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RESEARCH ARTICLE

EFFECT OF COMPUTER SIMULATION ON LEARNING OUTCOMES IN RELATION TO SELF-EFFICACY

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Abstract

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This study aims to determine the effect of using computer simulation on students' Learning outcomes in relation to self-efficacy. A sample of 120 students classified into two groups–experimental (60) and control (60)–from two senior secondary schools in Jalandhar city was the subject of a pre-test and post-test evaluation. Using the Statistical Package for the Social Sciences (SPSS), the Student's t-test and ANOVA were used to compare and analyze the test results given to the control and experimental groups of students. The findings imply that, in comparison to the control group, the experimental group had the best post-test performance. However, self-efficacy does not play a major role in explaining the observed variations in gain scores for science learning outcomes. In this regard, the study suggested that simulation software should be used and practiced to improve and increase scientific students' learning results.

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Introduction:-

The practical component and hands-on training are crucial to science education, particularly in secondary schools where students gradually apply what they have learned and employ their abilities in observation, analysis, and conclusion-making. A style or approach to simplify and facilitate the transfer of information in students' minds has become critical due to the abundance of information and increasing complexity of science. There are many various styles, methods, and tactics for teaching science.

Nowadays, information and communication technology is integral to the process of teaching and learning, particularly in the field of science education. Before modern technology permeated all facets of education, sciences were taught utilizing conventional methods in which the instructor held complete control over the class. For instance, using computer simulations increases students interest in the material and helps them acquire useful skills (Ambelu & Gebregziabher, 2011). Computer simulations are an essential teaching tool for achieving high-quality education, particularly in science classes where students would naturally be exposed to practical aspects of the subject.

Specifically, by adapting and applying scientific information in real-life settings, computer simulation-based instruction enhances students' academic achievement, particularly in science-based courses (Murugesan, 2019). Computer simulation is the practice of using a computer to replicate actions and scenarios that occur in real life. Through enhanced visualisation and interactive virtual reality of natural processes, computer simulations help

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scientific teachers and students learn more effectively (De Jong & Van Joolingen, 1998). Utilising computer simulation, which involves projecting outcomes from real-world scenarios, enhances academic performance (Huppert et al., 2002).

An important attribute of computer technology is creating simulations of real phenomena. Simulation is a model or imitation. Imitating a real situation to understand the components is a practical solution for circumstances when the real problem is not easy to observe. Computer simulation is a simulation run on the computer to provide an experience or reproduce the behavior of a system. A simulation of real phenomena is created through programming. The increasing availability of computers and related equipment such as smartboards and mobile devices, as well as the fact that computer simulations have become available for a wide range of science subjects (e.g., the PhET sims at http://phet.colorado.edu, 2011), have led to simulations becoming an integral part of many science curricula. This raises the question of how simulations are best used to contribute to improved learning of science.

Self-efficacy is the belief that one can succeed in performing particular behaviors; this is more strongly related to academic outcomes than many other individual characteristics like student gender, student self-concept, or the perceived usefulness of the knowledge later in the student's life Pajares and Miller (1994). Stemming the loss of self-efficacy in science as students progress through school is a crucial first step in improving student educational outcomes in science. So, we need to discover the new strategies of teaching and learning and their effectiveness in the field of science to find out what better prospects they can create in the field. In the present study researcher will investigate the effect of computer simulation-based instructional strategy on the learning outcomes of science students in relation to self-efficacy.

