EFFECTIVENESS OF ARIAS MODEL FOR TEACHING NEGATIVE NUMBERS ON LOGICAL MATHEMATICAL INTELLIGENCE OF SECONDARY SCHOOL STUDENTS

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ABSTRACT

Logical-Mathematical Intelligence plays a vital role in students' ability to reason, analyse patterns, and solve mathematical problems. However, secondary school students often experience conceptual difficulties in learning abstract topics such as negative numbers. The present study investigated the effectiveness of the ARIAS instructional model, comprising Assurance, Relevance, Interest, Assessment, and Satisfaction, in enhancing the Logical-Mathematical Intelligence of secondary school students. An experimental method with a pre-test post-test non-equivalent group design was adopted. The sample consisted of 84 Students of Standard IX students following the Kerala State syllabus, divided into an experimental group (43) and a control group (41). The experimental group was taught using ARIAS-based instruction, while the control group received activity-oriented instruction. A Logical-Mathematical Intelligence Test developed by the investigator was used. Statistical analysis using mean, standard deviation, t-test, and ANCOVA revealed a significant improvement in the Logical-Mathematical Intelligence of students taught through the ARIAS model compared to the control group. Further analysis indicated no significant difference in Logical-Mathematical Intelligence between boys and girls in the experimental group, suggesting that the ARIAS model is equally effective across gender. The findings highlight the instructional effectiveness and inclusivity of the ARIAS model in secondary mathematics education.

Keywords: ARIAS Model, Negative Numbers, Logical Mathematical Intelligence, Secondary School Students

INTRODUCTION

Education is a purposeful process aimed at developing an individual's cognitive abilities, reasoning skills, and capacity to respond effectively to life situations. It plays a crucial role in shaping intellectual growth and fostering analytical thinking among learners. Robinson (2016) emphasized that the purpose of education lies not merely in producing solutions but in creating learning environments that enable individuals to construct their own understanding through guided support. In this context, mathematics education assumes a central position, as it nurtures logical reasoning, problem-solving ability, and disciplined thinking.

Logical-Mathematical Intelligence, as proposed by Gardner (1983), refers to an individual's ability to reason logically, recognise patterns, analyse relationships, and solve problems systematically. This form of intelligence is fundamental to mathematics learning and is closely associated with higher-order cognitive processes such as reasoning, abstraction, and analytical thinking. The enhancement of Logical-Mathematical Intelligence contributes to the development of imagination, observation, creativity, originality, and logical reasoning, which are essential for academic success and effective decision-making in everyday life (Armstrong, 2000).

At the secondary school level, mathematics learning becomes increasingly abstract, and students often encounter difficulties in understanding complex concepts. Among these, negative numbers present a significant challenge due to their abstract nature and the shift in operational rules compared to positive numbers. Research indicates that misconceptions related to negative numbers adversely affect students' reasoning ability and conceptual clarity, thereby limiting the development of Logical-Mathematical Intelligence (Altiparmak & Özdoğan, 2009; Almeida & Bruno, 2014). Consequently, there is a need for instructional strategies that promote deeper conceptual understanding and logical reasoning rather than rote learning.

Instructional models serve as systematic frameworks that guide teachers in planning and delivering effective learning experiences. Traditional instructional approaches in mathematics often fail to sustain students' interest and do not adequately address cognitive engagement. In this regard, the ARIAS instructional model—comprising Assurance, Relevance, Interest, Assessment, and Satisfaction—offers a learner-centred approach that emphasizes motivation, engagement, and meaningful learning (Keller & Kopp, 1987). The ARIAS model is a modification of Keller's ARCS model and has been shown to improve learning motivation and achievement by fostering confidence and relevance in instructional processes (Siahaan et al., 2010).

The ARIAS model is particularly effective in enhancing Logical-Mathematical Intelligence by encouraging active reasoning, problem-solving, and application-based learning. By sustaining students' interest and reinforcing confidence through systematic assessment and satisfaction, the model creates an environment conducive to logical thinking and analytical reasoning (Nurimani & Zuhriyah, 2024). Hence, the present study seeks to examine the effectiveness of the ARIAS model for teaching negative numbers in enhancing the Logical-Mathematical Intelligence of secondary school students.

NEED AND SIGNIFICANCE OF THE STUDY

Mathematics is a fundamental discipline that nurtures logical reasoning, analytical thinking, and problem-solving ability. At the secondary school level, mathematics plays a decisive role in strengthening students' Logical-Mathematical Intelligence, which is essential not only for academic achievement but also for effective decision-making in everyday life (Gardner, 1983; Armstrong, 2000). However, many secondary school students struggle to develop adequate logical reasoning skills due to the abstract nature of mathematical concepts and the continued reliance on traditional instructional practices.

