International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 06, 2020
ISSN: 1475-7192

# Integrated Process Skills Fostering A Cognitive Variable For Problem Solving In Physics Teaching At Secondary Level

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***Abstract -*** *The study examines the correlation between problem solving and integrated process skills among secondary students of Kerala. Problem Solving Test and Integrated Process Skills Test were used as tools. The study was designed as a descriptive and normative survey. The sample of 100 students selected at random, from the secondary schools of Kerala. The five integrated process skills considered in the study were identifying variables, formulating hypothesis, defining operationally, interpreting data, and experimenting. The study revealed significant correlation between Problem Solving and Integrated Process Skills among secondary students. The findings of the study imply the need for development of integrated process skills adopting various problem solving strategies to facilitate the cognitive abilities of secondary students.*

***Key terms -*** *Integrated process skill: Problem solving*

## INTRODUCTION

Modern educational systems provide science education through actual scientific activities, experimentation and organisation of first-hand knowledge obtained through experimentation. Inquiry approaches in teaching science facilitate the acquisition of science process skills by providing adequate opportunity to enrich understanding of science and develop student abilities. When students focus on the processes of inquiry, they develop the ability to ask questions, define problems, investigate the world around them and use their observations to construct reasonable explanations for the problem (Krulik and Rudnick, 1996).Science processes are intellectual skills used in collecting and analysing data to solve problems. Scientific knowledge helps to develop the process skills and logical thinking abilities among students. The process of scientific thinking occurs naturally and spontaneously in our minds. By breaking down the steps in our thinking systematically and logically, we can use the scientific process of thinking to find how to answer our questions about the world. The processes of science are not only useful for learning science but also for understanding any situation that requires critical thinking and problem solving skills. When students are confronted with the problems of life, they should be able to solve them successfully. Students undergoing educational programs, which have well- defined academic objectives, will develop better efficiency in problem

**Received: 18 Jan 2020 | Revised: 09 Feb 2020 | Accepted: 02 Mar 2020** 

solving and thereby enjoy grater achievement in the acquisition of basic as well as integrated process skills. Therefore a shift in emphasis from the practice of teaching the science content to inquiry approaches and problem solving methods of teaching helps to develop competence in the acquisition of science processes.

Process skills can be either basic or integrated. Basic science process skills are lower order skills that enable an individual to conduct objective investigation and draw conclusions, which are helpful in studying science as well as non-science subjects. Whereas, integrated process skills are mental and physical abilities or competencies which serve as tools needed for the effective study of science and technology as well as for problem solving, individual and social development(Ango, 1992). Basic science process skills provide the foundation for learning and acquisition of more complex integrated process skills. According to Yagerand McCormark(1989) the basic process skills are observing, measuring, classifying, communicating, predicting, inferring, using number, using space / time relationship, questioning and integrated process skills are identifying and controlling variables, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. The American Association for the Advancement of Science (AAAS, 1994) classified science process skills into fifteen viz., observing, measuring, classifying, communicating, predicting, inferring, using number, using space / time relationship, questioning, controlling variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data (Bybee et. al. 1989).

Basic science process skills are vital for concept formation and learning science at primary and middle school levels, comparatively difficult and complex integrated process skills are more appropriate for the formation of models, experimenting and inferring at the secondary and higher secondary school levels. The integrated processes skills are defined as mental and physical abilities or competencies which serve as tools needed for the effective study and problem solving in science and technology as well as for individual and social development. Integrated process skills include *identifying and controlling variables, defining operationally, formulating hypotheses, experimenting and interpreting data.* Integrated process skills enable an individual to conduct objective investigation.

