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ORIGINAL ARTICLE

EFFECT OF CONCEPT MAPPING STRATEGY ON SCIENCE ACHIEVEMENT IN RELATION TO SCIENTIFIC APTITUDE AND PROBLEM SOLVING ABILITY OF SECONDARY SCHOOL STUDENTS

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Abstract:

Concept map is a device for representing the conceptual structure of a subject/discipline in a two-dimensional form, which is analogous to the road map. A concept, as defined by Novak, is regularity in objects or events designated by a specific label. Concept maps are diagrammatic representations, which show meaningful relationships between concepts in the form of propositions.

Propositions are two or more concept labels linked by words, which provide information on relationships or describe connections between concepts.

KEYWORDS:

Science, Conceptual Structure, Mapping, Aptitude, Students.

INTRODUCTION:

Concepts are generally isolated by circles and connected by lines. Lines are labeled with lining words, which describe how the connected concepts are related to each other. Two connected concepts make up a prepositional linkage' or a statement about how some piece of the world looks or works.

Concepts are arranged hierarchically, that is the most general concept (super ordinate) are less inclusive than higher ones. 'Cross links' are prepositional linkages that connect different segments of the concepts hierarchy. They may indicate syntheses of related concepts, a new interpretation of old ideas and some degree of creative thinking.

Concept maps use three types of knowledge: facts, concepts and generalization. It is learning strategy that was developed first as a research tool to represent learner's prior relevant knowledge and later as a tool to enhance meaningful learning.

CONCEPT MAPPING - IT'S MEANING

Concept mapping is a technique for representing knowledge in graphs. Knowledge graphs are networks of concepts. Networks consist of nodes (points/vertices) and links (arcs/edges). Nodes represent concepts and links represent the relations between concepts.

Concepts and sometimes links are labeled. Links can be non-uni- or bi-directional. Concepts and links may be categorized; they can be simply associative, specified or divided in categories such as casual or temporal relations.

Concept mapping can be done for several purposes:

To generate ideas (brain storming, etc,);
To design a complex structure (long texts, hypermedia large web sites, etc,);

To communicate complex ideas;
To aid learning by explicitly integrating new and old knowledge;
To assess understanding or diagnose misunderstanding.

Mind Mapping is a popular related technique, invented (and copyrighted) by Tony Buzan in the UK. He describes mind maps as: “a mind map consists of a central word or concept, around the central word you draw the 5 to 10 main ideas that relate to that word. You then take each of those child words and again draw the 5 to 10 main ideas that relate to each of those words.”

The difference between concept maps and mind maps is that a mind map has only one main concept, while a concept map may have several. This comes down to the point that a mind map can be represented as a tree, while a concept map may need a network representation.

The fundamental of Concept Mapping is based on the theory of meaningful learning by David Ausubel which in itself is based on the assumption that meaningful learning occurs when new concept are linked to familiar existing in the learner's cog native structure and can be applied to all subject matter.

IMPORTANCE OF CONCEPT MAPPING

The map is to construct a bounded graphic representation that corresponds to a perceived reality, it is not possible to map that area. Mapping follows knowing. Thus “to map” requires “knowing”. Map represents ones knowledge.

As stated earlier concept is a generalized idea which results from categorization of a number of observations.

A concept can be learnt by different methods. In concept formation method, learner categorized the objects into groups based on certain criteria of commodity and difference (community within the category and difference among those which all out of the category).

Concepts are classified into three categories based on how they are related to other concepts. The most general concept is a super ordinate concept. Among the examples of this general concept subcategories can be formed, which a subordinate concepts to the super ordinate concept. The subordinate concepts so formed, are co-ordinate concepts among themselves.

Concept mapping is a technique that allows understanding the relationships between ideas by creating a visual map of the connections.

Concept maps are also effective in identifying both valid and invalid idea held by students. In every general terms the teacher may identify for a given hierarchy concept that are omitted or valid relationships that ate neither justified in the light of current understanding or are missing.

