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Acquisition of Integrated Science Process Skills through 7E Learning Instructional Model in Relation to Science Self Efficacy: A Budding Paradigm Shift

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Abstract: ***The main purpose of the study was to investigate the effect of 7E learning instructional model on ninth grade students' integrated science process skills in relation to science self-efficacy. Data was collected using science self-efficacy scale and integrated science process skills test. The sample comprised of 120 secondary school students studying in government schools of Shaheed Bhagat Singh Nagar district, Punjab, India. The findings revealed that significant difference was found out between the experimental group and the control group in terms of mean gain scores of integrated science process skills for high, moderate and low science self-efficacy groups. Students in different levels of science self-efficacy of experimental group were positively affected by 7E learning model based teaching strategy but, it is the high science self-efficacy group students who got benefitted to the greatest extent with 7E learning model based instruction.***

Keywords: 7E learning instructional model, Integrated science process skills, Science self-efficacy.

1. Introduction

To overcome the challenges of the 21st century in science and technology sector, students need to be equipped with the 21st century skills to ensure their active participation in education sector. The COVID 19 pandemic has also forced sudden transformation in education sector. Such challenges have now become the new realities in developing countries. Therefore in order to mitigate the challenges, there must be a paradigm shift in the pedagogical approach in the education sector. The science education in today's education scenario should aim at understanding the nature of science (NOS) and the nature of science can be learned by doing science or learning through science. Understanding the nature of science is also a necessary ingredient for full realization of a human being. NCERT (2008) explicitly highlighted the importance of constructivism as a teaching approach for understanding the nature of science. By adopting such pedagogical approach , students will be able to understand or develop various processes involved in doing science since students are given spaces for their own ideas and imagination.

7E learning instructional model based on constructivism has been brought in the school science curriculum that will act as a catalyst for the students to foster the process skills in science and will also help in inculcating positive attitude and interest among the students.7E learning instructional model is a useful recommended strategy in science curriculum and teachers should be encouraged to incorporate this strategy into their teaching. The primary aim of the 7E learning cycle is to highlight the increasing importance of provoking previous understanding of transferring the concept to new contexts (Balta & Sarac, 2016). 7E learning model can stimulate students to recall previous material, can improve their learning outcomes because this model prioritizes student experience, motivate students to be more active and increase curiosity, train students to learn concepts through experimental activities (Marfilinda, Zaturrahmi & Indrawati , 2019).

2. Research Trends

A scrutiny of previous researchers revealed that process skills play a vital role in learning science. Different investigators used different interventions to enhance the science process skills. A research study conducted by Jannah et al., (2021) advocated that virtual laboratory assisted discovery learning was effective in improving the process skills in science. Haryadi & Pujiastuti (2020) found out that PhET interactive simulations technology significantly improved the integrated science process skills. Harahap et al., (2019) explored that blended learning technique was found to be significantly more effective in enhancing students' learning outcomes and process skills in plant tissue culture as compared to the traditional learning strategy. Nnoram & Rita (2017) used guided-inquiry and demonstration approach. Chan & Morales (2016) used customised cognitive fitness classroom approach in enhancing the process skills in science. It can also be culminated that science self-efficacy there exists significant relationship of self-efficacy with academic achievement in various subjects (Paixao and Panahandeh, 2017;

Fernando et al., 2017; Roebianto, 2020; Burns et al., 2021). Lee et al., (2019) indicated that the students' conceptions of science laboratory learning made a significant contribution to their perceptions of the science laboratory environment which consequently fostered their science learning self-efficacy. Zimmerman (2000) advocated that self-efficacy has emerged as highly effective predictor of student's motivation and learning. Fernando, Laura and Amparo (2017) revealed that students' expectancy-value beliefs, process expectancy, achievement expectancy and cost expectancy played a mediator role between academic self-efficacy and the achievement/satisfaction relationship. The

findings of Huang (2013); Uitto (2014) revealed that males had higher self-efficacy than females.