The items of the Tests belongs to the following five areas

*Behavioural outcomes for Integrated process skills*

1. *Identifying and controlling variables*

***A****ble to identifying variables that are constant or change under different conditions ;* ***I****dentifying extraneous variables that can affect an experimental outcome;* ***R****ecognize the conditions and variables that are top controlled during experiment;* ***I****dentify initial conditions required for an experiment;* ***U****nderstand the how changes made is our variable affect changes made in other variable.*

2. *Formulating Hypothesis*

***S****tating a tentative generalization of observation or inferences that may be used to explain a relatively larger number of events ;****C****oming up with a variety of appropriate explanations for a particular problem ;****F****orms inference that can be tested ;****S****uggest tentative solution to a problem ;****M****aking general statement or explanation ;****A****rriving at generalization based on observation.*

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*3. Defining Operationally*

***D**efining statement that present concrete descriptions of an objects or events by telling one what to do observe; **D**efining terms in a particular context of experience; **S**tate concept by describing what should be observes; **S**tating description of what should be done; **S**tating variables by describing what should be observed; **D**escribe an event or object by its action; **S**tating events in terms of measurable description.*

*4. Experimenting*

***S**elect or design appropriate process or experiment for a particular objective ; **S**elect and design apparatus or total for a particular objective ; **D**esign an investigation in which variables are controlled ; **S**tates a hypothesis and uses other processes of investigation ; **A**rrange the steps for an experiment ; **U**nderstands and correct arrangements and condition for an experiments ; **A**rranges experiments and apparatus correctly, reasonably.*

*5. Interpreting data:*

***A**ble to interpret geographical representations and tabled idea; **F**ind gaps in data; Derive conclusions that can be drawn from the data; **R**easoning of the situation given in a data.*

## NEED AND SIGNIFICANCE OF THE STUDY

The study examines the correlation between problem solving and integrated process skills among secondary students of Kerala. Educational institutions have the moral responsibility of preparing students for the future by enabling them to develop the integrated process skills for accomplishing problem-solving in real life situations. This requires an inquiry approach and problem-solving skill of teaching. Teaching for problem solving in a context- free situation has proved to be futile. It is preferable to use these stages in problem solving for developing the problem solving cycle. For facilitating effective problem solving among students, teachers should know the strengths and weaknesses of various problem solving strategies, realize what, why and how they are solving a problem, in order to understand the strategies completely and select the most appropriate ones. Science process skills are described as mental and physical abilities and competencies which serve as tools needed for the effective study of science and technology as well as problem solving, individual and societal development (Nwosu and Okeke, 1995). Valentino (2000) described science process skills as "skills used to gather information about the world". The development of science process skills empowers learners with the ability and confidence to solve problems in everyday life (Manoharan, 2006; Murali, 2006). Padilla (1990) observed that process skills are integrated to many transferable ideas that are useful to various science disciplines and the thinking strategies of scientists. The process skills foster inquiry and manipulating skills among students and discourage rote learning.

*Enhancing Integrated Process Skills through Problem Solving*

Teaching problem-solving to students in every field facilitates organization of ideas, development of different thought skills, and building consistent thought models. Physics courses must be taught conceptually to students through problem solving method before physics formulas and equations are taught. Other strategies should be researched, rather than relying on the problem solving method to increase success and for more understanding. The studies show that interactive engagement and collaborative methods have positive effects in physics problem

solving. To get expertise in physics concepts and problem-solving skills, student should get multiple exposures over extended time periods in a variety of contexts.

Several teaching methods can be used for teaching physics. Problem solving is one approach. Problem-solving involves knowing what to do in the situation of not knowing what to do. Problem-solving is not only finding the correct answer, but also is an action which covers a wide range of mental abilities. Students should realize what and why they are doing, and know the strengths of these strategies, in order to understand the strategies completely and be able to select appropriate ones.

## REVIEW OF STUDIES ON INTEGRATED PROCESS SKILLS AND PROBLEM SOLVING

Omiko (2015) investigated the levels of possession of science process skills by final year students of colleges of education in south-eastern states of Nigeria. The process skills assessed were observation, experimentation, measurement, communication, and inference. The study adopted the descriptive survey design on a sample of 200 out of 1000 final year NCE students who studied Biology, Chemistry, Physics. Science process skills tests (SPST) and assessment format for science process skills (AFSPS) were the tools used for the study. The results indicated high level possession of observation, experimentation and measurement skills and low level possession of communication and inference skills among the respondents and gender-related significant difference in level of possession of the skills. The findings revealed that the final year N.C.E students in the colleges of education, in the South Eastern part of Nigeria studying Biology, Chemistry, Physics and integrated science subjects possess high level skills in the science process skills of observation, experimentation and measurement. The study found that there is significant difference between male and female students in the levels of possession of science process skills.

