Strategies based on ICT Problem solving model for enhancing integrated process skills in Physics at the Higher Secondary level

Dr. Nithya Prem S.R.

Post Doctoral Fellow (ICSSR) Department of Education, University of Kerala, Thiruvananthapuram

ABSTRACT

The present study attempts to develop a Strategies based on ICT Problem solving model for enhancing integrated process skills in Physics at the Higher Secondary level. It is concerned with finding out the effectiveness of the Problem Solving Model in enhancing Integrated Process Skills in Physics at Higher Secondary Level. Samples of 84 students were selected for the study. The analysis of data for examining the significance of hypotheses formulated in this context was performed using appropriate statistical techniques. The major statistical techniques applied for the analysis of data are computation of coefficient of correlation, critical ratio, delayed post-test and analysis of covariance (ANCOVA). Findings from this study revealed that there is significant difference between the control and experimental groups with respect to the posttest scores for integrated process skills in physics at the Higher Secondary level. finding that the Problem Solving Model for enhancing the integrated process skills in physics at the Higher Secondary level is effective than the traditional method currently being practiced in the Higher Secondary schools of Kerala.

1. Introduction

Teaching is a means for generating an environment of learning. The major aim of teaching must be to create effective independent life-long learners. The content of study and skills of teaching functions as instructional inputs through which the student and teacher interact with each other. This interaction provides an opportunity to develop physical and social efficiency. 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 model 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.

Normah and Salleh (2006) observed that students who can successfully solve problems 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. Padilla, Dillashawand Okey(2006) expressed that although the philosophical importance of integrated process skills is unchallenged, there is a lack of research on when and how these skills may be best taught to students in the middle and secondary schools. Ayodele (2002) remarked that successful science teaching requires that the student make sense out of what they are taught. The traditional method of teaching means that the teacher stands in front of the silent group, while the students listen quietly during teaching. It is important for teachers to learn how to use a teaching method that encourages scientific processes and other desirable scientific attitudes. One of the ways by which this could be done is adopting a teaching method which encourages problem solving strategies. Erol (2006) observed that the implementation of the *No Child Left Behind Act(NCLB)* has prompted renewed efforts to hold schools and students accountable for meeting high academic standards, and as a result more specific approach to addressing academic difficulties, *Response To Intervention(RTI)* has been proposed as a component of problem solving. The results provides strong evidence that RTI can systematically improve the effectiveness of instruction for struggling students and provide school teams with evidence-based procedures that measures a student's progress and his or her need for special services. Several studies which highlight the nature of problem solving were reviewed. Phang (2010) observed that the patterns of problem solving and that of meta cognition is indistinguishable among children. Schmidt and Ford (2003) reported that student attitudes, behaviors, problem solving knowledge and skills become developed while solving a problem. Ayodhya (2007) found that Polya's heuristic approach is effective in developing problem solving skills. Downs and Downs (2004) proposed a teaching approach aimed to help students become aware of targeted strategy of significance in problem solving.

In woods (1975) model 'Think about it' requires the problem solver to engage in reflective thinking so as to 'let it simmer'. Woods model provide for a stage which involves to reflective thinking wherein the problem solver is encouraged to make a logical and critical analysis of the 'tentative solutions' formulated. Hence the woods model was selected as the theoritical base are and above the models developed by polya (1957), Heller and Heller(1995), Mayer (1995) for the problem solving model in the present study for developing integrated process skills. Science is taught through problem solving, pupils will eventually develop the integrated process skills which in turn will lead to effective problem solving and achievement in life.

2. Need and significance

Educators must teach an appropriate problem solving method and offer an opportunity for students to explore physics by preparing fun learning activities and by encouraging them to think critically and creatively (Snyder, 1998). Although much of the early implementation of problem-solving models has involved elementary schools, problem solving also has significant potential to improve outcomes for Higher Secondary school students. Therefore, it is important for Higher Secondary school administrators understand the basic concepts of problem solving and consider how components of this model could mesh with the needs of their schools and studentsneed and significance of undertaking the present study entitled "Strategies based on ICT Problem solving model for enhancing integrated process skills in Physics at the Higher Secondary level" is therefore well justified.

