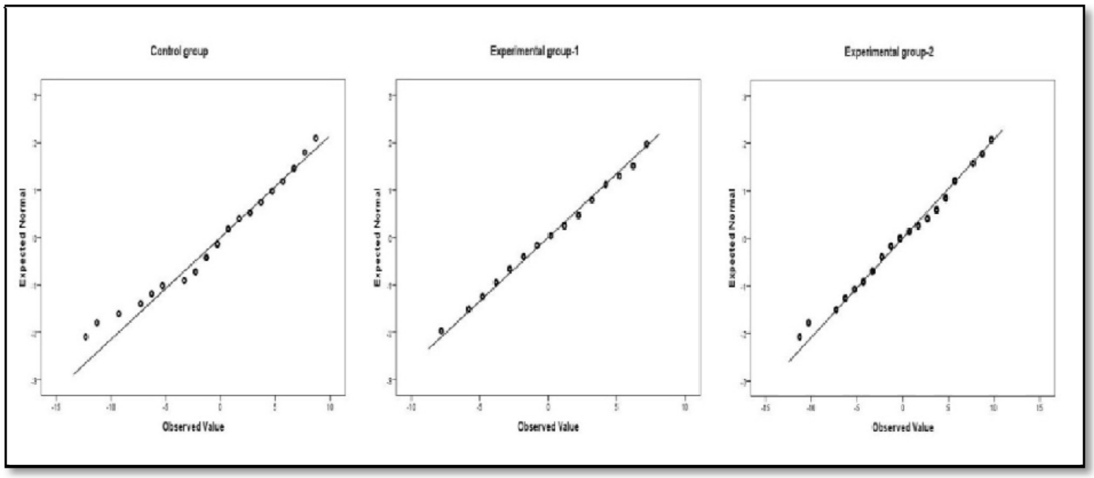


Figure 10. Q-Q plot of the residuals of Logical Mathematical Intelligence of the experimental and control groups

The variables, Non-Verbal Intelligence and Logical Mathematical Intelligence are included as covariates in the analysis. Wildt and Ahtola, (1978) pointed out that when the covariate and independent variable are not independent the treatment effect is concealed, false treatment effects can arise and at the very least the interpretation of the ANCOVA is seriously compromised. Field (2009) commended that this assumption can meet by randomizing participants to experimental groups, or by matching experimental groups on the covariate.

Thus, before including Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates in the analysis, performed one way Analysis of variance to test whether the covariates are independent of the instructional strategies. Since the assumption of homogeneity of variance was not met for the scores of Non-verbal intelligence, Welch test of Analysis of Variance (Welch- ANOVA) was used to check the independency of Non-verbal Intelligence and the instructional strategy.

The result of Welch- ANOVA of means scores of Non-verbal Intelligence reveals that there is no statistically significant main effect; Welch's F [$F(2,101.04)= 1.91.$, $p=.15$] indicating that all three study groups had almost same means of Non-verbal Intelligence (Exp-1: M= 48.62, Exp-2: M= 47.62, Cont: M = 47.02). This result indicates that, it is appropriate to use Non-verbal Intelligence as a covariate in the analysis.

Independence of Logical Mathematical Intelligence and instructional strategies was tested by using one way ANOVA with Logical Mathematical Intelligence as the outcome and instructional strategy as independent variable. The result is presented in Table 24.

Table 24

Comparison of Mean Scores of Logical Mathematical Intelligence for the Experimental and Control Groups

Source	Sum of Squares	df	Mean Square	F	Sig.
Between groups	65.365	2	32.68	1.69	.19
Within groups	3135.532	163	19.24		

Table 24 shows main effect of instructional strategy is not significant [F(2,163)=1.699, p=.19], which suggests that mean scores of Logical Mathematical Intelligence are almost equal in the three study groups (Exp-1: M=16.80, Exp-2: M=17.29, Cont: M = 18.30). This result indicates that it is appropriate to use Logical Mathematical Intelligence as a covariate in the analysis.

In order to verify the assumption that the covariates- Non-verbal Intelligence and Logical Mathematical Intelligence -are not overly correlated with one another, Pearson product-moment correlation coefficient was computed for total sample. The test result showed that there was a significant positive correlation between the Nonverbal Intelligence and Logical Mathematical Intelligence (r= .44, N=166, p<.001) at 0.01 level.

A scatter plot shown in Figure 11 summarizes the results Overall; there was a moderate, positive correlation between Non-verbal Intelligence and Logical Mathematical Intelligence.

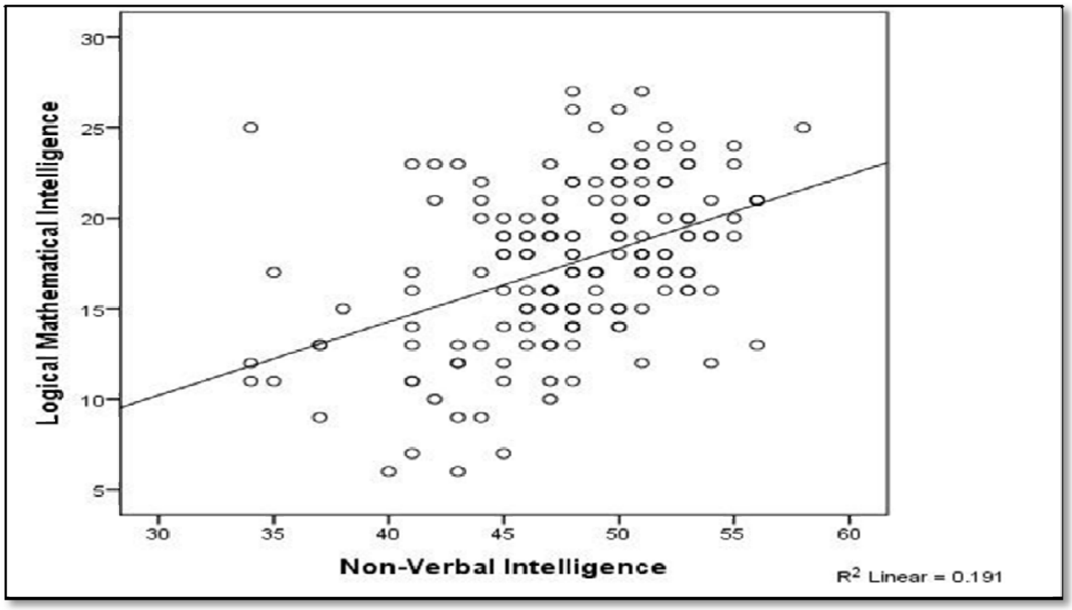


Figure 11. Scatter plot of correlation between Non-verbal Intelligence and Logical Mathematical Intelligence

Effect of Instructional strategy on Problem Solving Ability in Physics

The effect of instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) on Problem Solving Ability in Physics of experimental and control groups was investigated by comparing the scores of Problem Solving Ability for experimental and control groups before and after intervention.

Problem Solving Ability of Experimental and Control groups before intervention

The statistical indices of distribution pretest scores of Problem Solving Ability in Physics obtained for experimental and control groups of Higher Secondary School Students are indicated in Table 25.

Table 25

Statistical Constants of Distribution Pretest Scores of Problem Solving Ability for the Experimental and Control Groups

Study group	N	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental group-1	60	4.02	4	4.00	1.27	0.32(0.31[a])	-0.27(0.61[b])
Experimental group-2	52	4.19	4	3.50	1.93	0.23(0.33[a])	-0.64(0.65[b])
Control group	54	3.78	4	4.50	1.47	-0.28(0.33[a])	- 0.84(0.64[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 25 shows that, mean (4.02), median (4), and mode (4) of pretest scores of Problem Solving Ability are almost equal for experimental group-1. The indices of skewness (0.32) and kurtosis (-0.27) indicate that the distribution is slightly positively skewed and platykurtic. For the experimental group-1, the ratios between skewness and its standard error (1.03), and that between kurtosis and its standard error (-0.44) are less than 1.96, indicating that the pretest scores of Problem Solving Ability for experimental group-1 do not significantly deviate from normality.

Mean (4.19), median (4), and mode (3.5) of pretest scores of Problem Solving Ability are almost equal for experimental group-2. The indices of skewness (0.23) and kurtosis (-0.64) indicate that the distribution is slightly positively skewed and platykurtic. For the experimental group-2, the ratios between skewness and its standard error (0.69), and that between kurtosis and its standard error (-0.98) are less than 1.96, indicating that the pretest scores of Problem Solving Ability for experimental group-2 do not significantly deviate from normality.

Mean (3.78), median (4), and mode (4.5) of pretest scores of Problem Solving Ability are almost equal for control group. The indices of skewness (-0.28) and kurtosis (-0.84) indicate that the distribution is slightly negatively skewed and platykurtic. For the control group, the ratios between skewness and its standard error (-0.84), and that between kurtosis and its standard error (-1.13) are less than 1.96, indicating that the pretest scores of Problem Solving Ability for control group do not significantly deviate from normality.

In order to further test the normality of distribution of pretest scores of Problem Solving Ability in Physics for the study groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were performed. The results are presented in Table 26.

Table 26

Result of Shapiro-Wilk Test of Normality and Leven's Test of Homogeneity of Pretest Scores of Problem Solving Ability for the Experimental and Control Groups

Study groups	Shapiro-Wilk test of Normality			Levene's test of Homogeneity			
	df	Statistic	Sig.	df1	df2	F	Sig.
Experimental group-1	60	0.97	.15				
Experimental group-2	52	0.97	.18	2	163	6.05	.00
Control group	54	0.96	.09				

Shapiro-Wilk statistic of normality indicates a reasonable assumption normality for the pretest scores of Problem Solving Ability for both experimental groups (exp-1: S-W=0.97, df=60, p=.15; exp-2: S-W=0.97, df=52, p=.18) and control group (S-W=0.96, df=54, p=.09). Levene's test of homogeneity indicates that the variances of Problem Solving Ability of the experimental and control groups before intervention were not equal, $F(2, 163) = 6.05$, $p < .001$. Therefore Problem Solving Ability before intervention in the experimental and control groups are normal but the variances of the pretest scores of Problem Solving Ability of the three groups are inhomogeneous.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, box plot and Q-Q plot of residuals of pretest scores of Problem Solving Ability for each study group. The results are shown in Figure 12 & Figure 13.

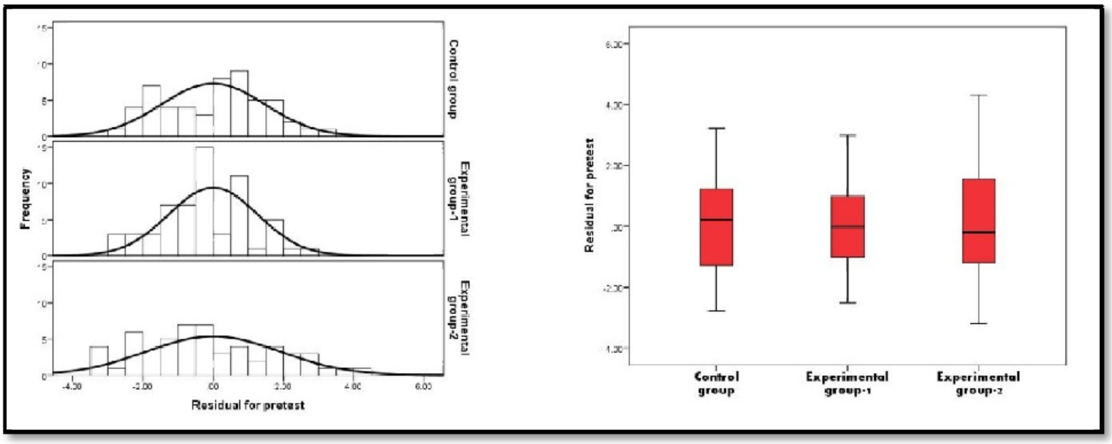


Figure 12. Histogram with normal curves and box plot of the residuals of pretest scores of Problem Solving Ability for the experimental and control groups

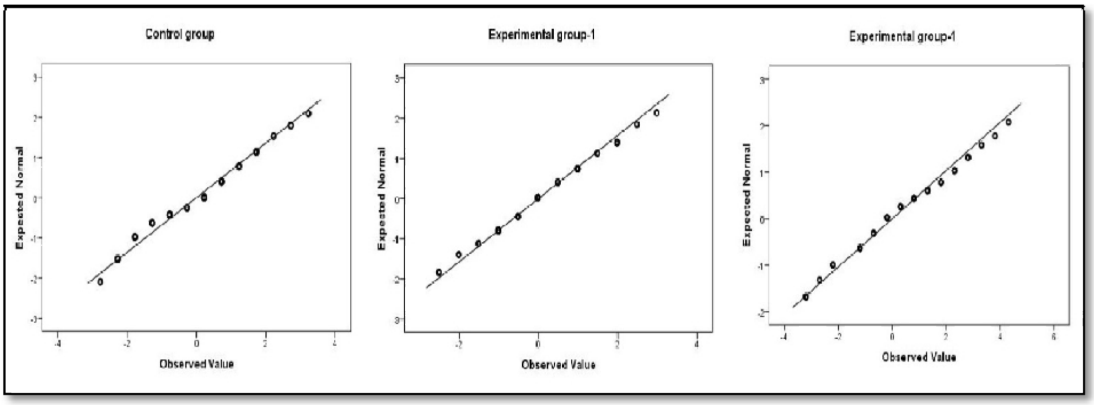


Figure 13. Q-Q plot of the residuals of pretest scores of Problem Solving Ability for the experimental and control groups

Since the assumption of homogeneity of variance was not met for the pretest scores of Problem Solving Ability, performed the Welch test of Analysis of Variance (Welch- ANOVA) to examine whether there is any statistically significant difference between the means of pretest scores of Problem Solving Ability in the experimental and control groups.

The result of Welch- ANOVA for means of pretest scores of Problem Solving Ability reveals that there is no statistically significant main effect, F(2,102.6) = 0.84, p=.44. This indicates that all three study groups had same means of pretest scores of Problem Solving Ability. Hence before intervention, experimental group-1, experimental group-2 and control group are equal on Problem Solving Ability in Physics.

Problem Solving Ability of Experimental and Control groups after intervention

In order to determine the effect of instructional strategy on Problem Solving Ability in Physics for Higher Secondary School Students, gain scores of Problem Solving Ability were utilized. Gain scores of the subjects were calculated by subtracting pre-test scores of Problem Solving Ability from that of post test scores. Analysis based on the gain scores of Problem Solving Ability is presented below.

Gain in Problem Solving Ability of the experimental and control groups

The statistical indices of distribution gain scores in Problem Solving Ability in Physics obtained for experimental and control groups of Higher Secondary School Students are presented in Table 27.

Table 27

Statistical Constants of Distribution of Gain Scores of Problem Solving Ability for the Experimental and Control Groups

Study group	N	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental group-1	60	14.19	15	15	3.62	- 0.15(0.31[a])	-0.24(0.61[b])
Experimental group-2	52	12.76	13.25	10	3.05	-0.51(0.33[a])	-0.38(0.65[b])
Control group	54	7.95	8	8	2.59	0.33(0.33[a])	- 0.59(0.64[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 27 shows that, mean (14.19), median (15), and mode (15) of gain scores in Problem Solving Ability are almost equal for experimental group-1. The indices of skewness (-0.15) and kurtosis (-0.24) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental group-1, the ratios between skewness and its standard error (-0.48), and that between kurtosis and its standard error (-0.39) are less than 1.96, indicating that the gain in Problem Solving Ability for experimental group-1 do not significantly deviate from normality.

Mean (12.76), median (13.25), and mode (10) of gain scores in Problem Solving Ability are almost equal for experimental group-2. The indices of skewness (-0.51) and kurtosis (-0.38) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental group-2, the ratios between skewness and its standard error (-1.55), and that between kurtosis and its standard error (-0.62) are less than 1.96, indicating that the gain in Problem Solving Ability for experimental group-2 do not significantly deviate from normality.

Mean (7.95), median (8), and mode (8) of gain scores in Problem Solving Ability are almost equal for control group. The indices of skewness (0.33) and kurtosis (-0.59) indicate that the distribution is slightly positively skewed and platykurtic. For the control group, the ratios between skewness and its standard error (1.00), and that between kurtosis and its standard error (-0.92) are less than 1.96, indicating that the gain in Problem Solving Ability for control group do not significantly deviate from normality.

In order to further test the normality of distribution of gain in Problem Solving Ability in Physics for the experimental and control groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were performed. The results are presented in Table 28.

Table 28

Result of Shapiro-Wilk test of Normality and Leven's test of Homogeneity of Gain in Problem Solving Ability for the Experimental and Control Groups

Study groups	Shapiro-Wilk test of Normality			Levene's test of Homogeneity			
	df	Statistic	Sig.	df_1	df_2	F	Sig.
Experimental group-1	60	0.99	.69				
Experimental group-2	52	0.96	.08	2	163	2.39	.09
Control group	54	0.97	.26				

Shapiro-Wilk test of normality indicates a reasonable assumption normality for the gain scores in Problem Solving Ability for both experimental groups (exp-1: S-W=0.99, df=60, p=.69; exp-2: S-W=0.96, df=52, p=.08) and control group (S-W=0.97, df=54, p=.26). Levene's test of homogeneity suggest that the variances of gain in Problem Solving Ability of the experimental and control groups were equal

[F (2, 163) =2.39, p=.09]. Therefore the gain in Problem Solving Ability in the experimental and control groups are normal and the variances of the gain scores in Problem Solving Ability of the three groups are homogeneous.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, box plot and Q-Q plot of the residuals of gain scores in Problem Solving Ability, for each study group. The results are shown in Figure 14 And Figure 15.

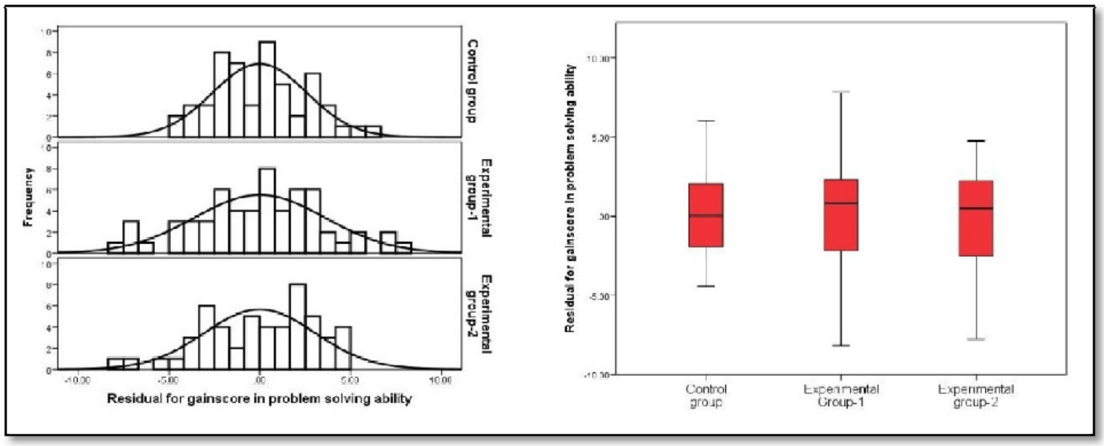


Figure 14. Histogram with normal curve and box plot of the residuals of gain scores in Problem Solving Ability for the experimental and control groups

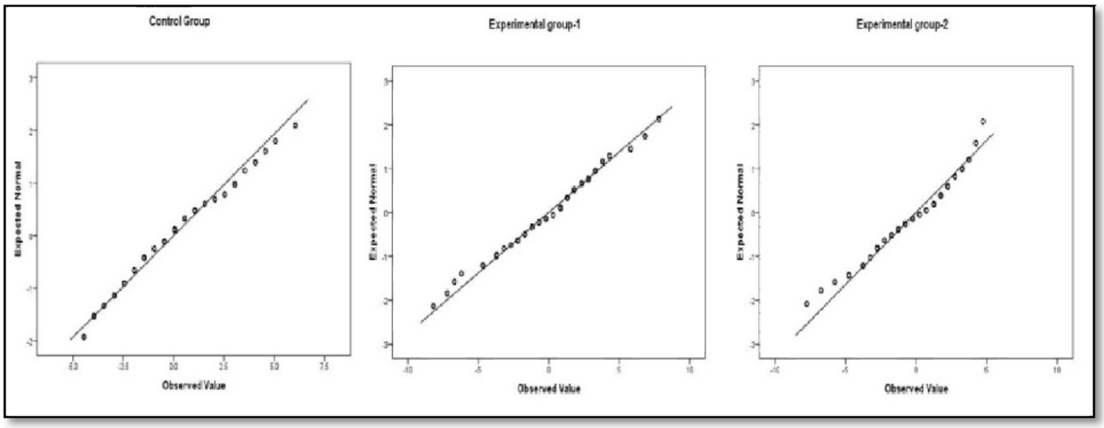


Figure 15. Q-Q plot of the residuals of gain scores in Problem Solving Ability for the experimental and control groups

To test the assumption homogeneity of regression slopes between gain scores in Problem Solving Ability and covariate Non-verbal Intelligence, plotted a scatter plot and regression lines for each study group with Non-verbal Intelligence on the

X-axis and the gain scores of Problem Solving Ability on the Y-axis. The results are shown in figure 16.

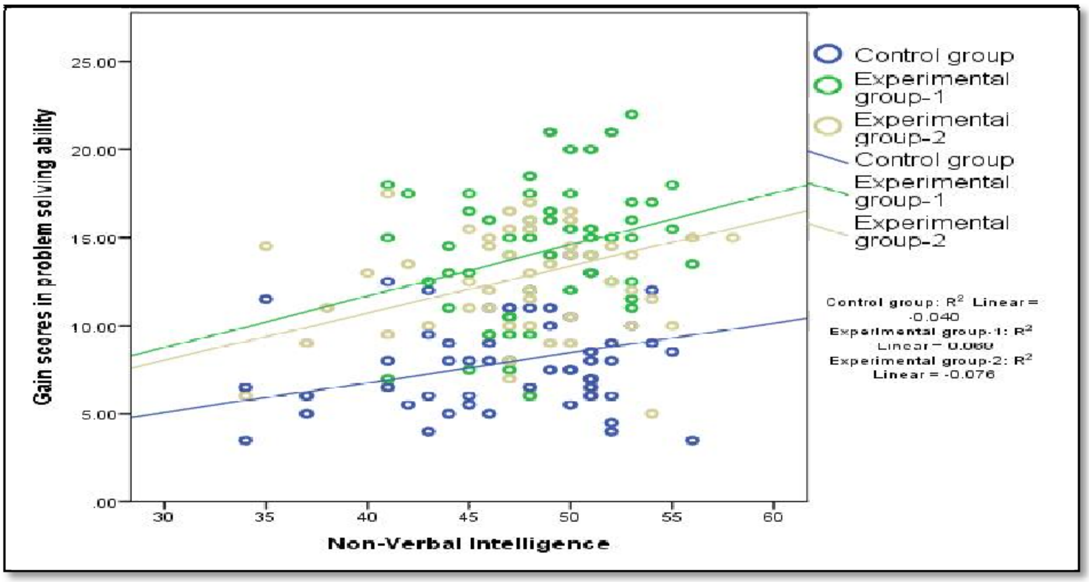


Figure 16. Scatter plot and regression lines of gain scores in Problem Solving Ability against Non-Verbal Intelligence for the experimental and control groups

Figure 16 displays the relationship between gain scores of Problem Solving Ability and Non-Verbal Intelligence for each study groups. The lines indicate the regression slopes for each study group. The regression line slopes upwards from left to right; it reveals that there is a positive relationship between gain scores of Problem Solving Ability and Non-verbal Intelligence in both experimental and control groups. The slopes of the lines for the three study groups are almost similar showing that the relationship between gain scores of Problem Solving Ability and Non-verbal Intelligence is almost similar in these three study groups. This indicates that regression slopes of gain scores of Problem Solving Ability against Non-verbal Intelligence for each study group are homogeneous.

Further judgment of homogeneity of regression slopes between gain scores of Problem Solving Ability and covariate Non-verbal Intelligence for the study groups was performed using one way ANCOVA (customized model). The results are presented in Table 29.

Table 29

Summary of ANCOVA Including Interaction Effect of Instructional Strategy and Non-Verbal Intelligence on Gain in Problem Solving Ability

Source	Sum of squares	df	Mean square	F	Sig.
Instructional Strategy	11.79	2	5.89	0.62	.54
NVI	60.95	1	60.95	6.36	.13
Instructional strategy* NVI	23.66	2	11.83	1.23	.29
Error	1533.73	160	9.59		

NVI-Non-verbal Intelligence

Table 29 shows that the interaction effect of instructional strategy and the covariate Non-verbal Intelligence on gain scores in Problem Solving Ability is statistically non-significant, F(2, 160)=1.23, p=.29. This indicates that the regression lines between gain scores of Problem Solving Ability and covariate Non-verbal Intelligence have almost same slopes for all three study groups.

To test the assumption homogeneity of regression slopes between gain scores in Problem Solving Ability and covariate Logical Mathematical Intelligence, plotted a scatter plot and regression lines for each study group with Logical Mathematical Intelligence on the X-axis and the gain scores of Problem Solving Ability on the Y-axis. The results are shown in Figure 17.

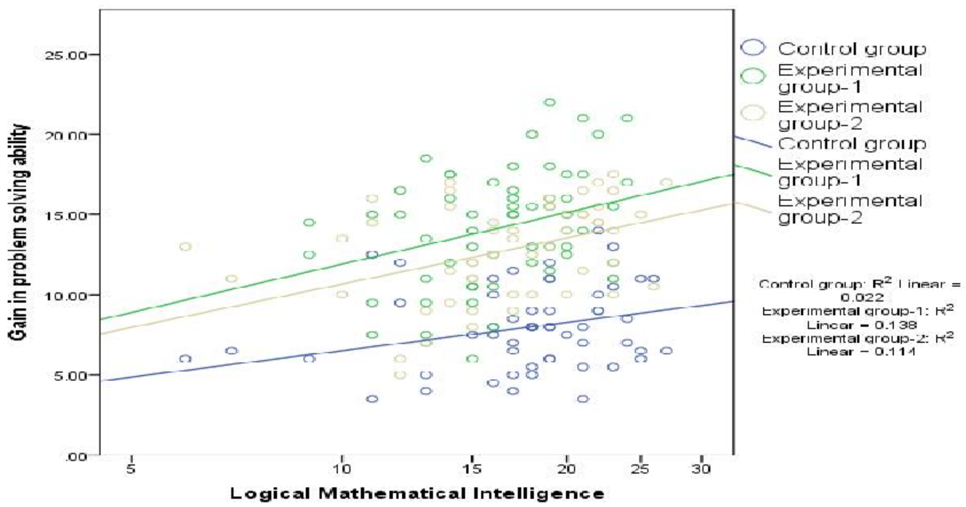


Figure 17. Scatter plot and regression lines of gain scores of Problem Solving Ability against Logical Mathematical Intelligence for the experimental and control groups

Figure 17 shows the relationship between gain scores of Problem Solving Ability and Logical Mathematical Intelligence for each study groups. The regression line slopes upwards from left to right; it reveals that there is a positive relationship between gain scores of Problem Solving Ability and Logical Mathematical Intelligence in both experimental and control groups. The slopes of the lines for the three study groups are almost similar showing that the relationship between gain scores of Problem Solving Ability and Logical Mathematical Intelligence is almost similar in these three study groups. This indicates that regression slopes of gain scores of Problem Solving Ability against Logical Mathematical Intelligence for each study group are homogeneous.

Further judgment of homogeneity of regression slopes between gain scores of Problem Solving Ability and covariate Logical Mathematical Intelligence for the study groups was performed using one way ANCOVA (customized model). The results are presented in Table 30.

Table 30

Summary of ANCOVA Including Interaction Effect of Instructional Strategy and Logical Mathematical Intelligence (LMI) on Gain in Problem Solving Ability

Source	Sum of squares	df	Mean square	F	Sig.
Instructional strategy	10.77	2	5.38	0.61	.54
LMI	178.76	1	178.76	20.39	.00
Instructional strategy* LMI	37.50	2	18.75	2.14	.12
Error	1402.73	160	8.77		

Table 30 shows that the interaction effect of Instructional strategy and the covariate Logical Mathematical Intelligence on gain scores in Problem Solving Ability is statistically non-significant at the specified .05 level, $F(2, 160)= 2.14$, $p=.12$. This indicates that the regression lines between gain in Problem Solving Ability and Logical Mathematical Intelligence have approximately similar slopes for all three study groups.

A one way ANCOVA was conducted to compare the effect of three Instructional strategies (Schema Based Instruction with Homework/Schema Based

Instruction without Homework/ Direct Translation Strategy of teaching problem solving) on gain scores in Problem Solving Ability of the experimental and control groups after controlling for Non-verbal Intelligence and Logical Mathematical Intelligence. The results are presented in Table 31.

Table 31

Summary of ANCOVA of Gain Scores in Problem Solving Ability for the Experimental and Control Groups

Source	Sum of Squares	df	Mean square	F	Sig.	Partial Eta squared(η_p^2)
Non-verbal Intelligence	0.77	1	0.77	0.09	.77	0.00
Logical-Mathematical Intelligence	117.93	1	117.93	13.19	.00	0.10
Instructional strategy	1218.89	2	609.45	68.17	.00	0.50
Error	1439.45	161	8.94			

From Table 31, it is clear that there was a significant effect of instructional strategy on gain in Problem Solving Ability after controlling for the effect of Non-verbal Intelligence and Logical Mathematical Intelligence, $F(2,161) = 68.17$, $p< .001$, $\eta_p^2=0.50$. The partial eta squared value indicates the effect size is large.

To determine which of the instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) showed statistically significant difference for the adjusted means of gain scores in problem solving ability, Post-hoc comparison (Bonferroni method) was done. All pair wise comparison among the instructional strategies were examined and the result of the same are shown in Table 32.

Table 32

Result of Post-hoc Pair Wise Comparison of Adjusted Mean of Gain Scores in Problem Solving Ability for the Experimental and Control Groups

Instructional strategies (pair wise)	Mean difference[b]	Std. Error	Sig.	95% CI
1vs. 2	1.52	0.57	.03	[0.14, 2.91]
1vs. 3	6.54	0.58	.00	[5.13, 7.95]
2 vs. 3	5.02	0.59	.00	[3.59, 6.44]

1=*Schema Based Instruction with Homework;* 2=*Schema Based Instruction without Homework; 3= Direct Translation Strategy of teaching problem solving;* [b]*significant at the .05 level;CI=Confidence Interval*

The post-hoc pair wise comparison of adjusted means of gain scores in Problem Solving Ability of experimental and control groups indicates statistically significant difference between instructional strategies 1 and 2 ($p=.03$), instructional strategies 1 and 3 ($p < .001$) and the instructional strategies 2 and 3 ($p < .001$) on means of gain scores in Problem Solving Ability. Comparing the estimated marginal means showed that the most gain in Problem Solving Ability was achieved on Schema Based Instruction with Home works (mean= 14.32) compared to Schema Based Instruction without home works (mean= 12.80) and Direct Translation Strategy of teaching problem solving (mean= 7.78) for problem solving in Physics.

Thus the ANCOVA result reveals that both Schema Based Instruction with Homework and Schema Based Instruction without Homework significantly increase the gain in Problem Solving Ability compared to Direct Translation Strategy of teaching problem solving usually practiced in schools. Also it reveals that Schema Based Instruction with Homework is better than Schema Based Instruction without Homework.

Effect of Instructional strategy on Conceptual Understanding of story problems in Physics

The effect of instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) on Conceptual Understanding of story problems in Physics of experimental and control groups was investigated by comparing the scores of Conceptual Understanding of story problems for experimental and control groups before and after intervention.

Conceptual Understanding of story problems in Physics for experimental and control groups before intervention

The statistical indices of distribution the pretest scores of Conceptual Understanding of story problems in Physics obtained for experimental and control groups of Higher Secondary School Students are indicated in Table 33.

