Effectiveness of Arias Model for Teaching Negative Numbers on Self-Efficacy of Secondary School Students

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ABSTRACT

Self-Efficacy is a crucial affective factor influencing students' motivation, persistence, and achievement in mathematics learning. Students often lack confidence while learning abstract mathematical concepts such as negative numbers. The present study examined the effectiveness of the ARIAS instructional model, comprising Assurance, Relevance, Interest, Assessment, and Satisfaction, in enhancing the Self-Efficacy of secondary school students. The study employed an experimental method using a pre-test post-test non-equivalent group design. The sample comprised 84 students of Standard IX students following the Kerala State syllabus, with 43 students in the experimental group and 41 in the control group. The experimental group received ARIAS-based instruction, while the control group was taught through activity-oriented instruction. Data were collected using a Self-Efficacy Scale developed by the investigator. Analysis using descriptive statistics, t-test, and ANCOVA showed that ARIAS-based instruction significantly improved students' Self-Efficacy compared to the control group. Further results revealed no significant difference in Self-Efficacy between boys and girls in the experimental group, indicating that the ARIAS model supports confidence development irrespective of gender. The study underscores the role of motivational instructional models in enhancing affective outcomes in mathematics learning.

Keywords: ARIAS Model, Self-Efficacy, Negative Numbers, Gender, Secondary School Students

INTRODUCTION

Education not only facilitates cognitive development but also plays a vital role in shaping learners' beliefs, motivation, and emotional readiness to learn. The effectiveness of teaching depends largely on how instructional practices influence students' confidence and engagement. According to Robinson (2016), education should empower learners to develop their own solutions through supportive and personalized learning environments. This perspective underscores the importance of addressing affective variables in classroom instruction, particularly in subjects like mathematics.

Self-Efficacy, as defined by Bandura (1997), refers to an individual's belief in their capability to organize and execute actions required to achieve specific goals. In the context of mathematics education, Self-Efficacy strongly influences students' effort, persistence, emotional responses, and academic performance. Students with high Self-Efficacy are more likely to engage in challenging tasks, apply effective strategies, and overcome learning difficulties, whereas low Self-Efficacy often leads to anxiety, avoidance, and underachievement.

Mathematics is widely regarded as a subject that induces fear and lack of confidence among students, particularly when abstract concepts are introduced at the secondary school level. Negative numbers, which represent quantities less than zero, are conceptually demanding and frequently result in misconceptions related to operations such as addition, subtraction, multiplication, and division (Devlin, 2000). These difficulties often undermine students' confidence and belief in their mathematical abilities, thereby negatively affecting their Self-Efficacy.

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Conventional teaching methods in mathematics primarily focus on procedural knowledge and rote practice, offering limited opportunities for confidence building and emotional engagement. Such approaches fail to address the affective dimensions of learning, which are essential for sustained academic success. Instructional models that integrate motivation, relevance, and feedback are therefore required to enhance students' Self-Efficacy and learning engagement.

The ARIAS instructional model—Assurance, Relevance, Interest, Assessment, and Satisfaction—provides a structured framework for fostering learner confidence and motivation (Keller & Kopp, 1987). The "Assurance" component directly supports confidence development, while "Satisfaction" reinforces positive learning experiences, both of which are critical for strengthening Self-Efficacy. Previous studies have demonstrated the effectiveness of the ARIAS model in improving learning motivation, mathematical thinking, and affective outcomes (Hamidah & Kusuma, 2021; Sharma et al., 2021).

While several motivational instructional models have been proposed, Keller's ARCS model primarily emphasizes Attention, Relevance, Confidence, and Satisfaction at a general design level. The ARIAS model, a modified and extended version of the ARCS framework, was selected for the present study as it operationalizes motivational principles more explicitly for classroom instruction through its five structured components—Assurance, Relevance, Interest, Assessment, and Satisfaction (Keller & Kopp, 1987). Unlike ARCS, ARIAS incorporates Assessment as a distinct and continuous component, enabling systematic feedback and reinforcement during instruction. This feature is particularly relevant in mathematics education, where frequent evaluation and corrective feedback are essential for confidence building. Furthermore, the Assurance component of ARIAS directly aligns with Bandura's (1997) concept of Self-Efficacy, making the model theoretically and pedagogically suitable for enhancing students' confidence in learning abstract mathematical concepts such as negative numbers.

By creating a supportive and engaging learning environment, the ARIAS model helps students experience mastery, receive positive reinforcement, and develop a belief in their ability to succeed. Therefore, the present study aims to investigate the effectiveness of the ARIAS model for teaching negative numbers in enhancing the Self-Efficacy of secondary school students.

Need And Significance Of The Study

Self-Efficacy is a critical affective variable that influences students' motivation, persistence, emotional responses, and academic performance. Bandura (1997) emphasized that learners' beliefs about their capabilities strongly determine how they approach learning tasks, particularly in challenging subjects such as mathematics. Students with high Self-Efficacy demonstrate greater effort, resilience, and willingness to engage in complex problem-solving, whereas low Self-Efficacy often results in anxiety, avoidance, and poor performance.

Mathematics education at the secondary school level is frequently associated with fear and lack of confidence among students. Abstract concepts, especially negative numbers, often lead to confusion and repeated failure experiences, which in turn weaken students' confidence in their mathematical abilities (Devlin, 2000). Despite the importance of Self-Efficacy in overcoming such challenges, traditional instructional methods predominantly emphasize procedural knowledge and rote practice, offering limited opportunities for confidence building and emotional engagement.