Integrated Process Skills in Physics at the Higher Secondary level:

Integrated Process Skills enable an individual to conduct objective investigation and draw conclusions. It is the ability of an individual to *identify and control variables, formulate hypotheses, define operationally, experiment and interpret data*. In the present study 'Integrated Process Skills in Physics at the Higher Secondary level' is operationally defined as the composite score of five sub-skills viz.,*identifying and controlling variables, formulating hypotheses, defining operationally, experimenting and interpreting data*, assessed on the basis of the responses of Higher Secondary school students studying in Standard XI and Standard XII in the Higher Secondary Schools of Kerala to various problem-based situations in Physics, presented through the *Integrated Process Skills Test in Physics at Higher Secondary Level*, developed by the investigators.

3. Problem Solving Model:

In the context of the present study, 'Problem Solving Model' is operationally defined as the instructional strategy designed to enhance Integrated Process Skills in Physics at Higher Secondary Level viz., *identifying and controlling variables, formulating hypotheses, defining operationally, experimenting and interpreting data.* The ***Problem Solving Model for enhancing Integrated Process Skills in Physics at Higher Secondary Level***, developed in the present study consists of four stages viz., ***Exposure***(defining the problem); ***Exploration*** (thinking about it and planning a solution), ***Execution*** (carrying out the plan) and ***Evaluation*** (looking back). These four stages were designed to enhance the five integrated process skills viz., *identifying and controlling variables, formulating hypotheses, defining operationally, experimenting and interpreting data.* According to Michalewicz and Fogel (2000), "A problem exists when there is a recognized disparity between the present and desired state. Solutions, in turn, are ways of allocating the available resources so as to reduce the disparity between the present and desired state".

Hypotheses

The Problem Solving Model is effective in enhancing Integrated Process Skills in Physics at the Higher Secondary level

Objective of the Study

To develop Strategies based on ICT Problem solving model for enhancing integrated process skills in Physics at the Higher Secondary level

4. Methodology

The present investigation entitled *"Strategies based on ICT Problem solving model for enhancing integrated process skills in Physics at the Higher Secondary level"* was designed as a quasi-experimental study adopted for collecting the data essential for the study. Pretest-posttest Non Equivalent Group Design was adopted for the study. The sample was selected from various Higher Secondary schools of Kerala giving due representation to gender and locale. Stratified random sampling was the technique followed for selecting the sample for study. The experimental study was conducted on a sample of 84 students studying in the Higher Secondary schools of Kerala. Twenty lesson templates on selected topics in Physics at Higher Secondary Level viz., *'Electric charges and fields' 'Current electricity' and Electrostatic potential and capacitance'* developed in accordance with the *Problem Solving Model for Enhancing Integrated Process Skills in Physics at Higher Secondary Level* developed by the investigators were used for the experimental study. The experimental treatment was conducted for a period of one month. The Integrated Process Skills Test in Physics at Higher Secondary level was administered for the experimental and control group as pretest and posttest. Delayed post test was conducted for the experimental group and control group after an interval of two weeks to examine the retention of integrated process skills in physics at Higher Secondary level. Appropriate statistical techniques viz., computation of mean, critical ratio, and analysis of covariance (ANCOVA) were employed for data analysis and interpretation of results.