Akinbobola and Afolabi (2010)analysed the science process skills in west african senior secondary school certificate physics practical examinations for a period of 10 years (1998-2007). Ex-post facto design was adopted for the study. The prominent science process skills identified in the study are: manipulating (17%), calculating (14%), recording (14%), observing (12%) and communicating (11%). The results also show high percentage rate of basic (lower order) science process skills (63%) as compared to the integrated (higher order) science process skills (37%). The results indicate that the number of basic process skills is significantly higher than the integrated process skills in the West African senior secondary school certificate physics practical examinations in Nigeria. Akinbobola and Afolabi (2010)recommended that the examination bodies in Nigeria should include more integrated science process skills into the senior secondary school physics practical examinations so as to enable the students to be prone to creativity, problem solving, reflective thinking, originality and invention which are vital ingredients for science and technological development of any nation.

Beaumont-Walters and Soyibo (2001)analysed the high school students' performance on five integrated process skills. The results indicated that the subjects mean score was low and unsatisfactory; their performance in decreasing order was: interpreting data, recording data, generalizing, formulating hypotheses and identifying variables; there were statistically significant differences in their performance based on their grade level, school type, student type, and SEB in favors. There was a positive, statistically significant and fairly strong relationship between their performance and school type, and weak relationships among their student type, grade level SEB performance.

The study suggests that student type, grade level and SEB are not influential factors in student performances, but it is school type. This too suggests that process skills can be taught, as school type directly influences teaching methods and infrastructure facilities of a school.

Normah and Salleh (2006) discovered that students who can successfully solve a problem possess good reading skills, have the ability to compare and contrast various cases, can identify important aspects of a problem, can estimate and create analogies and attempt trying various strategies.

Phang (2010) in their study on the patterns of physics problem-solving and meta cognition among secondary school students of UK and Malaysia compared patterns of physics problem solving and meta cognition. The problem-solving processes are "observed" by means of thinking-aloud technique followed by retrospective interviews and recorded using a digital video camera. The study found out that the basic problem-solving processes are identical among the two countries' students, the main divergence are in mathematical skills, reasoning skills and meta cognitive skills.

Erol (2006) conducted a study on 'Evaluation of problem solving behaviors of physics teacher candidates'. Numerous teaching methods can be used for problem-solving strategies. Therefore, the investigation of students' attitudes, behaviors, problem solving knowledge and skills becomes important while solving a problem. The effect of solving problem on a student's attitude toward science is incredibly important, because problem solving requires patience, persistence, perseverance and willingness to accept risks (Charles et al., 1987; Udousoro, 2002). Many researchers believed that if students were allowed to demonstrate higher cognitive abilities through problem solving, either through a teacher-centred approach or a student-centred approach, their attitudes towards physics might be positively affected. The studies reviewed suggest that there is a relationship between attitude and methods of instruction and between attitude and achievement.

Ayodhya (2007) in his study on problem solving skills effectiveness of conventional and polya's heuristic approach verifies the relative effectiveness of polya's heuristic approach over conventional method in developing problem solving skills. The investigation employed non randomized control group pre test and post test design to detect any significant change. 307 students participated in the experiment. Modified standardized problem solving test Idaho Direct Mathematics assessment (DMA) was used to measure problem solving skills of the students. Results of the t- test and analysis of covariance (ANCOVA) on pre test and post test scores revealed polya's heuristic approach is more effective than the conventional method in developing problem solving skills.

Sulaiman Seth and Ali Marlina (2008) performed a study on the level of problem solving ability and its relationship with meta cognitive skills among four physics students in secondary school in Johor with an aim to high light the intensity of problem solving ability and its relationship with meta cognitive skills among four physics students in secondary schools in Johor two well-validated instruments namely Meta cognitive Skills Questionnaire (MSQ) and Physics Problem Solving Ability Test (PPSAT) were conducted and the data collected were analyzed. Result of investigation shows significant correlation between meta cognitive skills and physics problem solving ability of the respondents, students with high meta cognitive skills had mean score on PPSAT which was significantly different from those students with moderate and weak meta cognitive skills. Finally the study detected

that there was no significant difference in problem solving skills between students with moderate and weak meta cognitive skills.