Among the various topics in secondary school mathematics, negative numbers present a significant conceptual challenge. Students often develop misconceptions related to number sense and operations involving negative values, which adversely affect their reasoning ability and logical thinking (Altiparmak & Özdoğan, 2009; Almeida & Bruno, 2014). These difficulties hinder the development of Logical-Mathematical Intelligence, resulting in mechanical learning rather than meaningful understanding. Hence, there is a strong need for instructional approaches that actively engage learners in reasoning, pattern recognition, and application-based learning.

Instructional models provide systematic frameworks for designing effective learning experiences that go beyond rote learning. The ARIAS instructional model, comprising Assurance, Relevance, Interest, Assessment, and Satisfaction, emphasises learner engagement, confidence, and meaningful learning experiences (Keller & Kopp, 1987). As a modification of Keller's ARCS model, ARIAS has been found to enhance learning motivation and achievement by integrating cognitive and motivational elements into classroom instruction (Siahaan et al., 2010). By encouraging active participation and logical reasoning, the ARIAS model holds strong potential for enhancing Logical-Mathematical Intelligence.

A review of related literature indicates that while studies have examined the effectiveness of the ARIAS model on learning outcomes, mathematical thinking, and motivation (Saminan et al., 2017; Nurimani & Zuhriyah, 2024), limited research has specifically investigated its impact on Logical-Mathematical Intelligence, particularly in the context of teaching negative numbers at the secondary school level. Moreover, most existing studies focus on achievement scores rather than deeper cognitive constructs such as reasoning ability and pattern recognition.

Therefore, the present study is significant as it addresses this research gap by empirically examining the effectiveness of the ARIAS model in enhancing Logical-Mathematical Intelligence among secondary school students. The findings of the study are expected to provide valuable insights for mathematics teachers, teacher educators, and curriculum planners by highlighting an instructional approach that promotes logical reasoning and meaningful learning in mathematics.

RESEARCH QUESTIONS

- Does ARIAS Model for teaching Negative Numbers effective for enhancing Logical Mathematical Intelligence of Secondary School Students?
- Is there any significant difference in the effectiveness of ARIAS Model for teaching Negative Numbers in enhancing Logical Mathematical Intelligence of Secondary School Students based on Gender - Boys and Girls?

STATEMENT OF THE PROBLEM

Mathematics education at the secondary school level aims to develop students' logical reasoning, analytical thinking, and problem-solving abilities. Abstract topics such as negative numbers pose significant learning difficulties for students, leading to misconceptions that hinder the development of Logical-Mathematical Intelligence. Although instructional models have been introduced to improve mathematics learning, there is a lack of systematic, learner-centred approaches that effectively integrate motivation with cognitive engagement. The ARIAS instructional model, comprising Assurance, Relevance, Interest, Assessment, and Satisfaction, offers a structured framework that promotes confidence, relevance, and meaningful learning experiences. While previous studies have reported the effectiveness of the ARIAS model in improving learning outcomes, its specific impact on Logical-Mathematical Intelligence in teaching negative numbers at the secondary school level remains unexplored. Therefore, the present study is entitled, "Effectiveness of ARIAS Model for teaching Negative Numbers on Logical-Mathematical Intelligence of Secondary School Students".

HYPOTHESES FORMULATED FOR THE STUDY

1. ARIAS Model for teaching Negative Numbers is significantly effective in enhancing Logical Mathematical Intelligence of Secondary School Students than activity oriented instruction.
2. There is a significant difference in Logical Mathematical Intelligence 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 Logical Mathematical Intelligence of Secondary School Students.
2. To find out the effectiveness of ARIAS Model for teaching Negative Numbers in enhancing Logical Mathematical Intelligence of Secondary School Students.
3. To find out whether there is any significant difference in Logical Mathematical Intelligence 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:

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: Logical Mathematical Intelligence 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.
- Logical Mathematical Intelligence Test. (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:

ANALYSIS ON THE LEVEL OF LOGICAL MATHEMATICAL INTELLIGENCE OF SECONDARY SCHOOL STUDENTS

- Analysis on the Level of Logical Mathematical Intelligence of Secondary School Students.

ANALYSIS ON THE EFFECTIVENESS OF ARIAS MODEL FOR TEACHING NEGATIVE NUMBERS ON LOGICAL MATHEMATICAL INTELLIGENCE OF SECONDARY SCHOOL STUDENTS

- Test of Significance of Difference Between Means of Pre-test Scores of Logical Mathematical Intelligence of Experimental and Control Groups.
- Test of Significance of Difference Between Means of Post-test Scores of Logical Mathematical Intelligence of Experimental and Control Groups.
- Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Logical Mathematical Intelligence of Experimental Group.