Analysis and Interpretation

Table: 1
Critical ratio test of significance for difference between the control and experimental groups with respect to Pretest, Posttest and Delayed Posttest scores of Integrated Process Skills in Physics at the Higher Secondary Level

Integrated Process Skills in Physics at the Higher Secondary level	Control Group			Experimental Group			Critical Ratio	
	N_1	M_1	σ_1	N_2	M_2	σ_2	t	P
Pretest	42	20.29	3.10	42	20.57	2.54	0.45	.01
Post test	42	30.71	2.49	42	52.83	2.65	39.39**	.01
Delayed Posttest	42	30.07	2.96	42	52.29	3.46	31.65**	.01

** Significant at .01 level of significance

Table 1 shows that there is no significant difference between the experimental group and control group with respect to the pretest scores of integrated process skills in physics at the Higher Secondary level (CR=0.45; *df*= 82; P<0.01).Whereas significant difference was observed between the experimental group and control group with respect to the posttest scores on integrated process skills in physics at the Higher Secondary level (CR = 39.39; *df* = 82; P<0.01). Further, comparison of the experimental and control groups with respect to the delayed post test scores on integrated process skills in physics at the Higher Secondary level revealed significant difference (CR = 31.65; *df*= 82; P<0.01).

Comparison of the experimental and control groups with respect to the gain scores of integrated process skills in physics at the Higher Secondary level

Gain Score Analysis was performed to examine the difference between the experimental group and control group with respect to the achievement of integrated process skills in physics at the Higher Secondary level. The null hypothesis formulated in this context was *"there is no significant difference between the experimental group and control group with respect to the gain score of integrated process skills in Physics at the Higher Secondary level"*. Table 2 represents the details of statistical analysis performed with respect to analysis of gain score.

Table 2.
Critical ratio test of significance for difference between the experimental and control groups with respect to the gain scores of integrated process skills in physics at the Higher Secondary level

Groups	N	M	σ	CR	*df*	P
Control	42	10.43	3.66	31.33**	82	0.01
Experimental	42	32.26	2.65			

** Significant at .01 level of significance

The critical ratio test of significance shows that there is significant difference between the control group and experimental group with respect to gain scores of integrated process skills in physics at the Higher Secondary level (C.R = 31.33; *df* = 82; P<0.01). From Table 2 it is evident gain in achievement of integrated process skills in physics at the Higher Secondary level is greater for the experimental group (M_1 = 32.26) than that of the control group (M_2 = 10.43).

Comparison of the experimental and control groups with respect to the Adjusted Post test scores of Integrated Process Skills in Physics at the Higher Secondary level

Analysis of covariance was conducted on the adjusted post test scores of integrated process skills in physics at the Higher Secondary level to examine the effectiveness of Strategies based on ICT Problem solving model for enhancing integrated process skills in Physics at the Higher Secondary level. The null hypothesis formulated in this context was *"There is no significant difference between the experimental group and control group with respect to the adjusted post test scores of integrated process skills in physics at the Higher Secondary level"*. The data and results of the analysis of covariance are presented in Table 3.

Table 3
Analysis of covariance of the Adjusted Post test scores of Integrated Process Skills in Physics at the Higher Secondary level for the experimental and control groups.

Test	Mean Exp	Mean Con	Source	Sum of squares	*df*	Mean Square	F	P
Pretest (X)	20.57	20.29	Between groups	1.71	1	1.71	**0.21**	.05
			Within groups	672.86	82	8.21		
			Total	674.57	83			
Post test (Y)	52.83	30.71	Between groups	10274.30	1	10274.30	**1514.17**	.01
			Within groups	556.40	82	6.79		
			Total	10830.70	83			
Sum of Co deviates SS_{xy}			Between groups	132.71				
			Within groups	186.43				
			Total	319.14				
Adjusted Post test(Y.X)	50.88	28.84	Between groups	10174.96	1	10174.96	**1633.22**	.01
			Within groups	504.75	81	6.23		
			Total	10679.71	82			