Concept map can be used by the classroom teacher to determine the extent meaningful learning has taken place for a particular topic. In a study by Heinz-fry and Jane Ann (1997) to evaluate the concept mapping as a tool for meaningful education, students felt mapping increased their integration of knowledge, helped to make sense of the material, clarified conned ions among concepts and helped them spend less time in memorizing.

Concepts maps were developed in 1972 in the course of Novak's research program at Cornell where he sought to follow and understand changes in children's knowledge of science (Novak & Musonda, 1991). During the course of this study the researchers interviewed many children, and they found it difficult to identify specific changes in the children's understanding of science concepts by examination of interview transcripts. This program was based on the learning takes place by the assimilation of new concepts and propositions into existing concept and prepositional frameworks held by the learner. This knowledge structure as held by a learner is also referred to as the individual's cognitive structure. Out of the necessity to find a better way to represent children's conceptual understanding emerged the idea of representing children's knowledge in the form of a concept map. Thus was born a new tool not only for use in research, but also for many other uses.

POINTS TO BE REMEMBERED WHILE PREPARING CONCEPT MAPS

Step 1. Selecting and reading a chapter in a textbook or a set of lecture notes on a particular topic, highlighting the important points and ideas.

Step 2. Deciding which concept (or concepts there may be more than one) is the most important or more exclusive idea, and making a list with this concept at the top.

Step 3. Constructing a concept map should begin with placing the name of the broadest, most inclusive concept's at the top of a piece of paper. Work down, adding more specific concepts.

Step 4. Joining the concepts with lines and label the lines with linking words that show meaningful connections between the concepts.

Step 5. Finishing of mapping in all concepts in the list and continuing to make the map grow by relating additional concepts from list to concepts already on the map.

Step 6. Map to studied to see if there are any other relevant relationships that should be illustrated between terms on the map. Such relationships, if they exist, may take the form of cross-links.

Step 7. When the concepts which are linked together to form a cause effect relationship, an arrow is used to show the direction of the relationship.

GENERAL METHODS OF DRAWING CONCEPT MAPS

Gather Your Writing and Drawing Materials
Gather Your Research Materials
Select One of the Concept Map Formats
Making Your First Map
Revising Maps
Using Maps as Preparation for Discussion Section

In the modern class room situation, the influence of science teaching is given vital importance and innovative instructional technology. Hence teaching science is a challenging task on the part of science teacher. These new innovative practices especially new pedagogies, self instructional materials and new electronic gadgets in teaching science brought significant changes in the process of teaching and learning science subjects to motivate the students for better performance in turn total academic achievement. Hence the present study is undertaken with a view to study the effect of concept mapping on science achievement of secondary school students and to identify the relative effectiveness of both conventional instruction and concept mapping in relation to scientific aptitude and problem solving ability.

NEED AND SIGNIFICANCE OF THE PROBLEM

Since the recommendations of secondary education commission report and other education commissions, we are teaching science on compulsory basis through out the school stages from primary to secondary level. The curriculum in science at secondary school level demands for rapid learning and clear understanding of new curriculum which is newly introduced program in the field of education. In this curriculum more concepts, theories in science have to be taught and students have to be trained and learn in attaining the teaching of objectives.

In the present study the researcher has considered some of the factors such as scientific aptitude, problem solving ability and teaching pedagogy that may effect the achievement in science of secondary students. Hence the present study is undertaken with a view to examine various factors effecting on science achievement.

In the modern class room situation, the influence of science teaching is given vital importance and innovative instructional technology. Hence teaching science is a challenging task on the part of science teacher. These new innovative practices especially new pedagogies, strategies, self instructional materials, in individualized instructional materials and new electronic gadgets in teaching science brought significant changes in the process of teaching and learning science subjects to motivate the students for better performance in turn total academic achievement. Hence the present study is undertaken with a view to study the effect of concept mapping on science achievement of secondary school students and to identify the relative effectiveness of both conventional instruction and concept mapping in relation to scientific aptitude and problem solving ability. Hence the present study has been taken for investigation. Hope that the findings of the present study would help classroom practitioners, researchers, teacher educators, school practitioners and policy makers in modifying the structure of pedagogies in science theoretically.