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

COMPARISON OF LOGICAL MATHEMATICAL INTELLIGENCE OF EXPERIMENTAL GROUP BASED ON GENDER – BOYS AND GIRLS

- Test of Significance of Difference Between Means of Post-test Scores of Logical Mathematical Intelligence of Boys and Girls in the Experimental Group.

The details of the analysis are given below:

ANALYSIS ON THE LEVEL OF LOGICAL MATHEMATICAL INTELLIGENCE AND SELF-EFFICACY OF SECONDARY SCHOOL STUDENTS

Analysis on the Level of Logical Mathematical Intelligence of Secondary School Students

The descriptive statistical scores of Logical Mathematical Intelligence of Secondary School Students are presented in Table 1.

Table 1

Descriptive Statistical Scores of Logical Mathematical Intelligence of Secondary School Students

Variable	N	Mean	Standard Deviation	Skewness	Kurtosis
Logical Mathematical Intelligence	84	16.16	4.31	-0.33	-0.74

Table 1 shows that the mean Logical Mathematical Intelligence score was 16.16, and the standard deviation was 4.31 for the selected 84 sample size. The Logical Mathematical Intelligence score is negatively skewed since the skewness factor was -0.33. Thus, most of the scores are concentrated at the upper end. The Kurtosis level was reported as -0.74. Both the skewness and kurtosis show that the distribution is not much deviated from the normal distribution (Das & Das, 2005).

The level of Logical Mathematical Intelligence of Secondary School Students was analysed, and the details are presented in Table 17. The calculated mean value for Logical Mathematical Intelligence is 16.16, and the standard deviation is 4.31. The secondary school students with scores greater than 20.47 (M + σ) have a high level of Logical Mathematical Intelligence, and those who scored less than 11.85 (M - σ) have a low level of Logical Mathematical Intelligence. The Secondary School Students who scored between these scores have an average level of Logical Mathematical Intelligence.

Table 2

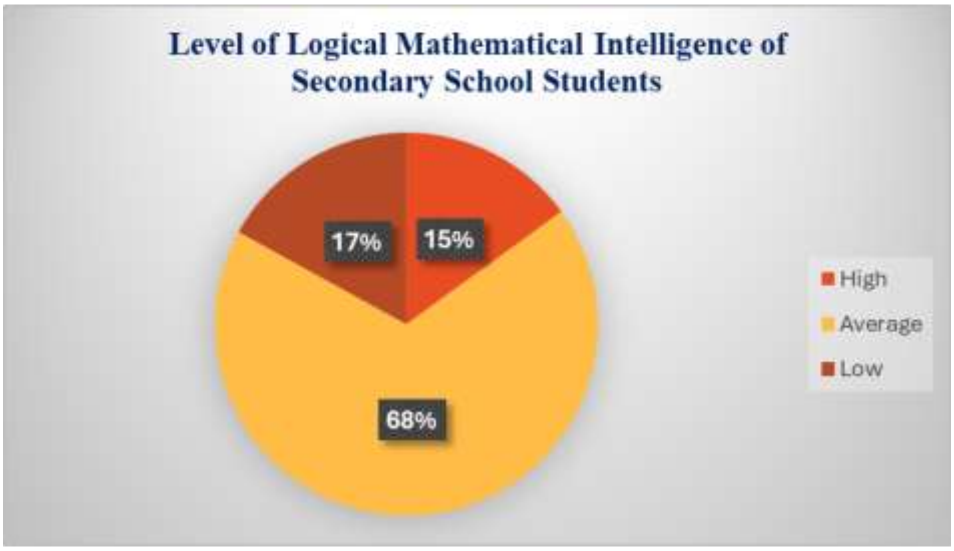
Number and Percentage of Secondary School Students belonging to different levels of Logical Mathematical Intelligence.

Level	Number of Students	Percentage
High	13	15
Average	57	68
Low	14	17
Total	**84**	**100**

From the table 2, it is clear that 15% of Secondary School Students out of the total sample belong to the high-level of Logical Mathematical Intelligence, 68% of Secondary School Students out of the total sample belong to the average level of Logical Mathematical Intelligence, and 17% of Secondary School Students out of the total sample belong to the low-level of Logical Mathematical Intelligence. Hence, the investigator concluded that the Logical Mathematical Intelligence of Secondary School Students is moderate. The diagrammatic representation of different levels of Logical Mathematical Intelligence is shown in Figure 1.

Figure 1

Pie Diagram showing the Percentage of different levels of Logical Mathematical Intelligence of Secondary School Students



ANALYSIS ON THE EFFECTIVENESS OF ARIAS MODEL FOR TEACHING NEGATIVE NUMBERS ON LOGICAL MATHEMATICAL INTELLIGENCE 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 Logical Mathematical Intelligence 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 Logical Mathematical Intelligence of Secondary School Students. The data was analysed using appropriate statistical techniques, and the results are given below.