3. Rationale of the Study

Research and statistics have shown that although the achievement level of science is quite satisfactory in science subject but there is a lower percentage of students actually interested in pursuing scientific careers at secondary or upper secondary level. Thus, practical value of this study lies in the fact that it is set to explore and formulate new teaching methodology that is 7E learning instructional model that may be able to bring about improvement in the science process skills in order to increase the ratio of the students who actually want to pursue their career in science field which could be a contribution not only to the nation but also in the field of education. The 7E model consists of series of seven inter-linked phases namely, elicit phase, engage phase, explore phase, explain phase, elaborate phase, evaluate phase and extend phase wherein students were exposed to innovative teaching learning activities viz., Simulations using softwares such as PhET, Algodoo (virtual labs) etc., concept maps, mind maps, venn diagrams, word bank, KWL charts, problem solving methods. Scientific experimentations, generalizing the learned concept in a novel situation so as to enhance the process skills in science having dimensions such as data interpretation, drawing inferences, experimentations etc.

Research Problem

To compare the mean gain integrated science process skills scores of the groups having high, moderate and low science self-efficacy.

Hypothesis

There will be no significant difference in the mean gain integrated science process skills scores of the groups (experimental and control group) having high, moderate and low science self-efficacy.

4. Research Methodology

Being experimental in nature, the study employed pre-test post-test control group design for the research work because the equivalence of the groups was not assured, therefore it was necessary to establish the equivalence of the groups in order to study the causal impact of intervention. After ascertaining the equivalence of the groups, the sections were assigned as experimental group and control group. This step was followed by classifying the students in both the groups into high, moderate and low science self-efficacy sub-groups. After classifying the students, pre-test of integrated science process skills was administered. The experimental group was then taught through 7E learning instructional strategy and control group was taught through the conventional chalk and talk method of teaching. Execution of the treatment was followed by the post-test of integrated science process skills.

5. Results and Discussion

The scores of pre and post-test of integrated science process skills were considered as near normal after subjected to descriptive analysis. Hence it was concluded that the sample was normally distributed.

Analysis of Mean Gain Scores of Integrated Science Process Skills for Different Subgroups of Science Self-Efficacy

The obtained mean gain scores of integrated science process skills were subjected to descriptive analysis to measure the effect of 7E learning instructional model. The mean and standard deviation of different subgroups of science self-efficacy viz., high, moderate and low have been calculated and presented in the table 1.

Table 1: Descriptive Statistics of Mean Gain Scores of Integrated Science Process Skills for Different Subgroups of the Experimental and Control group

Variable	Science Self Efficacy	Control Group Mean Gain			Experimental Group Mean Gain		
		N	Mean	SD	N	Mean	SD
Integrated Science Process Skills (Mean Gain)	High	20	0.85	2.94	20	8.90	2.22
	Moderate	20	0.25	2.61	20	5.85	2.28
	Low	20	0.65	2.46	20	5.05	2.28
	Total	60	0.58	2.64	60	6.60	2.78

The mean gain scores of integrated science process skills of students with different subgroups of science self-efficacy in control group and experimental group have also been depicted through the bar diagram in figure 1.