The ARIAS instructional model—Assurance, Relevance, Interest, Assessment, and Satisfaction—offers a structured approach that directly addresses motivational and affective dimensions of learning (Keller & Kopp, 1987). The components of Assurance and Satisfaction are particularly relevant for strengthening Self-Efficacy, as they promote confidence, reinforce success experiences, and encourage positive attitudes towards learning. Previous studies have reported that ARIAS-based instruction enhances learning motivation, active engagement, and mathematical thinking (Sharma et al., 2021; Hamidah & Kusuma, 2021).

However, a critical review of existing research reveals a notable gap in studies that specifically examine the effectiveness of the ARIAS model in enhancing Self-Efficacy in mathematics, particularly with reference to teaching negative numbers at the secondary school level. While Bandura (1997) highlighted the role of Self-

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Efficacy in academic success, there is limited empirical evidence linking specific instructional models, such as ARIAS, to the systematic development of mathematical Self-Efficacy among school students.

The present study is therefore significant as it seeks to bridge this research gap by investigating the effectiveness of the ARIAS model in enhancing the Self-Efficacy of secondary school students learning negative numbers. The findings are expected to contribute to mathematics education by offering practical insights into instructional practices that foster confidence, motivation, and positive learner beliefs. The study also holds implications for teachers, teacher educators, and curriculum developers in designing learner-centred instructional strategies that address both cognitive and affective domains of learning.

Research Questions

- Does ARIAS Model for teaching Negative Numbers effective for enhancing Self-Efficacy of Secondary School Students?

- Is there any significant difference in the effectiveness of ARIAS Model for teaching Negative Numbers in enhancing Self-Efficacy of Secondary School Students based on Gender - Boys and Girls?

Statement Of The Problem

Self-Efficacy plays a crucial role in shaping students' motivation, persistence, and performance in mathematics learning, particularly at the secondary school level, where abstract concepts often challenge learners' confidence. Negative numbers, as a foundational topic in mathematics, frequently lead to misconceptions and repeated failure experiences, thereby weakening students' belief in their mathematical abilities. Conventional teaching methods tend to focus on procedural knowledge while giving limited attention to affective factors such as confidence and motivation. The ARIAS instructional model, comprising Assurance, Relevance, Interest, Assessment, and Satisfaction, emphasises learner confidence and positive learning experiences. Although research has highlighted the role of Self-Efficacy in academic success, there is limited empirical evidence examining the effectiveness of the ARIAS model in enhancing Self-Efficacy in Mathematics. Hence, the present study is entitled, "Effectiveness of ARIAS Model for teaching Negative Numbers on Self-Efficacy of Secondary School Students".

Hypotheses Formulated For The Study

1. ARIAS Model for teaching Negative Numbers is significantly effective in enhancing Self-Efficacy of Secondary School Students than activity oriented instruction.

2. There is a significant difference in Self-Efficacy of Secondary School Students while using ARIAS Model for teaching Negative Numbers based on gender - boys and girls.

Objectives Of The Study

1. To find out the level of Self-Efficacy of Secondary School Students.

2. To find out the effectiveness of ARIAS Model for teaching Negative Numbers in enhancing Self-Efficacy of Secondary School Students.

3. To find out whether there is any significant difference in Self-Efficacy of Secondary School Students, while using ARIAS Model for teaching Negative Numbers based on gender - boys and girls.

METHODOLOGY IN BRIEF

A brief and precise description of the method adopted, sample selected, tools and statistical techniques employed for analysing the data are as follows:

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Method Adopted for the Study

The investigator adopted Experimental method for the present study.

Experimental Design Selected for the Study

The Pretest - Posttest Non-equivalent Group Design is selected for the present study.

Population of the Study

In the present study, population comprises of all the Secondary School Students following Kerala State Syllabus.

Sample Selected for the Study

The sample constitutes 84 students of standard IX, following Kerala State Syllabus from AMM High School in Kollam district.

Sampling Technique Adopted for the Study

The investigator adopted Simple Random Sampling technique for the present study.

Variables of the Study

In the present study, two variables are involved out of which one is the independent variable, and the other is dependent variable.

- Independent variable: The Independent variable in the present study is Instruction based on ARIAS Model.
- Dependent variables: Self-Efficacy is the dependent variables in the present study.

Tools and Materials Used for the Study

The tools and materials used for the present study are:

- Lesson transcripts based on ARIAS Model for teaching Negative Numbers.
- Lesson transcripts based on activity oriented instruction.
- Self – Efficacy Scale. (Developed by the Investigator)

Statistical Techniques Used for the Study

The following statistical techniques are used for the study:

- Descriptive Statistics : Arithmetic Mean, Standard Deviation, Skewness, Kurtosis
- Inferential Statistics : t- test, ANCOVA

Analysis And Interpretation

The obtained data, which were subjected to suitable statistical analysis, are interpreted under the following headings:

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Analysis On The Level Of Self-Efficacy Of Secondary School Students

- Analysis on the Level of Self-Efficacy of Secondary School Students.

Analysis On The Effectiveness Of Arias Model For Teaching Negative Numbers On Self-Efficacy Of Secondary School Students

- Test of Significance of Difference Between Means of Pre-test Scores of Self-Efficacy of Experimental and Control Groups.
- Test of Significance of Difference Between Means of Post-test Scores of Self Efficacy of Experimental and Control Groups.
- Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Self-Efficacy of Experimental Group.
- Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Self-Efficacy of Control Group.
- Test of Significance of Difference Between Means of Gain Scores of Self-Efficacy of Experimental and Control Groups.
- Analysis of Covariance of Pre-test and Post-test Scores in Self-Efficacy of Experimental and Control Groups.