Descriptive Statistics of Pre-Test and Post-Test Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Descriptive statistics refers to the methods used to summarise and present data in a meaningful form. In this section, the pre-test and post-test scores of Logical-Mathematical Intelligence for the experimental and control groups were analysed. The details of descriptive statistical scores are given below in Table 3.

Table 3

Descriptive Statistics of Pre-Test and Post-Test Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Groups		N	Mean	SD	Sk	Ku
Experimental Group	**Pre-test**	43	7.02	2.79	-0.27	-0.46
	Post-test	43	18.37	3.23	-0.42	-0.29
Control Group	**Pre-test**	41	6.29	2.02	-0.13	-0.67
	Post-test	41	13.85	4.1	0.08	-1.00

*N = Number of students

Max = Maximum

Min = Minimum

SD = Standard Deviation

Sk = Skewness

Ku = Kurtosis

Table 3 presents the change in Logical Mathematical Intelligence of the two groups before and after the instruction.

The pre-test scores of the experimental group, with a mean of 7.02, have a moderate spread as shown by the standard deviation of 2.79. The data is slightly negatively skewed (Sk = -0.27), indicating a slight concentration of scores on the higher end of the distribution. The kurtosis of -0.46 suggests the distribution is a bit flatter than a normal curve (Mangal, 2024).

After the instruction based on the ARIAS Model, the scores of the experimental group showed a major positive change. The mean score increased to 18.37, with a standard deviation of 3.23. The scores remain negatively skewed (Sk = -0.42), which means that more individuals scored higher than the average. The kurtosis of -0.29 indicates the distribution's shape became even more normal-like, with a balanced peak and tails (Mangal, 2024).

The skewness of -0.27 for pre-test scores shows that most students scored in the higher range of the pre-test, but the skewness of -0.42 for post-test scores is more negative than the pre-test, suggesting that after the instruction based on the ARIAS Model, more students clusters at the higher end of the scale for post-test. While pre-test scores give a slightly flatter peaked curve, post-test scores give a curve closer to a perfect bell curve in terms of its peak and tails. This change in distribution shows that the instruction based on the ARIAS Model not only increased the average score but also made the distribution of scores more normal in shape, with a more pronounced shift toward the higher end.

The pre-test scores of the control group, with a mean of 6.29, were comparable to the scores of the experimental group, which is ideal for a study design. The standard deviation of 2.02 shows the scores were more tightly clustered than the experimental group. The skewness of -0.13 is very close to zero, meaning the data is highly symmetrical, and the kurtosis of -0.67 suggests a slightly flatter distribution.

The post-test scores of the control group, with a mean of 13.85, showed a small increase from pre-test scores. The standard deviation of 4.10 is larger than its pre-test standard deviation, indicating a wider spread of scores. The skewness of 0.08 is close to zero, showing a nearly symmetrical distribution. However, the kurtosis of -1.00 indicates a very flat (platykurtic) distribution, suggesting that many students improved moderately, while others either did not or had extreme scores, leading to a scattered rather than clustered dataset.

This suggests that while the scores of the control group increased slightly, the activity-oriented instruction did not have a uniform effect. The widespread scores in the post-test, indicated by the large standard deviation and low kurtosis, show that some students improved, while others did not, resulting in a very diverse range of outcomes.

Test of Significance of Difference Between Means of Pre-test Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Table 4

Data and Results of Test of Significance of Difference Between Means of Pre-test Scores of Logical Mathematical Intelligence of Experimental and Control Groups

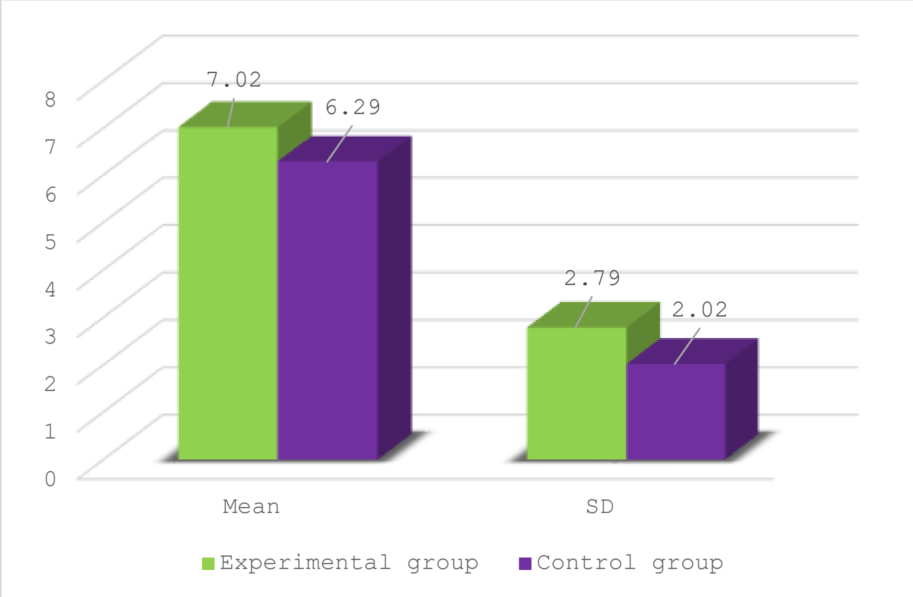
Groups	N	Mean	SD	CR	Level of Significance
Experimental Group	43	7.02	2.79	1.367	Not Significant
Control Group	41	6.29	2.02		