REVIEW OF RELATED STUDIES

Investigator has reviewed some of the related studies which are as follows:

Moreira (1977) used concept maps with university students in physics. Concept maps were used together with typical reorganization in experimental classes and traditional method was used in control classes. Moreira found that students in the experimental classes performed significantly better in the tests requiring graphical structuring of physical concepts. This difference increased over the semester course of study. No significant difference between the groups was found in traditional course examinations onward association tests, but the students were increasingly positively about the value of concept maps as the semester progressed.

Novak (1983) began using concept maps with children in grade I through IV, again with success and enthusiasm expressed by students and their teachers. These early effects were directed towards tryout of concept mapping strategies with various classes and in various subject matter area, primarily to assess and teacher reactions to the techniques and to workout techniques for introducing concept mapping in a variety of situations.

Snead (2003) used Concept maps with 282 high school biology students in a five-week unit of instructions, comparing achievement with 259 students receiving instructions in the same content, but without utilization of concept maps. There was a different favoring internal locus of control students and a significant interaction effect on the retention test scores between treatment and locus of control, with 'external' students, benefiting more from the concept map aided instructions.

Basconas and Novak (1985) found that mean scores on problem solving test in High school philosophy were higher for students preparing concept maps, when compared with students preparing concept maps a traditional philosophy program and not using concept maps. The concept map group excelled at all abilities levels based on Raven's progressive Matrices Test.

Cliburn (1987) found that students using concept maps during a 3 week on skeletal system showed significantly higher performance on retention post-test but not on an immediate post-test when other covariant were held constant.

Merill William (1987) studied whether concept mapping improves the understanding of the mathematical concept 'division'. He selected elementary teachers and found that none of them could map the division map at 75% criterion level. He suggested recommendations for further studies which include trying other mathematical concepts and see whether reasoning abilities influence concept mapping abilities.

Nicolus, James Edward (1987) examined the use of concept mapping as a strategy to facilitate meaningful learning based on theoretical structure. The study involved 3 groups an experimental group which utilized the concept mapping process, a traditional group which was taught by traditional teaching strategy and a control group which was denied the experimental and traditional treatments.

The experimental and traditional groups did significantly better on the contents post-test then the control group.

Allen, Jimmy Daniel (1989) examined the effects of concept maps as meaningful learning and achievement in Chemistry and tried to investigate if student's attitude towards mapping affects his/her abilities in acquiring meaningful learning.

Analysis of post test results revealed no significant difference between groups on measures for meaningful learning achievement at the $P<0.05$ level. But students recognized the importance of concept mapping which enhances meaningful learning.

James Wandersce (1990) revealed that concepts and principles from cartography and applies them to concept mapping. He invites researchers to conduct studies that investigate the graphic representation of scientific knowledge in order to create, evaluate and improve the graphics and graphic meta-cognitive tools such as concept mapping which is used in science teaching.

Olugbemiro Jegede and Lusho Alaiyemola (1990) studied to find out if the meta-cognitive strategy of concept mapping reduces anxiety and there by enhances achievement in Biology. Findings support the stand, that concept mapping is significantly more effective than traditional expository strategy of anxiety was noticed for male subjects.

Pankratius (1990) conduct a study titled 'Building an Organized base Concept Mapping and Achievement in the Secondary School Subject Physics' found that Concept Mapping in a key to organizing an effective knowledge base. Six intact school physics classes taught by this investigator took part in the study. Two classes were control group and received standard instruction. Four classes received six weeks of concepts mapping instruction prior to the unit under study.

Mason (1992) experimented on the use of Concept Mapping as a tool develops reflective science instruction. The subjects of this study were science majors enrolled in two courses designed specifically to address the aforementioned concerns. The use of Concept mapping as a tool to learning was introduced to the participant at the beginning. These potential teachers were presented with selected concept. The result shows that the Concept Mapping is an effective tool in conceptual restructuring and encouraging reflective science learning and teaching.