Comparison Of Self-Efficacy Of Experimental Group Based On Gender – Boys And Girls

- Test of Significance of Difference Between Means of Post-test Scores of Self-Efficacy of Boys and Girls in the Experimental Group.

The details of the analysis are given below:

Analysis On The Level Of Self-Efficacy Of Secondary School Students

Analysis on the Level of Self-Efficacy of Secondary School Students

The descriptive statistical scores of Self-Efficacy of Secondary School Students are presented in Table 1.

Table 1 Descriptive Statistical Scores of Self-Efficacy of Secondary School Students

Variable	N	Mean	Standard Deviation	Skewness	Kurtosis
Self-Efficacy	84	123.53	20.70	0.203	-1.46

Table 1shows that the mean Self-Efficacy score is 123.53, and the standard deviation is 20.7 for the selected 84 sample size. The skewness value of Self-Efficacy is 0.203, which shows that the data is approximately symmetric with only a mild positive skew. The Kurtosis level was reported as -1.46. Both the skewness and kurtosis show that the distribution is not much deviated from the normal distribution.

The level of Self-Efficacy of Secondary School Students was analysed, and the details are presented in Table 19. The calculated mean value for Self-Efficacy is 123.53, and the standard deviation is 20.70. The secondary school students with scores greater than 144.23 (M + σ) have a high level of Self-Efficacy, and those who scored less than 102.83 (M - σ) have a low level of Self-Efficacy. The Secondary School Students who scored between these scores have an average level of Self-Efficacy.

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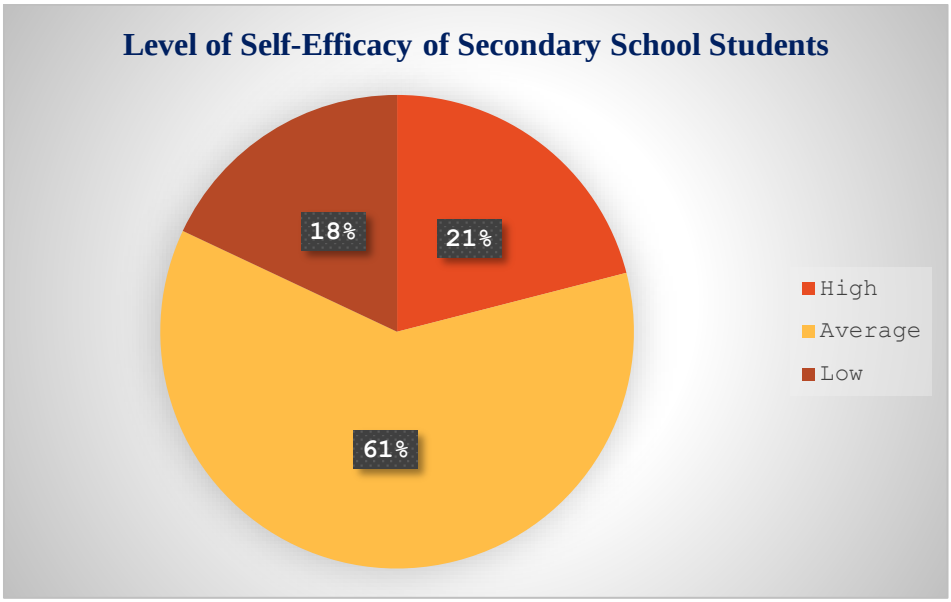
Table 2 Number and Percentage of Secondary School Students belonging to different levels of Self-Efficacy.

Level	Number	Percentage
High	18	21
Average	51	61
Low	15	18
Total	**84**	**100**

From the table 2, it is clear that 21% of Secondary School Students out of the total sample belong to the high-level of Self-Efficacy, 61% of Secondary School Students out of the total sample belong to the average level of Self-Efficacy, and 18% of Secondary School Students out of the total sample belong to the low-level of Self-Efficacy. Hence, the investigator concluded that the Self-Efficacy of Secondary School Students is moderate. The diagrammatic representation of different levels of Self-Efficacy is shown in Figure 1.

Figure 1 Pie Diagram showing the Percentage of different levels of Self-Efficacy of Secondary School Students



Analysis On The Effectiveness Of Arias Model For Teaching Negative Numbers On Self-Efficacy Of Secondary School Students

The major objective of the study was to find out the effectiveness of ARIAS Model for teaching Negative Numbers in enhancing Self-Efficacy of Secondary School Students. The pre-test and post-test scores were compared within and between the experimental and control groups to find out the effectiveness of ARIAS Model on Self-Efficacy of Secondary School Students. The data was analysed using appropriate statistical techniques and the results are presented below.

Descriptive Statistics of Pre-Test and Post-Test Scores of Self-Efficacy of Experimental and Control Groups

Descriptive statistics organize and present data in a meaningful form, making it easier to understand and interpret. In this section, the pre-test and post-test scores of Self-Efficacy for the experimental and control groups are analysed. The details of descriptive statistics are presented below in Table 3.

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Table 3 Descriptive Statistics of Pre-Test and Post-Test Scores of Self-Efficacy of Experimental and Control Groups

Groups		N	Mean	SD	Sk	Ku
Experimental Group	**Pre-test**	43	105.06	5.38	0.17	-0.23
	Post-test	43	141.67	10.97	-0.41	0.17
Control Group	**Pre-test**	41	103.12	5.78	0.12	-0.36
	Post-test	41	104.51	6.17	0.63	0.45

*N = Number of students Max = Maximum Min = Minimum

SD = Standard Deviation Sk = Skewness Ku = Kurtosis

Table 3 shows the change in Self-Efficacy of the two groups before and after the instruction.