Nakierdemir (2009) study on determining student's attitude towards physics through problem solving. The purpose of the study was to investigate whether or not the problem solving method has an effect on students attitude towards physics. To test the scores of the control group (LM) and experimental groups (PST and SLT) in the attitude scale before treatment were subjected to ANOVA in order to know whether they had a different attitude towards problem solving in physics (dynamics). The result showed that there is a significant difference in the attitude scores of the control group (LM) and experimental groups (PST and SLT) after treatment. In order to determine which group had a more positive attitude, the mean scores of the three groups were contrasted using Scheffe test, the results from the analysis indicate that there is no significant difference for students' attitude towards problem-solving of physics in experimental groups when evaluated with respect to problem solving method. The PST group had a slightly higher, though insignificant, positive attitude than the SLT group. This finding supports the findings of Mattern and Schau (2002) and Saleh (2004) that teaching using the problem solving method to experimental groups was effective on knowledge and skill usage by the students in solving problems.

Sandro and Lee (2006) illustrated diversity of opportunities for educational activities that can be found in the complex, yet easy-to-manipulate, trophic relationships between goldenrod plants, insects that induce gall formation, and the natural enemies of these gall makers. They suggested that gall collection, measurement and observation (exit holes, larval response, temperature etc.) can help students develop scientific process skills including observation, classification, measurement, inference, prediction, controlling experimental variables, and material manipulation.

## OBJECTIVES

1. To find out the correlation between integrated process skills and problem solving among secondary school students.

2. To compare the correlation between secondary school students with problem solving and the five integrated process skills viz., *identifying and controlling variables, formulating hypothesis, defining operationally, interpreting data, and experimenting.*

## HYPOTHESES

1. There is a significant correlation between problem solving and integrated process skills among secondary school students.

2. There is significant correlation between secondary school students with problem solving and five integrated process skills viz., *identifying and controlling variables, formulating hypothesis, defining operationally, interpreting data, and experimenting*.

## TOOLS

Integrated Process Skills Test in Physics, Problem Solving Test

**Received: 18 Jan 2020 | Revised: 09 Feb 2020 | Accepted: 02 Mar 2020** 

## METHODOLOGY

The ***'Integrated Process Skills Test in Physics at the Secondary Level'*** developed in the context of the present study intends to examine the integrated process skills in Physics at secondary level as well as the five integrated process skills viz., *identifying and controlling variables, formulating hypothesis, defining operationally, experimenting and interpreting data* among students studying in the secondary schools of Kerala. The Integrated Process Skills Test in Physics at the Secondary level consists of three forms viz., *Form 1 - Integrated Process Skills Test in 'Static Electricity'; Form 2 -Integrated Process Skills Test in 'Current Electricity' and Form 3 - Integrated Process Skills Test in 'Electrodynamics'*. Each form consists of 25 test items presented as objective type multiple choice questions. The correct answer is awarded one score. The maximum score for each test is 25 and the maximum time allowed for the completion of a test is 25 minutes. The total number of items in the *Integrated Process Skills Test in Physics at the Secondary Level* is 75 of which 15 items each are allocated for the five integrated process skills viz., *identifying and controlling variables, formulating hypothesis, defining operationally, experimenting and interpreting data*.

Problem solving involves the process of reflective thinking for the purpose of arriving at rational conclusions relevant to the problem situation. Problem solving depends on a person's previous experience and requires the capacity to reason, calculate, recognize patterns and handle logical thinking. The *Problem Solving Test for secondary school students of Kerala* intends to examine the ability of a person to solve problems using scientific reasoning, quantitative reasoning and qualitative reasoning. The *Problem Solving Test for secondary school students of Kerala* is designed as an objective type multiple choice test. The test consists of three parts viz., *Part 1 - Scientific Reasoning; Part 2 - Quantitative Reasoning* and *Part 3 - Qualitative Reasoning*. Each part of the test consists of 20 items. The answers are to be indicated in the response sheet provided using a √ mark in the respective box. The correct answer is awarded one score. The maximum score for test is 60 and the maximum time allowed for the completion of the test is 60 minutes. The reliability coefficient of the Test is determined by the split-half method was 0.88. The test- retest reliability of the test computed over a period of one month was found to be 0.91