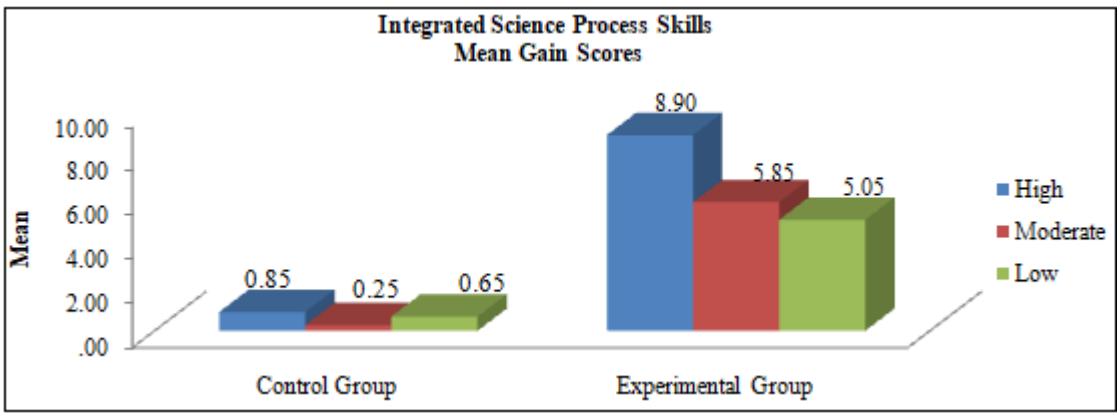

Figure 1: Bar diagram showing mean gain scores of integrated science process skills for different subgroups of control group and experimental group

A close scrutiny of the table 1 and figure 1 revealed that the total mean gain score of integrated science process skills of the experimental group was discreetly higher than the mean gain integrated science process skills scores of control group in all the three subgroups of science self-efficacy. In control group, the mean gain score of low science self-efficacy group (Mean gain=0.65) came higher than the mean gain score of moderate science self-efficacy group (Mean gain=0.25).These obtained results can be ascribed to uncontrollable factors or by chance factor. It was surprising to spot that in experimental group, low science self-efficacy group (Mean gain=5.05) gained almost equivalent integrated science process skills scores to that of moderate science self-efficacy group (Mean gain=5.85).An assessment of their respective mean gain scores as revealed in table 4.15 showed that students in high science-self-efficacy group (Mean gain=8.90) when instructed with 7E learning model based teaching method showed considerably superior performance in integrated science process skills as compared to high science self-efficacy group students (Mean gain=0.85) who were taught via conventional mode of instruction. Similarly students in moderate science self-efficacy group (Mean gain=5.85) and low science self-efficacy group (Mean gain=5.05) showed notably higher performance in their integrated science process skills scores when exposed to 7E learning model based teaching method as compared to moderate science self-efficacy group students (Mean gain=0.25) and low science self-efficacy group students (Mean gain=0.65) who were taught via conventional teaching method, thereby giving an impression that all the students in different levels of science self-efficacy of experimental group were positively affected by 7E learning model based teaching strategy but, it is the high science self-efficacy group students who got benefitted to the greatest extent with 7E learning model based instruction.To delve deep into the data, analysis of variance was calculated to infer the data statistically after satisfying the conditions of ANOVA.

F-values for both the groups were computed in order to further examine whether there were significant differences in mean gain integrated science process skills scores among high, moderate and low science self-efficacy groups of the control group and experimental group shown in table 2.

Table 2: A Summary of F-statistics of Mean Gain Integrated Science Process Skills Scores of Control Group and Experimental Group

ANOVA						
Integrated Science Process Skills (Mean Gain)		Sum of Squares	df	Mean Square	F-value	p-value
Control Group	Between Groups	3.733	2	1.867	.260	.772
	Within Groups	408.850	57	7.173		
	Total	412.583	59			
Experimental Group	Between Groups	165.100	2	82.550	16.153	.0001**
	Within Groups	291.300	57	5.111		
	Total	456.400	59			

*** Significant at 0.05 level of significance**
**** Significant at 0.01 level of significance**

The *F*-ratio in the **ANOVA** table 2 tests whether there were significant differences in mean gain integrated science process skills scores among high, moderate and low science self-efficacy levels of the students in control group and experimental group. As demonstrated in table 2 , the p-value of mean gain integrated science process skills scores of control group came out to be .772 which was found to be insignificant hence there exist no significant differences in mean gain integrated science process skills scores among high, moderate and low science self-efficacy levels of students in the control group which suggests that in control group, students in high, moderate and low science self-efficacy groups showed equal performance in integrated science process skills. In case of experimental group, the p-value came out to be .0001 which was found to be significant at 0.01 level of significance, therefore it can be concluded that there exist significant differences in the mean gain integrated science process skills scores among high, moderate and low science self-efficacy students in experimental group.