The pre-test scores of the experimental group have a wide range, from a minimum of 95 to a maximum of 117. The average score is 105.06, with a standard deviation of 5.38 shows that the scores are moderately spread. A skewness of 0.17 and kurtosis of -0.23 confirm that the data is within the acceptable range for a normal distribution (Mangal, 2024).

After the instruction based on the ARIAS Model, the average score increased to 141.67. The standard deviation of 10.97 is much larger than the pre-test, indicating that the scores became more spread out after the intervention. The skewness of -0.41 is negative, suggesting that more individuals scored more than the average. The kurtosis of 0.17 indicates a distribution very similar to a normal (Mangal, 2024).

The scores of the experimental group show a notable shift in both average performance and the shape of the distribution after the intervention. While pre-test scores have a skewness of -0.27, indicating a slightly negative skew, which means scores are concentrated towards the higher end of the scale, post-test Scores have a skewness of -0.41, which shows a stronger clustering of scores at the higher end of the scale. The kurtosis of pre-test scores suggests a flatter distribution than a normal curve, but the kurtosis of post-test scores indicates that the distribution's shape became more like a normal bell curve. This positive change suggests the intervention is successful in improving performance for a wider range of students.

The pre-test scores of the control group range from 92 to 116, with an average of 103.12. The standard deviation is 5.78, showing a similar spread to the experimental group. The skewness of 0.12 and kurtosis of -0.36 indicate that the data is nearly symmetrical and follows a normal distribution, confirming the two groups are comparable at the start of the study.

After the instruction using activity oriented method, the average score increased slightly to 104.51. This increase is small compared to the gain of the experimental group. The standard deviation of 6.17 shows a modest increase in the spread of scores. The skewness of 0.63 indicates a moderate positive skew, suggesting more scores are concentrated at the lower end of the distribution. The kurtosis of 0.45 is close to zero, suggesting a normal peak and tail structure.

The data from the control group reveal a different pattern of change, highlighting the lack of a uniform effect from the activity-oriented instruction. It also shows that some students improved, but others did not, leading to a wider, more varied set of data.

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Test of Significance of Difference Between Means of Pre-test Scores of Self-Efficacy of Experimental and Control Groups

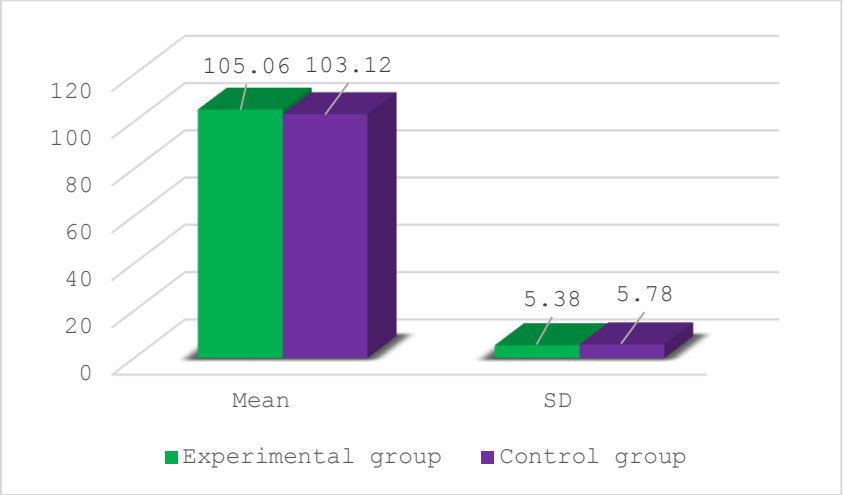
Table 4 Data and Results of Test of Significance of Difference Between Means of Pre-test Scores of Self-Efficacy of Experimental and Control Groups

Groups	N	Mean	SD	CR	Level of Significance
Experimental Group	43	105.06	5.38	1.591	Not Significant
Control Group	41	103.12	5.78		

Table 4 shows that the critical ratio obtained through the independent t-test is 1.591 and is less than the critical value of 2.58 at the 0.01 level of significance. It shows that the critical ratio is not statistically significant. Hence, there is no significant difference between the pre-test scores of the experimental and control groups. Thus, it can be concluded that both groups are similar in their initial test.

The diagrammatic representation of the comparison of mean and standard deviation of pre-test scores of Self-Efficacy of Experimental and Control Groups is given in Figure 2.

Figure 2 Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Pre-test Scores of Self-Efficacy of Experimental and Control Groups



Test of Significance of Difference Between Means of Post-test Scores of Self-Efficacy of Experimental and Control Groups

Table 5 Data and Results of Test of Significance of Difference Between Means of Post-test Scores of Self-Efficacy of Experimental and Control Groups

Groups	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Experimental Group	43	141.67	10.97	18.992	0.01	4.17
Control Group	41	104.51	6.17			

Table 5 shows that the critical ratio calculated through independent t-test is 18.992, which is greater than the critical value of 2.58 at 0.01 level of significance. The critical ratio is statistically significant at the 0.01 level.