Table 33

Statistical Constants of Distribution Pretest Scores of Conceptual Understanding of Story Problems in Physics for the Experimental and Control Groups

Study Group	N	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental group-1	60	2.33	2.5	2.5	0.77	0.02(0.31[a])	-0.22(0.61[b])
Experimental group-2	52	2.27	2.25	2.0	0.71	0.04(0.33[a])	0.03(0.65[b])
Control group	54	2.26	2..5	2.5	0.73	-0.04(0.33[a])	- 0.84(0.64[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 33 shows that, mean (2.33), median (2.5), and mode (2.5) of pretest scores of Conceptual Understanding of story problems in Physics are almost equal for experimental group-1. The indices of skewness (-0.02) and kurtosis (-0.22) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental group-1, the ratios between skewness and its standard error (-0.10), and that between kurtosis and its standard error (-0.36) are less than 1.96, indicating that the pretest scores of Conceptual Understanding of story problems for experimental group-1 do not significantly deviate from normality.

Mean (2.27), median (2.25), and mode (2.0) of pretest scores of Conceptual Understanding of story problems in Physics are almost equal for experimental group-2. The indices of skewness (-0.04) and kurtosis (0.03) indicate that the distribution is slightly negatively skewed and leptokurtic. For the experimental group-2, the ratios between skewness and its standard error (-0.12), and that between kurtosis and its standard error (0.05) are less than 1.96, indicating that the pretest scores of Conceptual Understanding of story problems in Physics for experimental group-2 do not significantly deviate from normality.

Mean (2.26), median (2.5), and mode (2.5) of pretest scores of Conceptual Understanding of story problems in Physics are almost equal for control group. The indices of skewness (-0.04) and kurtosis (-0.24) indicate that the distribution is slightly negatively skewed and platykurtic. For the control group, the ratios between skewness and its standard error (-0.12), and that between kurtosis and its standard error (-0.38) are less than 1.96, indicating that the pretest scores of Problem Solving Ability for control group do not significantly deviate from normality.

In order to further test the normality of distribution of pretest scores of Conceptual Understanding of story problems in Physics for the experimental and control groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were performed. The results are presented in Table 34.

Table 34

Result of Shapiro-Wilk test of Normality and Leven's test of Homogeneity of Pretest Scores of Conceptual Understanding of Story Problems in Physics for the Experimental and Control Groups

Study groups	Shapiro-Wilk test of Normality			Levene's test of Homogeneity			
	df	statistic	Sig.	df_1	df_2	F	Sig.
Experimental group-1	60	0.96	.08				
Experimental group-2	52	0.96	.07	2	163	0.12	.89
Control group	54	0.96	.07				

Shapiro-Wilk test of normality indicates a reasonable assumption normality for the pretest scores of Conceptual Understanding of story problems in Physics for both experimental groups (Exp-1: S-W=0.96, df=60, p=.08; Exp-2: S-W=0.96, df=52, p=.07) and control group (S-W=0.96, df=54, p=.07). Levene's test of homogeneity suggest that the variances of pretest scores of Conceptual Understanding of story problems in Physics for the experimental and control groups were equal [F (2, 163) =0.12, p=.89]. Therefore the pre-test scores of Conceptual Understanding of story problems in Physics for the experimental and control groups are normal and the variances of the pre-test scores of Conceptual Understanding of story problems in Physics for the three groups are homogeneous.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, box plot and Q-Q plot of the residuals of pre-test scores of Conceptual Understanding of story problems in Physics, for each study group. The results are shown in Figure 18 & Figure 19.

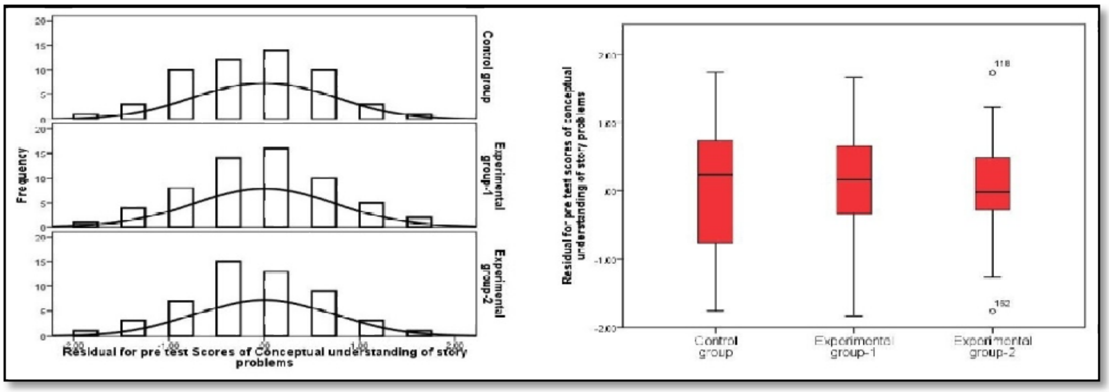


Figure 18. Histogram with normal curves and box plot of the residuals of pre-test scores of Conceptual Understanding of story problems in Physics for the experimental and control groups

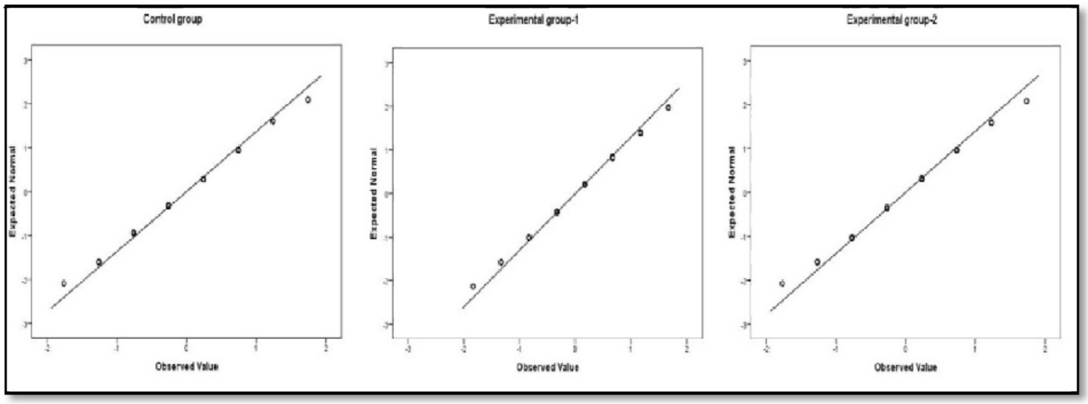


Figure 19. Q-Q plot of the residuals of pretest scores of Conceptual Understanding of story problems in Physics for the experimental and control groups

A one way ANOVA was conducted to examine a statistically significant difference between experimental group-1, experimental group-2 and control groups on mean of pretest scores of Conceptual Understanding of story problems in Physics. The result is given in Table 35.

Table 35

Result of One-way ANOVA for Pretest Scores of Conceptual Understanding of Story Problems in Physics by Instructional Strategies

Source	Sum of Squares	df	Mean Square	F	Sig.
Between groups	0.19	2	0.09	0.17	.84
Within groups	89.43	163	0.55		

Table 35 shows the main effect of instructional strategy is not significant, F(2,163)= .17, p=.84; which suggests that means of pretest scores of Conceptual Understanding of story problems in Physics are almost equal in the three study groups. Hence before intervention, experimental group-1, experimental group-2 and control group are equal on Conceptual Understanding of story problems in Physics.

Conceptual Understanding of story problems in Physics for experimental and control groups after intervention

In order to find the effect of instructional strategy on Conceptual Understanding of story problems in Physics for Higher Secondary School Students, gain scores of Conceptual Understanding of story problems were utilized. Gain scores of the subjects were calculated by subtracting pre-test scores of Conceptual Understanding of story problems from that of post test scores. Analysis based on the gain scores of Conceptual Understanding of story problems is presented below.

Gain in Conceptual Understanding of story problems in Physics for the Experimental and Control groups

The statistical indices of distribution gain scores in Conceptual Understanding of story problems in Physics obtained for experimental and control groups of Higher Secondary School Students are presented in Table 36.

Table 36

Statistical Constants of Distribution of Gain Scores in Conceptual Understanding of Story Problems in Physics for the Experimental and Control Groups

Study group	n	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental group-1	60	6.49	6.50	7.50	2.03	0.50(0.31[a])	0.53(0.61[b])
Experimental group-2	52	6.38	6.50	6.50	2.38	0.28(0.33[a])	-0.73(0.65[b])
Control group	54	3.06	3.00	3.50	1.55	-0.07(0.33[a])	0.64(0.64[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 36 shows that, mean (6.49), median (6.50), and mode (7.50) of gain scores in Conceptual Understanding of story problems in Physics are almost equal for experimental group-1. The indices of skewness (0.50) and kurtosis (0.53) indicate that the distribution is slightly positively skewed and leptokurtic. For the experimental group-1, the ratios between skewness and its standard error (1.61), and that between kurtosis and its standard error (0.87) are less than 1.96, indicating that the gain in Conceptual Understanding of story problems in Physics for experimental group-1 do not significantly deviate from normality.

Mean (6.38), median (6.50), and mode (6.50) of gain scores in Conceptual Understanding of story problems in Physics are almost equal for experimental group-2. The indices of skewness (0.28) and kurtosis (-0.73) indicate that the distribution is slightly positively skewed and platykurtic. For the experimental group-2, the ratios between skewness and its standard error (0.85), and that between kurtosis and its standard error (-1.12) are less than 1.96, indicating that the gain in Conceptual Understanding of story problems in Physics for experimental group-2 do not significantly deviate from normality.

Mean (3.06), median (3), and mode (3.50) of gain scores inConceptual Understanding of story problems in Physics are almost equal for control group. The indices of skewness (-0.07) and kurtosis (0.64) indicate that the distribution is slightly negatively skewed and leptokurtic. For the control group, the ratios between skewness and its standard error (-0.21), and that between kurtosis and its standard error (1.00) are less than 1.96, indicating that the gain in Conceptual Understanding of story problems in Physics for control group do not significantly deviate from normality.

In order to further test the normality of distribution of gain in Conceptual Understanding of story problems in Physics for the experimental and control groups, Shapiro- Wilk test of normality and Levene's Test of Homogeneity were performed. The results are presented in Table 37.

Table 37

Result of Shapiro-Wilk test of Normality and Leven's Test of Homogeneity of Gain in Conceptual Understanding of Story Problems in Physics for the Experimental and Control Groups

Study groups	Shapiro-Wilk test of Normality			Levene's Test of Homogeneity			
	df	statistic	Sig.	df_1	df_2	F	Sig.
Experimental group-1	60	0.97	.14	2	163	2.50	.09
Experimental group-2	52	0.96	.11				
Control group	54	0.97	.13				

Shapiro-Wilk test of normality indicates a reasonable assumption normality for the gain scores in Conceptual Understanding of story problems in Physics for both experimental groups (exp-1: S-W=0.97, df=60, p=.14; exp-2: S-W=0.96, df=52, p=.11;)and control group (S-W=0.97, df=54, p=.13). Levene's test of homogeneity suggest that the variances of gain in Conceptual Understanding of story problems in Physics of the experimental and control groups were equal [F (2, 163) =2.50, p=.09]. Therefore the gain in Conceptual Understanding of story problems in Physics for the experimental and control groups are normal and the variances of the gain scores in Conceptual Understanding of story problems in Physics for three groups are homogeneous.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, box plot and Q-

Q plot of the residuals of gain scores in Conceptual Understanding of story problems in Physics, for each study group. The results are shown in Figure 20 and Figure 21.

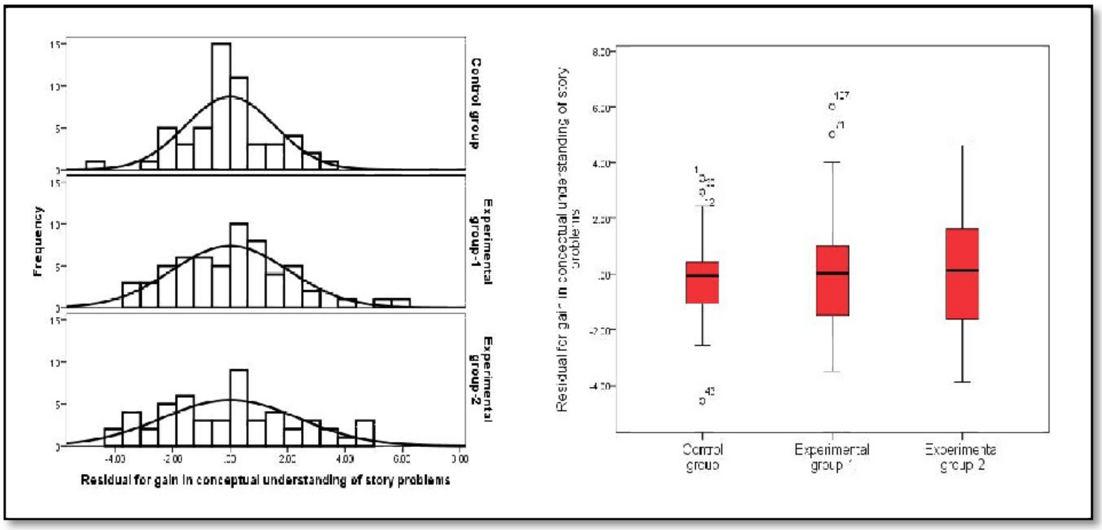


Figure 20. Histogram with normal curves and box plot of the residuals of gain scores of Conceptual Understanding of story problems in Physics for the experimental and control groups

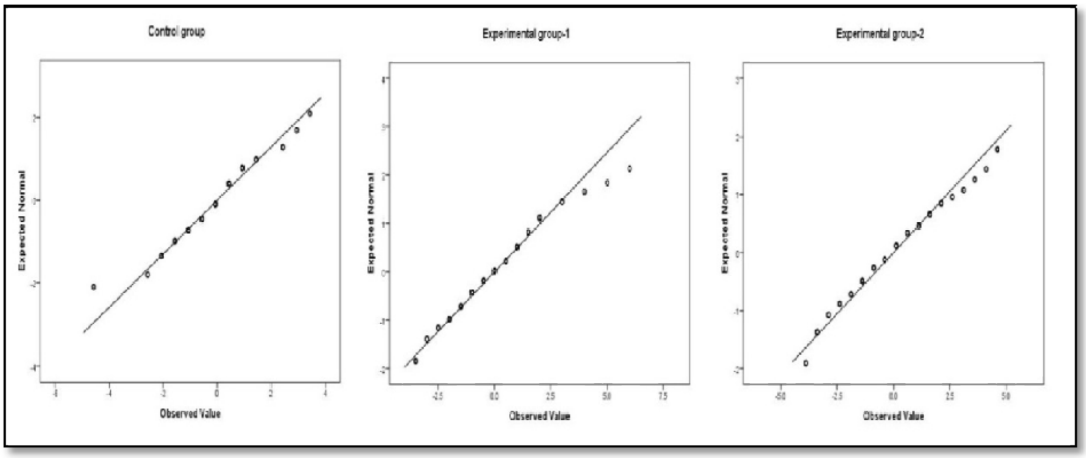


Figure 21. Q-Q plot of the residuals of pretest scores of Conceptual Understanding of story problems in Physics for the experimental and control groups

To test the assumption homogeneity of regression slopes between gain scores in Conceptual Understanding of story problems in Physics and the covariate Non-verbal Intelligence plotted a scatter plot and regression lines for each study group with Non-verbal Intelligence on the X-axis and the gain scores in Conceptual Understanding of story problems in Physics on the Y-axis. The results are shown in Figure 22.

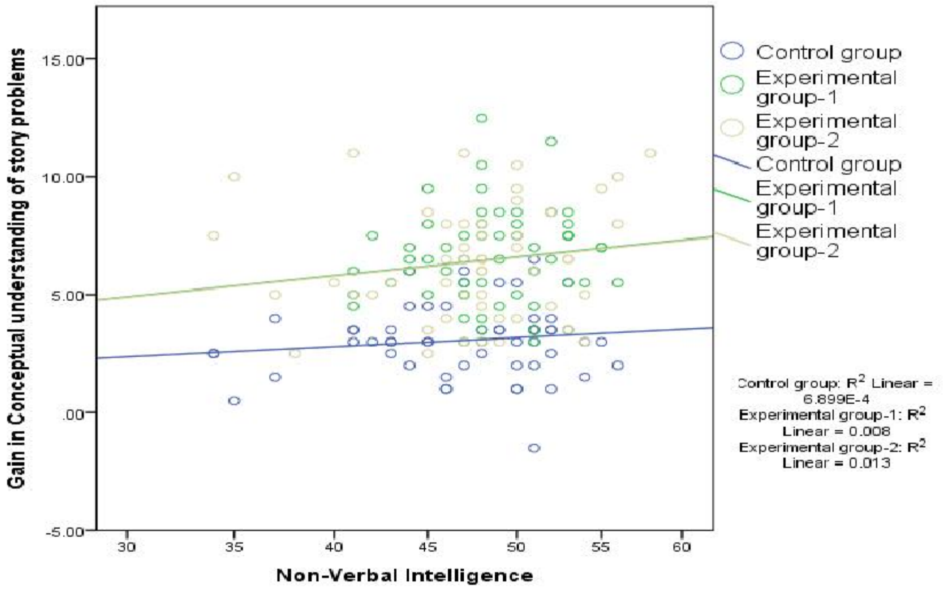


Figure 22. Scatter plot and regression lines of gain scores in Conceptual Understanding of story problems against Non-verbal Intelligence for the experimental and control groups.

Figure 22 displays the relationship between gain scores in Conceptual Understanding of story problems in Physics and Non-verbal Intelligence for each study groups. The lines indicate the regression slopes for each study group. The regression line slopes slightly upwards from left to right; it reveals that there is a positive relationship between gain scores in Conceptual Understanding of story problems in Physics and Non-verbal Intelligence in both experimental and control groups. The slopes of the lines for the three study groups are almost similar showing that the relationship between gain scores in Conceptual Understanding of story problems in Physics and Non-verbal Intelligence is almost similar in these three groups. This indicates that regression slopes of gain scores in Conceptual Understanding of story problems in Physics against Non-verbal Intelligence for each study group are homogeneous.

Further judgment of homogeneity of regression slopes between gain scores in Conceptual Understanding of story problems in Physics and covariate Non-verbal Intelligence for the study groups was performed using one way ANCOVA (customized model). The results are presented in Table 38.

Table 38

Summary of ANCOVA Including Interaction Effect of Instructional Strategy and Non-Verbal Intelligence on Gain Scores in Conceptual Understanding of Story Problems in Physics

Source	Sum of squares	df	Mean square	F	Sig.
Instructional Strategy	0.74	2	0.37	0.09	.91
NVI	6.72	1	6.72	1.66	.20
Instructional Strategy * NVI	1.56	2	0.78	0.19	.83
Error	649.59	160	4.06		

NVI =Non-Verbal Intelligence

Table 38 shows that the interaction effect of Instructional Strategy and the covariate, Non-Verbal Intelligence on gain scores in Conceptual Understanding of story problems in Physics is statistically non-significant, at .05 level, $F(2,160) = 0.19$, $p=.83$. This indicates that the regression lines between gain scores in Conceptual Understanding of story problems in Physics and Non-verbal Intelligence have almost same slopes for all three study groups.

To test the assumption homogeneity of regression slopes between gain scores in Conceptual Understanding of story problems in Physics and the covariate Logical Mathematical Intelligence plotted a scatter plot and regression lines for each study group with Logical Mathematical Intelligence on the X-axis and the gain scores in Conceptual Understanding of story problems in Physics on the Y-axis. The results are shown in Figure 23.

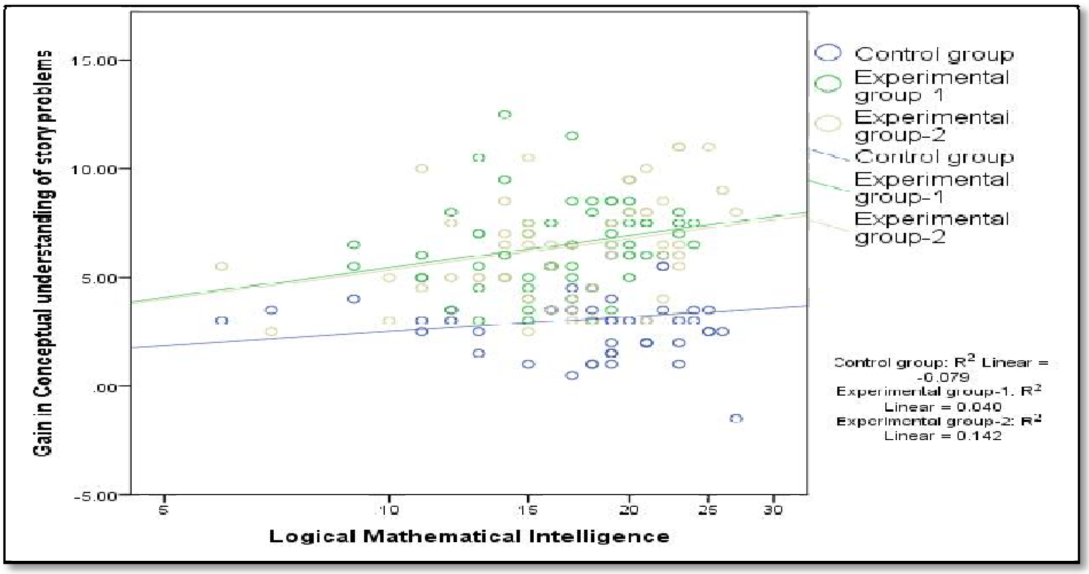


Figure 23. Scatter plot and regression lines of gain scores in Conceptual Understanding of story problems in Physics against Logical Mathematical Intelligence for the experimental and control groups

Figure 23 shows the relationship between gain scores in Conceptual Understanding of story problems in Physics and Logical Mathematical Intelligence for each study groups. The regression line slopes slightly upwards from left to right; it reveals that there is a positive relationship between gain scores in Conceptual Understanding of story problems in Physics and Logical Mathematical Intelligence in both experimental and control groups. The slopes of the lines for the three study groups are almost similar showing that the relationship between gain scores in Conceptual Understanding of story problems in Physics and Logical Mathematical Intelligence is almost similar in these three study groups. This indicates that regression slopes of gain scores in Conceptual Understanding of story problems in Physics against Logical Mathematical Intelligence for experimental and control groups are homogeneous.

Further judgment of homogeneity of regression slopes between gain scores in Conceptual Understanding of story problems in Physics and covariate Logical Mathematical Intelligence for the study groups was performed using one way ANCOVA (customized model). The results are presented in Table 39.

Table 39

Summary of ANCOVA Including Interaction Effect of Instructional Strategy and Logical Mathematical Intelligence on Gain Scores in Conceptual Understanding of Story Problems in Physics

Source	Sum of squares	df	Mean square	F	Sig.
Study groups	5.35	2	2.67	0.72	.490
LMI	25.87	1	25.87	6.97	.010
Instructional Strategy * LMI	22.38	2	11.19	3.01	.052
Error	593.46	160	3.71		

LMI = Logical Mathematical Intelligence

Table 39 shows that the interaction effect of Instructional Strategy and the covariate Logical Mathematical Intelligence on gain scores in Conceptual Understanding of story problems in Physics is statistically non-significant at .05 level, $F(2, 160) = 3.01$, $p = .052$. This indicates that the regression lines between gain scores in Conceptual Understanding of story problems in Physics and Logical Mathematical Intelligence have almost same slopes for experimental and control groups.

To test the effect of Instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Home work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on gain in Conceptual Understanding of story problems in Physics for the experimental and control groups, one way ANCOVA was done. The results are presented in Table 40.

Table 40

Summary of ANCOVA of Gain in Conceptual Understanding of Story Problems for the Experimental and Control Groups

Source	Sum of squares	df	Mean square	F	Sig.	η_p^2
NVI	.04	1	0.04	0.01	.92	.00
LMI	19.35	1	19.35	4.93	.03	0..03
Instructional strategy	418.10	2	209.05	53.27	.00	0.40
Error	631.798	161	3.92			

η_p^2= partial Eta square

Table 40 describes the one way ANCOVA performed to compare the effect of three instructional strategies on gain in Conceptual Understanding of story problems in Physics of the experimental and control groups after controlling for Non-verbal Intelligence and Logical Mathematical Intelligence. From Table 40, it is clear that there was a significant effect of instructional strategies on gain in Conceptual Understanding of story problems in Physics after controlling for the effect of Non-verbal Intelligence and Logical Mathematical Intelligence, at specified .05 level, $F(2,161) = 53.27$, $p < .001$, $\eta_p^2 = .40$. The partial eta squared value indicates the effect size is large.

To examine which of the instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Homework/ Direct Translation Strategy of teaching problem solving) showed statistically significant difference for the adjusted means of gain scores in Conceptual Understanding of story problems in Physics, Post-hoc comparison was done. All pair wise comparison among the instructional strategies were examined and the result of the same are shown in Table 41.

Table 41

Result of Post-hoc Pair wise Comparison of Adjusted Mean of Gain Scores in Conceptual Understanding of Story Problems for the Experimental and Control Groups

Instructional strategies	Mean difference	Std. Error	Sig.	95% CI of difference
1vs. 2	0.15	0.38	1.00	[-.77, 1.06]
1vs. 3	3.55*	0.39	.00	[2.62, 4.49]
2 vs. 3	3.41*	0.39	.00	[2.47, 4.35]

1 = Schema Based Instruction with Homework; 2 = Schema Based Instruction without Homework; 3 = Direct Translation Strategy of teaching problem solving; *significant at the .05 level; CI = Confidence Interval

The post-hoc pair wise comparison of adjusted means of gain in Conceptual Understanding of story problems in Physics for experimental and control groups indicates statistically significant difference between instructional strategies 1 and 3 ($p < .001$) and instructional strategies 2 and 3($p < .001$). Table 41 also reveals that there is no significant difference between the instructional strategies 1 and 2 on means of gain scores in Conceptual Understanding of story problems in Physics. Comparing the

Estimated Marginal Means (EMM) showed that the experimental group-1(EMM= 6.55), which received Schema Based Instruction with Homework and the experimental group-2 (EMM = 6.40) ,which received Schema Based Instruction without Homework have the highest mean of gain scores in Conceptual Understanding of story problems in Physics compared to control group (EMM = 2.99).

Thus the ANCOVA result reveal that both Schema Based Instruction with Homework and Schema Based Instruction without Homework significantly increase gain in Conceptual Understanding of story problems in Physics compared to the Direct Translation Strategy of teaching problem solving. Also it reveals that, to increase Conceptual Understanding of story problems, Schema Based Instruction with Homework is not significantly better than the Schema Based Instruction without Home work.

Interaction Effects of Instructional Strategy and Logical Mathematical Intelligence on Problem Solving Ability in Physics

To examine the interaction effects of instructional strategy and Logical Mathematical Intelligence on Problem Solving Ability, two-way ANOVA was conducted. The factor instructional strategy is presented at three levels: Schema Based Instruction with Home-Work (SBI with HW); Schema Based Instruction without Home-Work (SBI without HW) and Direct Translation Strategy of teaching problem solving (DTS). In the present study the cognitive variable Logical Mathematical Intelligence is considered as a confounding variable to the Problem Solving Ability. Based on Median score of the Logical Mathematical Intelligence (LMI), the subjects were classified into two levels: Below Average Logical Mathematical Intelligence (BALMI) and Above Average Logical Mathematical Intelligence (AALMI) groups (Details of these classifications were given in the methodology chapter). Therefore to determine the interaction effect of Instructional Strategy and Logical Mathematical Intelligence on gain in Problem Solving Ability, the investigator performed two way ANOVA (3X2 factorial design) for the total sample. The results are presented in Table 43 and the descriptive statistics for two way ANOVA for Problem Solving Ability are given in Table 42.

Table 42

The Descriptive Statistics for Two-Way ANOVA for Gain in Problem Solving Ability by Instructional Strategy and Logical Mathematical Intelligence

Level of LMI	Instructional strategy	Mean(SD)	n	95% CI
	SBI with HW	13.03(3.55)	34	[12.02, 14.03]
BALMI	SBI without HW	11.63(3.14)	28	[10.52, 12.73]
	DTS	7.43(2.8)	21	[6.15, 8.71]
	SBI with HW	15.71(3.18)	26	[14.56, 16.86]
AALMI	SBI without HW	14.08(2.37)	24	[12.89, 15.28]
	DTS	8.28(2.44)	33	[7.27, 9.31]

CI= Confidence Interval

Table 43

Result of Two Way ANOVA for Gain in Problem Solving Ability by Instructional Strategy and Logical Mathematical Intelligence (LMI)

Source	Sum of squares	df	Mean square	F	Sig.	η_p^2
Instructional strategy	1244.35	2	622.18	70.66	.00	.50
LMI	161.30	1	161.30	18.32	.00	.10
Instructional Strategy * LMI	26.23	2	13.11	1.49	.23	.02
Error	1408.86	160	8.81			

μ_p^2 = Partial Eta Squared

The Two-Way ANOVA for gain in Problem Solving Ability reveals that the interaction effect of Instructional strategy and Logical Mathematical Intelligence (LMI) on gain in Problem Solving Ability in Physics is statistically non-significant at .05 level, $F(2,160) = 1.49$, $p=.23$, $\eta_p^2 = .02$.

Table 43 also shows that the main effect of instructional strategy is statistically significant at .05 level, $F(2,160)= 70.66$, $p< .001$, $\eta_p^2 = .50$. Earlier the ANCOVA test had examined the effect of instructional strategy on gain in Problem Solving Ability and post-hoc analysis was done. The results also ratify earlier ANCOVA result that reveals that the Instructional Strategy significantly influences the Problem Solving Ability of subjects.

Interaction Effect of Instructional Strategy and Logical Mathematical Intelligence on Conceptual Understanding of story problems in Physics

To determine the interaction effect of instructional strategy and Logical Mathematical Intelligence on gain in Conceptual Understanding of story problems in Physics, Two-way ANOVA was conducted. The factor instructional strategy is presented at three levels: Schema Based Instruction with Home Work (SBI with HW); Schema Based Instruction without Home Work (SBI without HW) and Direct Translation Strategy of teaching problem solving (DTS). In the present study, the cognitive variable Logical Mathematical Intelligence is considered as a confounding variable to the Conceptual Understanding of story problems in Physics. Based on Median score of the Logical Mathematical Intelligence (LMI), the subjects were classified in to two levels: Below Average Logical Mathematical Intelligence (BALMI) and Above Average Logical Mathematical Intelligence (AALMI) groups (Details of these classifications were given in the methodology chapter). Therefore to determine the interaction effect of Instructional Strategy and Logical Mathematical Intelligence on gain in Conceptual Understanding of story problems, the investigator performed Two-Way ANOVA (3X2 factorial design) for the total sample. The results are presented in Table 45 and the descriptive statistics for Two Way ANOVA for gain in Conceptual Understanding are given in Table 44.

Table 44

The Descriptive Statistics for Two-Way ANOVA for Gain in Conceptual Understanding of Story Problems by Instructional Strategy and Logical Mathematical Intelligence (LMI)

Level of LMI	Instructional Strategy	Mean (SD)	n	95% CI
BALMI	SBI with HW	6.16(2.28)	34	[5.51, 6.81]
	SBI without HW	5.55(2.07)	28	[4.84, 6.27]
	DTS	3.40(1.42)	21	[2.58,4.23]
AALMI	SBI with HW	6.92(1.57)	26	[6.18, 7.66]
	SBI without HW	7.35(2.38)	24	[6.58, 8.13]
	DTS	2.94(1.43)	33	[2.28,3.60]

CI= Confidence Interval

Table 45

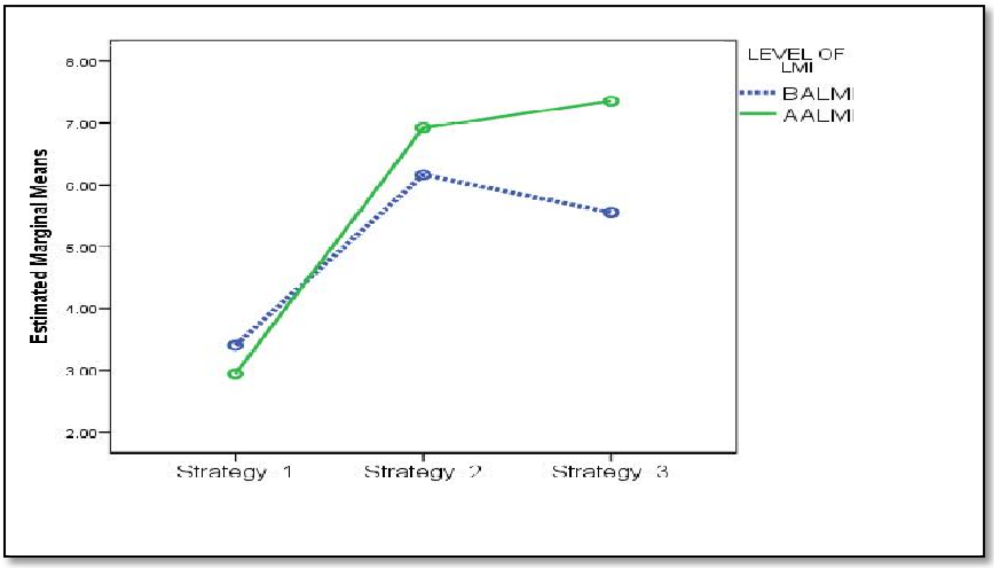
Result of Two Way ANOVA for Gain in Conceptual Understanding of story Problems by Instructional Strategy and Logical Mathematical Intelligence (LMI)

Source	Sum of Squares	df	Mean Square	F	Sig.	η_p^2
Instructional strategy	388..79	2	194.39	53.09	.00	.40
LMI	19.70	1	19.70	5.38	.02	.03
Instructional Strategy * LMI	25.14	2	12.57	3.43	.03	.05
Error	585.804	160	3.66			

Level of significance=0.05

Table 45 reveals that there was a statistically significant interaction effect at .05 level, between the instructional strategy and Logical Mathematical Intelligence of the subjects on the gain in Conceptual Understanding of story problems in Physics, $F(2,160)= 3.43$, $p= 0.03$, $\eta_p^2 = 0.05$. The partial eta squared value indicates small effect on the size of interaction.