Roth and Roy Choudhary (1992) studied the social construction of scientific concept or concept map as conscription device and tool for social thinking in high school science. This results show that concept maps can be used as tool for social thinking, a conscription device and an inscription method help us more in planning for appropriate group experiences and in working to better adopt the heuristic for interactive classrooms.

McClure, Sonak, and Suen (1999) conducted a study on 'Concept Map Assessment of Class-room Learning, Validity and Logistic practicality'. Finding suggests that the time required to provide training in Concept Mapping, produces concept, and score concept map as compatible with the adoption of Concept mapping as a classroom assessment technique.

Minagawa (1999) studies Effect of making in concept mapping, Examined the effect on concept mapping of instructions to make linking labels using the “atom” unit of senior high school chemistry.

Jolly, Anju (1999) the purpose of this study was to analyze the relationship of concept mapping to science problem solving in sixth grade elementary school children. Results from the analysis of covariance showed that the group receiving instruction in the concept mapping format performed significantly better than the group receiving instruction in traditional format.

Liu, Xiufeng (2004) studied on the Grade 12 chemistry class using collaborative computerized concept mapping on an ongoing basis during a unit of instruction. Analysis of progressive concept maps and interview transcripts of representative students and the teacher showed that ongoing and collaborative computerized concept mapping is able to account for student conceptual change in ontological, epistemological, and social/affective domains.

From the above stated reviews of related studies, it can be observed that most of the investigators have conducted only concept mapping in science instructions such as advanced organizers, means of assessing quality in secondary schools, but findings of all the above studies were not having significant results. Many studies were conducted abroad. Hence, the investigator has chosen the present study. Hoping that the findings would help the system of classroom instruction through concept mapping strategy.

THE VARIABLES CONSIDERED IN THE STUDY

The following are the variables considered for the present study.

1)Control Variables
a)Concept Mapping Strategy – Experimental Group
b)Conventional Method – Control Group
2)Dependent Variable
a)Achievement in Science
3)Independent Variables
a)Scientific Aptitude
b)Problem Solving Ability

SCOPE OF THE STUDY

The present study was limited to IX standard students of Dharwad District and the result in their examination had lot of significance to the individual and to the school. The students need to put up an improved performance in the examinations.

Achievement test in science constructed by the researcher helped them for revision and preparation of their exams, for better performance. For the above reasons the students of IX standard were involved in the present study.

OBJECTIVES OF THE PRESENT STUDY

The objectives of the present study are as follows.

To study whether there is significant difference between pre-test and post-test scores of science achievement of secondary school students in control group.
To study whether there is significant difference between pre-test and post-test scores of science achievement of secondary school students in experimental group.
To study whether there is significant difference between control and experimental group with respect to pre-test and post-test scores of science achievements of secondary school students.
To study whether there is significant difference between control and experimental group with respect to scientific aptitude scores and problem solving ability scores of secondary school students.
To study whether there is significant difference between boy and girl students of secondary schools with respect to scientific aptitude scores and problem solving ability.
To study whether there is significant relationship between concept mapping, scientific aptitude, scientific

aptitude and problem solving ability and science achievement of secondary school total students.

HYPOTHESES OF THE STUDY

In pursuance of the above stated objectives the following hypotheses were formulated.

Hypothesis-1 : There is no significant difference between pre-test and post-test scores of science achievement of secondary school students in control group.
Hypothesis-2 : There is no significant difference between pre-test and post-test scores of science achievement of secondary school students in experimental group.
Hypothesis-3 : There is no significant difference between control and experimental group with respect to pre-test and post-test scores of science achievements of secondary school students.
Hypothesis-4 : There is no significant difference between control and experimental group with respect to scientific aptitude scores and problem solving ability scores of secondary school students.
Hypothesis-5 : There is no significant difference between boy and girl students of secondary schools with respect to scientific aptitude scores and problem solving ability.
Hypothesis-6 : There is no significant relationship between concept mapping, scientific aptitude, scientific aptitude and problem solving ability and science achievement of secondary school total students.