## DISCUSSIONS ON RESULTS

*Correlation between integrated process skill test and problem solving*

In order to get the significant correlation between integrated process skill test and problem solving. The obtained data were analysed with the help of descriptive and inferential statistics used for integrated process skills and problem solving. The coefficient of correlation between integrated process skill test and problem solving among secondary schools of Kerala (r= 0.84) as shown in table 1.1

**TABLE 1.1**

**Correlation between integrated process skill test and problem solving**

**Received: 18 Jan 2020 | Revised: 09 Feb 2020 | Accepted: 02 Mar 2020** 

| **Variables** | Secondary school students (N = 100) | | | | |
|---|---|---|---|---|---|
| | **ean** | | ***f*** | | |
| **integrated process skill** | 3.64 | .33 | 8 | .90 | 01 |
| **problem solving** | 5.93 | .19 | | | |

There is a very strong significant correlation (r = 0.90) between integrated process skill test and problem solving in Physics among secondary schools of Kerala. Therefore, the Hypothesis I stand valid.

*Compare the correlation between problem solving and the five integrated process skills at secondary school students of Kerala.*

To test the hypothesis, the study reveals that correlation between the scores of problem solving and the five integrated process skills through employing person's coefficient of correlation technique. The correlation value has been presented in table 1.2

**Table 1.2.**

**Correlation between problem solving and the five integrated process skills test in Physics among secondary schools of Kerala. (N=100)**

| | ean | d | Integrated process skills | ean | d | |
|---|---|---|---|---|---|---|
| *Problem solving Test* | 5.93 | .19 | *identifying and controlling variables* | .28 | .55 | **.58** |
| | | | *formulating hypothesis* | .93 | .17 | **.93** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | *defining operationally* | .76 | .00 | **.84** |
| | | | *inter preting data* | .9 | .06 | **.68** |
| | | | *expe rimenting* | .77 | .93 | **.89** |

The coefficient of correlation between problem solving and the five integrated process skills: identifying and controlling variables computed ($r = 0.58$; $P<0.01$) was greater than the table value, hence the finding shows that the strength of the correlation is moderate; formulating hypothesis computed ($r = 0.93$; $P<0.01$) was greater than the table value, hence the finding shows that the strength of the correlation is very strong; defining operationally computed ($r = 0.84$; $P<0.01$) was greater than the table value, hence the finding shows that the strength of the correlation is strong; interpreting data computed ($r = 0.68$; $P<0.01$) was greater than the table value, hence the finding shows that the strength of the correlation is moderate; experimenting computed ($r = 0.89$; $P<0.01$) was greater than the table value, hence the finding shows that the strength of the correlation is strong. There is a significant correlation between integrated process skill test and problem solving in Physics among secondary schools of Kerala. Therefore, the Hypothesis II stands valid. ( According to Garrett)

## MAJOR FINDINGS

1. There is a positive correlation between integrated process skills and problem solving among secondary schools students of Kerala.
2. There is a positive correlation between problem solving and the five integrated process skills identifying and controlling variables, formulating hypothesis, defining operationally, interpreting data, and experimenting in Physics among secondary schools students of Kerala.

## CONCLUSION

Teaching problem-solving to students in every field facilitates organization of ideas, development of different thought skills, and building consistent thought models. Physics courses must be taught conceptually to students through problem solving method before physics formulas and equations are taught. The studies show that interactive engagement and collaborative methods have positive effects in physics problem solving. To get expertise in physics concepts and problem-solving skills, student should get multiple exposures over extended time periods in a variety of contexts.

## IMPLICATIONS

The findings of the study imply the need for development of integrated process skills adopting various problem solving strategies to facilitate the cognitive abilities of secondary students. The logical

thinking patterns developed through process approach can be readily transferred to new learning situations and life through best practices in science education. Since integrated process skills tend to last longer than the learned content and influence our problem solving in day to day life, directly or indirectly, constructivist approach for teaching science may be adopted to enhance integrated process skills through problem solving. Cognitive abilities are brain based skills we need to carry out any task form the simple to complex. They have more to do with the mechanisms of how we learn the process, remember and problem solving.

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**Received: 18 Jan 2020 | Revised: 09 Feb 2020 | Accepted: 02 Mar 2020** 

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**Received: 18 Jan 2020 | Revised: 09 Feb 2020 | Accepted: 02 Mar 2020** 