Figure 24 represents the statistically significant interaction effect of Instructional strategy and Logical Mathematical Intelligence on gain in Conceptual Understanding of story problems.



Strategy-1 = Direct Translation Strategy of teaching problem solving; Strategy-2 = Schema Based Instruction with Homework; Strategy-3=Schema Based Instruction without Homework

Figure 24. Profile plot for Estimated Marginal Means of Interaction- Instructional Strategy * LMI on Gain in Conceptual Understanding of story problems

The crossed lines on the graph (Figure 24) suggest that there is an interaction effect, which the significant p value for the instructional strategy* LMI term confirms (Field, 2009). From the graph it is clear that mean of gain in Conceptual Understanding of story problems in Physics was higher for AALMI group than BALMI group, when teaching them either through strategy 2(Schema Based Instruction with Homework) or strategy-3(Schema Based Instruction without Homework). However when teaching through strategy-1(Direct Translation Strategy of teaching problem solving), some of the students in AALMI group showed low gain in Conceptual Understanding of story problems than that of the students in BALMI group. Thus it reveals that the effect of instructional strategy was not same across the two levels of Logical Mathematical Intelligence.

A Post-hoc test of simple main effect was performed to understand the effect of levels of Instructional Strategy for each level of Logical Mathematical Intelligence on Gain in Conceptual Understanding of Story Problems. The results are presented in Table 46.

Table 46

Result of Simple Main Effects of Instructional Strategy within Each Level Combination of the Logical Mathematical Intelligence on Gain in Conceptual Understanding of Story Problems

Level of LMI		Sum of Squares	df	Mean Square	F	Sig.	η_p^2
BALMI	Contrast	102.34	2	51.17	13.98	.00	0.15
	Error	585.80	160	3.66			
AALMI	Contrast	351.43	2	175.71	47.99	.00	.38
	Error	585.80	160	3.66			

Level of significance =.025

Table 46 shows simple main effect of instructional strategy on gain in Conceptual Understanding of story problems in Physics was significant at .025 level, in both BALMI group, $F(2,160) = 13.98$, $p= .00$, $\eta_p^2 = 0.15$; and AALMI group, $F(2,160) = 47.99$, $p= .00$, $\eta_p^2=0.38$. To examine which of the instructional strategy (Schema Based

Instruction with Homework/ Schema Based Instruction without Home work/ Direct Translation Strategy of teaching problem solving) showed statistically significant difference for the adjusted means of gain in Conceptual Understanding of story problems for each level of Logical Mathematical Intelligence, the post-hoc pair wise comparison of adjusted means was done. All pair wise comparison among the instructional strategies were examined and the result of the same are shown in Table 47.

Table 47

Result of Post-hoc Pair wise Comparison of Adjusted Means of Gain in Conceptual Understanding of Story Problems for Each Level of Logical Mathematical Intelligence

Level of LMI	Instructional Strategy (I)	Instructional Strategy(J)	Mean Difference (I-J)	Sig.
BALMI	SBI with HW	DTS	2.76	.00
	SBI with HW	SBI without HW	.61	.22
	SBI without HW	DTS	2.15	.00
AALMI	SBI with HW	DTS	3.98	.00
	SBI with HW	SBI without HW	-4.31	.43
	SBI without HW	DTS	4.42	.00

Level of Significance = .025

Post-hoc pair wise comparison of adjusted meansof gain in Conceptual Understanding of story problems for each level of Logical Mathematical Intelligence indicates statistically significant difference between SBI with HW and DTS ($p< .001$), and SBI without HW and DTS ($p<.001$) on means of gain scores in Conceptual Understanding of story problems in Physics in both BALMI and AALMI groups. However no significant difference was found between SBI with HW and SBI without HW on gain in Conceptual Understanding of story problems for the two levels of Logical Mathematical Intelligence, BALMI: $p =.22$; AALMI: $p = .43$. Comparing the Estimated Marginal Means (Table 44) showed that the most gain in Conceptual Understanding of story problems in Physics for the two levels of Logical Mathematical Intelligence (BALMI and AALMI) was achieved in Schema Based Instruction, compared to Direct Translation Strategy of teaching problem solving. It is also noteworthy that gain in Conceptual Understanding made by Schema Based Instruction in BALMI group, SBI with HW: M=6.16, CI=[5.42, 6.90]; SBI without HW: M=5.55, CI=[4.74,6.37], was higher than that made by Direct Translation Strategy of teaching problem solving in AALMI groups, M=2.94, CI=[2.19,3.69].

A Post-hoc test of simple main effect was also performed to understand the effect of levels of Logical Mathematical Intelligence for each level of Instructional Strategy on gain in Conceptual Understanding of Story Problems. The results are presented in Table 48.

Table 48

Result of Simple Main Effects of Logical Mathematical Intelligence within Each Level Combination of the Instructional Strategy on Gain in Conceptual Understanding of Story Problems

Instructional Strategy		Sum of Squares	df	Mean Square	F	Sig.	η_p^2
SBI with HW	Contrast	8.54	1	8.54	2.33	.13	0.01
	Error	585.80	160	3.66			
SBI without HW	Contrast	41.90	1	41.90	11.44	.00	.07
	Error	585.80	160	3.66			
DTS	Contrast	2.78	1	2.78	.76	.39	.01
	Error	585.80	160	3.66			

Level of significance = .025

Table 48 indicates that mean scores of gain in Conceptual Understanding of story problems of Below Average Logical Mathematical Intelligence and Above Average Logical Mathematical Intelligence groups were not significantly different after the implementation of Schema Based Instruction with Home Works, $F(1,160) = 2.33$, $p = .13$, $\eta_p^2 = .01$. That indicates Schema Based Instruction with Homework showed almost equal effect on the gain in Conceptual Understanding of story problems for Below Average Logical Mathematical Intelligence and Above Average Logical Mathematical Intelligence groups. In the Direct Translation Strategy of teaching problem solving, no statistically significant difference was observed on the means of gain in Conceptual Understanding of story problems for the two levels of Logical Mathematical Intelligence, $F(1,160)= .76$, $p = .39$, $\eta_p^2 =.01$. It is noteworthy that there was statistically significant difference between Below Average Logical Mathematical Intelligence and Above Average Logical Mathematical Intelligence groups on gain in Conceptual Understanding of story problems after the performance of Schema Based Instruction without Home Works, $F(1,160) = 11.44$, $p < .001$,$\eta_p^2 =.07$. Comparing the estimated marginal means shows that gain in Conceptual Understanding of story problems in Physics of Above Average Logical Mathematical Intelligence group was higher (M=7.35) than that of Below Average Logical Mathematical Intelligence group (M= 5.55) when teaching through Schema Based Instruction without home works. Figure 25 offers the visual interpretation of the effect of instructional strategy with in the levels of Logical Mathematical Intelligence on gain in Conceptual Understanding of story problems in Physics.

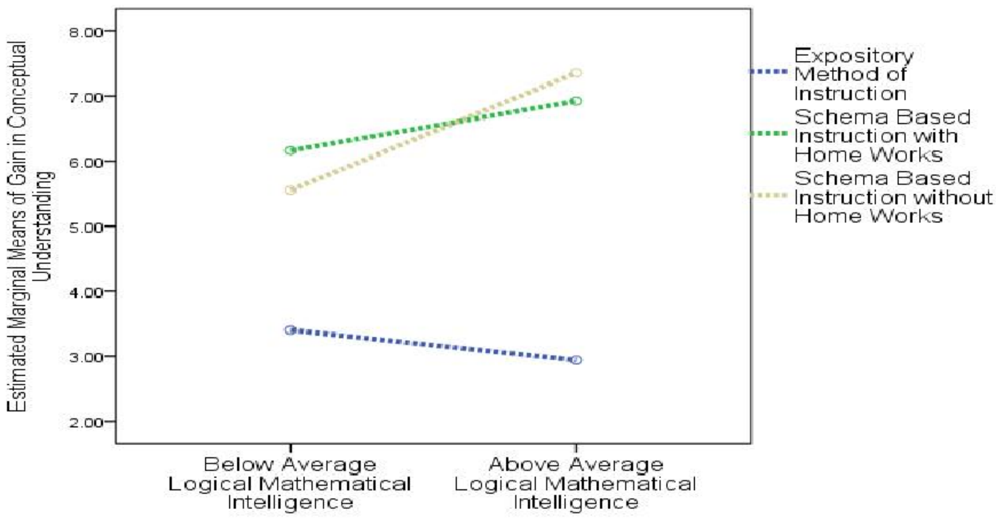


Figure 25. Plot of estimated marginal means of gain in Conceptual Understanding of story problems within the levels of Logical Mathematical Intelligence and Instructional strategy

Relation between Comprehension of Problem Schema and Gain in Problem Solving Ability

The statistical indices of distribution scores of test for assessing comprehension of problem Schema obtained for experimental groups of Higher Secondary School Students are indicated in Table 49.

Table 49

Statistical Constants of Distribution Scores of Test for Assessing Comprehension of Problem Schema for the Experimental Groups

Study group	N	Mean	Median	Mode	SD	Skweness	Kurtosis
Experimental groups	112	22.17	22.87	24.00	5.39	-0.17(0.23[a])	-0.51(0.45[b])

[a]SE of Skewness, [b]SE of Kurtosis

Table 49 shows that, mean (22.17), median (22.87), and mode (24) of scores of the test for assessing Comprehension of problem Schema are almost equal for experimental groups. The indices of skewness (-0.17) and kurtosis (-0.51) indicate that the distribution is slightly negatively skewed and platykurtic. For the experimental groups, the ratios between skewness and its standard error (-0.74), and that between kurtosis and its standard error (-1.13) are less than 1.96, indicating that the scores of the test for assessing Comprehension of problem Schema for experimental groups do not significantly deviate from normality.

In order to further test the normality of distribution of scores of the test for assessing comprehension of Problem Schema in the experimental groups, Shapiro-Wilk test of normality were performed. The results are presented in Table 50.

Table 50

Result of Shapiro-Wilk test of Normality of the Scores of the Test for Assessing Comprehension of Problem Schema for the Experimental Groups

Study group	Shapiro-Wilk test of Normality		
	df	Statistic	Sig.
Experimental groups	112	0.98	.19

Shapiro-Wilk statistic of normality indicates a reasonable assumption normality for the tests scores of the Comprehension of Problem Schema for the experimental groups, S-W = 0.98, df = 112, p =.19). Therefore test scores of Comprehension of Problem Schema in the experimental groups are normal.

Further Normality assumption was confirmed by visual inspection of the histogram of the distribution with normal curve which best fit on them, of test scores of Comprehension of problem schema. The results are shown in Figure 26.

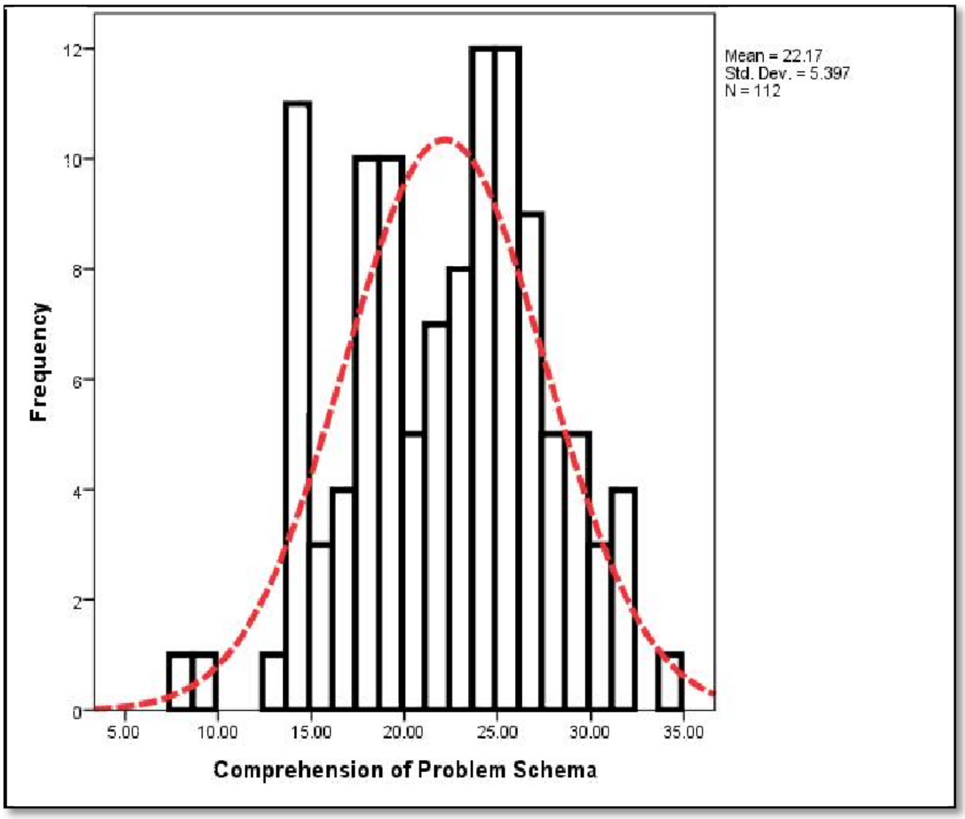


Figure 26. Histogram with normal curve of the scores of test for assessing Comprehension of Problem Schema for the experimental group

In order to determine the correlation between Comprehension of problem Schema and Problem Solving Ability in Physics Pearson product-moment correlation coefficient was computed for experimental groups. The test result is given in Table 51.

Table 51

Result of Correlation between Comprehension of Problem Schema and Problem Solving Ability in Physics

Variables	N	r	Sig.
Comprehension of Problem Schema & Problem Solving Ability	112	.76**	.00

**Correlation is significant at the 0.01 level (2-tailed)

From Table 51, it can be seen that there was a positive correlation between the Comprehension of Problem Schema and Problem Solving Ability in Physics, r= .76, N = 112, p< .001). A scatter plot shown in the figure 27 summarizes the results

Overall; there was a positive correlation between Comprehension of Problem Schema and Problem Solving Ability.

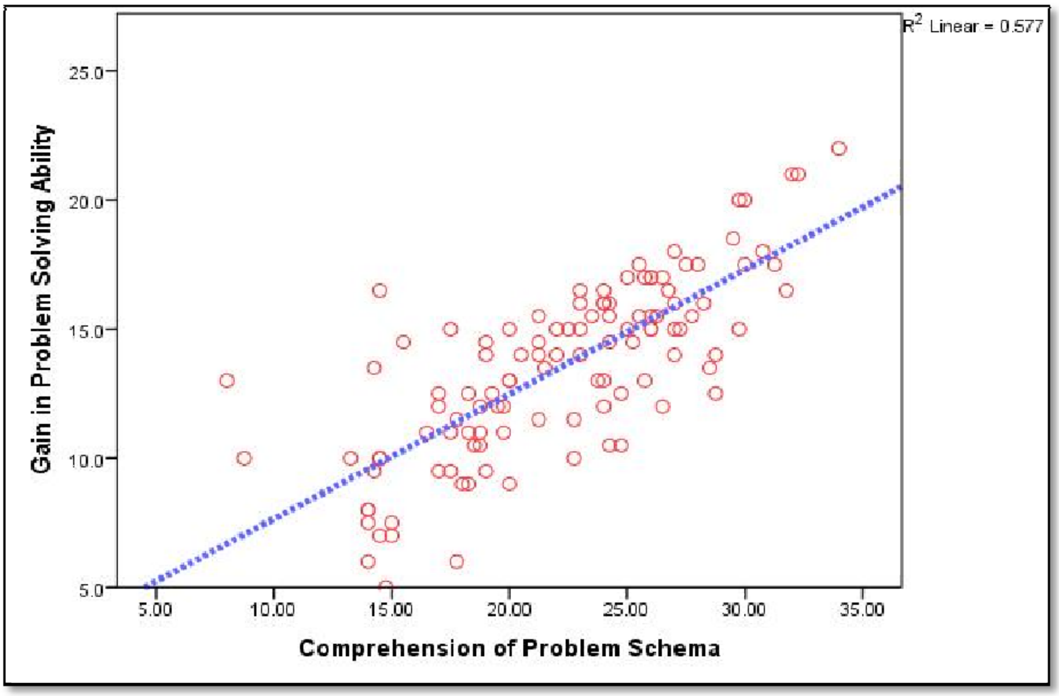


Figure 27. scatter plot of correlation between Comprehension of Problem Schema and Gain Problem Solving Ability in Physics for the experimental groups

Percentage analysis of Students' Perception of Schema Based Instruction

A strategy questionnaire for measuring students' perception of Schema Based Instruction was prepared and responses from 107 students who received Schema Based Instruction were collected. Questionnaire contains 20 items. First 12 items were related to cognitive domain and 8 were related to affective domain. Data collected and consolidated on the basis of these two domains. Details of the students' response to each statement related to their perception of Schema Based Instruction is given in Table 52.

Table 52

Percentage Analysis of the Student's Perception of Schema Based Instruction

Item No.	Statement		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	Perception Related to Cognitive Domain						
1	Schema Based Instruction (SBI) has helped me to think and analyze the structure of the problem in a meaningful way.	**n** **(%)**	1 (0.93)	13 (12.15)	4 (3.74)	65 (60.75)	24 (22.43)
2	The way of classifying problems into problem types helps me to better comprehend the problem.	**n** **(%)**	2 (1.87)	11 (10.28)	3 (2.80)	72 (67.29)	19 (17.76)
3	This method helps me to analyze and understand the situational aspects of the problem	**n** **(%)**	1 (0.90)	12 (11.20)	1 (0.90)	76 (71.00)	17 (15.90)
4	This method helps me to analyze and understand how the concepts are connected in the given problem situation	**n** **(%)**	1 (0.93)	16 (14.95)	2 (1.87)	72 (67.29)	16 (14.95)
5	This method helped me to identify similarities and differences embedded in the problems	**n** **(%)**	0 (0.00)	14 (13.10)	4 (3.70)	77 (72.00)	12 (11.20)
6	Familiarizing with different problem types helped me to recognize and identify the type of new problem given	**n** **(%)**	1 (0.93)	17 (15.89)	6 (5.61)	75 (70.09)	8 (7.48)

Item No.	Statement		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
7	This method is helpful to recognize and understand the relevant data embedded in the problems	**n** **(%)**	1 (0.93)	20 (18.69)	2 (1.87)	75 (70.09)	9 (8.41)
8	The variety of practice problems which were given helped me to increase my problem-solving skill.	**n** **(%)**	1 (0.93)	13 (12.15)	11 (10.28)	76 (71.03)	6 (5.61)
9	The structural map of connected concepts helped me to comprehend the relationship between them in its totality	**n** **(%)**	2 (1.87)	11 (10.28)	11 (10.28)	69 (64.49)	14 (13.08)
10	Schema diagram was helpful as it was visual and had key components of problems	**n** **(%)**	3 (2.80)	21 (19.63)	4 (3.74)	42 (39.25)	37 (34.58)
11	Schema diagram helped me to meaningfully solve a problem	**n** **(%)**	2 (1.87)	20 (18.69)	8 (7.48)	56 (52.34)	21 (19.63)
12	Schema Based Instruction helped me to better understand the concepts behind the problems I solved in class	**n** **(%)**	1 (0.90)	4 (3.70)	7 (6.50)	70 (65.40)	25 (23.40)
	Perception Related to Affective Domain						
13	I feel more comfortable while using schema for doing problems.	**n** **(%)**	3 (2.80)	9 (8.41)	22 (20.56)	61 (57.01)	12 (11.21)
14	I enjoyed drawing the situation diagram as part of this method.	**n** **(%)**	4 (3.74)	16 (14.95)	1 (0.93)	45 (42.06)	41 (38.32)

Item No.	Statement		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
15	Activities included in this method encouraged me to practice problem solving.	**n** **(%)**	0 (0.00)	34 (31.78)	16 (14.95)	49 (45.79)	8 (7.48)
16	I value the Systematic nature of this problem solving method as it increased my problem solving skill.	**n** **(%)**	1 (0.93)	4 (3.74)	18 (16.82)	47 (43.93)	37 (34.58)
17	By practicing this method I believe that I am able to solve even unfamiliar problems.	**n** **(%)**	2 (1.87)	16 (14.95)	38 (35.51)	46 (42.99)	5 (4.67)
18	I felt that I was comfortable with schema based learning.	**n** **(%)**	1 (0.93)	10 (9.35)	16 (14.95)	75 (70.09)	5 (4.67)
19	I appreciate this problem solving method and will use this method in future to solve problems	**n** **(%)**	1 (0.93)	2 (1.87)	24 (22.43)	60 (56.07)	20 (18.69)
20	Schema based problem solving consumes a lot of time	**n** **(%)**	5 (4.67)	27 (25.23)	20 (18.69)	39 (36.45)	16 (14.95)

The analysis of student's perception of Schema Based Instruction revealed that students have favorable opinion towards the Schema Based Instruction. Majority of the students under study perceived Schema Based Instruction as an effective strategy for learning problem solving in Physics.

Chapter 5

Summary, Major Findings, and Suggestions

This chapter presents the entire study in a nutshell, high lighting the major findings which emerged out of the study, tenability of hypotheses, conclusion arrived, educational implications and suggestion for further research.

Study in Retrospect

This section looks back at the title, variable, objectives, hypotheses, tools and statistical techniques of the study

Restatement of the Problem

The present study was entitled "**Effect of Schema Based Instruction on Solving Story Problems in Physics among Higher Secondary School Students**."

Variables in the Study

The variables of the present study were as follows

Dependent variables

The dependent variables in the present study were Problem Solving Ability in Physics and Conceptual Understanding of story problems of higher secondary school students.

Independent variable

The independent variable for the present study was the instructional strategy (Schema Based Instruction with homework/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving)

Controlled variables

The controlled variables were Non-Verbal Intelligence and Logical Mathematical Intelligence.

Objectives

The objectives of the study are presented below as one main objective and a set of specific objectives.

Main objective

To find out the effect of Schema Based Instruction on solving story problems in Physics among higher secondary school students.

Specific objectives

Following set of specific objectives of this study help to clarify the general objectives.

1. To find out the effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among higher secondary school students.

2. To find out the effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of Story Problems in Physics among higher secondary school students.

3. To study the interaction effect of instructional Strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.

4. To study the interaction effect of instructional strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Conceptual Understanding of Story Problems in Physics for total sample.
5. To find out the relation between Comprehension of Problem Schema and Problem Solving Ability in Physics of higher secondary school students taught through Schema Based Instruction.

Hypotheses

1. There will not be any significant effect of Instructional Strategy (Schema Based Instruction with Home Work/ Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among Higher Secondary School Students.
2. There will not be any significant effect of Instructional Strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/Direct Translation Strategy of teaching problem solving) with Non Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of Story Problems in Physics among Higher Secondary School Students.
3. There will not be any significant interaction effect of Instructional Strategy (Schema Based Instruction with Home Work/Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability in Physics for total sample.
4. There will not be any significant interaction effect of Instructional Strategy (Schema Based Instruction with Home Work/Schema Based Instruction

without Home Work/Direct Translation Strategy of teaching problem solving) and Logical mathematical Intelligence on Conceptual Understanding of Story Problems for total sample.

5. There will not be any significant relation between Comprehension of Problem Schema and Problem Solving Ability in Physics of higher secondary school students taught through Schema Based Instruction.

Methodology in Brief

The present study attempted to investigate the effect of Schema Based Instruction on solving story problems in physics among higher secondary school students. Hence the study was conducted to compare the effect of two types of instruction: Schema Based Instruction (with Homework/without Homework) and Direct Translation Strategy of teaching problem solving on enhancing the Problem Solving Ability and the depth of Conceptual Understanding of story problems in physics among higher secondary school students. For attaining the objectives of the investigation a quasi-experimental pretest-posttest control group design was used for the study. The study proceeded in three phases.

Phase 1: Exploration for identification of the major limitations of traditional approach to solving well-structured problems in physics, and identification of the nature of schema and essential cognitive requirements of schema construction.

Phase 2: Designing, problem schema of different problem types in select topics of physics; designing Schema Based Instructional strategy to problem solving in Physics; and development of measurement tools for the use in the experimental phase.

Phase 3: Testing the effect of the Schema Based instruction, using a quasi-experimental pretest-posttest control group design.

Design of the experimental phase of the study

The symbolic representation of the study is given below

G_1 $O_1 X_1 O_2$

G_2 $O_3 X_2 O_4$

G_3 $O_5 C O_6$

O_1, O_3, O_5 - Pre tests

O_2, O_4, O_6 -Post tests

$O_2 - O_1, O_4 - O_3, O_6 - O_5$ -Gain Scores

G_1 - Experimental group-1

G_2 -Experimental Group-2

G_3 -Control Group

X_1 - Application of Experimental treatment -1

X_2 - Application of Experimental treatment -2

C - Application of Control treatment

Sample

The standardization of the tools developed for the study is done with a sample of 100 grade 11 students doing science course. The experimental phase of the study was designed on a sample of grade 11 students doing science course. Three intact class divisions of 166 students (60 in experimental group-1, 52 in experimental group-2 and 54 in control group respectively) from two government schools(GHSS Cheemeni and GHSS Vellur from Kasargod and Kannur districts respectively) of rural background following Kerala syllabus was selected as the sample.

Tools used for the study

Nonverbal Intelligence Test, Logical Mathematical Intelligence Test, Test for assessing Problem Solving Ability in Physics, Test for assessing Conceptual Understanding of Story problems in Physics and Test for assessing Comprehension of Problem Schema were used in the study.

Statistical techniques used in the study

In addition to the basic descriptive statistics, the following statistical techniques were used for analysis of data.

1) Tests of normality and homogeneity
2) Analysis of variance (ANOVA)
3) Analysis of Covariance(ANCOVA)
4) Test of Correlation

Major Findings

The findings of the study can be summarized as follows.

1. There is a significant effect of instructional strategy on Problem Solving Ability in Physics for higher secondary school students. Both Schema Based Instruction with Homework and Schema Based Instruction without Homework significantly increase the gain in Problem Solving Ability in Physics compared to Direct Translation Strategy of teaching problem solving usually practiced in schools. Also Schema Based Instruction with Homework is significantly better than the Schema Based Instruction without Homework, for increasing Problem Solving Ability in Physics.

2. There is a significant effect of Instructional Strategy on Conceptual Understanding of Story Problems in Physics for higher secondary school students. Both Schema Based Instruction with Homework and Schema Based Instruction without Homework significantly increase the Conceptual Understanding of Story Problems in Physics compared to the Direct Translation Strategy of teaching problem solving. Also Schema Based Instruction with Homework is not significantly better than the Schema Based Instruction without Homework for increasing Conceptual Understanding of Story Problems.

3. There is no significant interaction effect of Instructional strategy and Logical Mathematical Intelligence on gain in Problem Solving Ability for the Higher Secondary School Students.

4. There is a significant interaction effect of Instructional Strategy and Logical Mathematical Intelligence on gain in Conceptual Understanding of Story Problems in Physics for Higher Secondary School Students. The most gain in Conceptual Understanding of story problems in Physics for the two levels of Logical Mathematical Intelligence (Below Average Logical Mathematical Intelligence and Above Average Logical Mathematical Intelligence) is achieved in Schema Based Instruction(with Homework/without homework) compared to Direct Translation Strategy of teaching problem solving. However no significant difference is found between Schema Based Instruction with Homework and Schema Based Instruction without Homework on gain in Conceptual Understanding of Story Problems in Physics for the two levels of Logical Mathematical Intelligence. The Below Average Logical Mathematical Intelligence group taught with Schema Based Instruction (with Homework/ without homework) showed significantly high gain in Conceptual Understanding of story problems, compared to Above Average Logical Mathematical Intelligence group taught with Direct Translation Strategy of teaching problem solving. Schema Based Instruction with home works made almost equal effect on the gain in Conceptual Understanding of story problems for Below Average Logical Mathematical Intelligence and Above Average Logical Mathematical Intelligence groups. But Above Average Logical Mathematical Intelligence groups taught with Schema Based Instruction without homework showed high gain in Conceptual Understanding of story Problems compared to Below Average Logical Mathematical Intelligence group taught with schema Based instruction Without Homework.

5. There is a positive correlation between Comprehension of Problem Schema and Problem Solving Ability in Physics for higher secondary school students.

Tenability of Hypotheses

1. The first hypothesis states that "There will not be any significant effect of instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Homework/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Problem Solving Ability in Physics among Higher Secondary School Students"

   The ANCOVA with instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Homework/ Direct Translation Strategy of teaching problem solving) as the Independent variable and Problem Solving Ability (total gain score of Problem Solving Ability) as the dependent variable treating the controlled variables namely, Non Verbal intelligence and Logical Mathematical Intelligence as covariates determined that effect of instructional strategy on the total score of Problem Solving Ability is statistically significant at 0.05 level. Therefore the first hypothesis is rejected.

2. The second hypothesis states that "There will not be any significant effect of instructional strategy (Schema Based Instruction with Home Work/ Schema Based Instruction without Home Work/ Direct Translation Strategy of teaching problem solving) with Non-Verbal Intelligence and Logical Mathematical Intelligence as covariates on Conceptual Understanding of story problems in Physics among Higher Secondary School Students".

   The ANCOVA with instructional strategy(Schema Based Instruction with Homework/ Schema Based Instruction without Homework/ Direct Translation Strategy of teaching problem solving) as the Independent variable and Conceptual Understanding of Story Problems (total gain score of Conceptual Understanding of Story problems) as the dependent variable treating the controlled variables namely, Non Verbal intelligence and Logical Mathematical Intelligence as covariates determined that effect of instructional strategy on the total score of Conceptual Understanding of Story problems is statistically significant at 0.05 level. Therefore the second hypothesis is rejected.

3. The third hypothesis states that "There will not be any significant interaction effect of instructional strategy (Schema Based Instruction with Homework/ Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Problem Solving Ability for total sample".

   The ANOVA performed for the total sample with factors instructional strategy and Logical Mathematical Intelligence upon the Problem Solving Ability ascertains that Instructional strategy and Logical Mathematical intelligence have no significant interaction effect on Problem Solving Ability at 0.05 levels. Thus the hypothesis is accepted.

4. The fourth hypothesis states that "There will not be any significant interaction effect of Instructional strategy (Schema Based Instruction with Homework/Schema Based Instruction without Homework/Direct Translation Strategy of teaching problem solving) and Logical Mathematical Intelligence on Conceptual Understanding of Story Problems for total sample".

   The ANOVA performed for the total sample with factors Instructional strategy and Logical Mathematical Intelligence upon the Conceptual Understanding of Story Problems in Physics ascertains that Instructional strategy and Logical Mathematical intelligence have a significant interaction effect on Conceptual Understanding of Story Problems in Physics at 0.05 levels. Thus the hypothesis is rejected.