In order to probe deeper, Post-hoc test (Scheffe's test) was run to find out multiple comparisons of different sub-groups of science self-efficacy for experimental group students with high, moderate and low science self-efficacy levels as shown in table 3 below.

Table 3: Scheffe's Test for Multiple Comparisons of Mean Gain Scores of Integrated Science Process Skills for Different Subgroups of Experimental Group

Multiple Comparisons (Experimental Group)							
Scheffe's Test							
Dependent Variable			Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
						Lower Bound	Upper Bound
Integrated Science Process Skills (Mean Gain)	High	Moderate	3.05	0.71	.0001**	1.25	4.85
		Low	3.85	0.71	.0001**	2.05	5.65
	Moderate	High	-3.05	0.71	.0001**	-4.85	-1.25
		Low	0.80	0.71	.538	-1.00	2.60
	Low	High	-3.85	0.71	.0001**	-5.65	-2.05
		Moderate	-0.80	0.71	.538	-2.60	1.00

*** Significant at 0.05 level of significance and ** Significant at 0.01 level of significance**

- It has been revealed in table 3 that high science self-efficacy group showed statistically significant difference with both moderate and low science self-efficacy groups with respect to mean gain integrated science process skills scores since p-values came out to be .0001 which were highly significant at 0.01 level of significance
- It was apparent from table 3 that moderate science self-efficacy group showed statistically significant difference with high science self-efficacy group with respect to mean gain integrated science process skills scores due to significant p-value of .0001, however moderate science self-efficacy group showed statistically no significant difference with low science self-efficacy group due to insignificant p-value of .538.
- Table 3 reveals that low science self-efficacy group showed statistically significant difference with high science self-efficacy group with respect to mean gain integrated science process skills scores as p-value came out to be .0001 which was significant at 0.01 level of significance, however low science self-efficacy group showed statistically no significant difference with moderate science self-efficacy group due to insignificant p-value of .538

The statistical analysis computed above explicitly reveals that ***the null hypothesis (H_{01}) stating that, "There will be no significant difference in the mean gain integrated science process skills scores of the groups (experimental and control group) having high, moderate and low science self-efficacy." was rejected at 0.05 level of significance."***

6. Conclusion

The results suggest that the mean gain integrated science process skills score of students with high, moderate and low science self-efficacy levels in experimental and control group differed significantly. This advocates that science self-efficacy affects the mean gain integrated science process skills scores of experimental and control group.By assessing the above findings it can be concluded that the mean gain integrated science process skills scores of experimental group students with different levels of science self-efficacy were appreciably higher than that of control group which leads to the conclusion that students possessing different levels of science self-efficacy when instructed with 7E learning model based instruction, their integrated science process skills augments notably.

In experimental group (taught via 7E learning instructional model), students with high science self-efficacy achieved higher on integrated science process skills as compared to their counterparts having moderate and low science self-efficacy levels, the students in moderate and low science self-efficacy groups showed almost equal gain in integrated science process skills. On the contrary, control group (taught via conventional teaching method) students with different levels of science self-efficacy did not attain considerable score in integrated science process skills and all the groups performed almost similar in integrated science process skills leading to the conclusion that conventional mode of instruction did not contribute radically in augmenting the integrated science process skills of students as compared to 7E learning instruction based teaching method. The probable reason for above results is that in case of experimental group, students in different science self-efficacy groups when exposed to 7E learning model based instruction put forth more efforts in gaining better understanding of science concepts.

The above findings were in accordance with the study of Cherry (2016) which advocates that students with high levels of science self-efficacy likely to develop deeper interest in the science activities and are intrinsically motivated to accomplish a particular task. On the other hand, students with a week or low sense of science self-efficacy tend to avoid challenging tasks and of their view that difficult situations or tasks are beyond their capabilities, quickly lose confidence in their abilities and focus on their personal failings and negative outcomes. Kurnia (2016) stated that 7E model is effective in improving the science self-efficacy and critical thinking skills.Lee, Liang and Wu (2020) indicated that the students' conceptions of science laboratory learning made a significant contribution to their perceptions of the science laboratory environment which consequently fostered their science learning self-efficacy.