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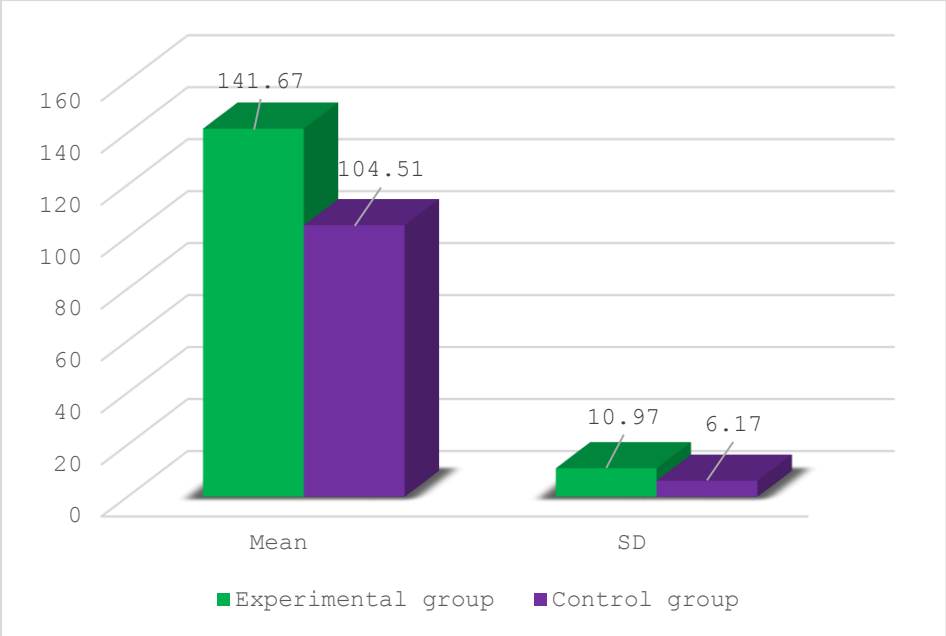
This shows that there is a significant difference between the means of the post-test scores of the experimental and control groups.

Cohen (1988) proposed rule of thumb for interpreting effect sizes as a small effect size is 0.20, a medium effect size is 0.50, and a large effect size is 0.80. Here, the effect size calculated using Cohen's d is 4.17, which is greater than 0.80, indicating a large effect. Hence, it can be concluded that the performance of the experimental group is better than the control group.

The diagrammatic representation of the comparison of mean and standard deviation of post-test scores of Self-Efficacy of Experimental and Control Groups is given in Figure 3.

Figure 3 Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Post-test Scores of Self-Efficacy of Experimental and Control Groups



Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Self-Efficacy of the Experimental Group

Table 6 Data and Results of Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Self-Efficacy of the Experimental Group

Test	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Pre-test	43	105.06	5.38	17.649	0.01	4.23
Post-test	43	141.67	10.97			

Table 6 shows the results of a paired t-test for comparing the mean differences of pre-test and post-test scores of Logical Mathematical Intelligence of the experimental group. The critical ratio obtained is 17.649, which is greater than the critical value of 2.58 at 0.01 level of significance. Hence, the critical ratio is statistically significant. This shows that there is a significant difference between the pre-test and post-test scores in the experimental group. The inference is that the mean score of the post-test is significantly greater than the mean score of the pre-test. The effect size calculated for the difference is 4.23; the limit set by Cohen's category indicates that the effect size is large. Hence, it can be concluded that the experimental group shows better performance after the implementation of ARIAS Model based instruction.

The diagrammatic representation of the comparison of mean and standard deviation of pre-test and post-test scores of Self-Efficacy of Experimental Group is given in Figure 4.

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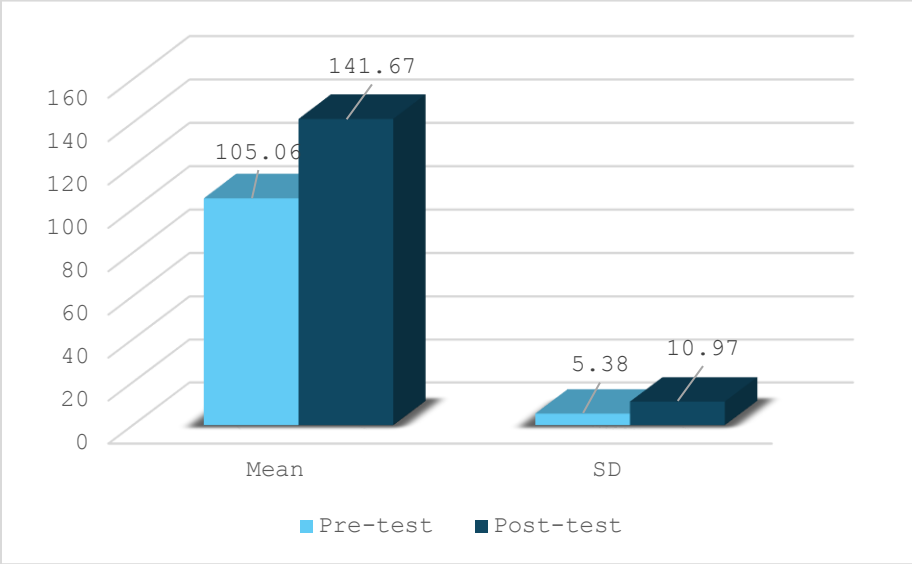
Figure 4 Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Pre-test and Post-test Scores of Self-Efficacy of the Experimental Group



Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Self-Efficacy of the Control Group