Table 3 shows that the F_x ratio calculated for the pre test scores for integrated process skills in physics at the Higher Secondary level (F_x = 0.21) is less than table values (F = 6.96; P<0.01 and F = 3.96; P <0.05). From the calculated value for $F_x$it is evident that there is no significant difference between the experimental group and control group with respect to the pre test scores for integrated process skills in physics at the Higher Secondary level. $F_y$ratio computed for the post test scores of integrated process skills in physics at the Higher Secondary level (F_y=1514.17), is greater than the statistical table value (F=6.96; P<0.01), which makes it evident that the experimental group and control group differ significantly with respect to the post test scores of integrated process skills in physics at the Higher Secondary level. The analysis of covariance computed from the adjusted post test scores of integrated process skills in physics at the Higher Secondary level shows that the calculated F ratio ($F_{Y.X}$= 1633.22) is significantly greater than the table value (F=6.96; P<0.01). Further, from the adjusted posttest means it is evident that the experimental group ($M_{Y.X}$=50.88) differ significantly from control group ($M_{Y.X}$= 28.84) with respect to the integrated process skills in physics at the Higher Secondary level. The results of ANCOVA presented in Table 3 converges to the finding that the Problem Solving Model for enhancing the integrated process skills in physics at the Higher Secondary level is effective than the traditional method currently being practiced in the Higher Secondary schools of Kerala. Hence, the Hypothesis *"Problem Solving Model is effective in enhancing Integrated Process Skills in Physics at the Higher Secondary level"* stands valid.

Comparison of the experimental and control group with respect to the retention of integrated process skills in physics at the Higher Secondary level

Delayed posttest analysis was done to compare the experimental and control groups with respect to the retention of integrated process skills in physics at the Higher Secondary level. The null hypothesis *"there is no significant difference between the experimental group and control group with respect to the retention of integrated process skills in physics at the Higher Secondary level"* was examined through critical ratio test of significance. The details of statistical analysis are presented in Table 4.

Table 4.

Critical ratio test of significance for difference between the experimental and control group with respect to the retention of integrated process skills in physics at the Higher Secondary level

Groups	**N**	**M**	**σ**	**CR**	***df***	**P**
Control	42	1.26	0.69	3.00**	82	0.01
Experimental	42	1.79	0.91			

** Significant at .01 level of significance

The critical ratio test of significance reveals that there is significant difference between the control and experimental groups with respect to the retention of integrated process skills in physics at the Higher Secondary level (C.R = 3.00; *df* = 82; P<0.01). The mean scores of delayed posttest for the experimental and control groups presented in Table 4 makes it evident that the experimental group (M_E = 1.79) has better retention of integrated process skills in physics at the Higher Secondary level than the control group (M_C = 1.26).

Major findings

i. There is no significant difference between the control and experimental groups with respect to the pretest scores (CR = 0.45; *df* = 82; P < .01) for integrated process skills in physics at the Higher Secondary level.

ii. There is significant difference between the control and experimental groups with respect to the posttest scores (CR = 39.39; *df* = 82; P < .01) for integrated process skills in physics at the Higher Secondary level.

iii. There is significant difference between the control and experimental groups with respect to the delayed post test scores (CR = 31.65; *df*= 82; P < .01) for integrated process skills in physics at the Higher Secondary level.

iv. There is significant difference between the control group and experimental group with respect to gain scores (C.R = 31.33; *df* = 82; P < .01) of integrated process skills in physics at the Higher Secondary level. The gain in achievement of integrated process skills in physics at the Higher Secondary level is greater for the experimental group (M_1 = 32.26) than that of the control group (M_2 = 10.43).

v. There is significant difference between the experimental group and control group with respect to the adjusted post test scores of integrated process skills in physics at the Higher Secondary level (($F_{Y.X}$ = 1633.22; *df* = 82; P < .01). The experimental group ($M_{Y.X}$ = 50.88) is significantly better than the control group ($M_{Y.X}$ = 28.84) with respect to the adjusted post test scores of integrated process skills in physics at the Higher Secondary level.

vi. There is significant difference between the control and experimental groups with respect to the retention of integrated process skills in physics at the Higher Secondary level (C.R = 3.00; *df* = 82; P < .01). The experimental group (M_1 = 1.79) has better retention of integrated process skills in physics at the Higher Secondary level than the control group (M_2 = 1.26).

