PROBLEM-SOLVING TEMPLATES IN PHYSICS FOR NURTURING THE SKILL OF EVALUATION IN CRITICAL THINKING SKILLS

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Abstract
The present study problem-solving templates in physics for nurturing the skill of evaluation in critical thinking skills as intended as a quasi-experimental study and a normative survey are adopted. Pre-test – post-test Non-Equivalent Group Design has opted for the experimental part of the study. The sample is selected from different secondary schools. Stratified random sampling was selected for the study. The experimental study is conducted for the experimental and control group as pre-test and post-test. The findings of the study concluded that Problem-solving templates in physics method for developing Skill of evaluation in Critical thinking skills in physics at the secondary level are more effective than the existing method currently being practiced in the secondary schools.
Key terms: Critical Thinking Skills, Problem-Solving, Skill of Evaluation.

Introduction

The National Education Policy (NEP) stipulates that rote learning will be minimized by the year 2022 in order to promote holistic development in the classroom. In the skills such as critical thinking, creativity, scientific temper, communication, collaboration, multilingualism, problem-solving, ethics, social responsibility, and digital literacy in lieu of rote learning. The present research focuses on developing problem-solving templates for nurturing the Skill of evaluation in Critical thinking skills in physics at the secondary stage. Component of critical thinking skills that enable learners to solve problems with the information. Facts are used as a basis for inductive reasoning. It is the process of conceptualizing, self-regulating, clarifying, rationalizing, and evaluating information to reach a conclusion using critical thinking skills. Disciplined thinking is based on evidence and is open-minded. The defining of the problem depends on an individual's experience; therefore strategies and problem-solving approaches are different for problem-solvers.

To find out the effectiveness of problem-solving templates in physics for nurturing the skill of evaluation in critical thinking skills. According to Horenstein and Niu (2011), the same instructional intervention may have different results depending on how it is implemented.

Based on the observation of the teacher, these were used to determine whether students exhibited critical thinking skills. Teachers, students, scientists, and educators have indicated to the Policy that the current curriculum content is severely overloaded. The MHRD Yashpal Committee report 1993 "Learning Without Burden" as well as the NCF 2005 emphasized the importance of reorganizing our curriculum content into a more accessible, holistic, experiential, and analytical form. In today's world, those well-researched recommendations are more relevant than ever. Students are rushing into the classrooms today to memorize all of the required curricula by rote, preventing them from developing critical thinking skills and learning through discovery, discussion, and analysis - which ultimately leads to a true understanding of the subject matter.

Significance of the study

Education in the 21st century must be holistic, integrated, enjoyable, and engaging. Today Curriculum and pedagogy reform will focus on moving the education system towards real understanding and learning how to learn - away from the culture of rote learning prevalent. A holistic and well-rounded education will focus not only on developing cognitive skills but also on building character and developing critical 21st-century skills. The deep-seated treasure that is knowledge can be manifested through education as an individual's perfection. In order to achieve these critical goals, the curriculum and pedagogy will be reoriented and revamped. Throughout the educational process, from preschool through higher education, certain skills and values will be identified and incorporated. These skills and values will be embedded in curriculum frameworks and transaction mechanisms instilled.

A learning environment that is conducive to essential learning can enhance critical thinking. Curriculum content will be reduced in each subject to its core essentials to foster critical thinking, inquiry-based learning, discovery-based learning, discussion-based learning, and analysis-based learning. Content requirements will be based on key concepts, ideas, applications, and problem-solving. There will be more interactive teaching and learning; students will be encouraged to ask questions, and classroom sessions will be more fun, creative, collaborative, and exploratory for students.

American Philosophical Association's Delphi project on the definition of critical thinking, is that the characteristics of a critical thinker include traits such as being inquisitive, fair-minded, flexible, diligent, and focused on inquiry (Facione 1990). In Facione's taxonomy (1990, p.12), critical thinking is composed of six main skills, each containing sub-skills, as -

- *Interpretation* – Clarifying the meaning, Categorization, decoding significance,
- *Analysis*- Examining ideas, Analyzing arguments, Identifying arguments,
- *Evaluation*- Assessing claims, Assessing arguments
- *Inference*- Conjecturing alternatives, Querying evidence, Drawing conclusions
- *Explanation*- Stating results justifying procedures, Presenting arguments
- *Self-Regulatory Behaviors*- "Self-consciously monitor one's cognitive activities.