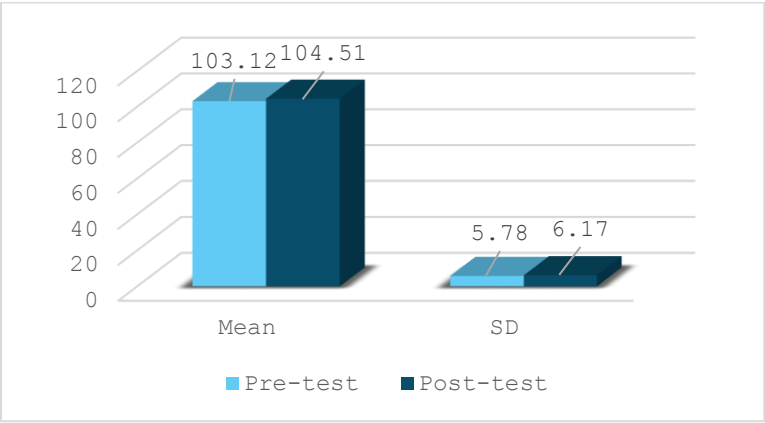
Table 7 Data and Results of Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Self-Efficacy of the Control Group

Test	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Pre-test	41	103.12	5.78	4.663	0.01	0.23
Post-test	41	104.51	6.17			

Table 7 shows that the critical ratio obtained through paired t-test is 4.663 and is greater than the critical value 2.58 at 0.01 level of significance. Hence, the critical ratio is statistically significant. This shows that there is a significant difference between the pre-test and post-test scores of the control group. The effect size calculated for the difference is 0.23, which indicates that the effect size is small.

The diagrammatic representation of the comparison of mean and standard deviation of pre-test and post-test scores of Self-Efficacy of Control Group is given in Figure 5.

Figure 5 Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Pre-test and Post-test Scores of Self-Efficacy of the Control Group



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Test of Significance of Difference Between Means of Gain Scores of Self-Efficacy of Experimental and Control Groups

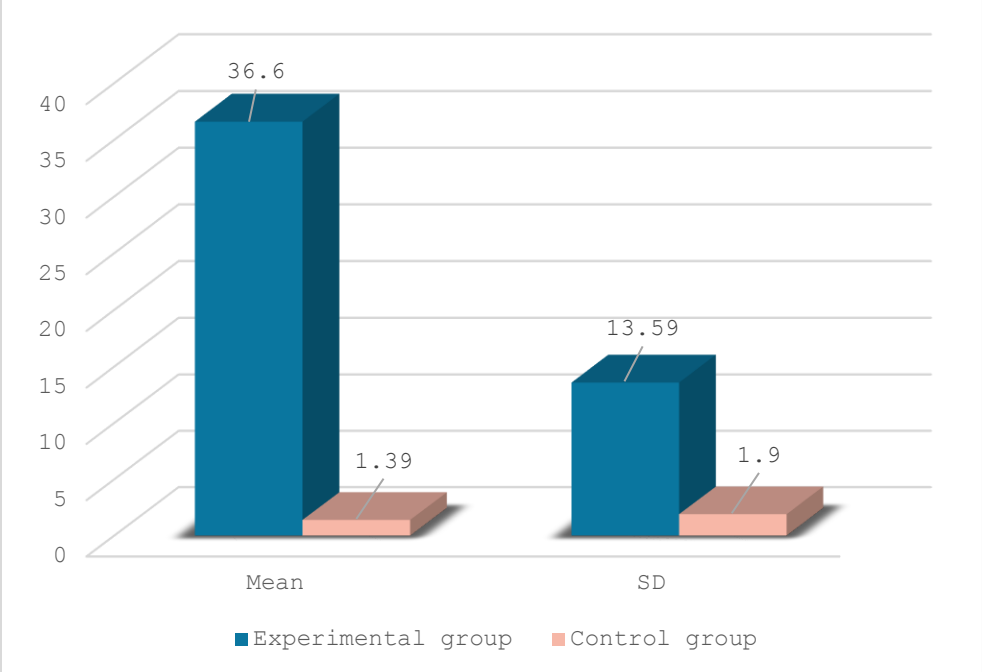
Table 8 Data and Results of Test of Significance of Difference Between Means of Gain Scores of Self-Efficacy of Experimental and Control Groups

Groups	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Experimental Group	43	36.6	13.59	16.43	0.01	3.62
Control Group	41	1.39	1.90			

Table 8 shows that the critical ratio is 16.43, which is statistically significant at 0.01 level of significance. This shows that there is a significant difference between the means of gain scores of the experimental and control groups. The mean gain score of the experimental group is significantly greater than the mean gain score of the control group. The effect size calculated using Cohen's d is 3.62, which indicates that the effect size is large. Hence, it can be concluded that the ARIAS Model had a larger effect in enhancing Self-efficacy than the activity oriented instruction.

The diagrammatic representation of the comparison of mean and standard deviation of gain scores of Self-Efficacy of Experimental and Control Groups is given in Figure 6.

Figure 6 Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Gain Scores of Self-Efficacy of Experimental and Control Groups



Analysis of Covariance of Pre-test and Post-test Scores in Self-Efficacy of Experimental and Control Groups

Only by analyzing the pre-test scores, post-test scores, gain scores, and by finding out the critical ratio, it cannot be concluded that the two groups may or may not differ significantly in their performance after the conduction of the experiment. Also, the investigator selected two intact classroom groups without considering any variables like sex, age, socioeconomic status, etc. So, it is necessary to analyze the data using the statistical technique 'Analysis of covariance '(ANCOVA).