5. The fifth hypothesis states that "There will not be any significant relation between Comprehension of Problem Schema and Problem Solving Ability in Physics among higher secondary school students taught with Schema Based Instruction".

   This hypothetical statement involves two variables: Comprehension of Problem Schema and Problem Solving Ability. Pearson's product moment coefficient of correlation (r) was performed to ascertain the Correlation between these two variables. It is found that there was positive correlation between Comprehension of Problem Schema and Problem Solving Ability in Physics among higher secondary school students taught with Schema Based Instruction (at 0.01 levels). Hence the hypothesis is rejected.

Conclusion

Schema Based Instruction plays major role not only in enhancing Problem Solving Ability but also in enhancing Conceptual Understanding of Story Problems in Physics. After giving Schema Based Instruction as an experimental intervention, students of both the experimental groups those who are given Schema Based Instruction with Homework and those without Homework have appreciable improvement in their Problem Solving Ability and Conceptual Understanding of story problems compared to the control group which was taught by Direct Translation Strategy of teaching problem solving. Thus it can be concluded that the Schema Based Instruction is effective in enhancing Problem Solving Ability and Conceptual Understanding of story problems in Physics among Higher Secondary School Students.

Students taught through Schema Based Instruction with Homework exhibited more Problem Solving Ability in Physics than those who were taught through Schema Based instruction without Homework. However there was no significant difference between Schema Based Instruction with Homework and Schema Based

Instruction without Homework in improving the Conceptual Understanding of story problems in Physics.

The study investigated the interaction effect of Instructional strategy and Logical Mathematical Intelligence on Problem Solving Ability and Conceptual Understanding of story problems. The study result reveals that there is no significant interaction effect between the instructional strategy and Logical Mathematical Intelligence of the students on the Problem Solving Ability in Physics. But there had been significant interaction effect between the Instructional strategy and Logical Mathematical Intelligence of students on Conceptual Understanding of story problems in Physics. When the effect of instructional strategy in improving the Conceptual Understanding of both the students with below average Logical Mathematical Intelligence and those with above average Logical Mathematical Intelligence were analyzed, it was concluded that the Schema Based Instruction (with Homework/without Homework) was more effective than the Direct Translation Strategy of teaching problem solving.

As a result of the application of Schema Based Instruction in teaching problem solving, the Conceptual Understanding of story problems for the students with below average Logical Mathematical Intelligence was found to be better than that of students with above average Logical Mathematical Intelligence who were taught through the Direct Translation Strategy of teaching problem solving. Another finding suggests that there was no significant difference between Schema Based Instruction with Homework and Schema Based Instruction without Homework in improving the Conceptual Understanding of story problems for both the students with below average Logical Mathematical Intelligence and those with above average Logical Mathematical Intelligence.

This finding corresponds to the research studies of Powell (2011), Jitendra et al. (2013), and Praveen (2017) which suggests that Schema Based Instruction develops skill of solving well-structured problems. Schema Based instruction uses concept map like structures which validates the study of Moore(2013) that suggests concept maps as advance organizers or navigation aids to promote Conceptual Understanding.

The traditional method of problem solving, 'Direct Translation Strategy' gives more importance to the memorization of mathematical formulae and mimic of mathematical procedure given in the worked out examples than the comprehension of the concepts underlying the story problem. As a result, teachers and students of Physics have seen problem solving in Physics as merely a mathematical procedure. This could be a cause for the conceptual aspect of the story problem being neglected. In Schema Based Instruction, the students are supposed to be exposed to a learning environment where they are encouraged to solve the problem with a Conceptual Understanding of it.

The problem schema should be constructed in the memory of the learner in order to solve the story problem effectively (Marshall, 1995, Jonassen, 2010, Jitendra, 2013). Schema Based Instruction designed in this study gives more emphasis to the construction and development of the problem schema in the learners. A quality problem schema will be constructed in a learner only if the learner could properly comprehend the relevant elements that are included in a problem schema of each problem type. The research also examined the relation of the comprehension of problem schema with Problem Solving Ability. The finding of the study indicates that there is positive correlation between comprehension of problem schema and Problem Solving Ability in Physics. The students who exhibited high Problem Solving Ability also had a higher level of comprehension of the problem schema. In short, the study elucidates that the proper construction of knowledge takes place effectively through Schema Based Instruction.

As part of this study investigator had collected perception of students on Schema Based Instruction. It was understood that the students perceived Schema Based Instruction as helpful, easily comprehensible, and meaningful. The students also perceived this method as comfortable and enjoyable one. Thus it is asserting that the students who were instructed with this strategy, value it for its cognitive aspects as well as affective aspects, as evident from the high percentages of positive perception detailed in Table 52.

Educational Implications

As story problem solving promotes meaningful conceptual learning, it has important role in Physics education. This study demonstrated how the Schema Based Instruction was effective in enhancing problem solving in Physics among higher secondary school students. It was found that both Schema Based Instruction with Homework and Schema Based Instruction without Homework significantly increase Problem Solving Ability and Conceptual Understanding of Story problems in Physics of 11th grade Students better than the usual Direct Translation Strategy of teaching problem solving. Based on the major findings of the study following implications can be stated.

1. Meaningful learning takes place when the learner solves problems with Conceptual Understanding. The study reveals that Schema Based Instruction is effective than Direct Translation Strategy of teaching problem solving to increase Problem Solving Ability and Conceptual Understanding. Therefore the present study suggests the use of Schema Based Instructional strategy for teaching Physics problem solving at higher secondary school level. Higher secondary school teachers may be trained for using Schema Based Instruction in teaching problem solving. For this a module can be constructed for training higher secondary school teachers. Another module to train students in schema based problem solving learning may also be attempted.
2. As Schema Based Instruction helps to increase Problem Solving Ability and Conceptual Understanding of Problems among the learners, an interactive learning environment can be developed with the help of computer by incorporating logical phases of Schema Based Instruction.

3. The way of teaching problem solving should be apt for the creation of problem schema, since its quality in the learners influences the process of problem solving (Jonassen, 2010). The Phases of schema based instruction of this study have been designed in such a way that it gives more focus to the creation and development of quality problem schema. In order to ensure the quality of problem schema, the assessment of problem solving should be one that is capable of assessing the attributes of the problem schema developed in the learner. The complete problem schema is not only includes the procedure for problem solving. It includes the concepts, structural relationships and situational characteristics related to each problem type (Jonassen, 2010).Thus, the assessment should give due importance to their ability to identify important conceptual elements in the problem situation, draw situation diagram, identify relevant & irrelevant physical quantities in the problem, identify problem type and to understand major concepts embedded in the problem in addition to considering factors such as the ability of the student to recall a mathematical formula and mathematical procedure. Study suggests that this can make the problem solving process more meaningful. Such tools can be developed for the assessment of problem solving.

4. Schema Based Instruction designed in this study has provided learners the chance to get acquainted with not only situationally dissimilar and structurally similar problems but also situationally similar and structurally dissimilar problems. This encouraged students to give more importance to the structural Information rather than surface level features of the problems, which is believed to have helped them enhance their Problem Solving Ability as well as Conceptual Understanding of the problem. Thus this study suggests that situationally similar and structurally dissimilar problems along with situationally dissimilar and structurally similar problems be included as

practice problems. This would prompt learners to focus more on the structural information of the story problems.

5. Students who acquired Problem solving Skill during their schooling should be able to transfer these skills to be applied in research and industry in the future. To ensure transfer of Problem Solving Ability, students have to develop deep Conceptual Understanding. The study suggests that the students require training to develop Conceptual Understanding through problem solving process. The Schema diagram and structure map of problem type can be utilized as a tool to do this. Construction of structure map for each problem type helps students in understanding the inter relationship between various physical quantities within the problem types. This enhances Conceptual Understanding.

6. Experts solve problems successfully, because they construct robust problem schema as which the novices fail to do (Chi et al., 1981).Students will be able to solve story problems successfully if they are taught to develop the same problem schema conceived by the experts. The schema diagram is designed in this study giving focus to the important attributes of the conceptual models (problem schema) developed by experts. The diagram helped the students to organize the situational characteristics, structural relationships and mathematical formulae as a meaningful pattern in their memory. Therefore this study suggests that the schema diagram for each type of problem can be designed with the help of experts and thus can be included in the teacher's handbook and the physics text books in order to help Schema Based Instruction and encouraged schema based learning respectively. This would help increase the comprehension of problem schema and enhance the Problem Solving Ability of the students.

Suggestions for Further Study

1. The present study was delimited to solving story problems in the topics 'Work Energy and Power' in Physics. Future researchers can examine the effect of Schema Based Instruction on solving story problems in other areas of Physics like, current electricity, Electrodynamics, Magnetism Nuclear physics, solid state physics, and properties of fluids.
2. Other science disciplines like Chemistry and Biology also give importance to problem solving. Therefore, future researchers can investigate the effect of Schema Based Instruction on Problem Solving Ability and Conceptual Understanding of story problems in those scientific domains.
3. Future researchers can explore the possibilities of Schema Based Instruction on enhancing Problem Solving Ability and Conceptual Understanding among Engineering and other undergraduate students.
4. The effect of schema based instruction on transfer of Problem Solving Ability in solving other story problems may be studied.

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Appendices

Appendix A

Structure Map of Problem Types:
Work Kinetic Energy Theorem and Conservation of Mechanical Energy

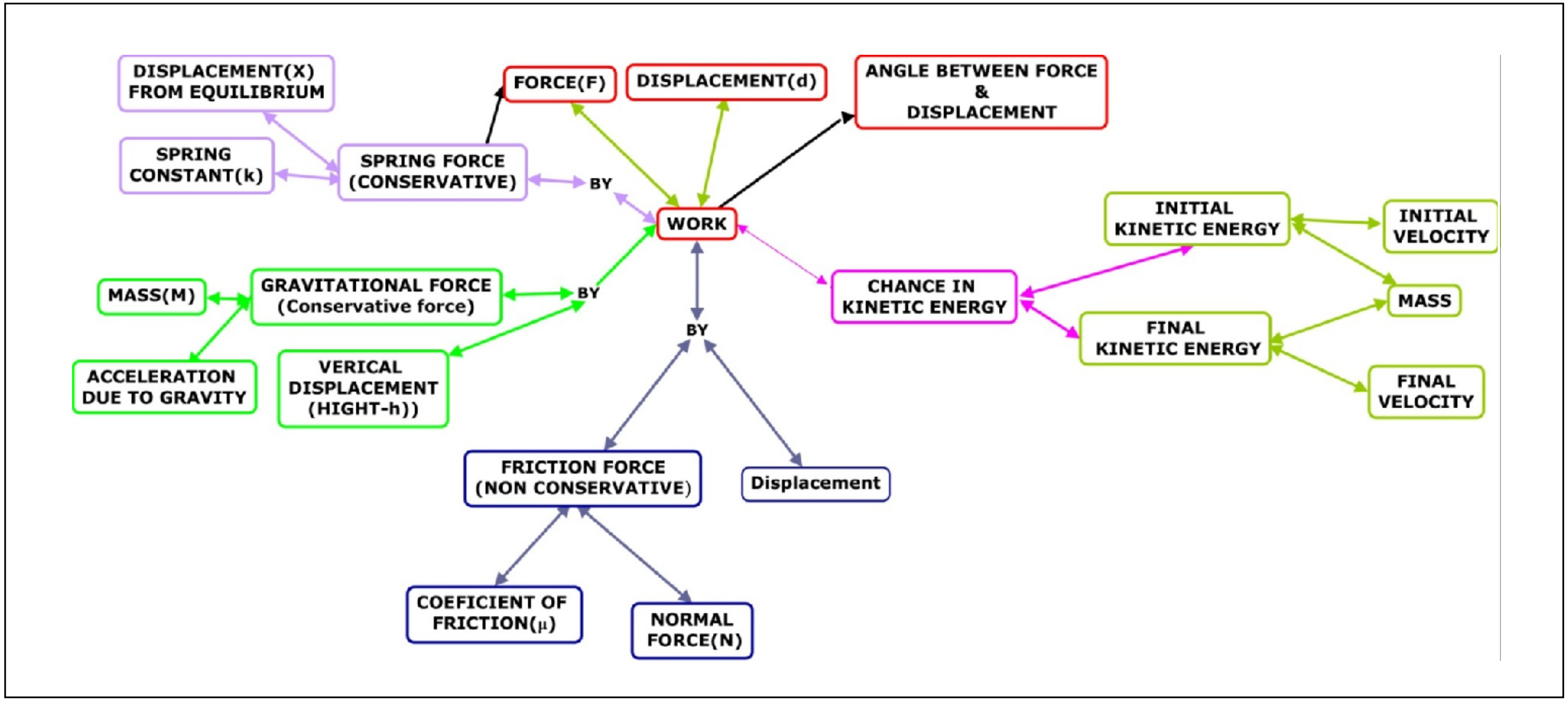


Figure A: Structure Map of Problem Types- Work Kinetic Energy Theorem

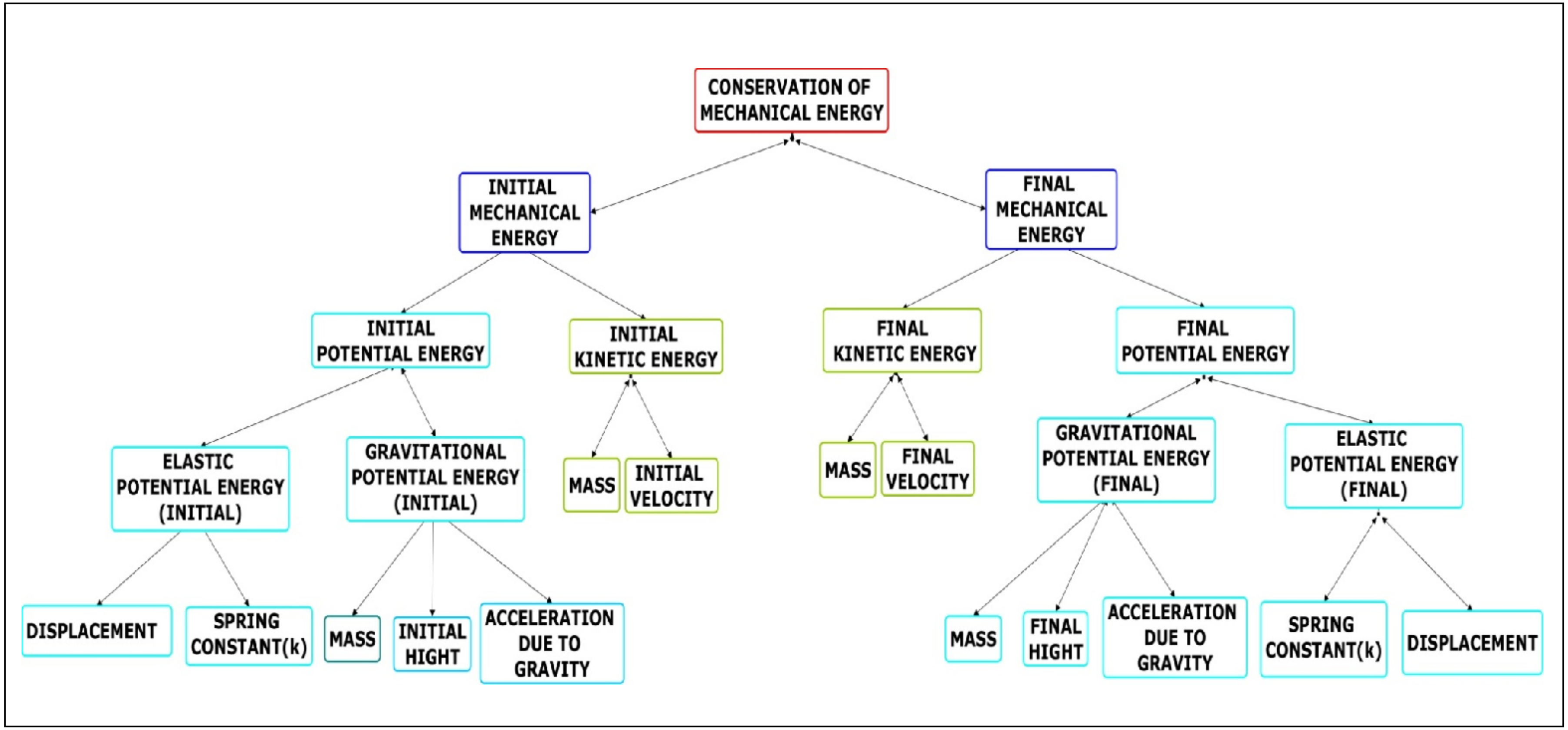
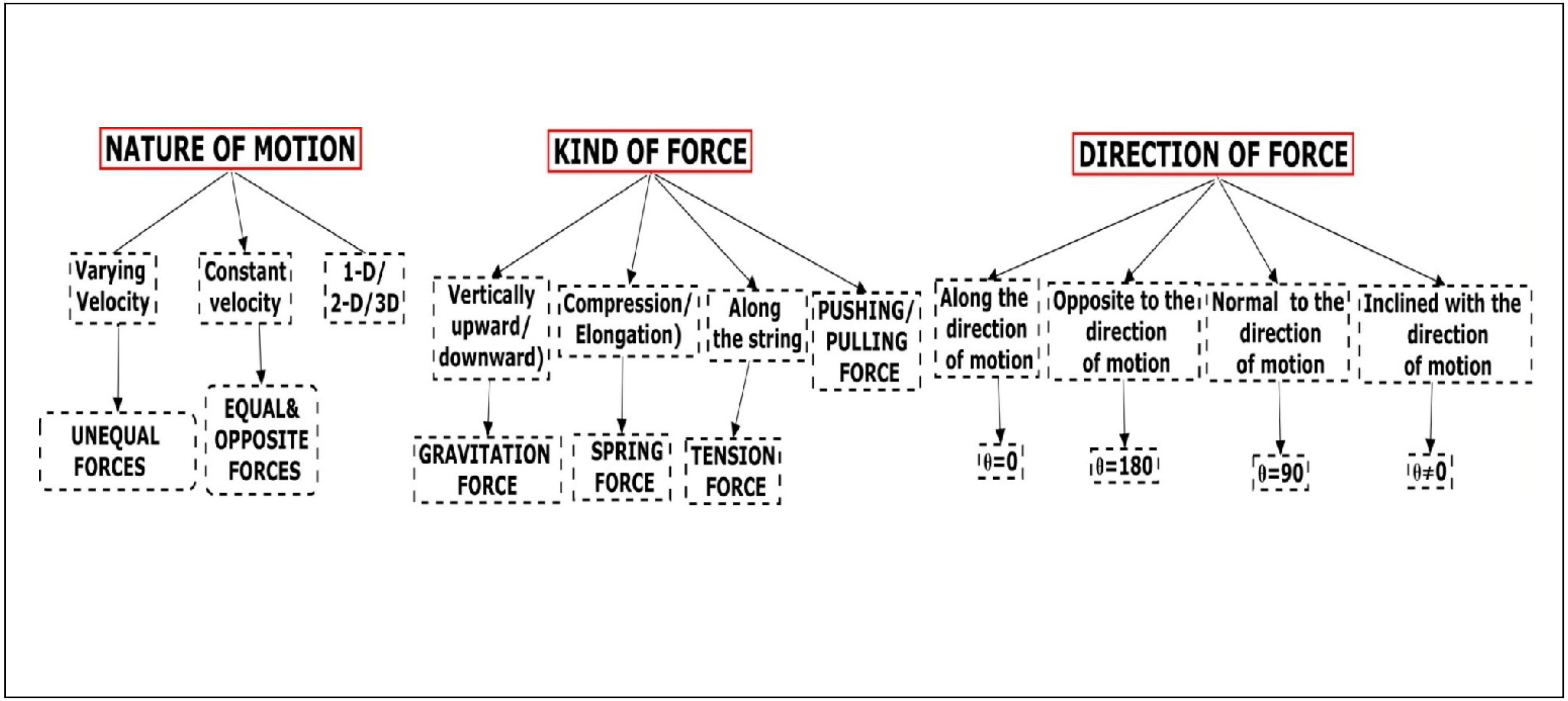


Figure B: Structure Map of Problem Type- Conservation of Mechanical Energy

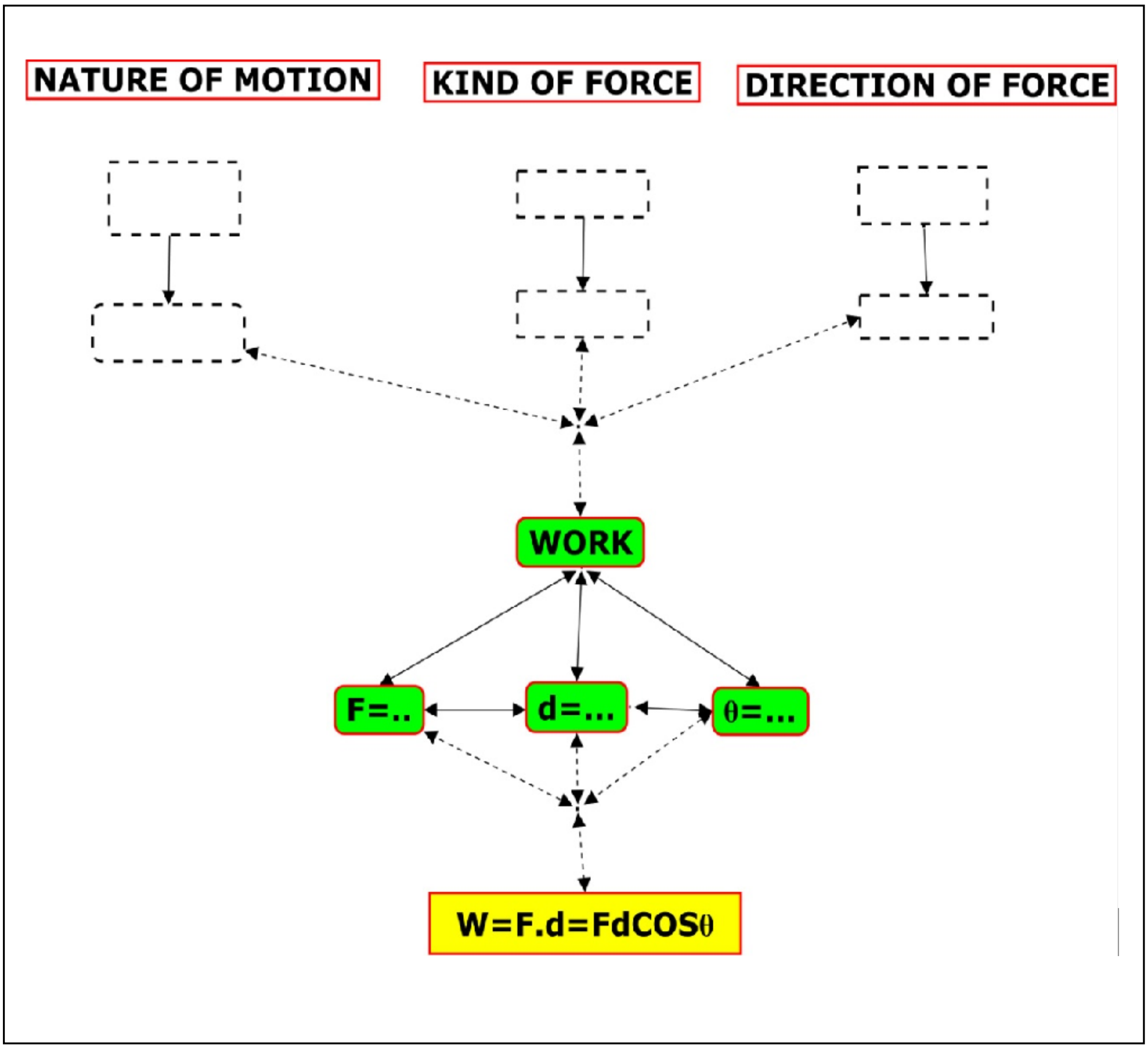
Appendix B1

Situational Model of Problem Type "Work"



Appendix B2

Problem Schema of "Work" Type Problems

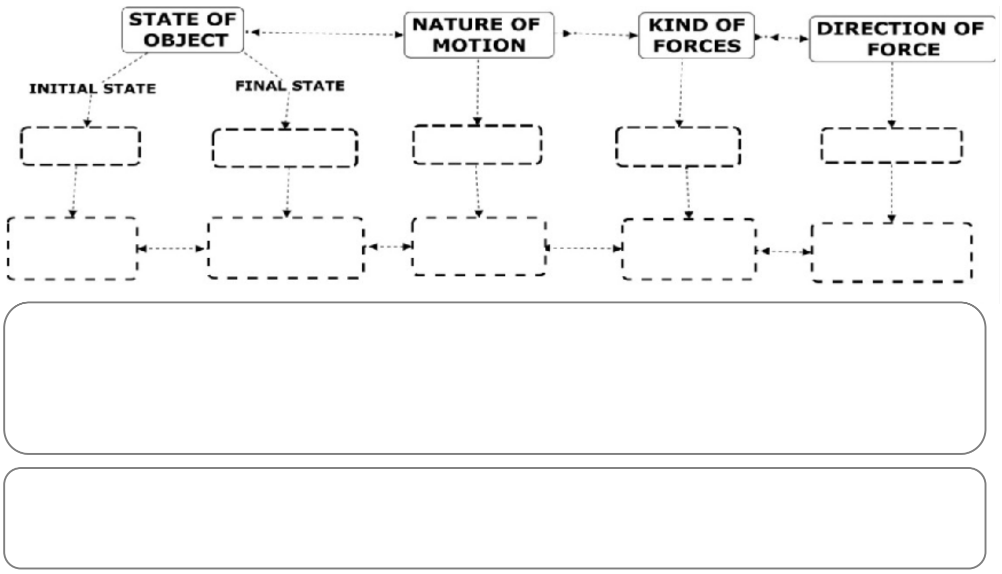


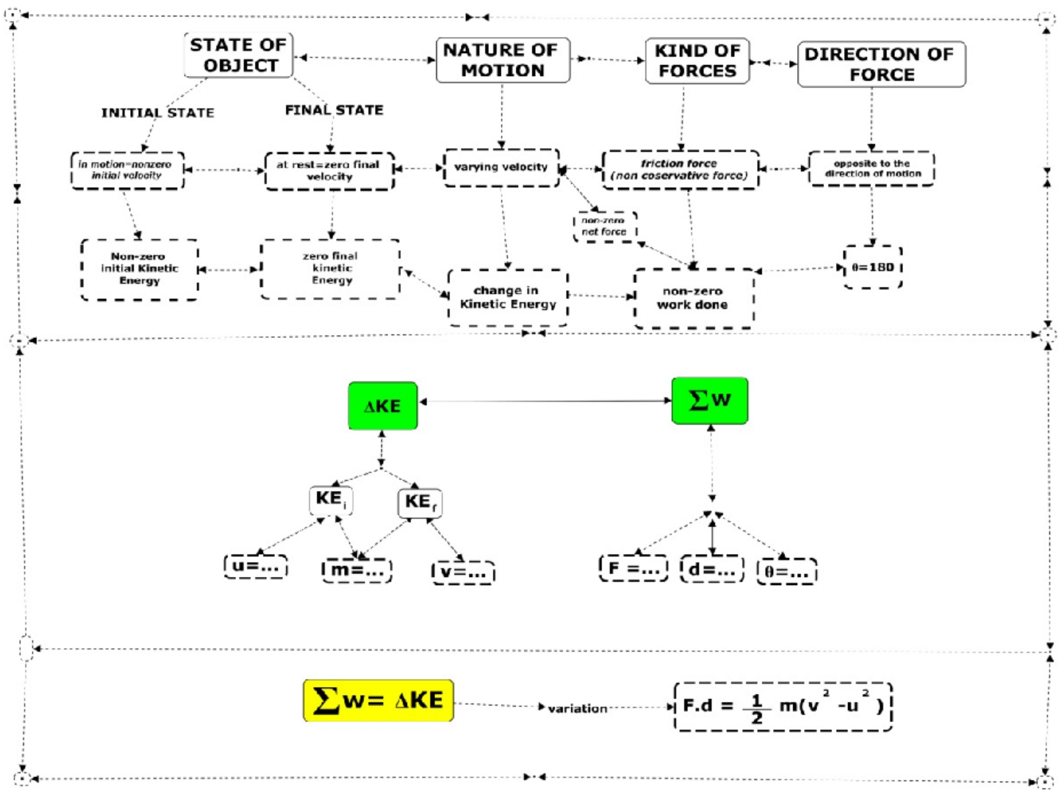
Appendix B3

Model of Worksheet and Problem Schema with Filled Slots

(*Problem Type 'Work-Kinetic Energy Theorem'*)

***Problem*: A 1200 kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?**





Appendix C1

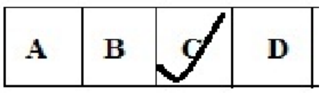
LOGICAL MATHEMATICAL INTELLIGENCE TEST

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

Instructions

1. This booklet contains 36 multiple choice questions, each worth 1 mark. (No negative mark)
2. Do not write anything on this booklet.
3. Answer all questions. Each question is followed by four choices (A,B,C,D), one of which is correct. You will record your responses on a separate answer sheet.
4. When marking answers on the answer sheet, for each question, Put [√] mark only on the box corresponding to the right answer. E.g. If the right answer is C ,



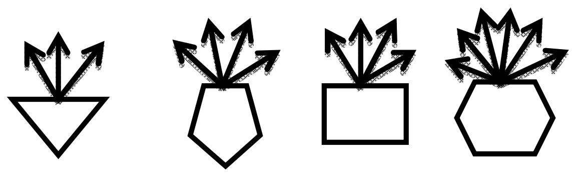
5. Make sure that your answer is clearly marked.
6. After the test please return this booklet along with answer sheet to the invigilator.

Directions: ***Three of the following four are alike in a certain way and so form a group. Which is the one that doesnot belong to that group?***

1. (A) 81 **(B)** 41 **(C)** 36 **(D)** 25

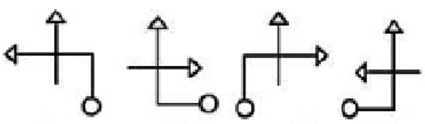
Choose the figure which is different from the rest

2.



(A) **(B)** **(C)** **(D)**

3. Which of the figure, you think best fits the series below?



A **B** **C** **D**

4. Identify the next number in the series,

9, 8, 8, 8, 7, 8, 6, ……….

(A) 5 (B) 6 (C) 8 (D) 4

5. Arrange the given words in alphabetical order and pick the one that comes first.

(A) NATURE (B) NATIVE (C) NARRATE (D) NASCENT

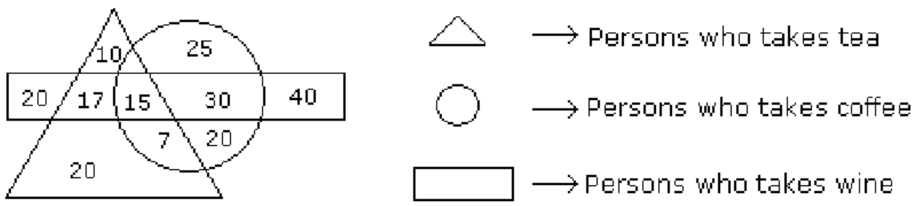
6. If the first and the third letters in the word NECESSARY were interchanged, also the fourth and the sixth letters and the seventh and the ninth letters, which of the following would be the 7th letter from the left?

(A) Y (B) R (C) E (D) A

7. In certain code **'FORM'** is written as **'ERQP'**How will **'CLEAN'** be written in that code?

(A) BOFDO (B)GKHBQ (C) BODDM (D)GMKBQ

Analys the diagram given below and answer each of the following questions:



8. How many persons who take tea and wine but not coffee?

(A) 20 (B) 17 (C) 25 (D) 15

Read the following information carefully and answer the question given below

9. Veena went to North. Thenshe turned right and proceed. Then she turned left and walked 5 km. Finally she turned left again. In which direction was she moving then?

(A) South (B) North (C) West (D) East

10. Tom walked 8 km towards south and turned right. After walking 5 km he turned to the left and walked 8 km. Then in which direction was he from the starting point.

(A)North-East (B)South- West (C)North-West (D) South –East

11. Rahul ranked ninth from the top and thirty eight from the bottom in a class. How many students are there in the class?