In Stupple, E. J. N et. al. (2017). Critical thinking skills include observation, interpretation, analysis, interpretation, evaluation, explanation, and metacognition, according to Reynolds (2011). A critical thinking environment includes individuals or groups considering, for instance, establishing. According to Ennis (2015), critical thinking involves conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observations, experiences, reflection, reasoning, or communication, and using that information to guide intellectually disciplined beliefs and actions.

Utami, Saputro, Ashadi, Masykuri, and Widoretno (2017) suggest critical thinking skills are a priority for education. According to Whitten and Brahmasrene (2011), critical thinking scores and their components differ significantly and are related to college classification, high school GPA, high school rank, SAT verbal scores, SAT mathematical scores, gender, race, and major. (Sabri, Ilyas & Amjad, 2015) Higher education female teachers' critical thinking skills are affected by an organizational learning culture. Depending on how an instructional intervention is implemented, Horenstein and Niu (2011) report that the same intervention can have different results. Teachers observed students' critical thinking skills and used them to determine whether they exhibited them·

To create more holistic, experiential, discussion-based, and analysis-based learning, reduce curriculum load in each subject to its essential core content. The mandated content of the curriculum will be reduced, in each subject area, to the essentials, with a focus on critical concepts and key ideas in each content area. There is more scope for discussion, nuanced understanding, analysis, and application of key concepts as a result of the extra space. It will attempt to make teaching and learning more interactive; open-ended questions will be encouraged, and students will be engaged in more fun, creative, collaborative, and exploratory activities for deeper and more experiential learning. So, the investigator selected the topic of *Problem-solving templates in Physics for nurturing the skill of evaluation in critical thinking skills.* The following were the major objectives of the present study

To find out the effectiveness of nurturing critical thinking skills using problem-solving templates in physics at the secondary stage.

1. To find out the correlation between nurturing *the skill of evaluation in* critical thinking skills using problem-solving templates in physics at the secondary stage.
2. To find out the effectiveness of nurturing the skills of Evaluation in critical thinking skills using problem-solving templates in physics at the secondary stage.

Hypotheses of the study

1. Nurturing critical thinking skills using problem-solving templates is effective in physics at the secondary stage.
2. There is a significant correlation between critical thinking skills and problem-solving templates in physics at the secondary stage.
3. The skills of Evaluation for nurturing critical thinking skills using problem-solving templates in physics at the secondary stage is effective.

Approach/Methodology

The present study problem-solving templates in physics for nurturing the skill of evaluation in critical thinking skills as intended as a quasi-experimental study and a normative survey is adopted. Pretest-posttest Non-Equivalent Group Design has opted for the experimental part of the study. The sample is selected from different secondary schools. Stratified random sampling was selected for the study. The experimental study is conducted for the experimental and control group as pre-test and post-test. A delayed post-test is conducted for the experimental group and control group after an interval of two weeks to examine the retention of 'components of critical thinking skills in physics at the secondary level. Appropriate statistical techniques viz., computation of mean, percentages, critical ratio, and analysis of covariance (ANCOVA) will be employed for data analysis and interpretation of results.

Analysis and interpretation

Comparison of the experimental group and control group with respect to the pretest scores, post test scores and delayed post test scores of Critical thinking Skills in Physics at the secondary Level was done using critical ratio test of significance. The data and results of the two-tailed test of significance for difference between means (Garrett, 1981, pp 213) are given in Table 1.