Table 4 shows that the critical ratio obtained through the independent t-test is 1.367 and is less than the critical value of 2.58 at the 0.01 level of significance. It shows that the obtained critical ratio is not statistically significant. Hence, there is no significant difference between the means of 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 Logical Mathematical Intelligence 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 Logical Mathematical Intelligence of Experimental and Control Groups



Test of Significance of Difference Between Means of Post-test Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Table 5

Data and Results of Test of Significance of Difference Between Means of Post-test Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Groups	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Experimental Group	43	18.37	3.23	5.626	0.01	1.22
Control Group	41	13.85	4.10			

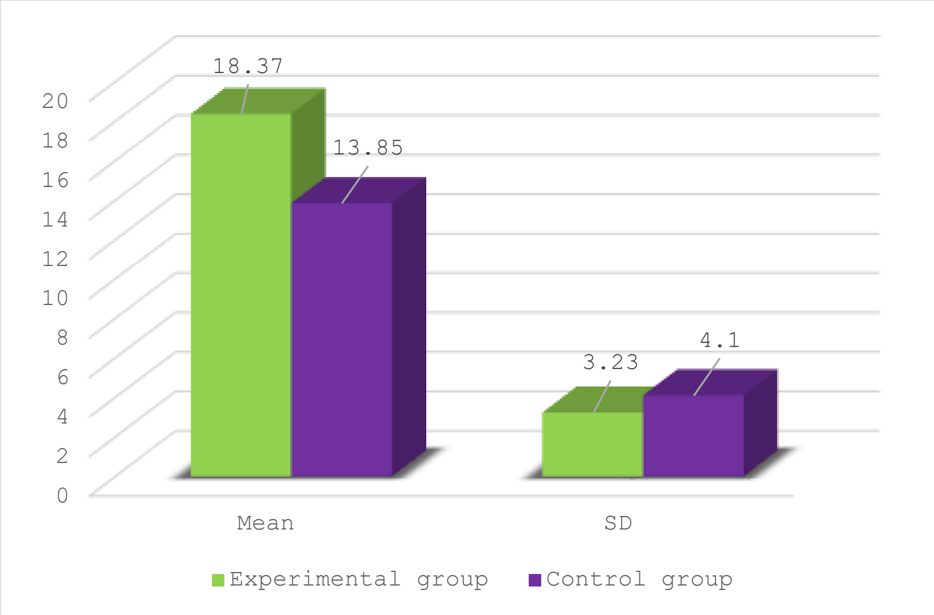
Table 5 shows that the critical ratio calculated through independent t-test is 5.626, which is greater than the critical value of 2.58 at 0.01 level of significance. The critical ratio is statistically significant at the 0.01 level. This shows that there is a significant difference between the means 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 1.22, 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 Logical Mathematical Intelligence 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 Logical Mathematical Intelligence of Experimental and Control Groups



Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Logical Mathematical Intelligence of Experimental Group

Table 6

Data and Results of Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Logical Mathematical Intelligence of Experimental Group

