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Examining the Interaction Effect of 7E Model of Constructivist Pedagogical Approach and Science Self-Efficacy on Integrated Science Process Skills

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Abstract: ***The main purpose of the study was to investigate the interaction effect of 7E learning instructional model and science self-efficacy on ninth grade students' integrated science process skills. 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 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. In today's education scenario, science education 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. It enshrines in Article 51A(h) of the constitution that it is the fundamental duty of every citizen of the country to inculcate, propagate and further disseminate the scientific temper in society (NCERT, 2006). 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. Constructivist approach is a philosophy which uses 7E learning instructional model (Lawson, 1995). The 7E learning instructional model is derived from mental development theory of Piaget. These sequence of the phases can effectively increase learners' learning motivation and knowledge (Eisenkraft, 2003). Various studies investigated that 7E learning approach promoted students' conceptual understanding and achievement level (Bulbul, 2010; Kanli & Yagbasan, 2008), their science process skills (Kanli & Yagbasan, 2008) and their thinking skills (Mecit, 2006). 7E learning instructional model is a useful recommended strategy in science curriculum and teachers should be encouraged to incorporate this strategy into their teaching.

Self-efficacy belief is another important aspect of human behaviour and motivation which must be studied. Self-efficacy influences the actions that can affect individual's life. The basic principle or a theory behind self-efficacy is that learners are more likely to engage in those activities for which they have high self-efficacy and less likely to engage in those for which they have low self-efficacy (Vander Bijl & Shortridge-Baggett,2002). All learners can identify their goals they would like to accomplish, things they want to achieve but putting such plans into actions is not so easy. In terms of thinking, a strong sense of competence will facilitates performance and cognitive processes in a variety of settings which includes academic achievement and decision making ability. In terms of act, self-related cognition is considered as a major ingredient of the motivation process in case of students with higher level of self-efficacy in comparison to low self-efficacy students (Litt,1988).According to Cherry (2016) learners' self-efficacy plays a vital role in how a specific task, goal or challenges are approached. Students with high level of science self-efficacy likely to develop deeper interest in the activities in which they take and in case if they fail to accomplish a task they also recover quickly from the disappointments and setbacks. 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. Science self-efficacy is concerned with persons' belief in their capability to produce given attainments in the subject of science. Although, self-efficacy beliefs are multifaceted, social cognitive theory identifies several conditions under which they may co-vary even across distinct domains of functioning (Bandura, 1997). In order to increase the success in science, it is important to develop science learning self-efficacy beliefs (Yildirim & Karatas,2020).The science learning self-efficacy beliefs are related to daily life practices, science communication, higher order thinking (Zorlu, 2017).

2. Research Trends

From the above review, it can be culminated that there exists significant relationship of self-efficacy with academic achievement in various subjects (Paixao and Panahandeh, 2017; Fernando at 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. Hoffman & Spatariu (2008) clearly stated that self-efficacy enhanced the problem solving performance among the students. 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) and Lima, Winsler & Kitsantas (2014) revealed that males had higher self-efficacy than females.

Kurnia & Nela (2016) stated that 7E model is effective in improving the self-efficacy and critical thinking skills among the students. Susskind (2005) found out improvement in student's self-efficacy attitude with power point multimedia. Baker & White (2003) revealed that geographic information system approach had a positive effect on student's self-efficacy and attitude towards science. Gardner (2014) investigated no significant predictive relationship between the predictor variables of self-efficacy, ethnicity or gender and academic performance. Rani (2011) found out no significant difference between the experimental and control group in terms of achievement in science and anxiety with high and low self-efficacy of experimental and control group. Kocakaya & Gonen (2010) found out that CAI (Computer Aided Instruction) 7E approach was more effective than 7E model in enhancing the self-efficacy of students.