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Table 9 Analysis of Variance of Pre-test and Post-test Scores of Self-Efficacy of Experimental and Control Groups

Sources of variation	**df**	**SS_X**	**SS_Y**	**MS_X (V_X)**	**MS_Y (V_Y)**	**F ratio**
Among-means	1	79.628	28985.20	79.628	28985.20	F_X = 2.555
Within-groups	82	2555.18	6587.68	31.16	80.337	F_Y = 360.79

The obtained F_X and F_Y ratios were tested for significance. The critical value of F ratio for degrees of freedom (1,82) is 3.96 at 0.05 level. So the obtained F_X is not significant at 0.05 level ($F_X = 2.555 < 3.96$). Since the F test applied to the pre- test scores F_X falls for short of significance at 0.05 level, it is clear that the X means do not differ significantly.

The critical value of F ratio for df (1,82) is 6.96 at 0.01 level. So, the obtained F_Y is significant at 0.01 level ($F_Y = 360.79 > 6.96$). Since the F_Y falls beyond the 0.01 level of significance, it can be tentatively interpreted that there is a significant difference between the Y means of the two groups.

The final Y scores were adjusted for differences in initial X scores. For that SS_Y has been adjusted for any variability in Y and SS_{YX}, and F ratio, F_{YX} were calculated. The summary of analysis of covariance of pre- test and post- test scores of pupils in experimental and control groups is given in Table 10.

Table 10 Analysis of Covariance of Pre-test and Post-test Scores of Self-Efficacy of Experimental and Control Groups

Sources of variation	**df**	**SS_X**	**SS_Y**	**SS_{XY}**	**SS_{YX}**	**MS_{YX} (V_{YX})**	**SD_{YX}**	**F_{YX}**
Among-means	1	79.62	28985.20	69.28	27405.14	27405.14	8.91	344.69
Within-groups	81	2555.18	6587.68	-48.61	6439.94	79.5		

(1 df is lost because of regression of Y on X)

The obtained F_{YX} ratio was tested for significance. Since the critical value of F ratio for df (1,81) is 6.96 at 0.01 level of significance, the obtained F_{YX} ratio is highly significant at 0.01 level ($F_{YX} = 344.69 > 6.96$). It is clear from the significant F_{YX} ratio that the two final means, which depend upon the experimental and control variables differ significantly after they have been adjusted for initial difference on X. The adjusted means of post-test scores (X, Y means) of pupils in the experimental and control groups were calculated. The difference between the adjusted Y means was tested for significance. The data for adjusted Y means of post- test scores of pupils in experimental and control groups are given in Table 11.

Table 11 Data of Adjusted Means of Post-test Scores on Self-Efficacy of Experimental and Control Groups

Groups	**N**	**M_X**	**M_Y**	**M_{YX} (Adjusted)**	**df**	**CR**	**Level of significance**
Experimental group	43	105.06	141.67	141.44	81	18.85	0.01
Control group	41	103.12	104.51	104.74			

Adjusted Y means for pre-test scores are tested for significance for degrees of freedom 81. The critical ratio obtained is 18.85 and the critical value for significant difference for df 81 is 2.64 at 0.01 level of significance ($t = 18.85 > 2.64$). The significant difference between the adjusted Y means indicates that the secondary school students of the experimental and control groups differ significantly in their Self-Efficacy in the post-test. The mean of the post- test scores of experimental and control groups clearly indicates that the students in the

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experimental group show more Self-Efficacy. It may therefore be tentatively interpreted that the Self-Efficacy of Secondary School Students taught through the ARIAS Model is better than that of Secondary School Students taught through the activity oriented method.

Comparison Of Self-Efficacy Of Experimental Group Based On Gender – Boys And Girls

The analysis focused on determining whether there is any significant difference in the Self-Efficacy while using the ARIAS Model for teaching Negative Numbers based on gender- boys and girls. The post-test scores of boys and girls in the experimental group were compared to test the significance of the difference between their means. The data was analysed using appropriate statistical techniques, and the results are presented in Table 12.

Test of Significance of Difference Between Means of Post-test Scores of Self-Efficacy of Boys and Girls in the Experimental Group

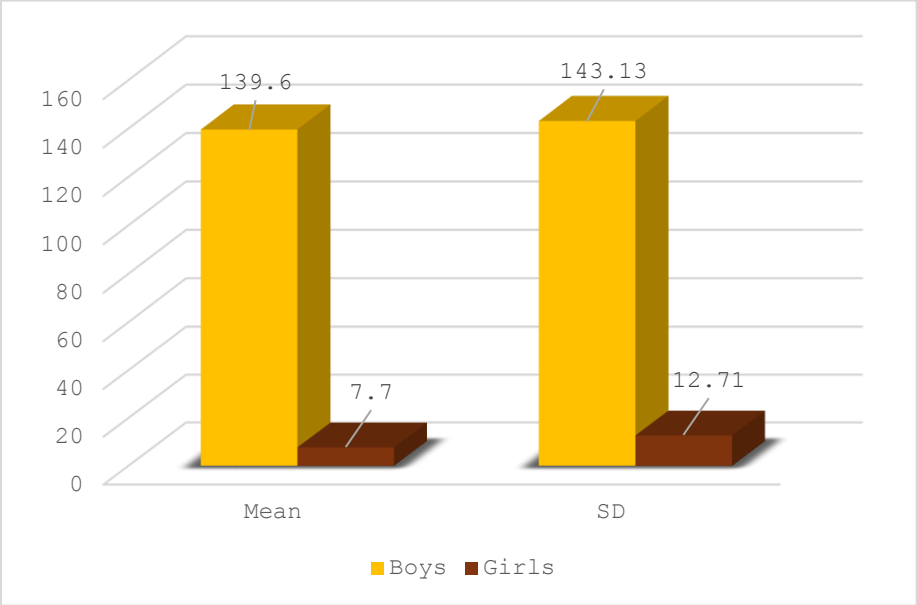
Table 12 Data and Results of Test of Significance of Difference Between Means of Post-test Scores of Self-Efficacy of Boys and Girls in the Experimental Group

Gender	N	Mean	SD	CR	df	Level of Significance
Boys	20	139.6	10.26	1.146	41	Not Significant
Girls	23	143.13	9.91			

Table 12 shows the results of an independent t-test conducted for a small sample. The critical ratio obtained is 1.146, which is less than the critical value of t with degrees of freedom $N_1 + N_2 - 2 = 41$ at the 0.01 level of significance is 2.71. It shows that the critical ratio is not statistically significant at the 0.01 level. Hence, there is no significant difference between the post-test scores of boys and girls in the experimental group. Hence, it can be concluded that the boys and girls in the experimental group are more or less equal in their post-test scores.