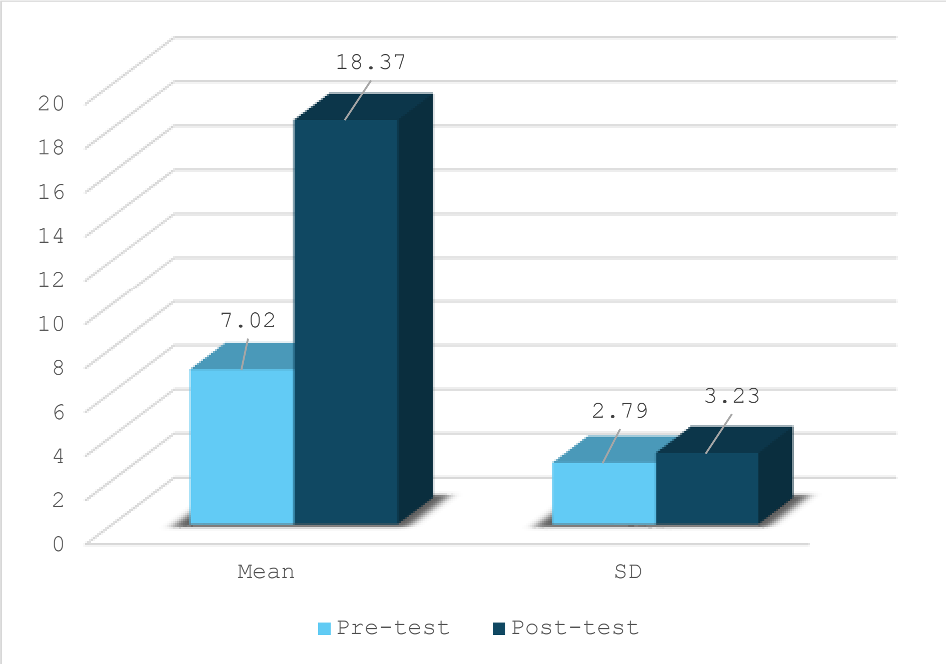
Test	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Pre-test	43	7.02	2.79	16.315	0.01	3.76
Post-test	43	18.37	3.23			

Table 6 shows the results of 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 16.315, which 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 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 3.76, 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 Logical Mathematical Intelligence of Experimental Group is given in Figure 4.

Figure 4

Diagrammatic Representation of the Comparison of Mean and Standard Deviation of Pre-test and Post-test Scores of the Logical Mathematical Intelligence of Experimental Group



Test of Significance of Difference Between Means of Pre-test and Post-test Scores of Logical Mathematical Intelligence 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 Logical Mathematical Intelligence of the Control Group

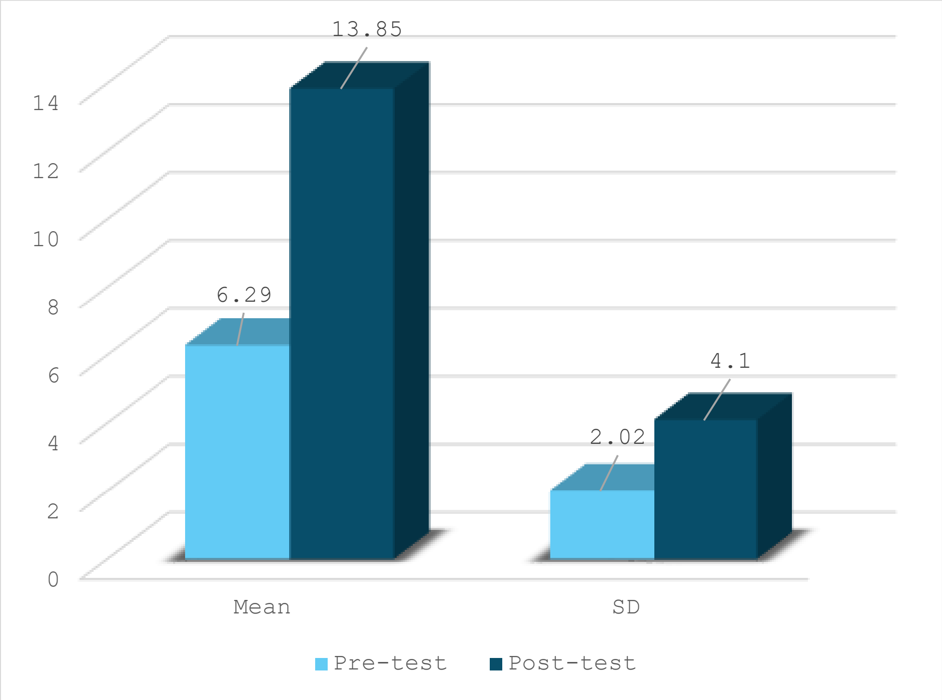
Test	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Pre-test	41	6.29	2.02	10.614	0.01	2.33
Post-test	41	13.85	4.10			

Table 7 shows that the obtained critical ratio is 10.614 and is greater than the critical value 2.58 at 0.01 level of significance. 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 2.33, which indicates that the effect size is large.