3. Rationale of the Study

Surveys conducted in science subject at middle, secondary stage levels in recent years presented grim pictures of students' interest in science subject and their achievement levels.Report issued by Program for International Student Assessment (PISA) in 2009 (as mentioned in OECD,2011) reflected that India ranked second last among the 73 countries that participated, leaving behind only Kyrgyzstan. Another report that raised concern regarding science education in India was from the survey conducted by the National Council of Applied Economic Research (NCAER,2013) which revealed that the number of students opting for science after the secondary school stage has dropped from 32 per cent to 19.7 per cent in recent years. This indicates that the young students particularly the brighter ones are drifting away from science. As reported by Homi Bhabha Centre for Science Education, very few students selected for olympiads in Chemistry, Physics or Biology. The choice of the National Talent Search awardees also reflected the same trend in recent years i.e. out of 750 awardees, only 100 opted for science. Report issued by National Achievement Survey (NAS, 2017) reflects that in science subject, students average performance on various learning outcomes (Reasoning/Interpretations/Calculations) was quiet low. So, we really need to diagnose the ailments and find the necessary cure by incorporating novel teaching strategies in the field of science.Hence a novel teaching strategy like 7E learning model must be incorporated into the science curriculum which offer humungous scope to the education fraternity to develop 21st century learning skills among students and to arouse their interest in persuing education in science field. Research studies of Indrawati, Suyatno & Yuanita (2017); Erlina, Jatmiko & Raharjo *(2016)* ; Mustafa (2019) stated that 7E learning model was able to enhance the students' critical thinking skills, attitude, interest and problem solving ability. *Komikesari et al., (2020) found out positive correlation between conceptual understanding in science and 7E learning model of teaching*. Balta & Sarac (2016); Kunduz & Secken (2013); Shaheen & Kayani (2015) and Khashan (2016) reported that 7E learning instructional model had a positive effect on student's achievement level.

Research Problem

To examine the interaction effect of instructional strategies and science self-efficacy on mean gain integrated science process skills scores.

Hypothesis

There will be no significant interaction effect of instructional strategies and science self-efficacy on mean gain integrated science process skills scores.

4. Research Methodology

The present research utilized factorial design to study the effect of two independent variables i.e. instructional strategies and science self-efficacy. The study used 2X3 factorial design to find out the interaction effect of instructional strategies and science self-efficacy on integrated science process skills. The 2X3 factorial design was employed to study the gains on integrated science process skills by studying the difference between pre-test and post test scores wherein method of instruction viz. 7E learning instructional model and science self-efficacy were independent variables and scores on integrated science process skills were dependent on that. Figure 1.1 summarizes the 2X3 factorial design for integrated science process skills.

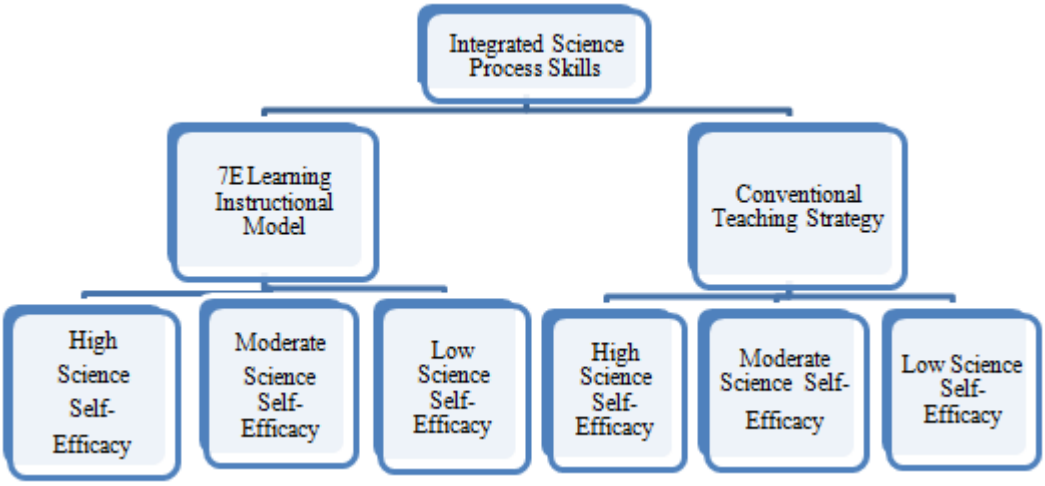

Figure 1.1: Schematic Layout of 2X3 Factorial Design for Integrated Science Process Skills

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. The equivalence between experimental and control group was established by matching the two groups on scores of integrated science process skills by employing t-test.Results of the Levene's test demonstrated that the assumption of homogeneity of variance has been satisfied as the p-value in all the sample groups was more than 0.05.Hence it is proved that the variances of the groups are equal. The 2X3 Analysis of Variance factorial design was employed and F-values were computed for mean gain integrated science process skills in order to study the interaction effect.