(A) 47 (B) 52 (C) 46 (D) 50

12. How many 6's are there in the following number series which are immediately preceded by 4 and followed by 7?

3, 1 ,2, 9, 6, 4, 7, 6, 4, 6 ,7 ,2 , 9, 7, 6, 4 , 4, 6, 7

(A)One (B)Two (C)Three (D) Four

Directions: ***In each question below, is given a statement followed by two assumptions numbered I and II. You are required to assess the given statement and decide which of the given assumptions is implicit in the statement.***

13. Statement: It is desirable to put the child in the school at the age of 5 or so

Assumptions:

I. At that age the child reaches appropriate level of development and ready to learn**.**

II. The school do not admit children after six yearsof age.

(A)Only assumption **I** is implicit (B) Only assumption **II** is implicit

(C) Both I and **II** are implicit (D) Neither I nor **II** are implicit

Directions*:* ***In each of the following questions, two statements numbered I and II are given. There may be cause and effect relationship between the two statements. These two statements may be the effect of the same cause or independent causes. These statements may be independent causes without having any relationship. Read both the statements in each question and mark your answer.***

14. Statements:

I. The government has recently fixed the fees for professional courses offered by the unaided institutions which are much lower than the fees charged last year.

II. The parents of the aspiring students launched a severe agitation last year protesting against the high fees charged by the unaided institutions.

(A) Statement I is the cause and statement II is its effect

(B)Statement II is the cause and statement I is its effect

(C) Both the statements I and II are independent causes

(D) Both the statements I and II are effects of independent causes

15. Statements:

I. The school authority has asked the X Std. students to attend special classes to be conducted on Sundays.

II. The parents of the X Std. students have withdrawn their wards from attending private tuitions conducted on Sundays**.**

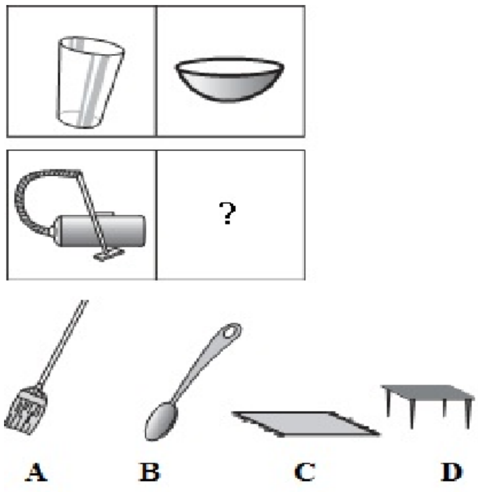
(A) Statement I is the cause and statement II is its effect

(B) Statement II is the cause and statement I is its effect

(C) Both the statements I and II are independent causes

(D) Both the statements I and II are effects of independent causes

16. Directions: ***Choose the picture that would go in the empty box so that the two bottom pictures are related in the same way as the top two are related***



17. If **K= 2P + 2W** then pick out the correct one

(A) W= $\frac{K}{2P}$ **(B) W=** $\frac{K-2P}{2}$ **(C) W=** $\frac{2P-K}{2}$ **(D) W=** $\frac{K+2P}{2}$

18. If- means x, x means + ,+ means ÷ and ÷ means – what will be the value of

40x12+3-6÷60 =….?

(A) 44 (B) 7.95 (C) 4 (D) 8

Directions: ***In each question below are given two statements followed by two conclusions numbered I and II. You have to take the given two statements to be true even if they seem to be at variance from commonly known facts. Read the conclusion and then decide which of the given conclusions logically follows from the two given statements, disregarding commonly known facts.***

19. **Statements:** Some clips are green. All greens are red

Conclusions: I. All clips are red **II.** Some clips are red

(A) Only conclusion I follows (B) Only conclusion II follows

(C) Neither I nor II follows (D) Both I and II follow

20. **Statements:** All planets are moons. All moons are stars.

Conclusions: I. All moons are planet **II.** All planets are stars

(A) Only conclusion I follows (B) Only conclusion II follows

(C) Neither I nor II follows (D) Both I and II follow

21. January 1 ,2007 was Monday. What Day of the week on January 1 ,2008?

(A) Monday (B) Tuesday (C) Wednesday (D) Sunday

22. If 25th August is Thursday, how many Mondays are there in August

(A) 3 (B) 4 (C)5 (D) 6

23. If the day after tomorrow is Sunday ,what was the day before yesterday

(A) Friday (B) Thursday (C) Wednesday (D) Saturday

24. Ajayan left home for the bus stop 15 minute earlier than usual. It takes 10 minute to reach the stop. He reached the stop at 8.40 AM. What time does he usually leave home for the bus stop?

(A) 8:30 AM (B) 8:45 AM (C) 8:55 AM (D) 8:25 AM

25. A watch reads 4:30 . If the minute hand points East ,then in which direction will hour hand point.

(A) North (B) North-East (C) South-East (D) North-West

26. The ages of Pinky, Rinky, Tinky and Minky are 20 yr, 15yr, 5yr, 8yr respectively. The average age of the four girls is ………

(A) 18 yr (B) 12 yr (C)15 yr (D) 13 yr

27. The average age of 36 students in a group is 14 years .When teacher's age is included to it, the average increases by one. What is the teacher's age in years?

(A) 31 (B) 36 (C)51 (D) 28

28. A does a work in 10 days and B does the same work in 15 days .In how many days they together will do the same work ?

(A) 6 days (B) 25 Days (C) 12 days (D) 5 days

29. A is twice as fast as B and B is thrice as fast as C . The Journey covered by C in 42 minutes will be covered by A in …..

(A) 7 min. (B)14 min. (C)28min. (D)63min.

30. In a school there are 256 students; boys and girls are in the ratio 9:7. Then the number of girls is

(A) 56 (B) 112 (C) 84 (D) 67

31. The sum of two numbers 40. Their difference is 4. The ratio of the number is

(A) 10:9 (B) 9:11 (C) 11:9 (D) 9:10

32. 24÷ 6(10-4) - 18+2=…….?

(A) 8 (B) 1.5 (C) 40 (D) 44

33. 4 of $\frac{3}{8} \div \frac{3}{8} + \frac{1}{7}$ = ……..?

(A) $7\frac{1}{4}$ (B) $1\frac{4}{7}$ (C) $4\frac{1}{7}$ (D) $\frac{10}{71}$

34. 50 + 50 % of 50 is………

(A) 60 (B) 70 (C) 75 (D) 100

35. In an examination 65% of the total students passed. If the number of failures is 420, the total number of students is ……

(A) 500 (B)1200 (C) 1000 (D)1625

36. The sum of the ages of father and a sun is 52. The difference of their ages is 28 then the age of the father is …..

(A) 48 (B) 34 (C) 40 (D) 36

Appendix C2

LOGICAL MATHEMATICAL INTELLIGENCE TEST

RESPONSE SHEET

Name of the student: ……………………………………. Gender: Male / Female

Class:…….Subject: ………………..Name of the School :……………………..

Category: Government / Aided / Private

- Put [✓] mark only on the box corresponding to the right answer.
  eg: If the right answer is C ,

Q NO:				
1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D
11	A	B	C	D
12	A	B	C	D

Q NO:				
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D
21	A	B	C	D
22	A	B	C	D
23	A	B	C	D
24	A	B	C	D

Q NO:				
25	A	B	C	D
26	A	B	C	D
27	A	B	C	D
28	A	B	C	D
29	A	B	C	D
30	A	B	C	D
31	A	B	C	D
32	A	B	C	D
33	A	B	C	D
34	A	B	C	D
35	A	B	C	D
36	A	B	C	D

TOTAL SCORE	

Appendix C3

LOGICAL MATHEMATICAL INTELLIGENCE TEST

SCORING KEY

Q.NO	ANS
1	B
2	B
3	A
4	C
5	C
6	A
7	C
8	B
9	C
10	B
11	C
12	B
13	A
14	B
15	A
16	A
17	B
18	C

Q.NO	ANS
19	B
20	B
21	B
22	C
23	C
24	B
25	B
26	B
27	C
28	A
29	A
30	B
31	C
32	A
33	C
34	C
35	B
36	C

Appendix D1

TEST FOR ASSESSING PROBLEM SOLVING ABILITY IN PHYSICS

DRAFT

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

Class: XI   Subject: Physics   Unit: Work Energy & Power   Max. Mark: 40   Time: 2h

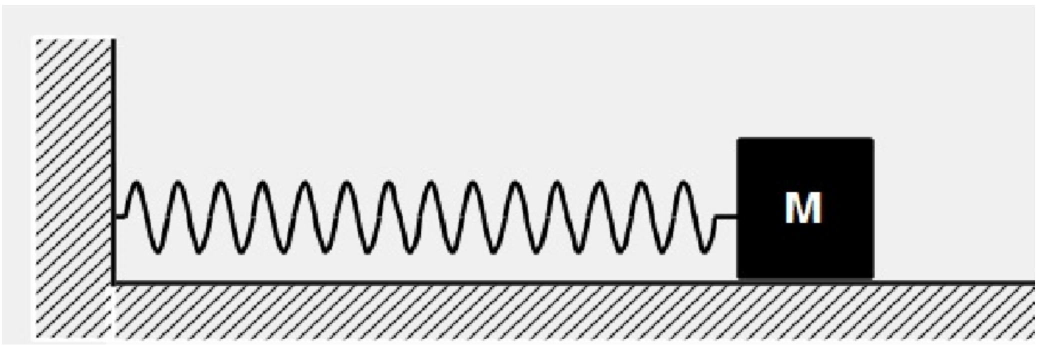
(PART-1)

General Instructions:

- This test paper consists of 10 problems (1- 10) of two marks each
- Solve all the problems.
- No negative marks for wrong answers.
- Use of calculators is permitted.

1. A man cleaning a floor pulls a vacuum cleaner with a force of magnitude F= 50 N at an angle of 30^o with the horizontal. Calculate the work done by the force on the vacuum cleaner as the vacuum cleaner is displaced 3 m to the right.

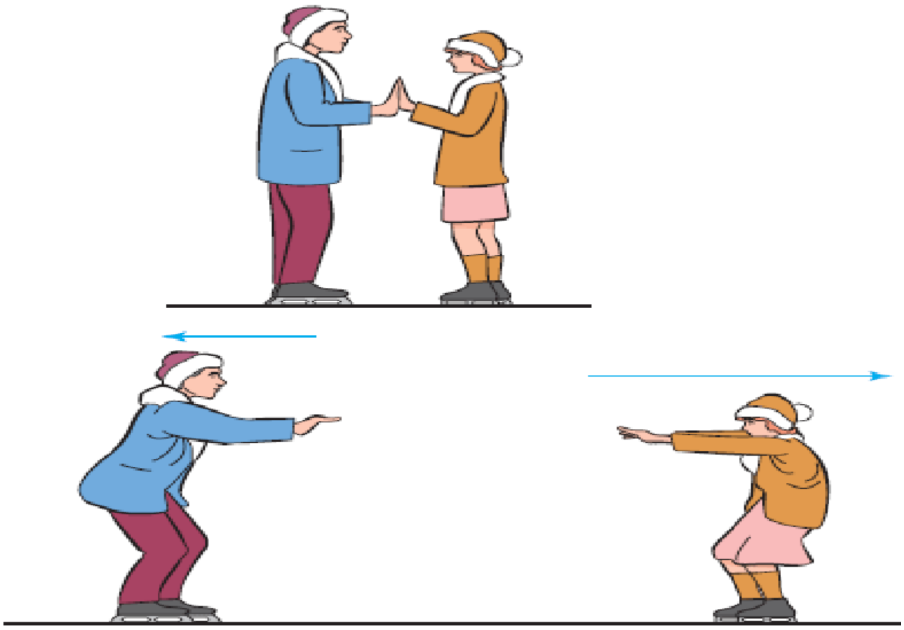
2. A block of mass 1.6 Kg is attached to a horizontal spring that has a force constant of $1x10^3$ N/m. The spring is compressed 2cm and is then released from rest. Calculate the work done by the spring?



3. A 1200kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?

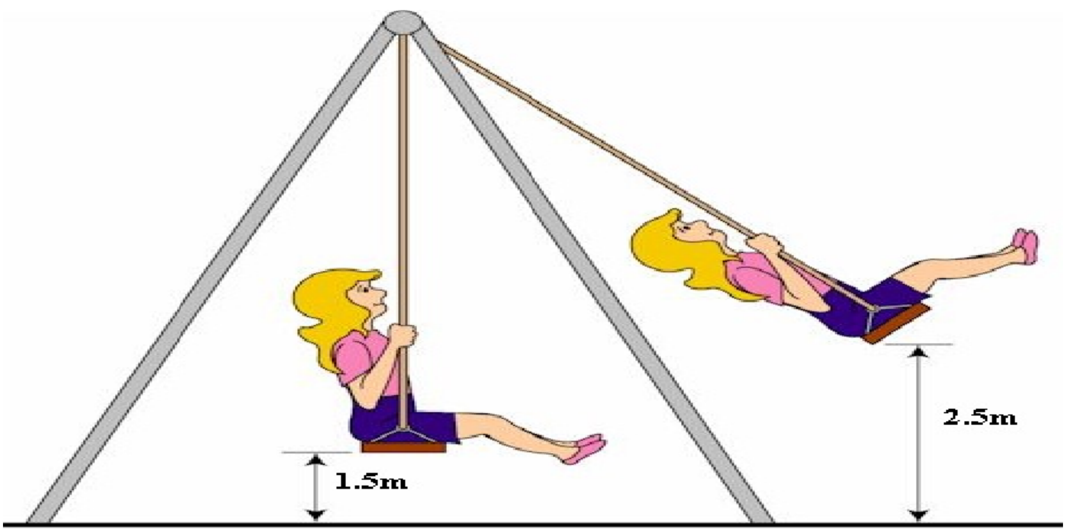
4. A 2000kg elevator rises from rest in the basement to the fourth floor, a distance of 25m. As it passes the fourth floor, its speed is 3m/s. There is a constant frictional force of 500N. Calculate the work done by the lifting mechanism.

5. A 62.1-kg male ice skater is facing a 42.8-kg female ice skater. They are at rest on the ice. They push off each other and move in opposite directions. The female skater moves backwards with a speed of 3.11 m/s. Determine the final speed of the male skater

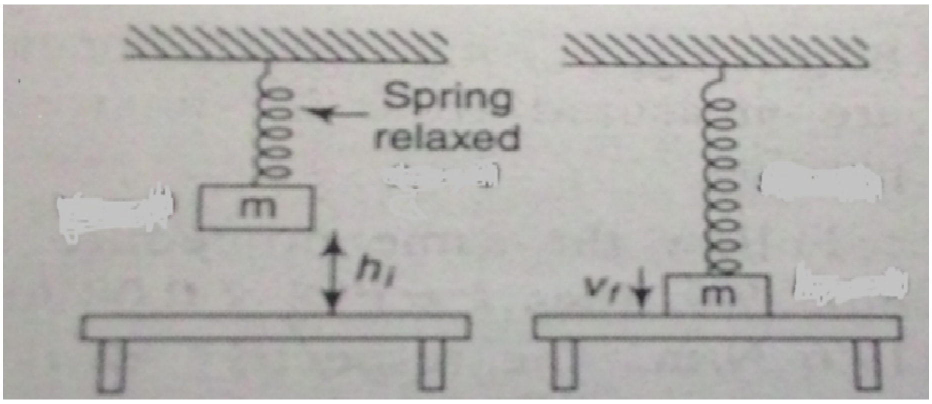


6. An engine expends 40 horse power (hp) in propelling a car along a level track at 15m/s. How large is the total retarding force acting on the car? (where 1hp=746W)

7. A girl in a swing is 2.5m above the ground at the maximum height and at 1.5 m above the ground at the lowest point. Calculate her maximum velocity in the swing ($g=10m/s^2$)



8. A body of mass 10g is attached to a hanging spring whose force constant is 10N/m. The body is lifted until the spring is in its unstretched state. The body is then released. Calculate the speed of the body when it strikes a table 15 cm below the release point



9. A man weighing 60kg climbs a staircase carrying a 20 kg load on his head. The stair case has 20 steps and each step has a height of 20cm. if he takes 10 second to climb, calculate the power.

10. A body A of mass 2kg moving with a velocity of 25m/s in the east direction collides with another body B of mass 3kg moving with velocity of 15m/s westwards. Calculate the velocity of each ball after the collision?

(PART- 2)

General Instructions:

- *This test paper consists of 10 problems(11- 20) of two marks each*
- *Solve all the problems.*
- *No negative marks for wrong answers.*
- *Use of calculators is permitted.*

---

11. A bullet of mass 20g is found to pass two points 30m apart in a time interval of 4 second. Calculate the kinetic energy of the bullet if it moves with constant speed?

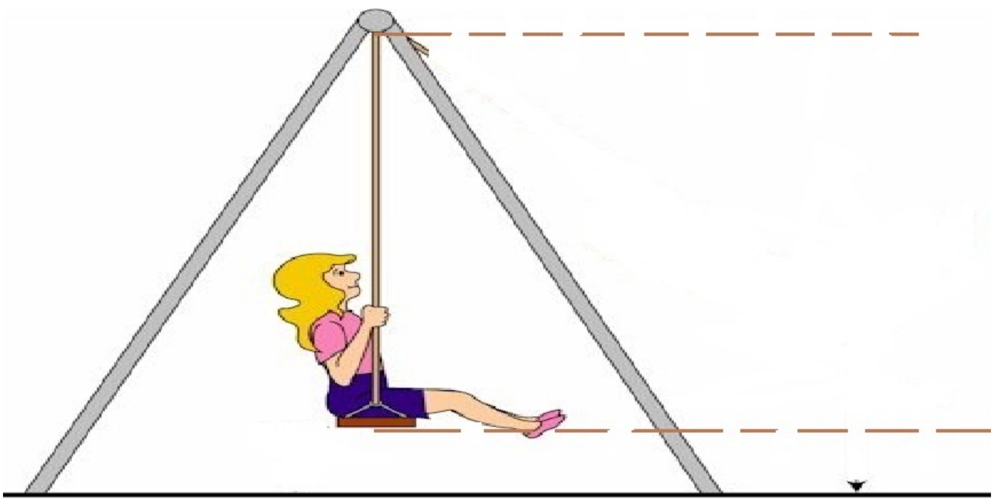
12. Two blocks of masses 0.3kg and 0.2kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. The blocks collide and stick together. The velocity of blocks after collision is (-0.1m/s). Find the loss in kinetic energy during the collision.

13. A running student has half the kinetic energy that his brother has. The student speeds up by 1 m/s, at which point he has the same kinetic energy as his brother. If the student's mass is twice as large as his brother's mass, what were the original speeds of both the student and his brother?

14. A spoon is raised 21 cm above a table. If the spoon and its contents have a mass of 30g, what is the gravitational potential energy associated with the spoon at that height relative to the table?

15. A spring with a force constant of 5.2 N/m has a relaxed length of 2.45 m. When a mass is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 3.57 m. Calculate the elastic potential energy stored in the spring?

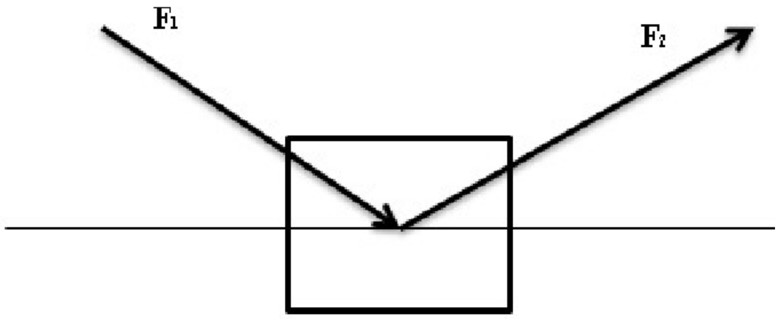
16. A 40 kg child is in a swing that is attached to ropes 2 m long. Find the gravitational potential energy associated with the child relative to the child's lowest position under the following condition: when the ropes are horizontal h=2, m=40,g=9.8



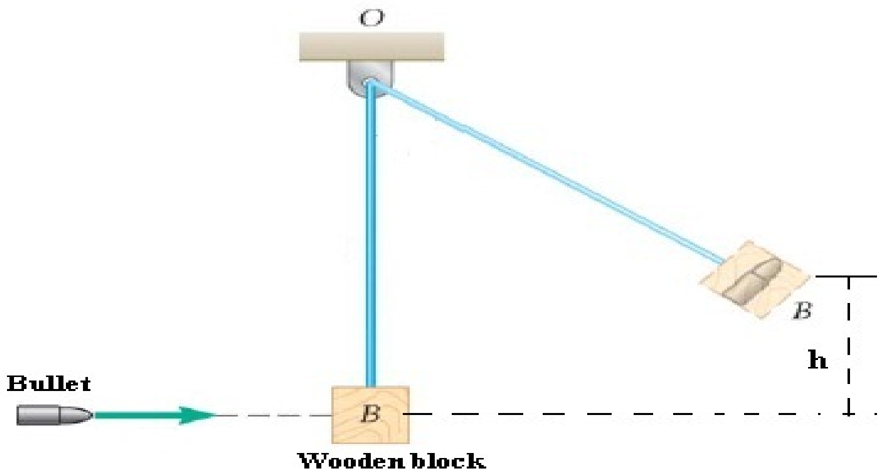
17. A 60-gram tennis ball is loaded into 2-kg homemade cannon. The cannon is at rest when it is ignited. Immediately after the impulse of the explosion, a photogate timer measures the cannon to recoil backwards a distance of 6.5 cm in 0.218 seconds. Determine the post-explosion speed of the cannon and of the tennis ball?

18. A Bomb of mass 30kg at rest explodes into two pieces of masses 18kg and 12kg. The velocity of 18kg mass is 6m/s. Calculate the kinetic energy of the other mass?

19. Two industrial men sliding an initially stationary 225 kg Box, a displacement S of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 30^{o} downward from the horizontal; the pull of man 2 is 10N directed at 40^{o} above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?



20. A Bullet of mass 10 g travels horizontally with a speed of 100m/s and is absorbed by a wooden block of mass 90 g suspended by a string. Calculate the vertical height through which the block rises. Given $g=10m/s^2$



Appendix D2

TEST FOR ASSESSING PROBLEM SOLVING ABILITY IN PHYSICS

FINAL

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

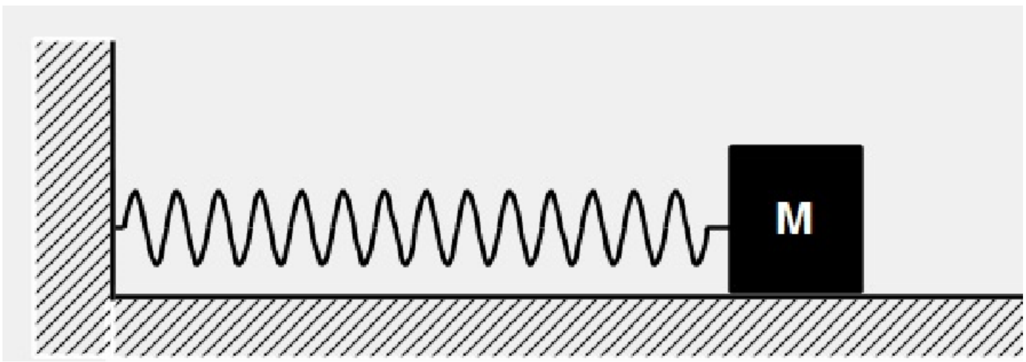
Class: XI   Subject: Physics   Unit:Work Energy & Power   Max. Mark: 28   Time:75 min

General Instructions:

- This test paper consists of 14 problems (1- 14) of two marks each
- Solve all the problems.
- No negative marks for wrong answers.
- Use of calculators is permitted.

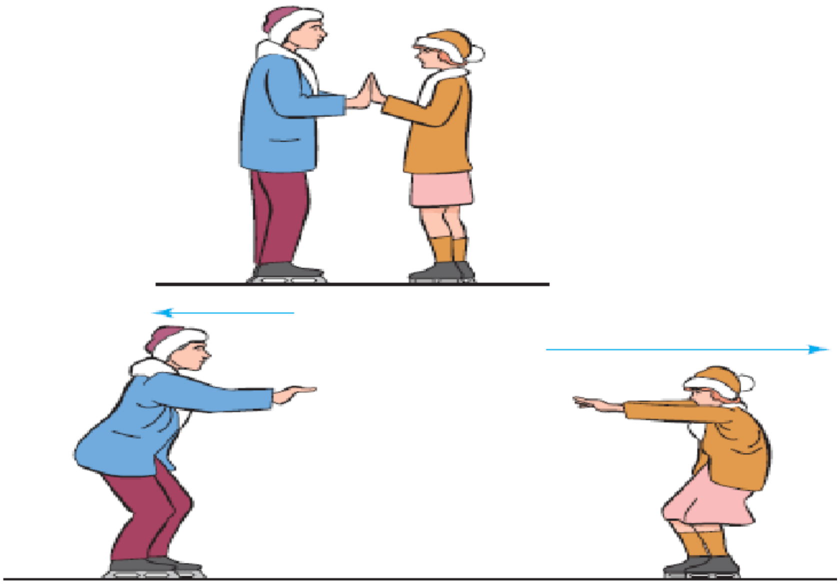
1. A man cleaning a floor pulls a vacuum cleaner with a force of magnitude F= 50 N at an angle of 30^o with the horizontal. Calculate the work done by the force on the vacuum cleaner as the vacuum cleaner is displaced 3 m to the right.

2. A block of mass 1.6 Kg is attached to a horizontal spring that has a force constant of $1x10^3$ N/m. The spring is compressed 2cm and is then released from rest. Calculate the work done by the spring?



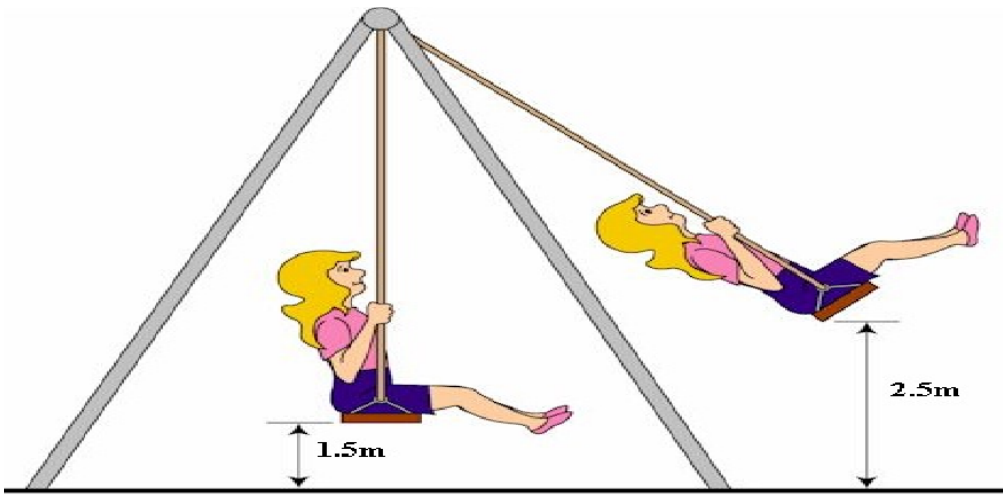
3. A 1200kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?

4. A 62.1-kg male ice skater is facing a 42.8-kg female ice skater. They are at rest on the ice. They push off each other and move in opposite directions. The female skater moves backwards with a speed of 3.11 m/s. Determine the final speed of the male skater



5. An engine expends 40 horse power (hp) in propelling a car along a level track at 15m/s. How large is the total retarding force acting on the car? (where 1hp=746W)

6. A girl in a swing is 2.5m above the ground at the maximum height and at 1.5 m above the ground at the lowest point. Calculate her maximum velocity in the swing ($g=10m/s^2$)



7. A man weighing 60kg climbs a staircase carrying a 20 kg load on his head. The stair case has 20 steps and each step has a height of 20cm. if he takes 10 second to climb, calculate the power.

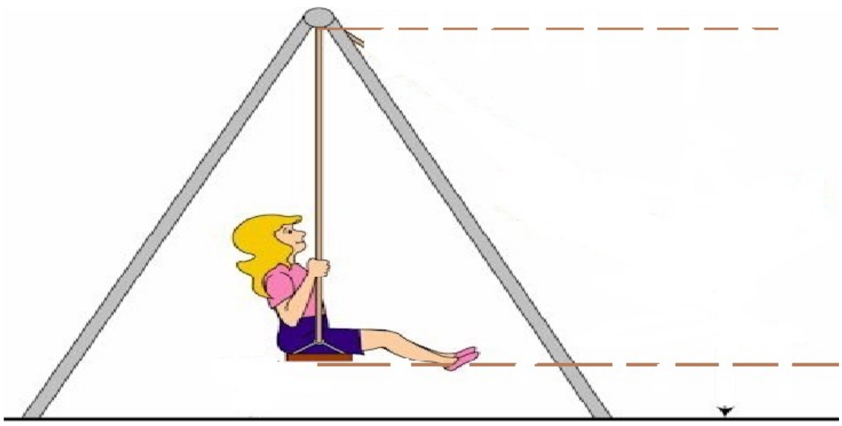
8. A body A of mass 2kg moving with a velocity of 25m/s in the east direction collides with another body B of mass 3kg moving with velocity of 15m/s westwards. Calculate the velocity of each ball after the collision?

9. A bullet of mass 20g is found to pass two points 30m apart in a time interval of 4 second. Calculate the kinetic energy of the bullet if it moves with constant speed?

10. A spoon is raised 21 cm above a table. If the spoon and its contents have a mass of 30g, what is the gravitational potential energy associated with the spoon at that height relative to the table?

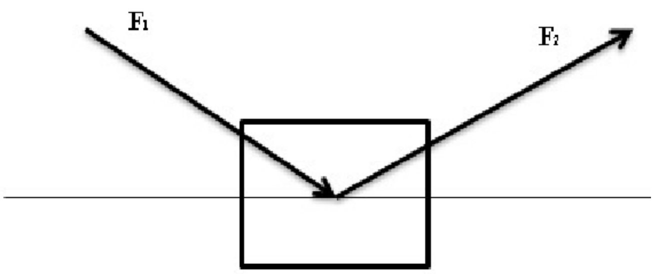
11. A spring with a force constant of 5.2 N/m has a relaxed length of 2.45 m. When a mass is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 3.57 m. Calculate the elastic potential energy stored in the spring?

12. A 40 kg child is in a swing that is attached to ropes 2 m long. Find the gravitational potential energy associated with the child relative to the child's lowest position under the following condition: when the ropes are horizontal h=2, m=40,g=9.8



13. A Bomb of mass 30kg at rest explodes into two pieces of masses 18kg and 12kg. The velocity of 18kg mass is 6m/s. Calculate the kinetic energy of the other mass?

14. Two industrial men sliding an initially stationary 225 kg Box, a displacement S of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 30^o downward from the horizontal; the pull of man 2 is 10N directed at 40^o above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?



Appendix D3

TEST FOR ASSESSING PROBLEM SOLVING ABILITY IN PHYSICS

RESPONSE SHEET

Name of the student: ……………………………………. Gender: Male / Female

Class:…….Subject: ………………..Name of the School :……………………..

Category: Government / Aided / Private

Write the Logical Steps and Mathematical Calculations required to solve the problems

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

13.

14.