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 nurturing the skill of evaluation in critical thinking skills in physics at the secondary stage

Skill of evaluation in critical thinking skills in Physics at the secondary stage	Control Group			Experimental Group			Critical Ratio	
	N_1	M_1	σ_1	N_2	M_2	σ_2	t	P
Pretest	36	13.00	0.71	36	12.81	0.74	1.11	.01
Post test	36	15.56	0.64	36	18.06	0.70	15.72**	.01
Delayed Posttest	36	14.83	1.55	36	17.11	1.41	6.52**	.01

** Significant at .01 level of significance

The null hypotheses formulated in connection with the comparison of experimental group and control group with respect to the pretest scores, post test scores and delayed post test scores of skill of evaluation in critical thinking skills in physics at the secondary stage are *"there is no significant difference between the control and experimental groups with respect to the pretest scores for* skill of evaluation in *critical thinking skills in physics at the secondary stage"*; *"there is no significant difference between the control and experimental groups with respect to the posttest scores for* skill of evaluation in *critical thinking skills in physics at the secondary stage"* as well as *"there is no significant difference between the control and experimental groups with respect to the delayed post test scores for* skill of evaluation in *Critical thinking skills in physics at the secondary stage"*.

Table 1 shows that there is no significant difference between the experimental group and control group with respect to the pretest scores of skill of evaluation in Critical thinking skills in physics at the secondary stage (CR=1.11; *df*= 70; P<0.01). Whereas a significant difference was observed between the experimental group and control group with respect to the posttest scores on Skill of evaluation in Critical thinking skills in physics at the secondary stage (CR = 15.72; *df* = 70; P<0.01). Further, comparison of the experimental and control groups with respect to the delayed post-test scores on Skill of evaluation in Critical thinking skills in physics at the secondary stage revealed a significant difference (CR = 6.52; *df*= 70; P<0.01).

Comparison of the experimental and control groups with respect to the gain scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage

Gain Score Analysis was performed to examine the difference between the experimental group and control group with respect to the achievement of Skill of evaluation in Critical thinking skills in physics at the secondary stage. 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 Skill of evaluation in Critical thinking skills in Physics at the secondary stage".* 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 Skill of evaluation in Critical thinking skills in physics at the secondary stage

Groups	N	M	σ	CR	*df*	P
Control	36	2.56	0.86	10.85**	70	0.01
Experimental	36	5.25	1.21			

** 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 Skill of evaluation in Critical thinking skills in physics at the secondary stage (C.R = 10.85; *df* = 70; P<0.01). From Table 2 it is evident gain in achievement of Skill of evaluation in Critical thinking skills in physics at the secondary stage is greater for the experimental group (M_1 = 5.25) than that of the control group (M_2 = 2.56).

Comparison of the experimental and control groups with respect to the Adjusted Post-test scores of Skill of evaluation in Critical thinking skills in Physics at the secondary stage

Analysis of covariance was conducted on the adjusted post-test scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage to examine the effectiveness of problem-solving templates in physics for nurturing the skill of evaluation in critical thinking skills. 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 Skill of evaluation in Critical thinking skills in physics at the secondary stage"*. 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 Skill of evaluation in Critical thinking skills In Physics at the secondary stage for the experimental and control groups.

Test	Mean Exp	Con	Source	Sum of squares	df	Mean Square	F	P
Pretest (X)	12.81	13.00	Between groups	0.68	1	0.68	1.26	0.01

			Within groups	37.64	70	9.27		
			Total	38.32	71			
Post test (Y)	18.06	15.56	Between groups	112.50	1	112.50	240.25	0.01
			Within groups	32.78	70	0.47		
			Total	145.28	71			
Sum of Co deviates SSxy			Between groups	8.75				
			Within groups	4.61				
			Total	13.36				
Adjusted Post test(Y.X)	18.57	16.09	Between groups	108.41	1	108.41	230.66	0.01
			Within groups	32.21	69	0.47		
			Total	140.62	70			