Review of Related Literature:-

Banda & Nzabahimana (2022) examined how PhET simulation-based learning affected Malawian secondary pupils' motivation and academic performance when they were studying oscillations and waves. PhET simulation-based learning enhances students' academic performance and motivation by using teaching tools and visualizations that make content knowledge simple to understand. **Lioyd (2024)** investigated the effectiveness of computer simulation in the academic performance and engagement of Grade 10 Physics students. The study revealed that Physics students taught with computer simulations performed better than the students taught with the conventional method of teaching. Additionally, these students were more engaged in the learning process compared to the students taught with traditional teaching methods. **Trongtirakul, et al (2022)** outlined the paper's objectives, which included examining how computer simulation-based learning affected students' self-efficacy in an electric circuit analysis course. The long-term average score revealed that the students had surpassed their prior accomplishments. The use of computer simulations in education increases students' sense of self-efficacy. Students thought the learning experience was worthwhile as well. **Gudayu et al. (2015)** evaluated student happiness, self-efficacy, and related aspects of simulation-based learning among Gondar University's midwifery students. A cross-sectional study with a sample of 144 pupils was carried out for this reason. Participants in this study reported 54.2% and 50.7%, respectively, of satisfaction and trust in simulation learning. Students who were satisfied and thought that the instructors' help was "good" during skill practice demonstrated statistically significant confidence, whereas students who thought that the instructors' aid was "good" during skill practice demonstrated statistically significant contentment. The findings indicated that midwifery students had poor levels of satisfaction and self-efficacy with simulation-based learning.

Objectives of the study:-

The study is guided by some research questions in gathering information on the effectiveness of computer-based Instructional Strategy in comparison to conventional Instructional methods.

1. To study the difference in mean gain scores of learning outcomes between groups taught through computer-based simulation and conventional instructional methods.
2. To study the interaction between instruction strategy and self-efficacy on learning outcomes.

Hypothesis of the study

$H_0$1: There is no significant difference in mean gain scores of learning outcomes between groups taught through computer-based simulation and conventional instructional methods.

$H_0$2: There is no significant interaction between instruction strategy and self-efficacy in learning outcomes.

Research Design
A quasi-experimental design has been employed in this investigation. Pre- and post-tests are given to both the control and experimental groups in the nonequivalent pre-test and post-test control group design; however, only the experimental group receives intervention. Both groups took the pre-tests for the science learning outcomes. Sections that remained intact served as the experimental and control groups. The control group was then instructed using the traditional teaching approach, whereas the experimental group was instructed using computer simulation-based instructional methodologies. The post-test of the learning outcomes was executed after the completion of the treatment.

Sampling Procedure
The private senior secondary schools in this study were chosen for experimentation using a purposive sample technique. Only two schools that met the following requirements were chosen for the study:
1. The medium of instruction should be English.
2. Schools should be affiliated with the CBSE Board.
3. Availability of Smart Classroom or projectors in the school.

Research Instruments:
The study involves the use of the following instruments:
1. Self-efficacy scale: The standardized Self-efficacy scale developed by Arun Kumar and Shruti Narain (2014) was used for measuring the self-efficacy of students. The test-retest reliability was found to be 0.82 and the split-half reliability was found to be 0.74.
2. **Achievement test of Science:** The achievement test in science was constructed and validated by the researcher. After the advice of science teachers and pedagogical experts of science, necessary modifications were made and the test was carried out with 100 students of class IX to examine the reliability of the test items. The reliability was calculated using Kuder–Richardson Formula 20 (KR-20), which came out to be 0.75.
3. **Teaching Modules**: The researcher also created modules based on the computer-based simulation method and the conventional way for the selected topics. Numerous scientific subject matter experts validated these modules.

Statistical Techniques:
Descriptive analysis, viz. mean, median, S.D., Skewness, and kurtosis were used for the calculation of scores of learning outcomes in science and Self-Efficacy. Graphical representations showing the qualitative analysis for the score of Learning outcome in science and Self-Efficacy. For Inferential analysis, Hypotheses were tested by using ANOVA for mean gain scores of Learning outcomes in science.

Analysis of the Data:
Data was gathered from Science students of class IX from private schools in the Jalandhar district. The students were provided with a Science Achievement test and a standardized tool for self-efficacy. The five-point Likert scale was used to measure self-efficacy of science students and to measure learning outcomes, a science achievement test was used. The students were given sufficient time to answer and response sheets were collected from the students.

Results:-
This section presents the results of the study in line with the primary purpose of the research. The main objective of the research was to study the difference in mean gain scores of Learning outcomes between groups taught through computer-based simulation and conventional instructional method and the second objective was to determine the interaction between instruction strategy and self-efficacy on Learning outcomes. The study presents descriptive and Inferential statistics for the analysis of data.

Table 1:- Descriptive Statistics for Pre-test Scores, Post-test Scores, and Gain Scores in the Context of Learning Outcome.