Appendix D4

TEST FOR ASSESSING PROBLEM SOLVING ABILITY IN PHYSICS

Scoring Key

Q. NO	QUESTIONS	VALUE POINTS	MARK DISTRIBUTION	TOTAL
1	A man cleaning a floor pulls a vacuum cleaner with a force of magnitude F= 50 N at an angle of 30o with the horizontal. Calculate the work done by the force on the vacuum cleaner as the vacuum cleaner is displaced 3 m to the right	f=50N, θ=30, d=3m	Data identification=1/2	2
		Work (w)= fd cos θ	appropriate mathematical formula=1/2	
		50x3xcos30x	Correct mathematical procedure =1/2	
		w=130J	Accuracy in answer and unit consistency=1/2	
2	A block of mass 1.6 Kg is attached to a horizontal spring that has a force constant of $1x10^3$ N/m. The spring is compressed 2cm and is then released from rest. Calculate the work done by the spring?	$K=1x10^3$N/m, x= 2cm	Data identification=1/2	2
		Work done by spring w=$^1/_2$ (kx^2)=	appropriate mathematical formula=1/2	
		= $1/2x10^3x$	Correct mathematical procedure=1/2	
		0.20J	Accuracy in answer and unit consistency =1/2	
3	A 1200kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?	M=1200kg,u=30m/s, f=6000N, v=0m/s	Data identification=1/2	2
		According to work energy theorem w=ΔKE = -540 KJ	appropriate mathematical formula=1/2	
		w= -f.d= -540kj	Correct mathematical procedure=1/2	
		d=90m	Accuracy in answer and unit consistency=1/2	

Q. NO	QUESTIONS	VALUE POINTS	MARK DISTRIBUTION	TOTAL
4	A 62.1-kg male ice skater is facing a 42.8-kg female ice skater. They are at rest on the ice. They push off each other and move in opposite directions. The female skater moves backwards with a speed of 3.11 m/s. determine the final speed of the male skater	m_1=62.1kg, m_2=42.8kg, u_1=0m/s u_2=0m/s ,v_1=3.11m/s	Data identification=1/2	2
		By conservation of linear momentum $M_1u_1+m_2u_2= m_1v_1+ m_2v_2$	appropriate mathematical formula=1/2	
		$0= m_1v_1+(- m_2v_2)$ $m_1v_1= m_2v_2$ 62.1xv1=42.8x3.11	Correct mathematical procedure=1/2	
		=2.14m/s	Accuracy in answer and unit consistency =1/2	
4	An engine expends 40 hp in propelling a car along a level track at 15m/s. How large is the total retarding force acting on the car?	P= 40hp, v=15m/s	Data identification=1/2	2
		P= F v	appropriate mathematical formula=1/2	
			Correct mathematical procedure=1/2	
		=1989 N	Accuracy in answer and unit consistency= ½	
6	A girl in a swing is 2.5m above the ground at the maximum height and at 1.5 m above the ground at the lowest point . calculate her maximum velocity in the swing is ($g=10m/s^2$)	h_1= 2.5m, h_2=1.5m,	Data identification=1/2	2
		at highest point v=0 $E1=Mgh_1$ at lowest point, $E2=mgh_2+1/2\ mv^2$	appropriate mathematical formula=1/2	
		by conservation of energy, E1==E2 $V=\sqrt{(2g(h_1—h_2))}$=	Correct mathematical procedure=1/2	
		$=2\sqrt{5}$ m/s=4.47M/S	Accuracy in answer and unit consistency=1/2	

Q. NO	QUESTIONS	VALUE POINTS	MARK DISTRIBUTION	TOTAL
7	A man weighing 60kg climbs a staircase carrying a 20 kg load on his head. The stair case has 20 steps and each step has a height of 20cm. if he takes 10 second to climb, calculate the power.	M=60kg, m=20, h_1=20cm, n=20	Data identification=1/2	2
		total mass= M+m=60+20=80kg , h=$h_1$xn= 20x0.20=4m work done by the man w= mgh	Appropriate mathematical formula=1/2	
		w=80x9.8x4 p=w/t=	Correct mathematical procedure=1/2	
		313.6 watt	Accuracy in answer and unit consistency =1/2	
8	A body A of mass 2kg moving with a velocity of 25m/s in the east direction collides with another body B of mass 3kg moving with velocity of 15m/s westwards. Calculate the velocity of each ball after the collision?	m_1=2kg, u_1=25m/s m_2=3kg u_2=(- 5)	Data identification=1/2 appropriate mathematical formula=1/2 Correct mathematical procedure=1/2 Accuracy in answer and unit consistency =1/2	2
		$V_1=\frac{m_1 - m_2}{m_1 + m_2}u_1 + \frac{2m_2}{m_1+m_2}u_2$		
		$V_2=\frac{m_2 - m_1}{m_1 + m_2}u_2 + \frac{2m_1}{m_1+m_2}u_1$		
		V_1=(-23)m/s V_2= 17m/s		
9	A bullet of mass 20g is found to pass two points 30m apart in a time interval of 4 second. Calculate the kinetic energy of the bullet if it moves with constant speed?	M=20kg, d=30m, t=4sec, v=?, KE=?	Data identification=1/2	2
		speed v= distance/time =30/4= 7.5m/s	appropriate mathematical formula=1/2	
		KE= 1/2 Mv^2	Correct mathematical procedure=1/2	
		= 0.56J	Accuracy in answer and unit consistency=1/2	

Q. NO	QUESTIONS	VALUE POINTS	MARK DISTRIBUTION	TOTAL
10	A spoon is raised 21 cm above a table. If the spoon and its contents have a mass of 30g, what is the gravitational potential energy associated with the spoon at that height relative to the table?	M = 30 g = .03 kg, h = 21 cm = .21 m,	Data identification=1/2	2
		Gravitational PE =mgh	Appropriate mathematical formula=1/2	
		=0.03(9.8)x 0.21	Correct mathematical procedure=1/2	
		=.06174 J	Accuracy in answer and unit consistency=1/2	
11	A spring with a force constant of 5.2 N/m has a relaxed length of 2.45 m. When a mass is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 3.57 m. Calculate the elastic potential energy stored in the spring?	K = 5.2 N/m x = 3.57-2.45 =1.12 m	Data identification=1/2	2
		Elastic PE = ½ k x^2	appropriate mathematical formula=1/2	
		= ½ (5.2)$(1.12)^2$	Correct mathematical procedure=1/2	
		= 3.26 J	Accuracy in answer and unit consistency=1/2	
12	A 40 kg child is in a swing that is attached to ropes 2 m long. Find the gravitational potential energy associated with the child relative to the child's lowest position under the following condition: when the ropes are horizontal h=2, m=40,g=9.8	M=40 kg , h=2, g=9.8	Data identification=1/2	2
		GPE=mgh	appropriate mathematical formula=1/2	
		=40(9.8)(2)	Correct mathematical procedure=1/2	
		=784J	Accuracy in answer and unit consistency=1/2	

Q. NO	QUESTIONS	VALUE POINTS	MARK DISTRIBUTION	TOTAL
13	A Bomb of mass 30kg at rest explodes into two pieces of masses 18kg and 12kg. The velocity of 18kg mass is 6m/s. Calculate the kinetic energy of the other mass?	$M=30$, $M_1=18kg$, $M_2 = 12kg$, $u=0m/s$, $u_1=6m/s$	Data identification=1/2	2
		BY conservation of linear momentum , $0=M_1u_1+M_2u_2$ $u_2=9m/s$	appropriate mathematical formula=1/2	
		$KE=1/2M_2u_2^2$	Correct mathematical procedure=1/2	
		=486J	Accuracy in answer and unit consistency=1/2	
14	Two industrial men sliding an initially stationary 225 kg Box, a displacement S of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 30^0 downward from the horizontal; the pull of man 2 is 10N directed at 40^0 above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?	$W_1=$ 88.33 J ,$W_2=$ 65.11 J	Data identification=1/2	2
		net work done w= w1+w2=153.4 J	appropriate mathematical formula=1/2	
		w=change in KE $V=\sqrt{\left(\frac{2W}{M}\right)}$	Correct mathematical procedure=1/2	
		=1.17M/S	Accuracy in answer and unit consistency=1/2	
	TOTAL			28

Appendix E1

TEST FOR ASSESSING CONCEPTUAL UNDERSTANDING OF STORY PROBLEMS IN PHYSICS

DRAFT

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

Class: XI Subject: Physics Unit: Work Energy& Power Max. Mark: 24 Time: 75 minutes

General Instructions:

1. The question paper consists of 14 questions. All questions are compulsory
2. Question Numbers 1 to 7 carry 1 mark each
3. Question numbers 8 to 10 carry three marks each
4. Question numbers 11 to 14 carry two marks each
5. No negative marks for wrong answers.

You are given a problem below:

Consider a car initially at rest and out of fuel. A group of people get behind the car and push on its rear bumper with net force of 560 N in the forward direction for a distance of 15.0 m. Predict the final speed of the car after the 15.0m displacement?

(Score: 1)

1) For this problem I think,

A. There is sufficient data presented to solve the problem.
**If so, what are those data, needed to solve the given problem?

B. There is insufficient data presented to solve the problem
** If so, what additional data I need to solve the given problem?

C. There is more data presented than is needed to solve the problem.
**If so, what are the irrelevant data presented in the problem?

Problem:

Two blocks of masses 0.3kg and 0.2kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. The blocks collide and stick together. Find the loss in kinetic energy during the collision.

(Score: 1)

2) For this problem I think,

A. There is sufficient data presented to solve the problem.
**If so, what are those data, needed to solve the given problem?

B. There is insufficient data presented to solve the problem
**If so, what additional data I need to solve the given problem?

C. There is more data presented than is needed to solve the problem.
**If so, what are the irrelevant data presented in the problem?

Problem:

A bomb of mass 30 kg at rest explodes in to two pieces of masses 18kg and 12kg. The velocity of 18kg mass is 6m/s. Calculate the velocity of the other mass?

(Score: 1)

3) For this problem I think,

A. There is sufficient data presented to solve the problem.
**If so, what are those data, needed to solve the given problem?

B. There is insufficient data presented to solve the problem
**If so, what additional data I need to solve the given problem?

C. There is more data presented than is needed to solve the problem.
**If so, what are the irrelevant data presented in the problem?

You are given the situation of a problem below

A child of mass 20kg rides on an irregularly curved slide height h=2m. The child starts from rest at the top. Assuming no friction is present.

4) Which question, when added to the situation above, will make a solvable problem, that requires all of the following equations to solve?

$$KE=\frac{1}{2}MV^2$$

$$PE=M\,g\,h$$

$$E= KE+PE$$

(Score: 1)

A. Determine the work done by frictional force on the child
B. How much time does the child take to reach the bottom of the slide?
C. What is the average force of air resistance acting on the child?
D. Determine child's speed at the bottom of the slide?

You are given below a worked out solution to a problem.

P= W/t
= PE + KE
=Mgh + KE
=224 W
= 0.33 hp

5) I think the correct story problem that can be solved by using the solution given above is ………. *(Score: 1)*

A	In an unloading grain from the hold of a ship, an elevator lifts the grain through a distance of 12m. Grain is discharged at the top of the elevator at a rate of 2kg each second and the discharge speed of each grain particle is 3m/s. Find the minimum horse power of motor that can elevate grain in this way
B	Find the mass of the block that a 40hp engine can pull along a level road at 15 m/s if the friction coefficient between block and road is 0.15
C	An engine expends 40 hp in propelling a car along a level track at 15m/s. How large is the total retarding force acting on the car
D	A force of 100N acts on a 20kg roller initially at rest on a frictionless surface. The roller travels 5m while the forces acts. Find the work done on the roller and its kinetic energy?

You are given below a worked out solution to a problem.

Solution:

$$m_1u_1+m_2u_2=m_1v_1+m_2v_2$$
$$0 = m_1v_1+m_2v_2$$
$$m_1v_1=(-m_2v_2)$$
$$v_1= (-0.3)\text{m/s}$$

6. I think the correct story problem that can be solved by using the solution given above is ………. *(Score: 1)*

A	A girl in a swing is 2.5m above the ground at the maximum height and at 1.5 m above the ground at the lowest point. Calculate her maximum velocity in the swing ($g=10m/s^2$)
B.	A spherical ball of mass 20 kg is stationary at the top of a hill of height 100m. It rolls down a smooth surface to ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground .Calculate the velocity attained by the ball
C.	A Sky Lab astronaut of mass 70 kg discovered that while concentrating on writing some notes, he had gradually floated to the middle of an open area in the spacecraft. Not wanting to wait until he floated to the opposite side, he asked his colleagues for a push. But his colleagues decided not to help him, and so he had to take off his uniform of mass 1kg and throw it at a speed of 20m/s in one direction so that he would be propelled in the opposite direction. Estimate his resulting velocity?
D.	A toy car with mass of 2kg starts at rest. A spring performs 196 joules of work on the car. What is the toy car's final velocity?

You are given below a worked out solution to a problem.

Solution: **Total Initial mechanical energy,** $E_i = (^1/_2)\, m_1 v_1^2 + (^1/_2)\, m_2 v_2^2$ **Total final mechanical energy,** $E_f = (^1/_2)\, k\, x_1^2 + (^1/_2)\, k\, x_2^2$ **By symmetry** $x = x_1 = x_2$ $E_f = 2\, [\, (^1/_2)\, k\, x^2]$	**By conservation of mechanical energy,** $E_f = E_i$ $2\, [\, (^1/_2)\, k\, x^2\,] = 1.8$ J $x = 0.024$ m $\underline{x = 2.4 \text{ cm}}$

7. **I think the correct story problem that can be solved by using the solution given above is** *(Score: 1)*

A	A spring with a force constant of 5.2 N/m has a relaxed length of 2.45 m. Whena mass is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 'x' cm. The elastic potential energy stored in the spring is 3.26 J. Determine the value of 'x'?
B	Identical air cars (m = 200 g) are equipped with identical springs (k = 3000 N/m). The cars move toward each other with speeds of 3.00 m/s on a horizontal air track and collide, compressing the springs. Find the maximum compression of each spring.
C	A 5.0g bullet is compressed against a spring in a gun of mass 300g. The spring is released and the gun allowed to recoil with no friction as the bullet leaves the gun. If the speed of the recoiling gun is 8.0m/s, what is the speed of the bullet?
D	The force constant of a spring is 550 N/m. 0.0396J elastic potential energy is stored in the spring when the spring is compressed a distance of 'X' cm. calculate the value of 'x'?

You are given some important concepts/principles/laws in the chapter 'work, energy, power' below.

[1] Work, **[2]** Kinetic Energy, **[3]** Potential Energy **[4]** Work-Kinetic Energy theorem **[5]** Collision **[6]** Power **[7]** Conservation of Mechanical Energy **[8]**Conservation of linear momentum **[9]** kinetic Energy & Linear momentum Conservation

8. **Group the given problems together based on the major concepts/principles/ laws needed to solve the problems? Write the name of the concepts/principles /laws behind your grouping?** *(Score: 3)*

A.	A football of mass 0.43kg traveling with a velocity of 5 m/s hits another ball of the same mass, which is stationary. The collision is head on and elastic. Find the final velocities of both balls.

B.	Two blocks of masses 5kg and 7 kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. The blocks collide and stick together. The velocity of blocks after collision is (-0.1m/s) .Find the loss in kinetic energy during the collision.

C.	Two blocks of masses 5kg and 7kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. Find the final velocity of each block, if the collision is completely elastic.

D.	A bullet of mass 20g is found to pass two points 30m apart in a time interval of 4 second. Calculate the kinetic energy of the bullet if it moves with constant speed?

9. Group the given problems together based on the major concepts/ principles/ laws needed to solve the problems? Write the name of the concepts/ principles/ laws behind your grouping? *(Score: 3)*

A	An 878kg car skids to a stop across a horizontal surface over a distance of 45.2m. The friction force acting up on a car is 7160N. Determine the work done on the car by friction?

B	An 878kg car skids to a stop across a horizontal surface over a distance of 45.2m. The friction force acting up on a car is 7160N. Determine the initial kinetic energy of the car by friction?

C.	Two industrial men sliding an initially stationary 225 kg Box, a displacement S of magnitude 8.5m, straight toward the truck. The push of man 1 is 20 N directed at an angle of 300 downward from the horizontal; the pull of man 2 is 15N directed at 40o above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. What is the net work done on the box by forces F1&F2 during the displacement?

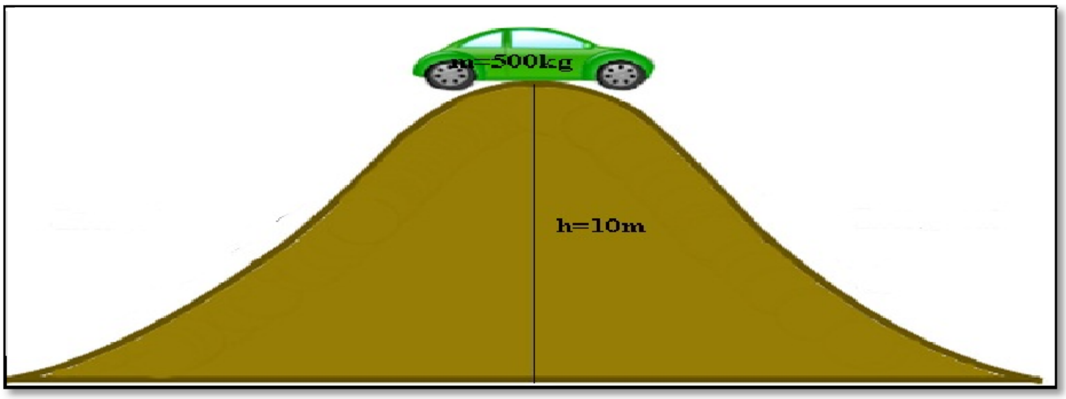
D.	Two industrial men sliding an initially stationary 225 kg Box , a displacement S of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 300 downward from the horizontal; the pull of man 2 is 10N directed at 400 above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?

10. Group the given problems together based on the major concepts/ principles/ laws needed to solve the problems? Write the name of the concepts/ principles/ laws behind your grouping? *(Score: 3)*

A.	A 1500kg car accelerates from rest to a speed of 25m/s over a distance of 45m. what is the net work done on the car?
B.	A 2.5 g bullet travelling with a velocity 'u' hits in to a stationary block of wood (m=5kg) and slows uniformly to a stop while penetrating a distance of 12cm in to the block. The speed of the bullet-plus-wood combination immediately after the collision is measured as 0.600m/s. What was the initial velocity (u) of the bullet?
C.	A 2.5 g bullet travelling with a velocity 350m/s hits in to a stationary block of wood(m=5kg) fixed on the wall, and slows uniformly to a stop while penetrating a distance of 12cm in to the block. What force was exerted on the bullet in bringing it to rest?
D.	A railroad car of mass 2.50 x 10^4kg is moving with a speed of 4.00 m/s. It collides and couples with three other coupled railroad cars, each of the same mass as the single car and moving in the same direction with an initial speed of 2.00 m/s. What is the speed of the four cars after the collision?

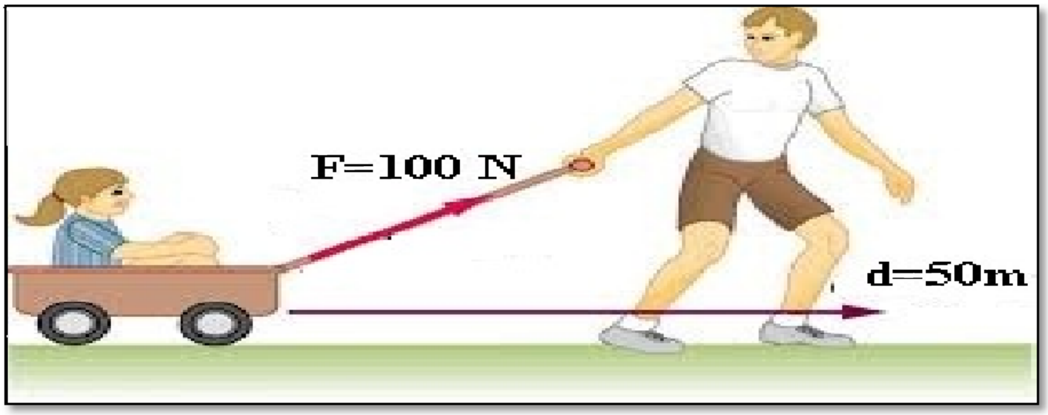
Direction (QNo. 11–Qno. 14): The following figures represent the situations of different types of Story problems in physics. Based on the situations of each figure create suitable Story Problem that can be solved using familiar ideas/concepts/laws/principles which you have studied in the chapter 'Work, Energy and Power'. (2 marks for each)

11. Create story problem based on the situations of Fig.1



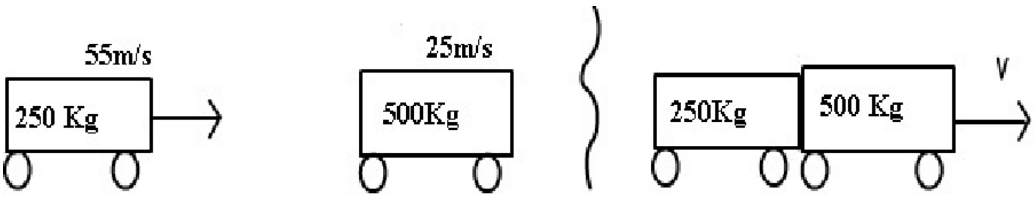
(Fig.1)

12. Create story problem based on the situations of Fig.2



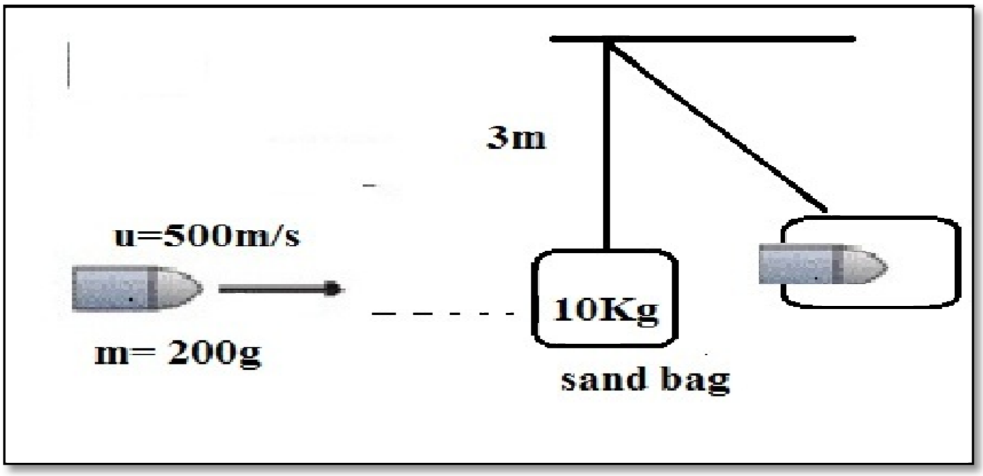
(Fig.2)

13. Create story problem based on the situations of Fig.3



(Fig.3)

14. Create story problem based on the situations of Fig.4



Appendix E2

TEST FOR ASSESSING CONCEPTUAL UNDERSTANDING OF STORY PROBLEMS IN PHYSICS

FINAL

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

Class: XI Subject: Physics Unit: Work Energy& Power Max. Mark: 17 Time: 1 hr

General Instructions:

1. The question paper consists of 10 questions. All questions are compulsory
2. Question Numbers 1 to 5 carry 1 mark each
3. Question numbers 6 to 7 carry three marks each
4. Question numbers 8 to 10 carry two marks each
5. No negative marks for wrong answers.

You are given a problem below:

Consider a car initially at rest and out of fuel. A group of people get behind the car and push on its rear bumper with net force of 560 N in the forward direction for a distance of 15.0 m. Predict the final speed of the car after the 15.0m displacement?

(Score: 1)

1) For this problem I think,

A. There is sufficient data presented to solve the problem.
  **If so, what are those data, needed to solve the given problem?

B. There is insufficient data presented to solve the problem
  ** If so, what additional data I need to solve the given problem?

C. There is more data presented than is needed to solve the problem.
  **If so, what are the irrelevant data presented in the problem?

Problem:

Two blocks of masses 0.3kg and 0.2kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. The blocks collide and stick together. Find the loss in kinetic energy during the collision.

(Score: 1)

2) For this problem I think,

A. There is sufficient data presented to solve the problem.
  **If so, what are those data, needed to solve the given problem?

B. There is insufficient data presented to solve the problem
  **If so, what additional data I need to solve the given problem?

C. There is more data presented than is needed to solve the problem.
  **If so, what are the irrelevant data presented in the problem?

You are given the situation of a problem below

A child of mass 20kg rides on an irregularly curved slide height h=2m. The child starts from rest at the top. Assuming no friction is present.

3) Which question, when added to the situation above, will make a solvable problem, that requires all of the following equations to solve?

$$KE=\frac{1}{2}MV^2$$

$$PE=M\,g\,h$$

$$E=KE+PE$$

(Score: 1)

A. Determine the work done by frictional force on the child
B. How much time does the child take to reach the bottom of the slide?
C. What is the average force of air resistance acting on the child?
D. Determine child's speed at the bottom of the slide?

You are given below a worked out solution to a problem.

Solution:

$$m_1u_1+m_2u_2=m_1v_1+m_2v_2$$

$$0 = m_1v_1+m_2v_2$$

$$m_1v_1=(-m_2v_2)$$

$$v_1= (-0.3)m/s$$

4) I think the correct story problem that can be solved by using the solution given above is ………. *(Score: 1)*

A	A girl in a swing is 2.5m above the ground at the maximum height and at 1.5 m above the ground at the lowest point. Calculate her maximum velocity in the swing ($g=10m/s^2$)
B.	A spherical ball of mass 20 kg is stationary at the top of a hill of height 100m. It rolls down a smooth surface to ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground .Calculate the velocity attained by the ball
C.	A Sky Lab astronaut of mass 70 kg discovered that while concentrating on writing some notes, he had gradually floated to the middle of an open area in the spacecraft. Not wanting to wait until he floated to the opposite side, he asked his colleagues for a push. But his colleagues decided not to help him, and so he had to take off his uniform of mass 1kg and throw it at a speed of 20m/s in one direction so that he would be propelled in the opposite direction. Estimate his resulting velocity?

D.	A toy car with mass of 2kg starts at rest. A spring performs 196 joules of work on the car. What is the toy car's final velocity?

You are given below a worked out solution to a problem.

Solution:	**By conservation of mechanical energy,**
Total Initial mechanical energy,	$E_f = E_i$
$E_i = (^1/_2)\, m_1 v_1^2 + (^1/_2)\, m_2 v_2^2$	$2\, [\, (^1/_2)\, k\, x^2\,] = 1.8\ J$
Total final mechanical energy,	$x = 0.024\ m$
$E_f = (^1/_2)\, k\, x_1^2 + (^1/_2)\, k\, x_2^2$	$\underline{x = 2.4\ cm}$
By symmetry	
$x = x_1 = x_2$	
$E_f = 2\, [\, (^1/_2)\, k\, x^2]$	

5) I think the correct story problem that can be solved by using the solution given above is *(Score: 1)*

A	A spring with a force constant of 5.2 N/m has a relaxed length of 2.45 m. Whena mass is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 'x' cm. The elastic potential energy stored in the spring is 3.26 J. Determine the value of 'x'?

B	Identical air cars (m = 200 g) are equipped with identical springs (k = 3000 N/m). The cars move toward each other with speeds of 3.00 m/s on a horizontal air track and collide, compressing the springs. Find the maximum compression of each spring.

C	A 5.0g bullet is compressed against a spring in a gun of mass 300g. The spring is released and the gun allowed to recoil with no friction as the bullet leaves the gun. If the speed of the recoiling gun is 8.0m/s, what is the speed of the bullet?

D	The force constant of a spring is 550 N/m. 0.0396J elastic potential energy is stored in the spring when the spring is compressed a distance of 'X' cm. calculate the value of 'x'?

You are given some important concepts/principles/laws in the chapter 'work, energy, power' below.

[1] Work, [2] Kinetic Energy, [3] Potential Energy [4] Work-Kinetic Energy theorem [5] Collision [6] Power [7] Conservation of Mechanical Energy [8]Conservation of linear momentum [9] kinetic Energy & Linear momentum Conservation

6. Group the given problems together based on the major concepts/principles/ laws needed to solve the problems? Write the name of the concepts/principles /laws behind your grouping? *(Score: 3)*

A.	A football of mass 0.43kg traveling with a velocity of 5 m/s hits another ball of the same mass, which is stationary. The collision is head on and elastic. Find the final velocities of both balls.

B.	Two blocks of masses 5kg and 7 kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. The blocks collide and stick together. The velocity of blocks after collision is (-0.1m/s) .Find the loss in kinetic energy during the collision.

C.	Two blocks of masses 5kg and 7kg are moving towards each other along a horizontal frictionless surface with velocities of 0.5m/s and 1m/s respectively. Find the final velocity of each block, if the collision is completely elastic.

D.	A bullet of mass 20g is found to pass two points 30m apart in a time interval of 4 second. Calculate the kinetic energy of the bullet if it moves with constant speed?

7. Group the given problems together based on the major concepts/ principles/ laws needed to solve the problems? Write the name of the concepts/ principles/ laws behind your grouping? *(Score: 3)*

A.	A 1500kg car accelerates from rest to a speed of 25m/s over a distance of 45m. what is the net work done on the car?

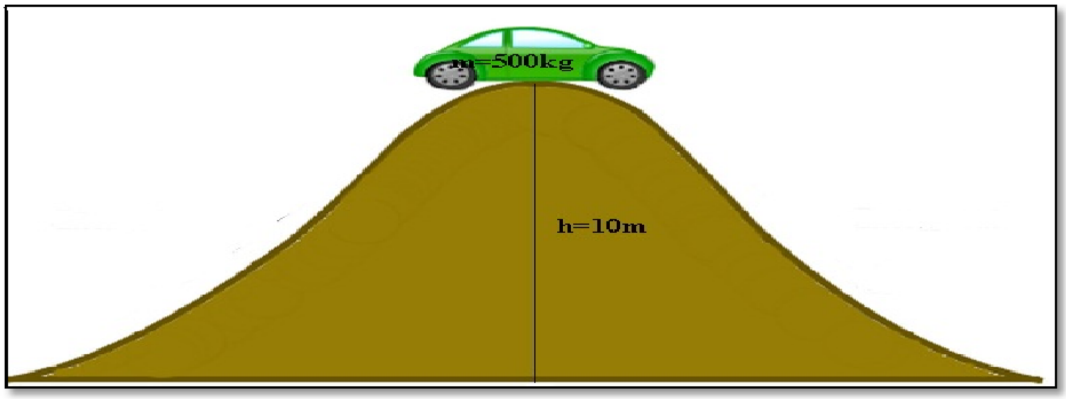
B.	A 2.5 g bullet travelling with a velocity 'u' hits in to a stationary block of wood (m=5kg) and slows uniformly to a stop while penetrating a distance of 12cm in to the block. The speed of the bullet-plus-wood combination immediately after the collision is measured as 0.600m/s. What was the initial velocity (u) of the bullet?

C.	A 2.5 g bullet travelling with a velocity 350m/s hits in to a stationary block of wood(m=5kg) fixed on the wall, and slows uniformly to a stop while penetrating a distance of 12cm in to the block. What force was exerted on the bullet in bringing it to rest?

D.	A railroad car of mass 2.50 x 10^4kg is moving with a speed of 4.00 m/s. It collides and couples with three other coupled railroad cars, each of the same mass as the single car and moving in the same direction with an initial speed of 2.00 m/s. What is the speed of the four cars after the collision?