The diagrammatic representation of the comparison of mean and standard deviation of pre-test and post-test scores of Logical Mathematical Intelligence 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 the Logical Mathematical Intelligence of Control Group



Test of Significance of Difference Between Means of Gain Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Table 8

Data and Results of Test of Significance of Difference Between Means of Gain Scores of Logical Mathematical Intelligence of Experimental and Control Groups

Groups	N	Mean	SD	CR	Level of Significance	Effect Size Cohen's d
Experimental Group	43	11.34	4.561	3.797	0.01	0.91
Control Group	41	7.56	4.560			

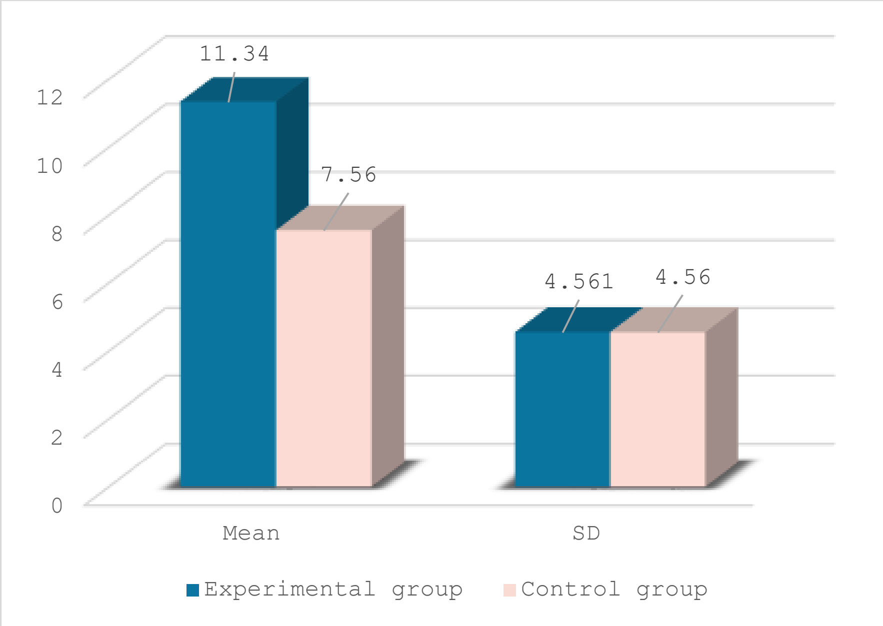
Table 8 shows that the obtained critical ratio is 3.797, which is statistically significant at 0.01 level of significance. This shows that there is a significant difference between the means of gain scores of the experimental and control groups. The mean gain score of experimental group is significantly greater than the mean gain scores of control group.

The effect size calculated using Cohen's d is greater than 0.8, the limit set by Cohen's category is large. Hence, it can be concluded that the ARIAS Model had a larger effect in enhancing Logical Mathematical Intelligence than activity oriented instruction.

The diagrammatic representation of the comparison of mean and standard deviation of gain scores of Logical Mathematical Intelligence of the 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 Logical Mathematical Intelligence of Experimental and Control Groups



Analysis of Covariance of Pre-test and Post-test Scores in Logical Mathematical Intelligence of Experimental and Control Groups

Analysis of Covariance represents an extension of the method of analysis of variance, to allow a correlation between initial and final scores. After the study or experiment has been performed, it helps the researcher in exercising proper statistical control over the uncontrolled covariates that have been left uncontrolled at the start of the experiment. (Mangal, 2024)

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).

Table 9

Analysis of Variance of Pre-test and Post-test Scores of Logical Mathematical Intelligence 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	11.202	428.498	11.202	428.498	$F_X = 1.86$ $F_Y = 31.50$
Within-groups	82	493.464	1115.168	6.017	13.599	

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 ($F_X = 1.86 < 3.96$). 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 ($F_Y = 31.50 > 6.96$). 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 Logical Mathematical Intelligence 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	11.20	428.49	69.28	432.44	432.44	3.702	31.564
Within-groups	81	493.46	1115.16	-48.61	1110.37	13.70		

(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 ($F_{YX} = 31.564 > 6.96$). 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 Logical Mathematical Intelligence of Experimental and Control Groups

Groups	**N**	**M_X**	**M_Y**	**M_{YX} (Adjusted)**	**df**	**CR**	**Level of significance**
Experimental group	43	7.02	18.37	18.408	81	5.635	0.01
Control group	41	6.29	13.85	13.853			

Adjusted Y means for pre-test scores are tested for significance for degrees of freedom 81. The critical ratio obtained is 5.635 and the critical value for significant difference for df 81 is 2.64 at 0.01 level of significance ($t = 5.635 > 2.64$). The significant difference between the adjusted Y means indicates that the secondary school students of the experimental and control groups differ significantly in their Logical Mathematical Intelligence in the post-test. The mean of the post- test scores of experimental and control groups clearly indicates that the students in the experimental group show more Logical Mathematical Intelligence. It may therefore be tentatively interpreted that the Logical Mathematical Intelligence 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 LOGICAL MATHEMATICAL INTELLIGENCE OF EXPERIMENTAL GROUP BASED ON GENDER – BOYS AND GIRLS