Table 3 shows that the F_x ratio calculated for the pre-test scores for Skill of evaluation in Critical thinking skills in physics at the secondary stage (F_x = 1.26) is less than table values (F = 3.98; P<0.01 and F = 1.97; 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 the Skill of evaluation in Critical thinking skills in physics at the secondary stage. F_y ratio computed for the post-test scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage (F_y=240.25), is greater than the statistical table value (F=3.98; P<0.01), which makes it evident that the experimental group and control group differ significantly with respect to the post-test scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage. The analysis of covariance computed from the adjusted post-test scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage shows that the calculated F ratio ($F_{Y.X}$= 230.66) is significantly greater than the table value (F=3.98; P<0.01). Further, in the adjusted post-test means it is evident that the experimental group ($M_{Y.X}$=18.57) differs significantly from the control group ($M_{Y.X}$= 16.09) with respect to the Skill of evaluation in Critical thinking skills in physics at the secondary stage. The results of ANCOVA presented in Table 3 converges to the finding that the Problem-solving templates for developing the Skill of evaluation in Critical thinking skills in physics at the secondary stage is more effective than the existing method currently being practiced in secondary schools. Hence, the Hypothesis *"Problem-solving templates is effective in developing Skill of evaluation in Critical thinking skills in Physics at the secondary stage"*.

Comparison of the experimental and control group with respect to the retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage

Delayed posttest analysis was done to compare the experimental and control groups with respect to the retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage. The null hypothesis *"there is no significant difference between the experimental group and control group with respect to the retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage"* was examined through a critical ratio test of significance. The details of the 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 Skill of evaluation in Critical thinking skills in physics at the secondary stage

Groups	N	M	σ	CR	*df*	P
Control	36	1.33	0.71	0.89**	70	0.01
Experimental	36	1.50	0.90			

** Significant at .01 level of significance

The critical ratio test of significance reveals that there is a significant difference between the control and experimental groups with respect to the retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage (C.R = 0.89; *df* = 70; P<0.01). The mean scores of delayed post-test for the experimental and control groups presented in Table 4 make it evident that the experimental group (M_1 = 1.50) has better retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage than the control group (M_2 = 1.33).

Findings emerged from the section

1. There is no significant difference between the control and experimental groups with respect to the pretest scores (CR = 1.11; *df* = 70; P<0.01) for the Skill of evaluation in Critical thinking skills in physics at the secondary stage.
2. There is a significant difference between the control and experimental groups with respect to the posttest scores (CR = 15.72; *df* = 70; P<0.01) for the Skill of evaluation in Critical thinking skills in physics at the secondary stage.
3. There is a significant difference between the control group and experimental group with respect to gain scores (C.R = 10.85; *df* = 70; P<0.01) of Skill of evaluation in Critical thinking skills in physics at the secondary stage. The gain in the achievement of Skill of evaluation in Critical thinking skills in physics at the secondary stage is greater for the experimental group (M_1 = 5.25) than that of the control group (M_2 = 2.56).
4. There is a significant difference between the experimental group and control group with respect to the adjusted post-test scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage (($F_{Y.X}$ =230.66; *df* = 70; P<0.01). The experimental group ($M_{Y.X}$ = 18.06) is significantly better than the control group ($M_{Y.X}$ = 15.56) with respect to the adjusted post-test scores of Skill of evaluation in Critical thinking skills in physics at the secondary stage.

5. There is a significant difference between the control and experimental groups with respect to the delayed post-test scores (CR = 6.52; *df*=70; P<0.01) for Skill of evaluation in Critical thinking skills in physics at the secondary stage.
6. There is a significant difference between the control and experimental groups with respect to the retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage (C.R = 0.89; *df* = 70; P<0.01). The experimental group (M_1=1.50) has better retention of Skill of evaluation in Critical thinking skills in physics at the secondary stage than the control group (M_2 = 1.33).

The implication of the study

Educators play a crucial role in ensuring that citizens of the nation become scientifically literate. As part of the National Policy on Education, 2020, citizens should have scientific literacy, a technical skill set, a solid understanding of scientific knowledge, and a passion for science. A minority of students master school science; most students do not gain a meaningful understanding of science or use their scientific knowledge effectively and creatively. By focusing on the processes of inquiry, students learn to ask questions, investigate the world around them, and come up with reasonable explanations for their observations.