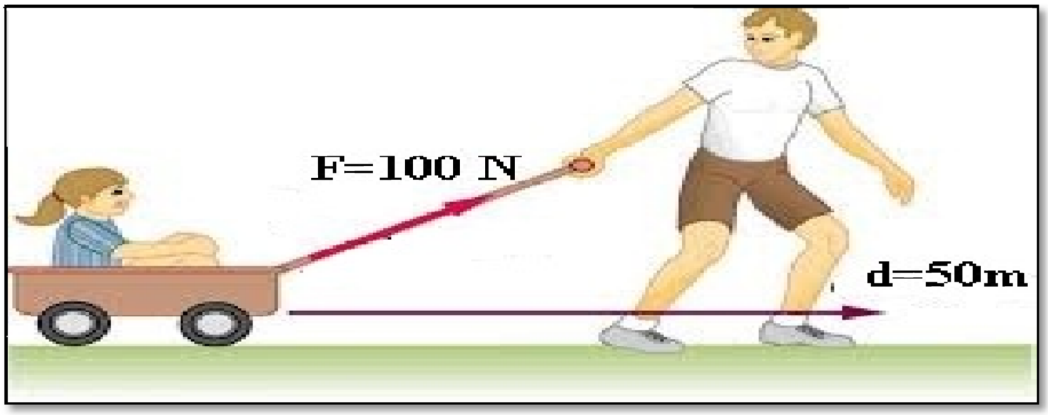
Direction (QNo. 8–Qno. 10): The following figures represent the situations of different types of Story problems in physics. Based on the situations of each figure create suitable Story Problem that can be solved using familiar ideas/concepts/laws/principles which you have studied in the chapter 'Work, Energy and Power'. (2 marks for each)

8. Create story problem based on the situations of Fig.1



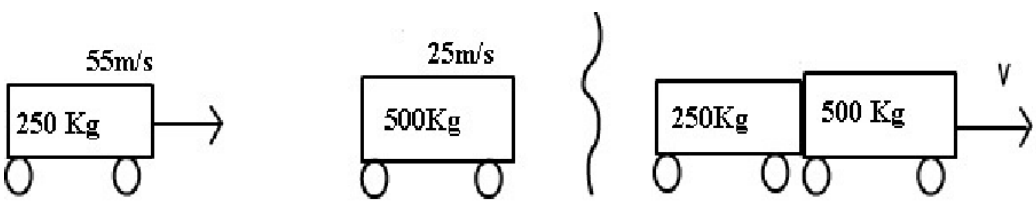
(Fig.1)

9. Create story problem based on the situations of Fig.2



(Fig.2)

10. Create story problem based on the situations of Fig.3



(Fig.3)

Appendix E3

TEST FOR ASSESSING COMPREHENSION OF PROBLEM SCHEMA

ANSWER SHEET

Name:……………………………………………………………………..Gender:M/F

School:…………………………………………………….Class: XI- Science Div:…

Q.NO	ANSWERS(Put√ mark)				Q.NO	ANSWER(Put√ mark)			
1	A	B	C	D	**3**	A	B	C	D
**					**4**	A	B	C	D
2	A	B	C	D	**5**	A	B	C	D
**									

		Name of the Concepts/ principles/laws…	Problems (Put√ mark)			
6	GROUP 1.		Problem **A**	Problem **B**	Problem **C**	Problem **D**
	GROUP 2		Problem **A**	Problem **B**	Problem **C**	Problem **D**
7	GROUP 1		Problem **A**	Problem **B**	Problem **C**	Problem **D**
	GROUP 2		Problem **A**	Problem **B**	Problem **C**	Problem **D**

8	

9	
10	

Appendix E4

TEST FOR ASSESSING CONCEPTUAL UNDERSTANDING OF STORY PROBLEMS IN PHYSICS

SCORING KEY

Q NO	ANSWERS		Score distribution	Total score
1	B,	** =mass (m) of the car	$^1/_2 + ^1/_2$	1
2	B,	** =Velocity of the block after collision	$^1/_2 + ^1/_2$	1
3	D		1	1
4	C		1	1
5	B		1	1
	Group name	problems		
6	Kinetic energy	Problem B, D	½ , ½ , ½	3
	KE&Linear momentum conservation	Problem A, problem C	½ , ½ , ½	
7	Work-kinetic energy theorem	A, C	½ , ½ , ½	3
	Conservation of linear momentum	B, D	½, ½ , ½	
8	Any Problem related to either W , PE, KE Work-Energy theorem or conservation of mechanical energy.		Situational attributes=½ Relevant physical quantities=½ Structural elements =½ problem statement=½	2
9	Any Problem related to the concepts work, Kinetic Energy, Work-Energy theorem, Power		Situational attributes=½ Relevant physical quantities=½ Structural elements =½ problem statement=½	2
10	Problem related to the concepts Work, Work-Energy theorem, and conservation of linear momentum		Situational attributes=½ Relevant physical quantities=½ Structural elements =½ problem statement=½	2
Total				**17**

Appendix F1

TEST FOR ASSESSING COMPREHENSION OF PROBLEM SCHEMA

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

CLASS: XI   Subject: Physics   Unit: Work Energy & Power   Max. Mark: 48   Time: 75 minutes

General Instructions:

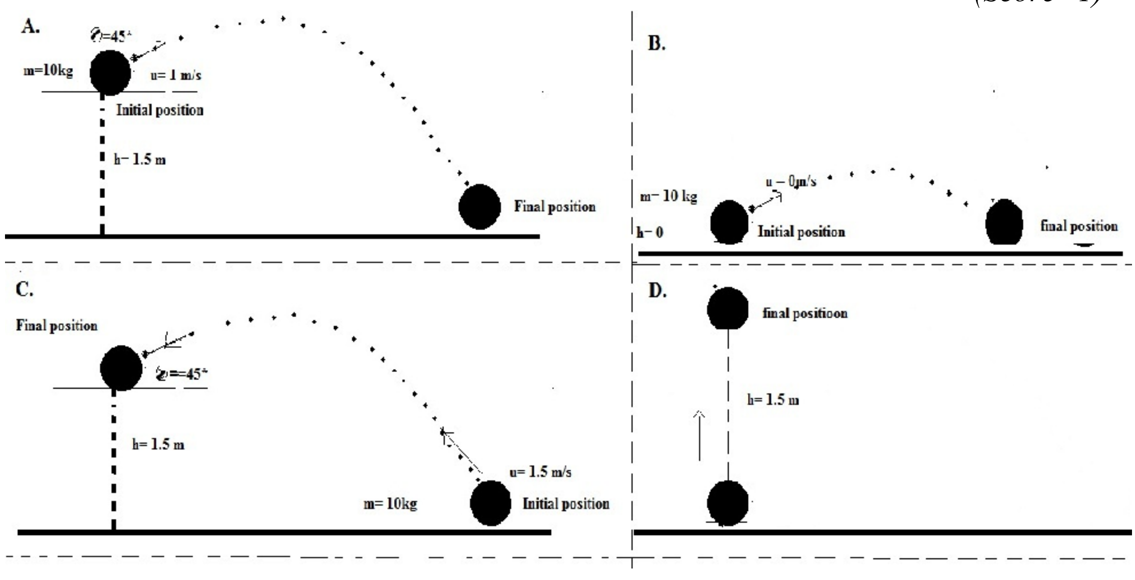
1. This booklet consists of 6 problems (1 to 6) from the unit Work Energy and Power.
2. Each problem has 8 (a,b,c,d,e,f,g,h) sub questions. Each sub questions carries 1 mark.
3. All questions are compulsory
4. No negative marks for wrong answers.

1. **In a shot put event an athlete of mass 80kg throws the shot put of mass 10kg with an initial speed of 1m/s at 45^0 from a height 1.5 m above ground. Assuming air resistance to be negligible and acceleration due to gravity to be $10m/s^2$, <u>what is the kinetic energy of the shot put when it just reaches the ground.?</u>** (solve this question only after attending the sub question a, b, c, d, e, f, and g)

a) **What are the key features of the problem situation given above? (select all that apply)** *(Max. Score=1)*

A. Presence of non-conservative force
B. Absence of non-conservative force
C. Work done by non-conservative force
D. Object -Earth system
E. Change in the state (the position and velocity) of object.
F. Work done by conservative force
G. No change in the state (the position and velocity) of object

b) **Identify the diagram that correctly represents the situation of the problem?** *(Score=1)*



c) Which of the following quantities are directly given/stated in the problem? (select all that apply) *(Max. score=1)*

A) Mass of the shot put B) height from the ground
C) Initial speed of the shot put D) final velocity of the shot put
E) Acceleration due to gravity F) final kinetic energy of the shot put

d) Identify what kind of problem it is? (*Score*=1)

A) Work
B) Kinetic energy
C) Conservation of mechanical energy
D) Conservation of linear momentum
E) Kinetic energy and linear momentum conservation
F) Mechanical power
G) Potential energy

e) What laws/ideas are needed to solve this problem? (*Score* =1)

A) Total linear momentum before collision=total linear momentum after collision
B) Total Work done= change in kinetic energy
C) Power = rate of change of work done
D) Mechanical energy of the system = constant (when only conservative forces are acting on the system)

f) Which of the following quantities are not relevant for solving the problem? *(Max. Score=1)*

A) 80kg B)10kg C)1m/s D) 45^0 E) 1.5m F) $10m/s^2$
G) Need all the information given to solve the problem

g) Which of the following equation/equations are required to solve the problem? *(Max. Score=1)*

A	W= F.d	E	W= ΔKE	I	KE= $1/2 MV^2$
B	E= KE+PE	F	$P=\frac{W}{t}$	J	PE= Mgh
C	$V_1=\frac{(M_1-M_2)u_1+2M_2u_2}{(M_1+M_2)}$	G	$V_2=\frac{(M_2-M_1)u_2+2M_1u_1}{(M_1+M_2)}$	K	f= μmg
D	F= ma	H	$M_1u_1+M_2u_2=M_1v_1+M_2v_2$	L	W=Fv

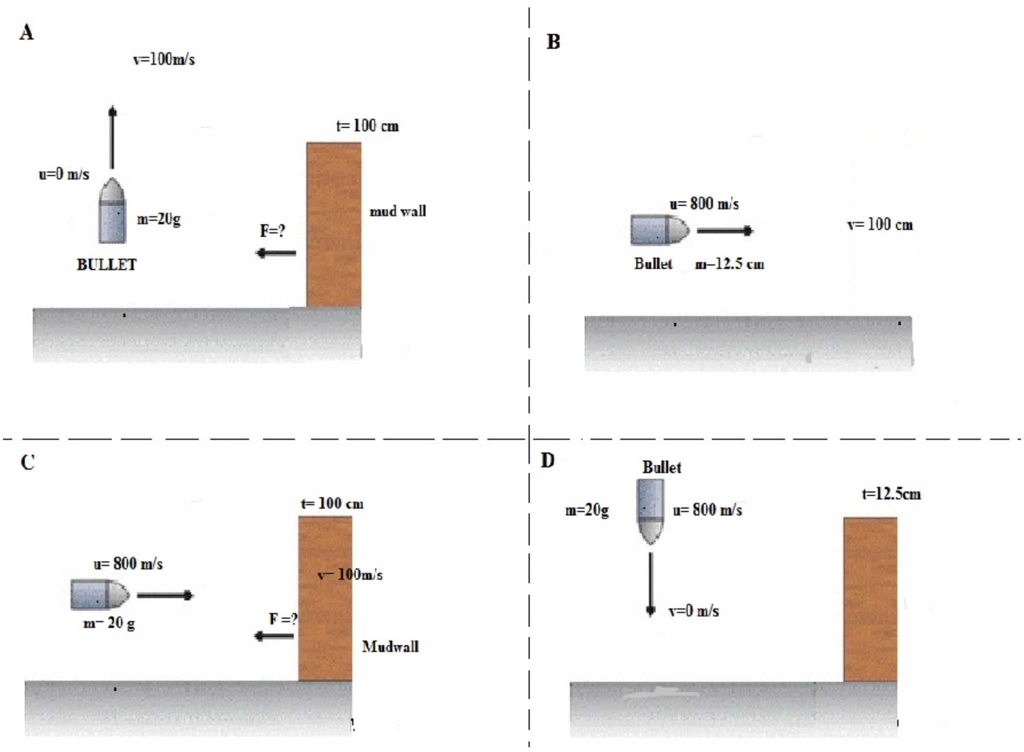
h) What is the kinetic energy of the shot put when it just reaches the ground? (Apply the equation and calculate the final answer with unit consistency) *(Max. score=1)*

2. A bullet of mass 20 g is fired from a rifle of diameter 12.7cm, with a velocity of 800m/s. After passing through a mud wall 100 cm thick, velocity drops to 100 m/s. <u>What is the average resistance of the wall neglecting friction due to air?</u>
(Solve this question only after attending the sub question a, b, c, d, e, f, and g)

a) What are the key features of the problem situation given above? (select all that apply) *(Max. Score=1)*

A) Constant velocity ⟶ Constant kinetic energy
B) Increase in velocity ⟶ Increase in kinetic energy.
C) Decrease in velocity ⟶ Decrease in kinetic energy
D) Total work done is zero
E) Total work done is positive
F) Total work done is negative.

b) Identify the diagram that correctly represents the situation of the problem? (*Score*=1)



c) Which of the following quantities are directly given/stated in the problem? (select all that apply) *(Max. Score=1)*

A) Mass of the bullet
B) Mass of the mud wall
C) Initial and final velocities of bullet
D) Thickness of mud wall
E) Diameter of the rifle
F) Resistive force of mud wall

d) Identify what kind of problem it is? (*Score*=1)

A) Work B) Work-Kinetic energy theorem
C) Collision D) Potential energy
E).Conservation of linear momentum F).Kinetic energy
G). Mechanical power

e) What laws/ideas are needed to solve this problem? (*Score*=1)

A) Total linear momentum before collision=total linear momentum after collision
B) Applied force=product of mass and acceleration
C) Work done by net force =change in kinetic energy
D) Power= rate of change of work done

f) Which of the following quantities are not relevant for solving the problem? *(Max. Score=1)*

A) 20g B) 12.7cm C).800m/s D).100cm E).100m/s

F) Need all the information given to solve the problem

g) Which of the following equation/equations are required to solve the problem? (*Score*=1)

A	**W= F.d**	**E**	**W= ΔKE**	**I**	**KE=** $^1/_2MV^2$
B	**E= KE+PE**	**F**	**P=** $\frac{W}{t}$	**J**	**PE= Mgh**
C	$V_1 = \frac{(M_1 - M_2)u_1 + 2M_2 u_2}{(M_1 + M_2)}$	**G**	$V_2 = \frac{(M_2 - M_1)u_2 + 2M_1 u_1}{(M_1 + M_2)}$	**K**	**f= μmg**
D	**F=ma**	**H**	$M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$	**L**	**W=Fv**

h) What is the average resistance of the wall neglecting friction due to air? (Apply the equation and calculate the final answer with unit consistency) *(Max. Score=1)*

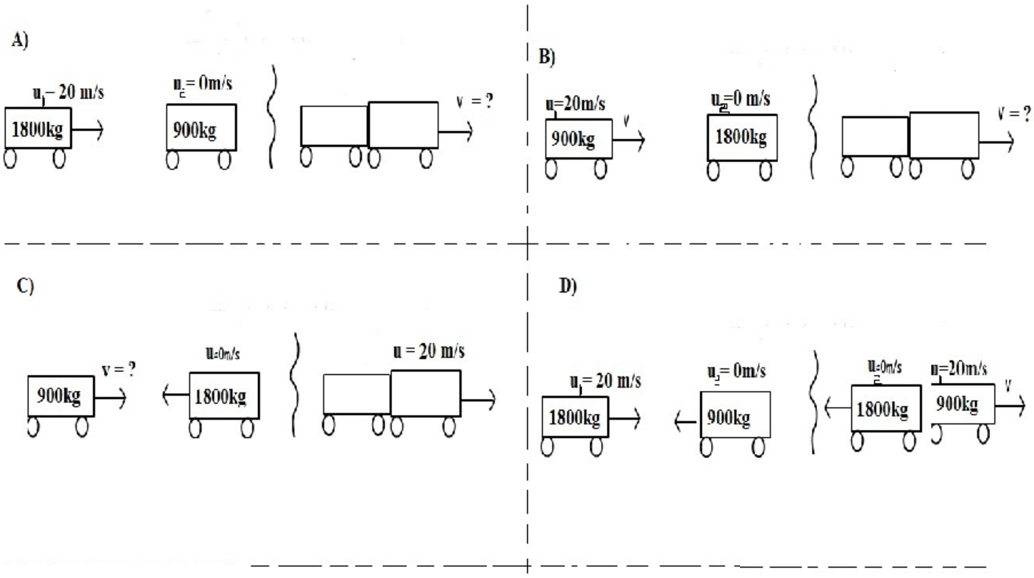
3. A car of mass 1800 kg stopped at a traffic light is struck from the rear by a 900-kg car, and the two become entangled. If the smaller car was moving at 20.0 m/s before the collision, <u>what is the velocity of the entangled cars after the collision?</u> (Solve this question only after attending the sub question a, b, c, d, e, f, and g)

a) What are the key features of the problem situation given above? (select all that apply) *(Max. Score=1)*

A) Isolated system with two object
B) Isolated system with three objects
C) Non- isolated system with two objects

D) Elastic collision in one dimension
E) Elastic collision in two dimension.
F) Inelastic collision in two dimension.
G) Inelastic collision in one dimension
H) non isolated system with three objects

b) Identify the diagram that correctly represents the situation of the problem? (*Score*=1)



c) Which of the following quantities are directly given/stated in the problem? (select all that apply) *(Max. Score=1)*

A) Mass of the big car
B) Mass of the small car
C) Initial velocity of big car
D) Initial velocity of small car
E) Final velocity of big car
F) Final velocity of small car

d) Identify what kind of problem it is? (*Score=1*)

A) Work-Kinetic energy theorem
B) Collision
C) Mechanical power
D) Conservation of linear momentum
E) Kinetic energy and linear momentum conservation

e) What laws/ideas are needed to solve this problem? *(Score=1)*

A) Total linear momentum before collision= total linear momentum after collision

B) Applied force=product of mass and acceleration

C) Work done by net force =change in kinetic energy

D) Power= rate of change of work done

f) Which of the following quantities are not relevant for solving the problem?

(Max. Score=1)

A) 1800kg B) 900kg C) 20m/s

D) Need all the information given to solve the problem

g) Which of the following equation/equations are required to solve the problem?

(*Score=1*)

A	**W= F.d**	**E**	**W= ΔKE**	**I**	**KE=** $\mathbf{^1/_2 MV^2}$
B	**E= KE+PE**	**F**	**P=** $\frac{W}{t}$	**J**	**PE= Mgh**
C	$V_1 = \frac{(M_1 - M_2)u_1 + 2M_2 u_2}{(M_1 + M_2)}$	**G**	$V_2 = \frac{(M_2 - M_1)u_2 + 2M_1 u_1}{(M_1 + M_2)}$	**K**	**f= μmg**
D	**F=ma**	**H**	$M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$	**L**	**W=Fv**

h) What is the velocity of the entangled cars after the collision? (Apply the equation and calculate the final answer with unit consistency)

(Max. Score=1)

4. **A 40 horse power (hp) Engine pulls a block along a level road with a velocity 15m/s. The friction coefficient between block and road is 0.15. <u>Find the mass (in kg) of the block</u> (where 1hp=746W)**(Solve this question only after attending the sub question a, b, c, d, e, f, and g)

   a) What are the key features of the problem situation given above? (Select all that apply) *(Max. Score=1)*

   A) Motion along a level road with varying velocity

   B) Motion along a level road with Constant velocity

   C) Motion along an inclined plane with constant velocity

   D) Power supplied to move a body against friction

   E) Power supplied to lift a body against gravity

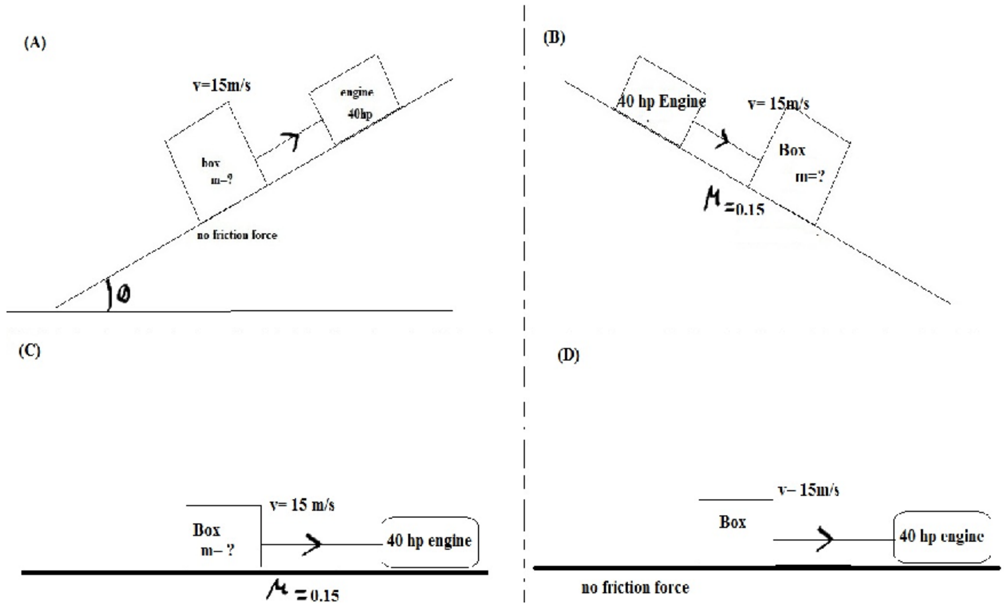
   F) Work done by gravitational force

   G) Work done by frictional force

   H) Energy expended by the engine goes in to thermal energy

   I) Energy expended by the engine goes in to increase the kinetic energy

b) Identify the diagram that correctly represent the situation of the problem? (*Score*=1)



c) Which of the following quantities are directly given/stated in the problem? (select all that apply) *(Max. Score=1)*

A) Mass of the engine
B) Mass of the block
C) Velocity of the block
D) Power of the engine
E) Coefficient of friction
F) Distance travelled

d) Identify what kind of problem it is? (*Score=1*)

A) Work
B) Work-Kinetic energy theorem
C) Kinetic energy
D) Conservation of linear momentum
E) Kinetic energy and linear momentum conservation
F) Mechanical power
G) Potential energy

e) What laws/ideas are needed to solve this problem? (*Score=1*)

A) Total linear momentum before collision=total linear momentum after collision
B) Applied force=product of mass and acceleration
C) Work done by net force =change in kinetic energy
D) Power= rate of change of work done

f) Which of the following quantities are not relevant for solving the problem? *(Max. Score=1)*

A) 40hp
B) 15m/s
C) 0.15

D) Need all the information given to solve the problem

g) Which of the following equation/equations are required to solve the problem? (*Score=1*)

A	**W= F.d**	**E**	**W= ΔKE**	**I**	**KE=** $^1/_2 MV^2$
B	**E= KE+PE**	**F**	**P=** $\frac{W}{t}$	**J**	**PE= Mgh**
C	$V_1 = \frac{(M_1 - M_2)u_1 + 2M_2\, u_2}{(M_1 + M_2)}$	**G**	$V_2 = \frac{(M_2 - M_1)u_2 + 2M_1\, u_1}{(M_1 + M_2)}$	**K**	**f= μmg**
D	**F=ma**	**H**	$M_1 u_1 + M_2 u_2 = M_1 v_1 + M_2 v_2$	**L**	**W=Fv**

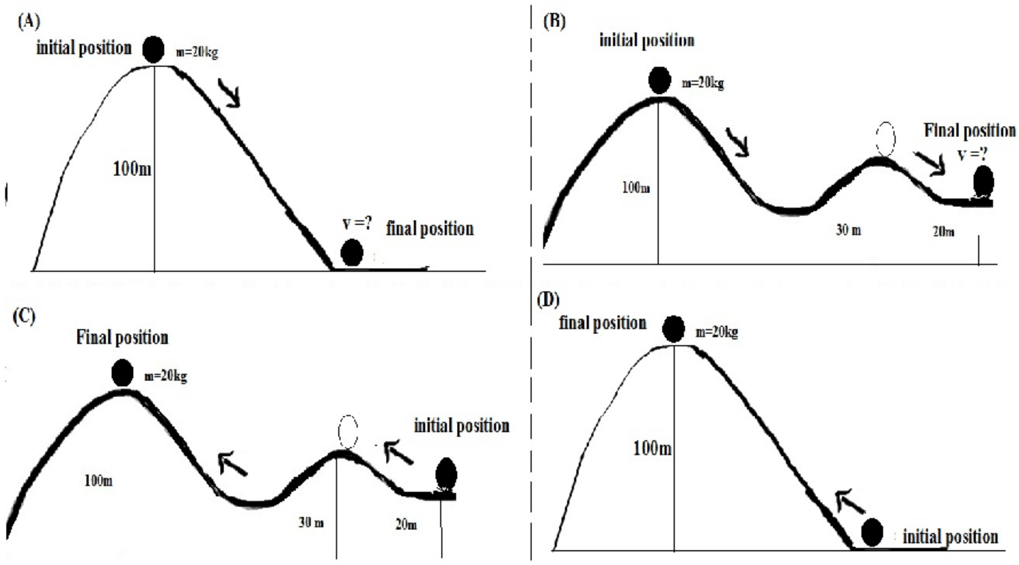
h) Find the mass (in kg) of the block (Apply the equation and calculate the final answer with unit consistency) *(Max. Score=1)*

5. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. Calculate the velocity attained by the ball? (Solve this question only after attending the sub question a, b, c, d, e, f, and g)

a) What are the key features of the problem situation given above?(select all that apply) *(Max. Score=1)*

A) Presence of frictional force
B) Absence of frictional force
C) Work done by frictional force
D) Ball-Earth system
E) Change in the state (the position and velocity) of object.
F) Work done by gravitational force
G) No change in the state (the position and velocity) of object

b) Identify the diagram that correctly represents the situation of the problem? (*Score=1*)



c) Which of the following quantities are directly given/stated in the problem? (select all that apply) *(Max. Score=1)*

A) Mass of the ball
B) Height of the hills
C) Initial velocity of the ball
D) Height of the horizontal base
E) Final velocity of the ball

d) Identify what kind of problem it is? *(Score=1)*

A) Work
B) Kinetic energy
C) Conservation of mechanical energy
D) Conservation of linear momentum
E) Kinetic energy and linear momentum conservation
F) Mechanical power[G].Potential energy

e) What laws/ideas are needed to solve this problem? *(score=1)*

A) Total linear momentum before collision =total linear momentum after collision
B) Applied force=product of mass and acceleration
C) Initial kinetic energy +initial potential energy= final kinetic energy + final potential energy
D) Power= rate of change of work done

f) Which of the following quantities are not relevant for solving the problem? *(Max. Score=1)*

A) 20kg B) 100m C) 30m D) 20m
E) Need all the information given to solve the problem

g) Which of the following equation/equations are required to solve the problem? *(Score=1)*

A	**W= F.d**	**E**	**W= ΔKE**	**I**	**KE=** $\frac{1}{2}MV^2$
B	**E= KE+PE**	**F**	**P=** $\frac{W}{t}$	**J**	**PE= Mgh**
C	$V_1=\frac{(M_1-M_2)u_1+2M_2\,u_2}{(M_1+M_2)}$	**G**	$V_2=\frac{(M_2-M_1)u_2+2M_1\,u_1}{(M_1+M_2)}$	**K**	**f= µmg**
D	**F=ma**	**H**	$M_1u_1+M_2u_2=M_1v_1+M_2v_2$	**L**	**W=Fv**

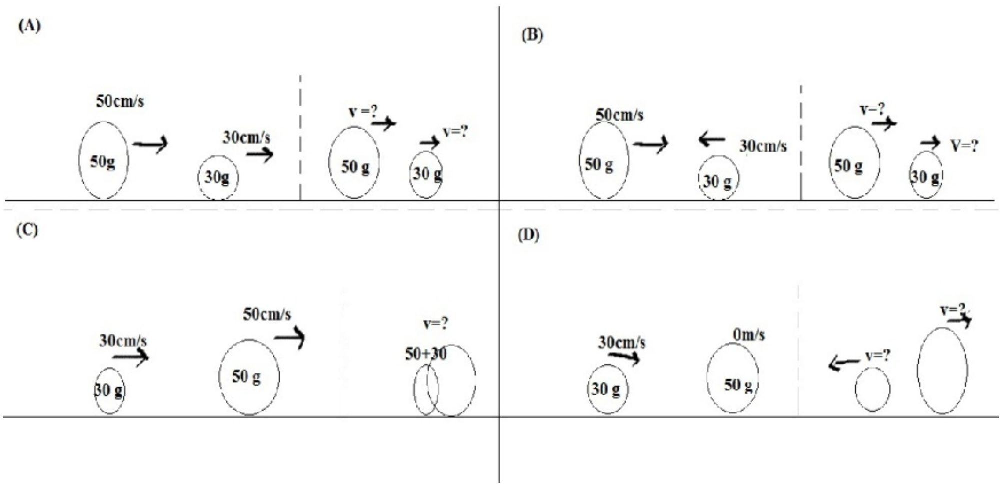
h) Calculate the velocity attained by the ball (Apply the equation and calculate the final answer with unit consistency) *(Max. Score=1)*

6. **Two bodies of masses 50g and 30g moving in the same direction, along the same straight line with velocities 50 cm/s and 30cm/s respectively suffer one dimensional elastic collision. <u>Calculate their velocities after the collision?</u>**(Solve this question only after attending the sub question a, b, c, d, e, f, and g)

   a) **What are the key features of the problem situation given above? (Select all that apply)** *(Max. Score=1)*

   A) Isolated system with two objects
   B) Non isolated system with two objects
   C) Unknown initial velocities and known final velocities
   D) Known initial velocities and unknown final velocities.
   E) Elastic collision in one dimension
   F) Elastic collision in two dimension
   G) Inelastic collision in two dimension
   H) Inelastic collision in one dimension
   I) initial velocities are in same direction
   J) Initial velocities are in opposite direction

   b) **Identify the diagram that correctly represents the situation of the problem?** *(Score=1)*



   c) **Which of the following quantities are directly given/stated in the problem? (select all that apply)** *(Max. Score=1)*

   A) Mass of the first body
   B) Mass of the second body
   C) Initial velocity of the first body
   D) Initial velocity of the second body
   E) Final velocity of the first body
   F) Final velocity of the second body

d) Identify what kind of problem it is? *(Score=1)*

A) Work
B) Work-Energy/kinetic energy theorem
C) Collision
D) Conservation of linear momentum
E) Kinetic energy and linear momentum conservation
F) Mechanical power
G) Potential energy

e) What laws/ideas are needed to solve this problem?(select all that apply) *(Max. Score=1)*

A)Total linear momentum before collision=total linear momentum after collision
B) Total kinetic energy before collision =total kinetic energy after collision
C) Work done by net force =change in kinetic energy
D) Power= rate of change of work done

f) Which of the following quantities are not relevant for solving the problem? *(Max. Score=1)*

A) 50kg B) 30kg C) 50cm/s D) 30cm/s
E) Need all the information given to solve the problem

g) Which of the following equation/equations are required to solve the problem? *(score=1)*

A	**W= F.d**	E	**W= ΔKE**	I	**KE=** $^1/_2 MV^2$
B	**E= KE+PE**	F	**P=** $\frac{W}{t}$	J	**PE= Mgh**
C	$V_1 = \frac{(M_1 - M_2)u_1 + 2M_2 u_2}{(M_1 + M_2)}$	G	$V_2 = \frac{(M_2 - M_1)u_2 + 2M_1 u_1}{(M_1 + M_2)}$	K	**f= µmg**
D	**F=ma**	H	$M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$	L	**W=Fv**

h) Calculate their velocities after the collision?(Apply the equation and calculate the final answer with unit consistency) *(Max. Score=1)*

Appendix F2

TEST OF ASSESSING COMPREHENSION OF PROBLEM SCHEMA

RESPONSE SHEET

Name:……………………………………………… ………………..Gender: M / F

School:………………………………………………………Class: XI Div:…........

PROBLEM NO:					
QNO	**ANSWERS**	**QNO**	**ANSWERS**	**QNO**	**ANSWERS**
a		**b**		**c**	
d		**e**		**f**	
g					
h					

TOTAL SCORE	

Appendix F3

TEST FOR ASSESSING COMPREHENSION OF PROBLEM SCHEMA

SCORING KEY

PROBLEM : 1						PROBLEM :2					
Q. NO.	**Ans**	**Score distribution**	**Q. No**	**Ans**	**Score distribution**	**Q No**	**Ans**	**Score distribution**	**Q No**	**Ans**	**Score Distribution**
a	B, D, E, F	0.25 0.25 0.25 0.25 =1	**b**	A	1	**a**	C, F	0.5 0.5 =1	**b**	C	1
c	A, B, C, E	0.25 0.25 0.25 0.25 =1	**d**	C	1	**c**	A, C, D, E	0.25 0.25 0.25 0.25 =1	**d**	B	1
e	D	1	**f**	A, D	0.5 0.5 =1	**e**	C	1	**f**	B	1
g	B, I, J	0.33 0.33 0.33 =1				**g**	E, A, I	0.33 0.33 0.33 =1			

h	E= KE+PE $PE_i + KE_i = PE_f + KE_f$ Mgh+ $^1/_2 MV^2$ = 0+KE_f KE_f =150+5=**155J**				=1	**h**	Loss in KE= ½(Mv2-Mu2)=6300J WORK DONE=F.d **work done= change in KE** F.d=6300 F=6300N				=1
	ANS = **155J**						ANS=F=**6300N**				
PROBLEM : 3						**PROBLEM :4**					
a	A, G	0.5 0.5 =1	**b**	B	1	**a**	B, D, G, H	0.25 0.25 0.25 0.25 =1	**b**	C	1
c	A, B, C, D	0.25 0.25 0.25 0.25 =1	**d**	D	1	**c**	C, D, E	0.33 0.33 0.33 =1	**d**	F	1
e	A		**f**	D	1	**e**	D	1	**f**	D	1
g	H	1				**g**	F, K, L	0.33 0.33 0.33 =1			

h	m1=1800kg, m2=900kg, u1=0m/s u2=20m/s ,v=? By conservation of linear momentum M1u1+m2u2= m1v1+ m2v2 (m1+ m2) v= m2u2 V = 6.67m/s	1
	ANS=**V = 6.67m/s**	

PROBLEM : 5

a	B, D, E, F	0.25 0.25 0.25 0.25 =1	**b**	B	1
c	A, B, C, D	0.25 0.25 0.25 0.25 =1	**d**	C	1
e	C	1	**f**	A	1
g	B, I, J	0.33 0.33 0.33 =1			
h	MgH= KE+PE MgH= 1/2MV2+ Mgh V= √ (2g(100-20)= =40 m/s	= 1			
	ANS==**40 m/s**				

h	P=w/t==fv f= µmg P= µmg.v P=40hp=(40x746)= 0.15 x9.8x15x M M=1353kg	1
	ANS=**M=1353kg**	

PROBLEM :6

a	A, D, E, I	0.25 0.25 0.25 0.25 =1	**b**	A	1
c	A, B, C, D	0.25 0.25 0.25 0.25 =1	**d**	E	1
e	A, B	0.5 0.5	**f**	E	1
g	C, D	0.5 0.5 =1			
h	v1=35cm/s v2=55cm/s	0.5 0.5 =1			
	ANS= **v1=35cm/s v2=55cm/s**				

Appendix G

STUDENT'S PERCEPTION OF SCHEMA BASED INSTRUCTION

VIJESH K
Senior Research Fellow
Farook Training College

Dr. MANOJ PRAVEEN G
Associate Professor in Education
Farook Training College

Name .... Gender : Male / Female

Please read each of the statements and express your feedback with a tick mark (✓) in the appropriate box.