							Skewness		**Kurtosis**	
	N	**Mean**	**Median**	**SD**	**Minimum**	**Maximum**	**Skewness**	**SE**	**Kurtosis**	**SE**
Pre Test Scores (Achievement in Science)	120	12.78	13.00	3.45	5	22	0.0738	0.221	-0.555	0.438

Post Test Scores (Achievement in Science)	120	17.94	18.00	3.20	9	25	-0.1856	0.221	-0.194	0.438
Gain scores (Achievement in Science)	120	5.19	5.00	2.35	1	11	0.3156	0.221	-0.188	0.438

The above table presents descriptive statistics for pre-test scores, post-test scores, and gain scores in the context of learning outcomes in science for a sample of 120 participants. For the pre-test scores, the mean is 12.78 with a median of 13.00, indicating a slight negative skewness of 0.0738. The standard deviation is 3.45, suggesting a moderate degree of variability in the scores. The distribution ranges from a minimum of 5 to a maximum of 22.

Moving to post-test scores, the mean increases to 17.94 with a median of 18.00, and the standard deviation decreases to 3.20. The skewness for post-test scores is -0.1856, indicating a slight negative skewness. The distribution ranges from a minimum of 9 to a maximum of 25.

Gain scores, representing the difference between post-test and pre-test scores, have a mean of 5.19 and a median of 5.00, with a standard deviation of 2.35. The distribution of gain scores has a skewness of 0.3156, reflecting a positive skewness. The gain scores range from a minimum of 1 to a maximum of 11. Overall distribution can be considered as a normal distribution (Field,2009).

In terms of kurtosis, both pre-test and post-test scores exhibit negative kurtosis (-0.555 and -0.194, respectively), suggesting that the distributions are flatter than a normal distribution. The kurtosis for gain scores is also negative (-0.188), indicating a similar flattened distribution.

The standard errors (SE) for skewness and kurtosis are consistent across the three sets of scores, with values of 0.221 and 0.438, respectively. Overall, these descriptive statistics provide a comprehensive overview of the central tendency, variability, and distribution shape for pre-test scores, post-test scores, and gain scores in the study of learning outcomes in science (Field,2009).

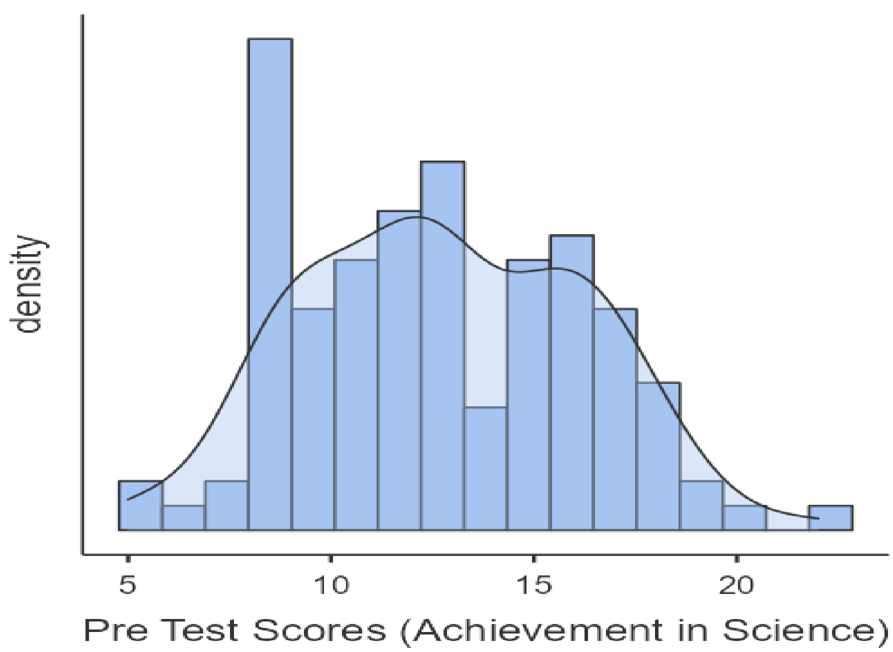

Figure 1:- Histogram on Pre-Test Scores of Achievement in Science for Total Data (N=120).