Relevance of the study to society:

Teaching aims to create effective independent lifelong learners. Learning content and teaching skills serve as instructional inputs through which students and teachers interact. Interactions like this provide opportunities for physical and social development. By developing skill of evaluation in Critical thinking skills for problem-solving in real-life situations, educational institutions are responsible for preparing students for the future. It requires a problem-solving approach and an inquiry approach to teaching. The teaching of problem-solving in a context-free environment has proven futile. Educators need to understand the strengths and weaknesses of various problem-solving strategies and how they are solving a problem in order to facilitate effective problem-solving among students. A template-based approach to classroom teaching would open up new horizons of research and applications. Based on the research on Problem Solving templates, this study has significant contributions to producing learning outcomes and developing the skill of evaluation in Critical thinking skills in Physics. In almost all critical thinking skill development around the globe, science processes serve as the pivot.

Conclusion

Problem-solving templates for developing Skills of evaluation in Critical thinking skills in physics at the secondary level is effective than the existing method currently being practiced in secondary schools. Teaching Problem-solving templates to students in every field facilitates the organization of ideas, the development of different thought skills, and the building consistent thought models. Physics courses must be taught conceptually to students through Problem-solving templates before physics formulas and equations are taught. The studies show that interactive engagement and collaborative methods have positive effects on physics problem-solving. To get expertise in physics concepts and a Skill of evaluation in Critical thinking skills, students should get multiple exposures over extended time periods in a variety of contexts.

Reference

Behar-Horenstein, L. S., & Niu, L. (2011). Teaching Critical Thinking Skills In Higher Education: A Review Of The Literature. Journal of College Teaching & Learning (TLC), 8(2). https://doi.org/10.19030/tlc.v8i2.3554

Ennis, Robert H. (2015), "Critical Thinking", The Palgrave Handbook of Critical Thinking in Higher Education, Palgrave Macmillan, doi:10.1057/9781137378057.0005, ISBN 9781137378057

Ennis, Robert H. (2015), "Critical Thinking", The Palgrave Handbook of Critical Thinking in Higher Education, Palgrave Macmillan, doi:10.1057/9781137378057.0005, ISBN 9781137378057

Facione, P. A. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. California Academic Press.

Garrett, H. E., & Worth, W. (1981). *Statistics in Psychology and Education*. New York, NY: David MarcKay Company.

National Curriculum Framework (2005) https://ncert.nic.in/pdf/nc-framework/nf2005-english.pdf

Reynolds, Martin. (2011).Critical thinking and systems thinking: towards a critical literacy for systems thinking in practice.In: Horvath, Chrii. and Forte, James M. eds. Critical Thinking. Nova Science Publishers.

Reynolds, Martin. (2011).Critical thinking and systems thinking: towards a critical literacy for systems thinking in practice.In: Horvath, Chrii. and Forte, James M. eds. Critical Thinking. Nova Science Publishers.

Sabri, P.S.U., Ilyas, M., & Amjad, Z. (2015). Organizational learning culture and its effects on critical thinking skills on female teachers of public sector higher education institutions. Bulletin of Education and Research, 37 (2) 69-90.

Stupple, E. J., Maratos, F. A., N. Elander, J., Hunt, T. E., Cheung, K. Y., & Aubeeluck, A. V. (2017).Development of the Critical Thinking Toolkit (CriTT): A measure of student attitudes and beliefs about critical thinking. Thinking Skills and Creativity.

The National Education Policy (NEP) (2020) https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

Utami, B., Saputro, S., Ashadi, Masykuri, M., & Widoretno,S. (2017). Critical thinking skills profile of high school students in learning chemistry. International Journal of Science and Applied Science: Conference Series, 1 (2), 124-130.

Whitten D., & Brahmasrene, T. (2011). Predictors of critical thinking skills of incoming business students. Academy of Educational Leadership Journal, 15 (1), 1-13

Yashpal Committee report (1993) https://www.aicte-india.org/downloads/Yashpal-committee-report.pdf