Sl. No.	Statements	Totally Disagree	Disagree	Neutral	Agree	Totally agree
PERCEPTION RELATED TO COGNITIVE DOMAIN						
1	Schema Based Instruction (SBI) has helped me to think and analyze the structure of the problem in a meaningful way.					
2	The way of classifying problems into problem types helps me to better comprehend the problem.					
3	This method helps me to analyze and understand the situational aspects of the problem					
4	This method helps me to analyze and understand how the concepts are connected in the given problem situation					
5	This method helped me to identify similarities and differences embedded in the problems					
6	Familiarizing with different problem types helped me to recognize and identify the type of new problem given					
7	This method is helpful to recognize and understand the relevant data embedded in the problems					

Sl. No.	Statements	Totally Disagree	Disagree	Neutral	Agree	Totally agree
8	The variety of practice problems which were given helped me to increase my problem-solving skill.					
9	The structural map of connected concepts helped me to comprehend the relationship between them in its totality					
10	Schema diagram was helpful as it was visual and had key components of problems					
11	Schema diagram helped me to meaningfully solve a problem					
12	Schema based instruction helped me to better understand the concepts behind the problems I solved in class					
	PERCEPTION RELATED TO AFFECTIVE DOMAIN					
13	I feel more comfortable while using schema for doing problems.					
14	I enjoyed drawing the situation diagram as part of this method					
15	Activities included in this method encouraged me to practice problem solving.					
16	I value the Systematic nature of this problem solving method as it increased my problem solving skill.					
17	By practicing this method I believe that I am able to solve even unfamiliar problems					
18	I felt that I was comfortable with schema based learning					
19	I appreciate this problem solving method and will use this method in future to solve problems					
20	Schema based problem solving consumes a lot of time					

Thank you for your feedback – Your suggestions will be taken care of in further studies

Appendix H

Lesson Transcript

SCHEMA BASED INSTRUCTION

Name of the teacher: Vijesh K Std: 11. Sub: Physics

Chapter :	**Work, Energy, and Power**
Problem type	**Work-Energy theorem**
Learning objectives	1. Pupil understands, how to use the relationship between total work and change in kinetic energy(Work-Energy theorem) to solve problems in mechanics 2. Solving different Work-Energy problems Pupil understands how the total work done on a body changes the body's kinetic energy 3. Pupil develops robust problem schema of problem type: Work-Energy theorem by encountering different story problems related to Work-Energy theorem.
Conceptual knowledge	1. The total work done on a body by external forces is related to the body's displacement—that is, to changes in its position. But the total work is also related to changes in the speed of the body. 2. when a particle undergoes a displacement, it speeds up if$W_{Total}>0$, slows down if $W_{Total}<0$ and maintains the same speed if$W_{Total}=0$ 3. The work done by the net force on a particle equals the change in the particle's kinetic energy:
Prerequisites	Force, work , work done by: gravitational force, spring force, and friction force, Kinetic Energy, Work – Energy theorem
Teaching aids	Diagram of situational model, structural map of problem type Work-Energy theorem, problem schema

TEACHER'S ACTIVITY	STUDENT'S ACTIVITY
<u>**PHASE 1: PREPARATION FOR PROBLEM SOLVING.**</u>	
Step. 1.1: ***Presentation of Work-Energy Problem***	
• Teacher presents a story problem of problem type 'work-energy theorem' before the students. **Problem:** *A 1200kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?*	
Step 1. 2: ***Identifying familiar and unfamiliar concepts in the problem***	
Teacher evaluates students prerequisites about the given problem situation based on the physical quantities, conceptual elements and target variables. Teacher requests students to list out familiar and unfamiliar concepts and principles embedded in the problem scenario **Teacher's statements:** ❖ classify the information given in the problem as familiar concepts and unfamiliar concepts	Students analysis story context and make an effort to list out their perception in terms of familiar concepts and unfamiliar concepts.
Step 1.3: ***Drawing situation diagram***	
Teacher requests students to draw a simple sketch of the problem scenario.	Drawing situation diagram by including conceptual elements of the problem scenario
Step 1.4: Providing conceptual knowledge	
Teacher evaluates learners' prerequisites and based on them, provides content knowledge about the unfamiliar concepts/principles embedded in the problem scenario.	Understanding unfamiliar concepts presented in the problem

<table>
<tr><th>TEACHER’S ACTIVITY</th><th>STUDENT’S ACTIVITY</th></tr>
<tr><td colspan="2">PHASE 2: FAMILIARIZING WITH THE PROBLEM TYPE ‘WORK-ENERGY THEOREM’</td></tr>
<tr><td colspan="2">Step 2.1: Identifying situational elements needed to solve the problem</td></tr>
<tr><td>In order to planning situational analysis of the problem, teacher provides students the first part of schema diagram that consisting of physical conditions-state of the object, Nature of Motion, Kind of forces & Direction of force; and number of slots corresponding to each physical condition(figure:2). Following that teacher presents a situational model of the problem type Work-Energy theorem(figure 1) that consist of situational elements of ‘work energy theorem’ problems. And request students to fill the slots by identifying relevant situational elements needed to solve the problem at hand and their interpretations. For that they are asked to compare situational elements presented in the problem with situational model presented by the teacher.
Teacher statement:
1. What part(s) of the situational model is/are best representative of the given problem situation?</td><td>By comparing problem situation with situational model provided by the teacher, students identify relevant situational elements, interpret the identified situational elements and make constructive inference about the major concept embedded in the problem. And map these elements onto the slots corresponding to each physical condition in the situational part of schema diagram (Figure 2).</td></tr>
<tr><td colspan="2">

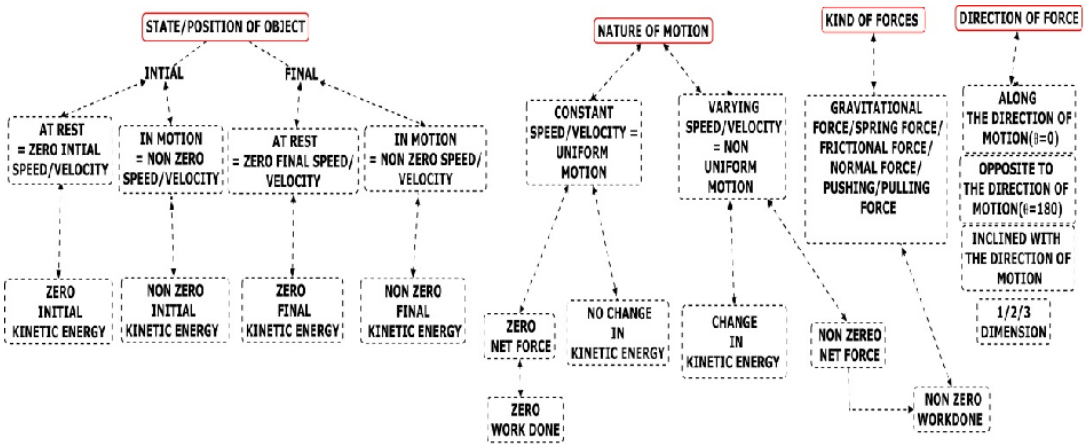
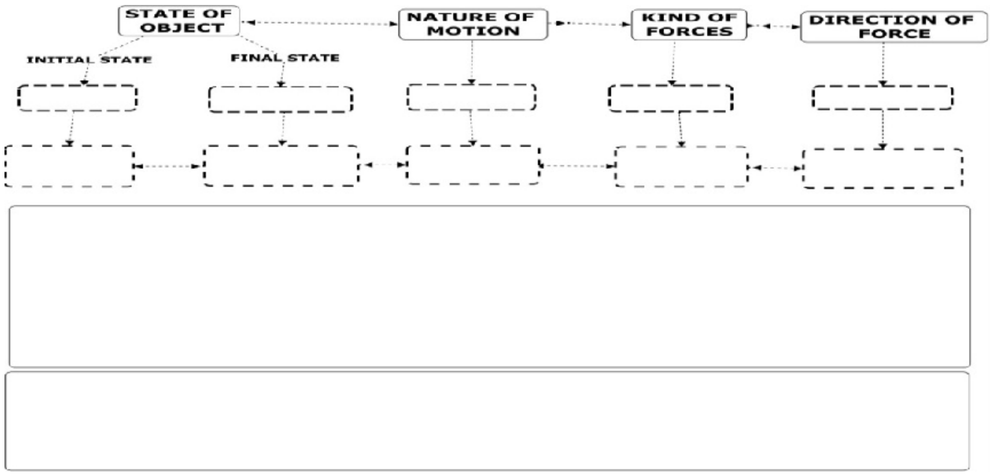
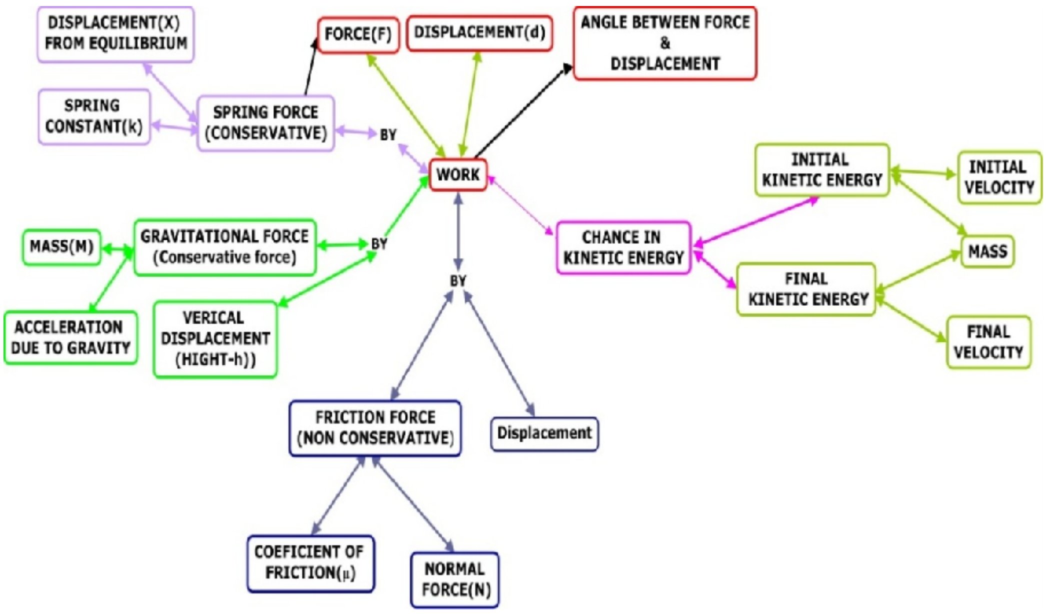


Figure: 1

</td></tr>
</table>

TEACHER'S ACTIVITY	STUDENT'S ACTIVITY
 Figure: 2	
Step 2.2: ***Identifying correct structural relationship in the problem***	
Teacher asks students to identify the correct structural relationship embedded in the problem Teacher statement: What part(s) of the structural map(figure.3) is/are best representative of the structural relationship in the given problem?	Identifying appropriate structural relationships from the structural map and map them onto the problem schema of Work energy problem(figure4)
 Figure: 3	

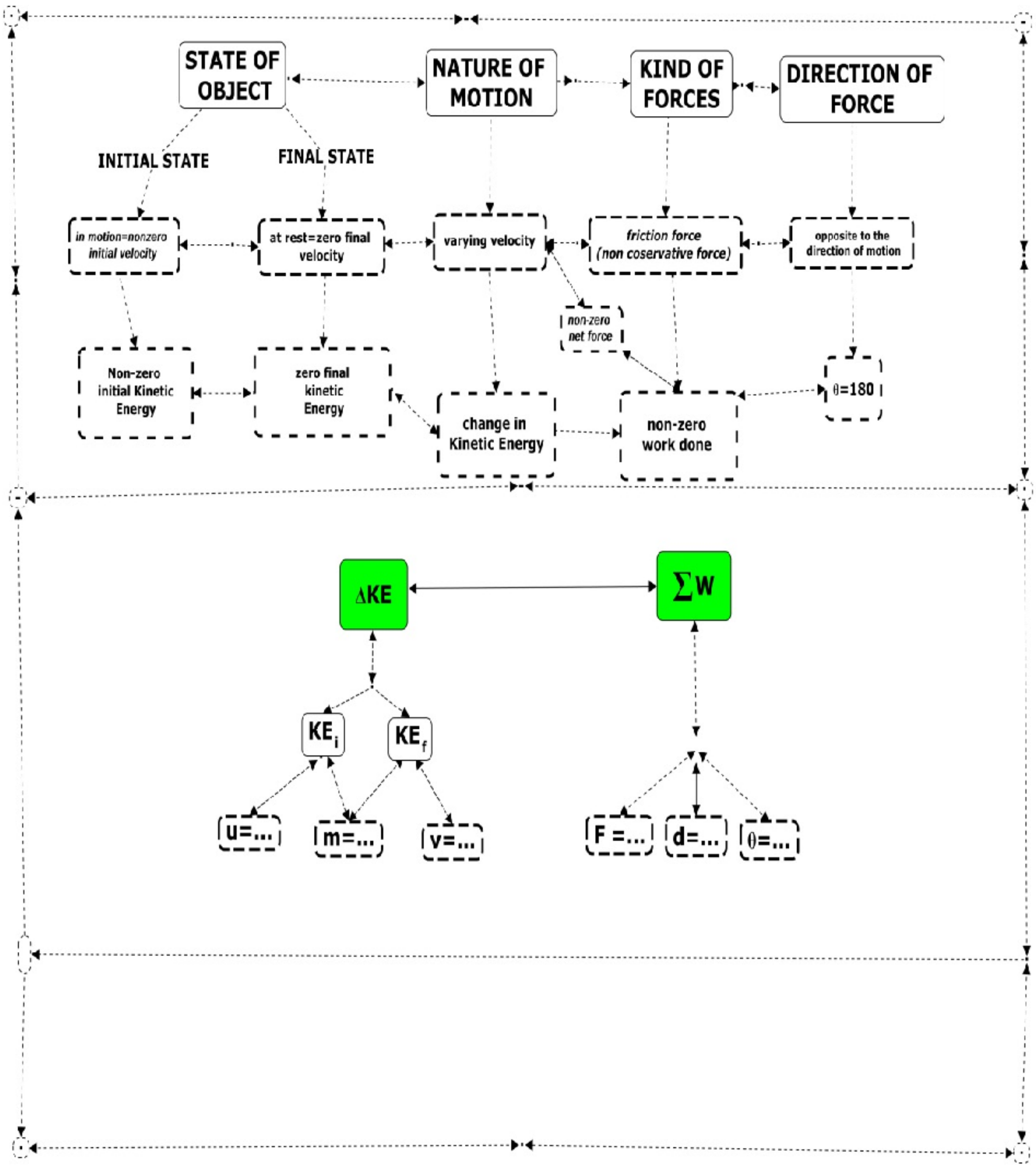
<table>
<tr><th>TEACHER’S ACTIVITY</th><th>STUDENT’S ACTIVITY</th></tr>
<tr><td colspan="2">


Figure: 4
</td></tr>
<tr><td colspan="2">Step 2.3: Retrieving correct mathematical formula of problem type: Work Energy theorem</td></tr>
<tr><td>Based on the structural relationship embedded in the problem, students are asked to retrieve correct mathematical formula</td><td>Retrieving correct mathematical formula and mapping them onto the schema diagram (figure5)</td></tr>
</table>

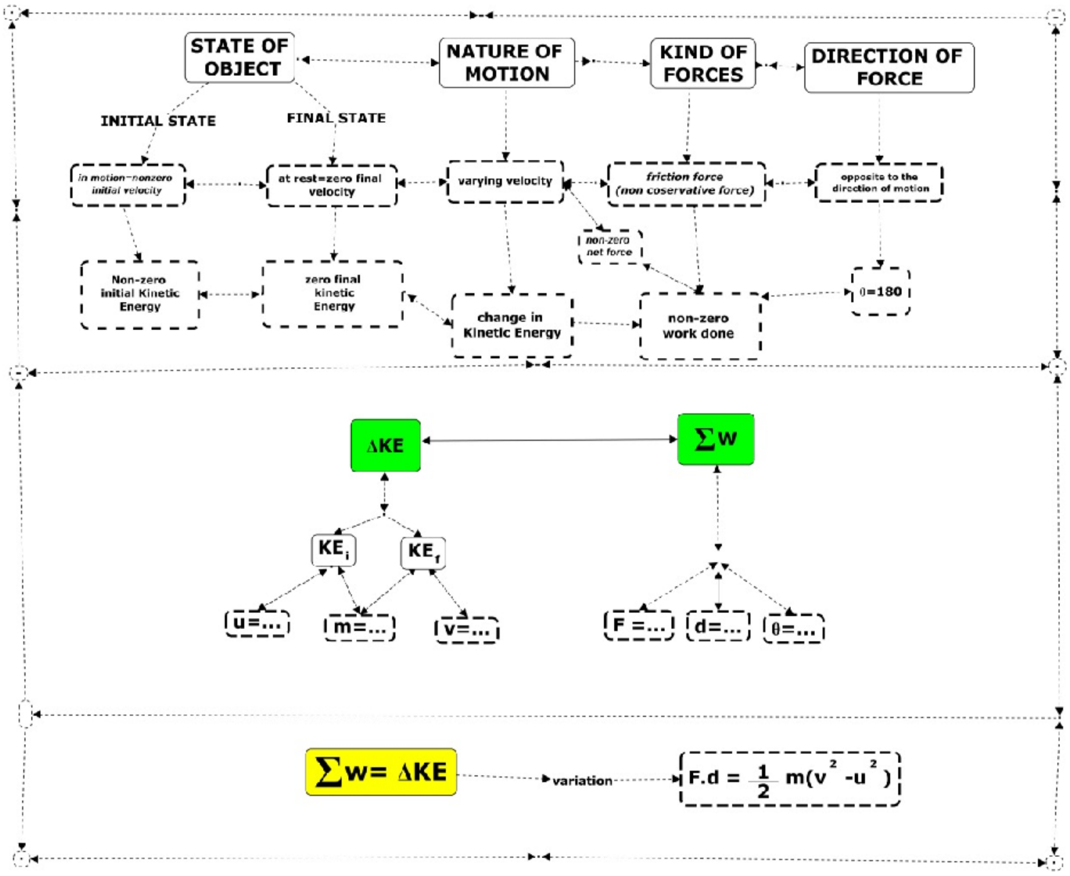
<table>
<tr><th>TEACHER’S ACTIVITY</th><th>STUDENT’S ACTIVITY</th></tr>
<tr><td colspan="2">

Figure: 5</td></tr>
<tr><td colspan="2">Step 2.4: Superimposing data on Schema</td></tr>
<tr><td>Find out the correct numerical values of the conceptual elements and superimpose them on the appropriate schema elements.</td><td>Super imposing numerical values on the appropriate schema elements</td></tr>
<tr><td colspan="2">Step 2.5: Substitute the values, and solve the equation(unit)</td></tr>
<tr><td>Students are requested to substitute the values of conceptual elements in the problem and solve the equation</td><td>Plugging relevant data on to the mathematical formula and finding the numerical value of target variable</td></tr>
<tr><td colspan="2">Step 2.6: Reflection</td></tr>
<tr><td>Teacher request students to Attribute the values and conceptual elements on the visual diagram to get a holistic picture.</td><td></td></tr>
</table>

<table>
<tr><th>TEACHER'S ACTIVITY</th><th>STUDENT'S ACTIVITY</th></tr>
<tr><td colspan="2">PHASE 3: FAMILIARIZING WITH SITUATIONALLY DISSIMILAR AND STRUCTURALLY SIMILAR PROBLEMS:</td></tr>
<tr><td colspan="2">Step 3.1: Presentation of situationally dissimilar and structurally similar story problems:</td></tr>
<tr><td>Teacher presents another examples of work energy problems and asks students to identify situational elements, structural elements and mathematical formula with the help of schema diagram constructed by them for previous problem(repeat the steps explained in phase 2) and solve the problem

Problem 2: A bullet of mass 20 g is fired from a rifle with a velocity of 800m/s. After passing through a mud wall 100 cm thick, velocity drops to 100 m/s. What is the average resistance of the wall neglecting friction due to air?

Problem 3. A bullet having a speed of 153 m/s crashes through a plank of wood. After passing through the plank its speed is 130 m/s. Another bullet, of the same mass and size but travelling at 92 m/s, is fired at the plank. What will be this second bullet's speed after tunneling through? Assume that the resistance of the plank is independent of the speed of the bullet.</td><td>Repeating steps mentioned in phase 2 and solving problems</td></tr>
<tr><td colspan="2">PHASE 4: FAMILIARIZING WITH SITUATIONALLY SIMILAR AND STRUCTURALLY DISSIMILAR PROBLEMS:</td></tr>
<tr><td colspan="2">Step 4.1: Presentation of situationally similar and structurally dissimilar problems</td></tr>
<tr><td>Teacher presents situationally similar and structurally dissimilar problems. Students are requested to select problems that can be solved with schema of work energy theorem.</td><td></td></tr>
</table>

TEACHER'S ACTIVITY	STUDENT'S ACTIVITY
Problem1:1. *Two industrial men sliding an initially stationary 225 kg Box, a displacement S of magnitude 8.5m, straight toward the truck. The push of man 1 is 20 N directed at an angle of 300 downward from the horizontal; the pull of man 2 is 15N directed at 40o above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. What is the net work done on the box by forces F1&F2 during the displacement?* *Problem.2: 6. Two industrial men sliding an initially stationary 225 kg Box , a displacement S of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 30o downward from the horizontal; the pull of man 2 is 10N directed at 40o above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?* **Teacher statement:** 1. Select the problems that can be solved with schema of work energy theorem. 2. What element(s) of the situational model of the problem schema of work energy theorem is/are best representative of the context of given problems?	
Step 4.2: ***Argumentation:***	
Teacher asks students to formulate arguments	Formulating arguments for their selection on the basis of concepts

<table>
<tr><th>TEACHER’S ACTIVITY</th><th>STUDENT’S ACTIVITY</th></tr>
<tr><td>for their selection of problems.
Teacher statements:
1. Explain your reason for your selection?</td><td>and principles.</td></tr>
<tr><td colspan="2">PHASE 5: PRACTICING PROBLEM SOLVING USING PROBLEM SCHEMA:</td></tr>
<tr><td>Teacher requests students to solve the following work- energy problems by identifying situational elements, relevant data, structural relationship in the problem, and mathematical equations.
<u>Practice problem 1</u>
A bullet having a speed of 153 m/s crashes through a plank of wood. After passing through the plank its speed is 130 m/s. Another bullet, of the same mass and size but travelling at 92 m/s, is fired at the plank. What will be this second bullet’s speed after tunneling through? Assume that the resistance of the plank is independent of the speed of the bullet.
1. What are the key features of the given problem situations?
2. What are the relevant data given in the problem?
3. Draw the diagram that correctly represents the situation of the problem?
4. What quantities are directly given/stated in the problem?
5. Identify what kind of problem it is?
6. Identify the core idea embedded in the problem scenario
7. What equation is needed to solve the given problem?
8. What will be this second bullet’s speed after tunneling through?</td><td>Students
1. Identify the key features of the problem scenario.
2. Identify target variable.
3. Identify relevant data.
4. Prepare thumbnail sketch of the problem situation.
5. Identify the problem type and structural relationship.
6. Identify the core idea embedded in the problem scenario
7. Apply data on the mathematical formula and Find out target variable</td></tr>
</table>

TEACHER'S ACTIVITY	STUDENT'S ACTIVITY
Practice problem 2. *Two industrial men sliding an initially stationary 225 kg Box , a displacement S of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 30o downward from the horizontal; the pull of man 2 is 10N directed at 40o above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?* 1. What are the key features of the given problem situations? 2. What are the relevant data given in the problem? 3. Draw the diagram that correctly represents the situation of the problem? 4. What quantities are directly given/stated in the problem? 5. Identify what kind of problem it is? 6. Identify the core idea embedded in the problem scenario 7. What equation is needed to solve the given problem? 8. What is the speed v at the end of the 8.5m displacement? Practice problem: 3 *A toy car with mass of 2kg starts at rest. A spring performs 196 joules of work on the car. What is the toy car's final velocity?* 1. What are the key features of the given problem situations?	

TEACHER'S ACTIVITY	STUDENT'S ACTIVITY
2. What are the relevant data given in the problem? 3. Draw the diagram that correctly represents the situation of the problem? 4. What quantities are directly given/stated in the problem? 5. Identify what kind of problem it is? 6. Identify the core idea embedded in the problem scenario 7. What equation is needed to solve the given problem? 8. What is the toy car's final velocity?	

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Appendix I

Lesson Transcript

DIRECT TRANSLATION STRATEGY

Name of the teacher: Vijesh K   Std: 11.   Sub: Physics

Chapter :	**Work, Energy, and Power**
Topic	**Work-Energy theorem**
Learning objectives	1. Pupil understands, how to use the relationship between total work and change in kinetic energy(Work-Energy theorem) to solve problems in mechanics 2. Solving different Work-Energy problems Pupil understands how the total work done on a body changes the body's kinetic energy
Conceptual knowledge	1. The total work done on a body by external forces is related to the body's displacement—that is, to changes in its position. But the total work is also related to changes in the speed of the body. 2. when a particle undergoes a displacement, it speeds up if $W_{Total}>0$, slows down if $W_{Total}<0$ and maintains the same speed if $W_{Total}=0$ 3. The work done by the net force on a particle equals the change in the particle's kinetic energy:
Prerequisites	Force, work , work done by: gravitational force, spring force, and friction force, Kinetic Energy, Work –Energy theorem
Teaching aids	Charts for displaying story problems and equations

Teacher Activity	**Student Activity**
Preparation for Problem solving	
The teacher checks the prerequisites of the students on concepts like Force, Work, Kinetic Energy, Work Kinetic Energy (Work-Energy) theorem etc. Teacher Statement: 1. How is Force measured? 2. Which equation is used for calculating the amount of work done by an object? 3. Which equation is used for calculating the kinetic Energy done of an object? 4. How is the Kinetic Energy related to the Work done by an object?	1.$F= Ma$ 2.$W= F.d$ 3.$K=\frac{1}{2} Mv^2$ 4.$W=\Delta KE$
Presentation of the Problem	
A story problem including concepts as force, Work, and Kinetic Energy are presented in front of the students, to be solved. Problem 1: *A 1200kg car going 30m/s applies its brakes and skids to rest. If the friction force between the sliding tyres and the road is 6000N, how far does the car skid before coming to rest?*	The students read the problem carefully.
Reading the Problem	
The teacher asks the students to read and comprehend the given problem carefully.	

Teacher Activity	**Student Activity**
Representing the Unknown with letters	
The teacher asks the students to assign an appropriate letter to the unknown physical quantity in the given problem. Teacher statement: 1. What does the problem ask you to find out? 2. In this problem, you are asked to find the stopping distance. What letter do you use to denote distance?	1.How far does the car skid before coming to rest 2.“d”
Identifying the Key Values	
the teacher asks the students to find the values given in the problem situation that will help them find the stopping distance. Teacher statement: What are the values of the physical quantities given in the problem that will help you find the stopping distance.	Students identify the following values from the problem. M=1200kg V=30m/s F= 600N
Identifying the Correct equation	
The teacher asks the students to identify the correct equation in order to find the stopping distance with the help of the values given in the problem situation Explanation : 1. Force is applied to bring the car to rest. As a result, a work is done in this situation. 2. The amount of work done is dependent on force applied and the displacement produced. 3. There was a change in the Kinetic Energy of the car.	

Teacher Activity	**Student Activity**
Find the correct equation based on the conceptual information given above.	
Inserting Values into formula	
Apply the key values identified from the problem situation in the equation.	
Solving equation to find the values of unknowns	
The teacher explains the mathematical procedure for solving the equation. The students calculate the stopping distance based on it.	
Presentation of Problem 2 and problem 3	
The teacher presents problem 2 and problem 3 infront of the students. Problem 2: *A bullet of mass 20 g is fired from a rifle with a velocity of 800m/s. After passing through a mud wall 100 cm thick, velocity drops to 100 m/s. What is the average resistance of the wall neglecting friction due to air?* Problem 3*:* *A bullet having a speed of 153 m/s crashes through a plank of wood. After passing through the plank its speed is 130 m/s. Another bullet, of the same mass and size but travelling at 92 m/s, is fired at the plank. What will be this second bullet's speed after tunneling through? Assume that the resistance of the plank is independent of the speed of the bullet* The students solve problem 2 by repeating the steps of problem 1 with the help of the teacher. After that, they solve problem 3 as	

Teacher Activity	Student Activity
well using the above steps, with the help of the teacher.	
Practicing Problem Solving	
The teacher asks students to solve the following story problems *Problem1.* *Two industrial men sliding an initially stationary 225 kg Box, a displacements of magnitude 8.5m, straight toward the truck. The push F1 of man 1 is 12 N directed at an angle of 30o downward from the horizontal; the pull of man 2 is 10N directed at 40o above horizontal. The magnitude and direction of these forces do not change as the box moves, and floor and box make frictionless contact. The work done by the force F1 and F2 is 88.33 J and 65.11 J respectively. What is the speed v at the end of the 8.5m displacement?* Problem 2: *A bullet having a speed of 153 m/s crashes through a plank of wood. After passing through the plank its speed is 130 m/s. Another bullet, of the same mass and size but travelling at 92 m/s, is fired at the plank. What will be this second bullet's speed after tunneling through? Assume that the resistance of the plank is independent of the speed of the bullet.* Problem 3: *A toy car with mass of 2kg starts at rest. A spring performs 196 joules of work on the car. What is the toy car's final velocity?*	

Appendix J

CERTIFICATES OF CONSULTATION WITH EXPERTS

CERTIFICATE

This is to certify that Mr. Vijesh K Senior Research Fellow (UGC), Farook Training College Research Center in Education have consulted me regarding his Research on Schema Based Instruction. He have discussed with me about the Classification of problems in Mechanics, selection of test items, design of Structure Map, Situational Model of different Problem Types, design of Instructional Phases etc.

I have gone through the maps, diagrams and tests he designed for the study and suggested appropriate modifications wherever necessary.

Dr. Vishnu Kavungal

Researcher

Technological University Dublin

Dublin, Ireland

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Signature

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I have gone through the maps, diagrams, Instructional strategy and tests he designed for the study and suggested appropriate modifications wherever necessary.

Govt. Fisheries Vocational Higher Secondary School Cheruvathur

Signature

15/06/19

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Principal & NVT Physics

GFVHSS, Cheruvathur

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RAJAPURAM
Date: 7-6-19

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