The diagrammatic representation of the comparison of the mean and standard deviation of boys and girls in the Experimental group is given in Figure 7.

Figure 7 Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Boys and Girls in Experimental group



FINDINGS OF THE STUDY

The following findings were obtained from the analysis of data:

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1. The level of Self-Efficacy of Secondary School Students is average.

2. Test of significance of difference between means of pre-test scores of Self-Efficacy of experimental and control group revealed that there is no significant difference between the means of experimental group and control group in pre-test scores.

3. Test of significance of difference between means of post-test scores of Self-Efficacy of experimental and control group revealed that there is a significant difference between the means of the experimental group and control group in post-test scores. This indicates that the performance of the experimental group is better than the control group.

4. Test of significance of difference between means of pre-test and post-test scores of Self-Efficacy of the experimental group revealed that there is a significant difference in the pre-test and post-test scores of the experimental group. It indicates that the experimental group shows better performance after the instruction based on ARIAS Model for teaching Negative Numbers.

5. Test of significance of difference between means of pre-test and post-test scores of Self-Efficacy of the control group revealed that there is significant difference in the pre-test and post-test scores of control group. It indicates that the activity oriented instruction lack a uniform effect on the Self-Efficacy.

6. Test of significance of difference between means of gain scores of Self-Efficacy of experimental and control groups revealed that there is a significant difference in the gain scores of experimental and control groups. This ensures that the performance of the experimental group is better than the control group.

7. Analysis of covariance of pre-test and post-test scores of Self-Efficacy of experimental and control groups revealed that there is a significant difference between the post-test scores of the experimental group and control group after they have been adjusted for the difference in the pre-test scores. This indicates that instruction based on ARIAS Model for teaching Negative Numbers is effective than activity oriented instruction in enhancing Self-Efficacy of Secondary School Students.

8. Test of significance of difference between means of post-test scores of Self-Efficacy of boys and girls in the experimental group revealed that there is no significant difference in the means of post-test scores of boys and girls. This indicates that the boys and girls in the experimental group are more or less equal in their post-test scores.

Educational Implications Of The Study

The present study indicates that the ARIAS Model for teaching Negative Numbers is more effective than the activity oriented instruction in enhancing Self-Efficacy of Secondary School Students. The findings of the present study have direct implications at the instructional level of students, teachers, teacher educators, and educational planners. The following are the implications of the present study:

1. The study suggests that incorporating ARIAS Model based instruction into the formal curriculum can simplify complex calculations, making mathematics more accessible and reducing learning barriers.

2. The ARIAS Model fosters deeper conceptual understanding of abstract mathematical ideas, particularly negative numbers, through systematic and student-centered instruction.

3. Teachers can use the ARIAS Model based instruction to diversify their instructional strategies, catering to different learning styles. This can help to foster greater student engagement and improve the overall effectiveness of Mathematics Education.

4. ARIAS Model based instruction boosts the Self-Efficacy of students, helping them approach Mathematics with confidence, persistence, and reduced fear of failure.

5. By implementing ARIAS Model, teachers can create inclusive classrooms, as the model benefits students irrespective of gender or learning style.

6. The ARIAS Model based instruction enhances classroom engagement, encouraging interaction, participation, and collaborative learning among students.

7. It improves teaching practices, guiding teachers towards structured, activity based, and reflective pedagogy instead of traditional rote methods.

8. At the curriculum level, ARIAS promotes innovation, supporting the integration of learner-centered pedagogical models that balance cognitive and affective development.

9. At the research and policy level, ARIAS encourages further studies in different subjects and provides useful guidance for teachers, curriculum planners, and policymakers.

CONCLUSION

The present study on the Effectiveness of the ARIAS Model for Teaching Negative Numbers on Self-Efficacy of Secondary School Students clearly demonstrates that the ARIAS Model is an effective, student-centred instructional approach. The study was conducted within the context of the Kerala State syllabus, which emphasizes conceptual understanding, activity-based learning, and learner-centred pedagogical approaches at the secondary school level. Mathematics instruction under this curriculum aims to develop reasoning ability and real-life application skills; however, abstract concepts such as negative numbers continue to pose learning challenges for students. ARIAS Model successfully enhanced Self-Efficacy of learners, enabling them to engage with abstract mathematical concepts with greater clarity, confidence, and motivation. The findings reaffirm the importance of innovative pedagogical strategies in Mathematics Education, highlighting that meaningful learning occurs when cognitive and affective domains are addressed simultaneously. Furthermore, the study showed that the model was equally effective across genders, underscoring its inclusivity and potential to minimize disparities in mathematics performance. In summary, this research not only validates the pedagogical worth of the ARIAS Model but also provides a practical reference for teachers, curriculum designers, and policymakers to enrich mathematics instruction and promote holistic student development.

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