The analysis focused on determining whether there is any significant difference in the Logical Mathematical Intelligence 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 Logical Mathematical Intelligence 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 Logical Mathematical Intelligence of Boys and Girls in the Experimental Group

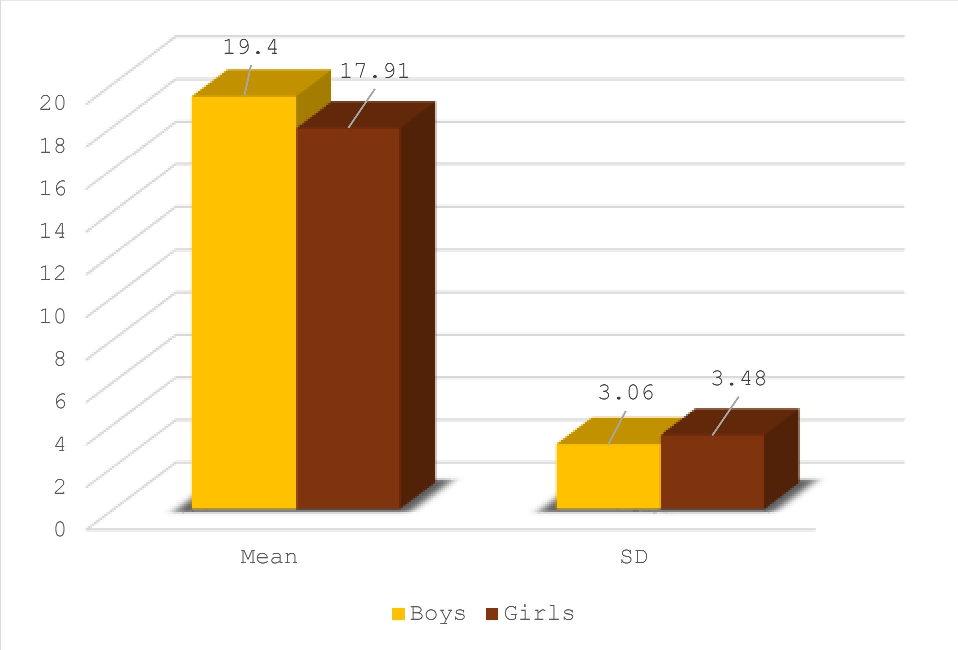
Gender	N	Mean	SD	CR	df	Level of Significance
Boys	20	19.4	3.06	1.477	41	Not Significant
Girls	23	17.91	3.48			

Table 29 shows the results of an independent t-test conducted for a small sample. The critical ratio obtained is 1.477, which is less than the critical value of t with degrees of freedom $N_1 + N_2 - 2 = 41$ at 0.01 level of significance is 2.71 (Mangal, 2024). It shows that the critical ratio is not statistically significant at 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 the Experimental Group



FINDINGS OF THE STUDY

The following findings were obtained from the analysis of data:

1. The level of Logical Mathematical Intelligence of Secondary School Students is average.
2. Test of significance of difference between means of pre-test scores of Logical Mathematical Intelligence of experimental and control group revealed that there is no significant difference in the pre-test scores of the experimental group and control group.
3. Test of significance of difference between means of post-test scores of Logical Mathematical Intelligence of experimental and control group revealed that there is a significant difference in the post-test scores of the experimental group and control group. This indicates that the performance of the experimental group is better than that of the control group.
4. Test of significance of difference between means of pre-test and post-test scores of the Logical Mathematical Intelligence of the experimental group revealed that there is significant difference in the pre-test and post-test scores of experimental group. It indicates that the experimental group shows better performance after the implementation of ARIAS Model for teaching Negative Numbers.
5. Test of significance of difference between means of pre-test and post-test scores of Logical Mathematical Intelligence of control group revealed that there is significant difference in the pre-test and post-test scores of the control group. It indicates that while the scores of the control group increased slightly, the activity oriented instruction did not have a uniform effect.
6. Test of significance of difference between means of gain scores of Logical Mathematical Intelligence of experimental and control groups revealed that there is a significant difference in the means of 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 Logical Mathematical Intelligence 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 the ARIAS Model based instruction is effective than activity oriented instruction in enhancing Logical Mathematical Intelligence among secondary school students.
8. Test of significance of difference between means of post-test scores of Logical Mathematical Intelligence of boys and girls in the experimental group revealed that there is no significant difference in the 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 Logical Mathematical Intelligence 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. Beyond Mathematical proficiency, ARIAS Model enhances Logical Mathematical Intelligence, enabling learners to think critically, reason logically, and apply concepts to real-life scenarios.
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 Logical-Mathematical Intelligence of Secondary School Students clearly demonstrates that the ARIAS Model is an effective, student-centred instructional approach. It successfully enhanced the Logical Mathematical Intelligence 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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