7. Educational Implications

- The present study has established that 7E learning based instruction is a more effective teaching strategy than conventional teaching in terms of improving the integrated science process skills and attitude towards science. Therefore, 7E learning instructional model can be used by teachers in their courses to attain an effective student-centered learning environment in the classrooms.
- Because of the positive effect of 7E learning model based instruction on students' integrated science process skills and attitude towards science, this technology can make learning science easy and motivates more and more students to opt science for higher studies which would further offer better future prospects for them.
- 7E learning demands students to resolve a particular problem by doing in-depth research or it may ask students to learn a topic or a subject in detail. So, in this way 7E learning instructional model based instruction can serve as an exceptional way for instilling creativity in students.
- 7E learning model based instruction is a student-centered teaching technique where teacher plays a role of facilitator and guide students in completing their task. This kind of atmosphere stimulates students to think sensibly and logically augmenting their high order thinking skills which is a crucial aspect to enhance learning achievement of students.
- The 7E learning instructional approach was found helpful in developing the questioning ability, creativity in framing questions, inductive reasoning, problem solving ability and creative thinking skills among the students.
- The 7E learning instructional model is effective for the students in terms of arising curiosity, generating interest in science, better retention of the concepts.
- This study revealed that students become more enthusiastic and encouraged to use this in other subjects also. Therefore, this study thus has implications for all

concerning authorities i.e. for school administrators, curriculum developers, teachers, parents and students.

- The 7E learning instructional strategy brought changes among learners as various strategies like collaborative learning, simulations, think pair share, group discussion, mind maps, experiments etc were used. Such strategies created opportunities for the students to work together and developed a sense of mutual respect and care for each other.
- There must also be in-service and pre-service teacher training programmes to make teacher and perspective teachers aware about the 7E learning instructional model that broadens their horizon of understanding the subject.
- The teachers must include such activities during the teaching learning process that involves various senses and movement as it caters to multiple intelligence.

8. Suggestions for Further Researches

Based on the findings and respective conclusions drawn from the present study, few suggestions have been proposed for related future studies discussed as below:

- The present study was confined to Shaheed Bhagat Singh (S. B. S) Nagar district of Punjab state, however the study may be extended to other states of India and other countries.
- The present study was demarcated to the students of class IXth only, however to further corroborate this finding, the same experiment may be carried out on the students at elementary, higher secondary, college and university level. Thus offering a broader scope in variability in academic performance.
- The present study dealt with students of government schools only, however same type of study may be conducted in a sample selected from private and government-aided schools.
- In this study, only one classifying variable (science self-efficacy) was selected. There can be more classificatory variables such as socio economic status, cognitive styles, motivational achievement etc.
- The present study was confined to only two dependent variables i.e. integrated science process skills and attitude towards science, however academic achievement, problem solving ability, interest, critical thinking, motivation, reflective thinking, self concept etc may be used as dependent variables.
- Gender can also be considered as one of the major variable during teaching through 7E learning instructional model. The studies may be conducted to see the effect of this approach on stream or on locale also.
- As the study was conducted in the subject of science only, other school subjects could also be explored to see the impact of 7E learning instructional model in order to enhance the achievement among the students in these subjects.
- The comparative studies may be conducted in which 7E Learning instructional approach can be compared with other instructional approaches.
- The study can be replicated on the students of same class to validate and generalize the results.
- The studies can be conducted to assess the awareness about 7E learning instructional model among in-service teachers and pre-service teacher trainees.
- Studies can be conducted to understand the attitude/perception of teachers towards 7E learning instructional model.
- The studies can be done to study the perception of science teachers and teacher trainees about teaching methods in relation to awareness about 7E learning instructional model.
- The study included students selected randomly having different cognitive levels. The same can be implemented on the sample of bright learners as well as slow bloomers to further explore its effectiveness on acquisition of concepts among learners at upper and lower extreme end.

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