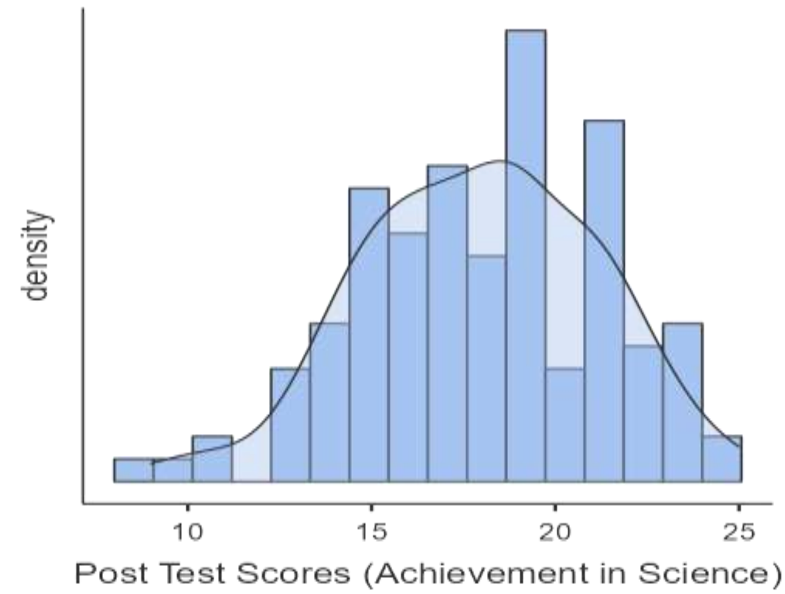

Figure 2:- Histogram on Post-Test Scores of Achievement in Science.

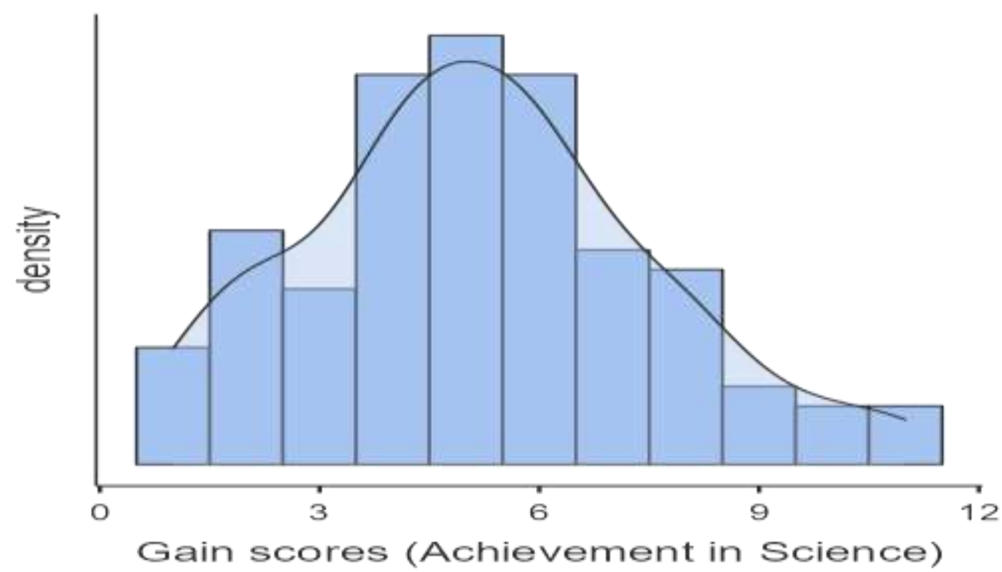

Figure 3:- Histogram on Gain Scores of Achievement in Science for Total Data (N=120).

Inferential Statistics

The study will be designed to test the following hypotheses:

$H_0$1: There is no significant difference in mean gain scores of Learning outcomes between groups taught through computer-based simulation and conventional instructional method.

$H_0$2:There is no significant interaction between instruction strategy and self-efficacy on achievement.

Table 2:- ANOVA - Gain scores (Achievement in Science).