Table 1.1: A Summary of 2X3 Analysis of Variance on Mean Gain Integrated Science Process Skills Scores

Tests of Between-Subjects Effects					
Dependent Variable: Integrated Science Process Skills (Mean Gain)					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F-value**	**p-value**
Instructional strategy (A)	1086.008	1	1086.008	176.826	.0001**
Science self-efficacy (B)	99.617	2	49.808	8.110	.001**
Instructional strategy X Science self-efficacy (AXB)	69.217	2	34.608	5.635	.005**
Error	700.150	114	6.142		
Total	1954.992	119			
R Squared = .603 (Adjusted R Squared = .586)					

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

The interaction effect of instructional strategies and science self-efficacy on mean gain integrated science process skills scores was examined by computing the p-value as mentioned in table 1.1.The p-value came out to be .005 which was significant at 0.01 level of significance. The statistical analysis computed above explicitly reveals that ***the null hypothesis (H_{01}) stating that, "There will be no significant interaction effect of instructional strategies and science self-efficacy on mean gain integrated science process skills scores was rejected at 0.05 level of significance."*** The results indicate that the mean gain integrated science process skills scores differed significantly due to the interaction of instructional strategies and science self-efficacy.

6. Conclusion

The results explain that different groups attained different mean gain integrated science process skills score on the variable of integrated science process skills for two types of

instructional strategies and three levels of science self-efficacy which suggests that students possessing different levels of science self-efficacy (Low, moderate and high) achieved differently in their integrated science process skills scores when taught with different instructional strategies (7E learning model and conventional teaching method).The graphical representation of same is illustrated in figure 1.2.

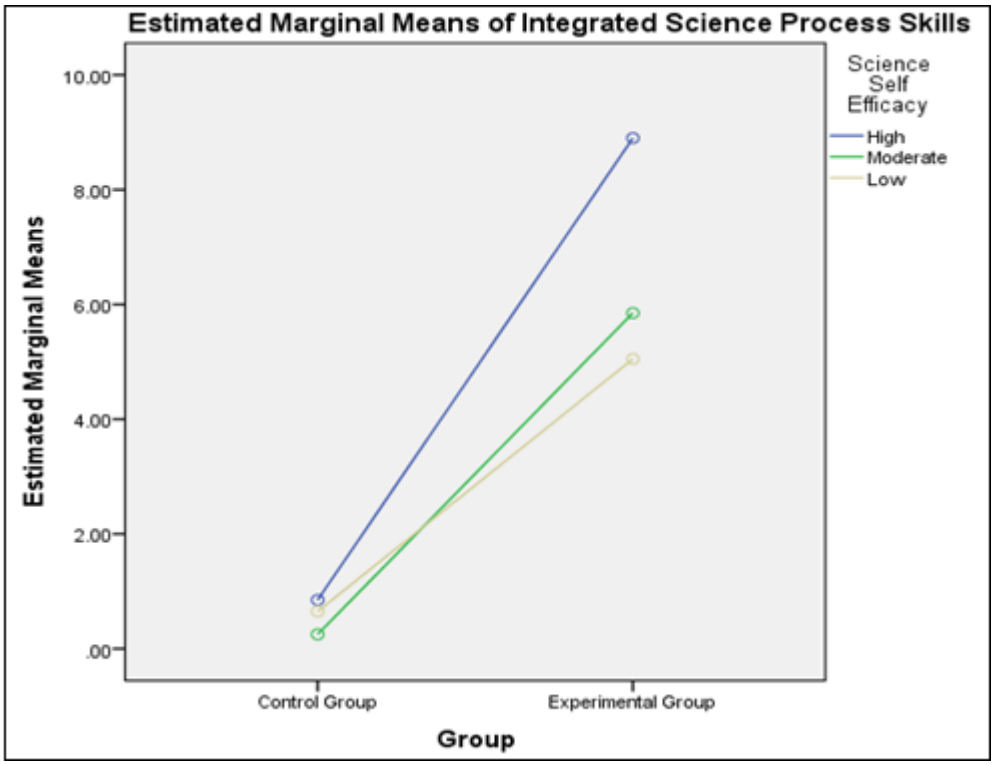

Figure 1.2: Graph showing interaction effect of instructional strategies and science self-efficacy on mean gain integrated science process skills scores.

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. 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, 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 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.
- 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.
- 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:

- 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 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.
- During experiment, the investigator realized that students who were taught through 7E learning instructional model felt freedom to ask questions in a democratic environment in the classroom. So, there

must be more researches on teaching of science through 7E learning instructional model on different classes.

- 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 such as Economics, Political Science, Social Studies and Languages could be explored to see the impact of 7E learning instructional model in order to enhance the achievement among the students in these subjects, since the literature review mostly provide ground of experiments related to science and maths subject only.
- The comparative studies may be conducted in which 7E Learning instructional approach can be compared with other instructional approaches.

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