Implications

The findings of the present study revealed that there is a positive correlation between problem solving and integrated process skills in physics at the Higher Secondary level among students in the Higher Secondary schools of Kerala. The findings imply the need for science educators to adopt process approach in science education along with the product approach for developing scientific concept and related scientific skills. 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.

5. Conclusion

Problem Solving Model for enhancing the integrated process skills viz., *identifying and controlling variables, formulating hypotheses, defining operationally, experimenting and interpreting data* in physics at the Higher Secondary level is effective than the traditional method currently being practiced in the Higher Secondary schools of Kerala.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.

6. Reference

[1] Ayodele, A. F. (2002). *Obstacles to the effective teaching and learning of chemistry at the secondary school level: Curriculum implications for sustainable educational development.* Nigeria.: Heinemann Educational Books PLC.

[2] Ayodhya, P. (2007). Problem Solving Skills. Effectiveness of Conventional and Poly's Heuristic Approach. *Eddxutracks*, *7*(3), 34-39.

[3] Downs, M. J., & Downs, M. (2004). Realization of Techniques in Problem Solving: The Construction of Bijections for Enumeration Tasks. *Educational Studies in Mathematics*, *56*(3), 235-253.

[4] Erol, M. (2006). Evaluation of problem solving behaviours of physics teacher candidates. *H.U. Journal of Education, 30*(2), 73-81.

[5] Heller, K., & Heller, P. (1995). *The Competent Problem Solver*. Minnesota, MN: University of Minnesota.

[6] Martinez, M. E. (1998). *What is problem solving?Phi Delta Kappan*. *79*(8), 605-609.

[7] Mayer, R. E. (1995). Structural analysis of science prose. *ACM SIGDOC Asterisk Journal of Computer Documentation, 19*(3), 3-25.

[8] Michalevicz, Z., &Fogel, D. B. (2000). *How to Solve It*. Heidelberg: Spinger: Modern Heuristics

[9] Normah.Y.,& Salleh, I. (2006). *"Problem solving skills in probability among matriculation students".* Paper presented at National Educational Research Seminar XIII, 40-55.

[10] Padilla, M. J., Dillashaw, G. F., & Okey, J. F. (2006). *Study on "Test of Integrated Science Process Skills in Secondary School Students*. Retrieved from http://onlinelibrary.wiley.com/

[11] Phang, F. A. (2010). Patterns of Physics Problem-solving and Metacognition among Secondary School Students. *The International Journal of Interdisciplinary Social Sciences: Annual Review*, *5*(8), 309-324.

[12] Polya, G. (1957). *How to solve it: A new aspect of mathematical method*. New York: Doubleday Anchor Books.

[13] Risk, T. M. (1965). *Principles and practices of teaching in secondary schools*. New Delhi: Eurasia publishing House Ltd

[14] Schmidt, A. M., & Ford, J. K. (2003). Learning within a learner control training environment: The interactive effects of goal orientation and metacognition instruction on learning outcomes. *Personnel Psychology*, *56*(2), 405-429.

[15] Snyder, R. F. (1998). A clinical study of three high school problem solvers. *High School Science Education*, *20*(2), 40-45

[16] Wood, D., & Middleton, D. (1975). A study of assisted problem solving. *British Journal of Psychology*, *66*(2), 181-19*Implication in science, technology and mathematics education.* Nigeria: Heinemann Educational Book PLC.

Author:

1. Dr. Nithya Prem S. R.

Post Doctoral Fellow (ICSSR) Department of Education,

University of Kerala,

Thiruvananthapuram, Kerala, India

e-mail id : nithyavibin@gmail.com

contact no : 9995849017