	Sum of Squares	**df**	**Mean Square**	**F**	**p**	**η²p**
Group (0=Experimental, 1 = Control)	127.43	1	127.43	32.703	< .001	0.223
Self Efficacy	13.32	2	6.66	1.710	0.186	0.029

Group (0=Experimental, 1 = Control) ∗ Self Efficacy	7.55	2	3.78	0.969	0.383	0.017
Residuals	444.22	114	3.90			

The above ANOVA table presents the results of an Analysis of Variance (ANOVA) conducted to examine the impact of different factors on gain scores of learning outcomes in science. The factors considered include the experimental group (Group), self-efficacy, and the interaction between the group and self-efficacy.

The first row of the table corresponds to the Group variable, where 0 represents the experimental group and 1 represents the control group. The table reports the Sum of Squares (127.43), degrees of freedom (df=1), Mean Square (127.43), F-statistic (32.703), p-value ($< .001$), and effect size ($\eta^2p=0.223$) for this variable. The significant p-value indicates that there is a statistically significant difference in gain scores between the experimental and control groups, suggesting that the group factor (Experimental and Control Group) has an impact on learning outcomes in science.

Table 3:- Post Hoc Comparisons - Group (0=Experimental, 1 = Control).

Comparison								
Group (0=Experimental, 1 = Control)		**Group (0=Experimental, 1 = Control)**	**Mean Difference**	**SE**	**Df**	**t**	**p_{tukey}**	**Cohen's d**
0	-	1	2.44	0.426	114	5.72	< .001	1.24
Note. Comparisons are based on estimated marginal means								

The table provides information on post hoc comparisons between two groups: the experimental group (Group 0) and the control group (Group 1). The comparison involves the mean difference, standard error (SE), degrees of freedom (df), t-value, p-value, Tukey's HSD (Honestly Significant Difference) statistic, and Cohen's d effect size. In this specific comparison, Group 0 (Experimental) is being compared to Group 1 (Control). The mean difference between these two groups is 2.44, with a standard error of 0.426. The degrees of freedom for the comparison is 114, resulting in a t-value of 5.72. The p-value is less than 0.001, indicating statistical significance. Tukey's HSD statistic is also provided as <.001, reinforcing the significance of the difference between the groups. Additionally, Cohen's d, a measure of effect size, is reported as 1.24, suggesting a large effect. The comparisons are based on estimated marginal means, and the results suggest a substantial and statistically significant difference between the experimental and control groups in the measured variable.

The second row in the ANOVA table pertains to the Self Efficacy variable, with 13.32 as the Sum of Squares, 2 degrees of freedom, 6.66 as the Mean Square, a corresponding F-statistic of 1.710, a p-value of 0.186, and an effect size of $\eta^2p=0.029$. The non-significant p-value suggests that self-efficacy alone does not significantly contribute to the differences in gain scores.

The third row involves the interaction between Group and Self Efficacy. The Sum of Squares is 7.55, with 2 degrees of freedom, a Mean Square of 3.78, an F-statistic of 0.969, a p-value of 0.383, and an effect size of $\eta^2p=0.017$. The non-significant p-value implies that the interaction effect between group and self-efficacy is not statistically significant in explaining the differences in gain scores.

So H0-2 is not rejected at 0.05 level of significance.

Conclusions:-

In summary, the ANOVA results indicate that group factors (Experimental and Control Group) significantly influence learning outcomes in science, while self-efficacy alone and the interaction between group and self-efficacy do not contribute significantly to the observed differences in gain scores of learning outcomes in Science.

Recommendations of the study:-

Based on the findings of the study it has been found that computer-based interactive simulations are powerful tools to help students understand scientific concepts and to enhance their academic performance. This instructional strategy is based on individual differences; provides immediate feedback and can be adjusted to the individual's pace of learning.

Consequently, steps need to be taken to construct computer-based interactive simulations in an organised manner so they can be incorporated into the curriculum. This calls on the State and Central Governments to work together to promote. Schools should be furnished with computers and modern technology by governmental and non-governmental organisations so that educators and students can easily access them. To enable teachers to exploit these new technologies when they are offered to schools, the government (Centre and State) should provide free computer training. The use of interactive computer simulations as creative teaching tactics for science courses can be the focus of workshops and seminars.

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