TOOLS USED FOR DATA COLLECTION

The following tools were used for collecting the required data.

a)Concept Mapping in Science : Concept mapping is constructed by the investigator by using systematic procedure. It is intended to develop concept mappings in order to learn the subject matter through concept mapping and to know the effect of concept mappings on science achievement. In the pilot study, 48 concept mappings were constructed and administered. After going through all responses of small group, large group and expert opinion, 36 concept mappings were retained for the final version of the concept mapping which covers required content.

b)Science Achievement Test : Achievement test was constructed and standardized by the investigator by using systematic procedure. The test consists 80 multiple choice items. Stability coefficient of the test was 0.8609, consistency coefficient was 0.8443 and concurrent validity of the test was computed by using classroom test scores and science achievement scores was found to be 0.7568 which is significant.
c)Problem Solving Ability : This test is constructed and standardized by Chauhan N.S. Test consists of 40 multiple choice items and intended to assess the problem solving ability. The reliability coefficient was 0.782 and stability coefficient was 0.768 which were found to be significant.
d)Scientific Aptitude Test : This test is constructed and standardized by Tandon R.K. This test consists of 50 items related to science and it is intended to measure the candidates knowledge in the field of science and potential ability. The coefficient of stability is 0.725 and consistency coefficient is 0.531 which were found to be significant.

SAMPLE OF THE STUDY

The study involves a sample of 141 of IX standard students of Dharwad city. Stratified random sampling procedure is used to select the sample and again divided into control and experiment group which were made equivalent group by using intelligence test.

STATISTICAL TECHNIQUES USED

Mean, SD, t-test were used to study the significant difference among the mean scores of the group. Correlation analysis used to investigate the correlationship between independent and dependent variables.

ANALYSIS AND INTERPRETATION OF DATA

Groupwise data were analysed by using appropriate statistical techniques which is as follows:

Table 1 :The Results of Paired t-Test Between Pre-test and Post-Test Scores of Science Achievement of Secondary School Students in Control Group

Test	Mean	Std.Dv.	Mean Diff.	SD Diff.	Paired t-value	p-value	Signi.
Pre-test	67.8000	15.9656	-2.3833	12.9116	-2.0221	<0.05	S
Post-test	70.1833	14.1040					

From the above Table, it is clearly seen that, a difference between pre-test (mean=67.8000) and post-test (mean=70.1833) science achievement scores of secondary school students in control group is found to be statistically significant (t=-2.0221, p<0.05, S) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the post-test science achievement scores are higher compared to pre-tests scores of secondary school students in control group. The mean and SD values are also presented in the following diagram.

Fig.1 : Comparison of Pre and Post-test Scores of Science Achievement of Secondary School Students in Control Group

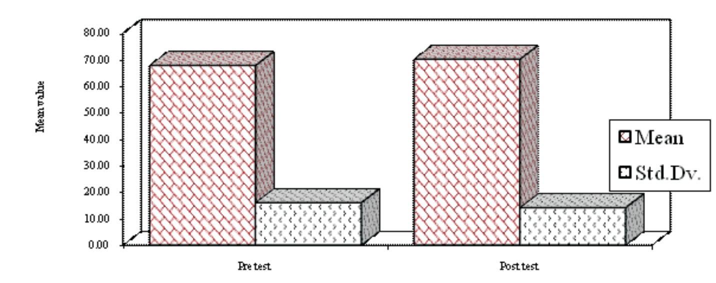

Table 2 :The Results of Paired t-Test between Pre-test and Post-Test Scores of Science Achievement of Secondary School Students in Experimental Group

Test	Mean	Std.Dv.	Mean Diff.	SD Diff.	Paired t-value	p-value	Signi.
Pre-test	66.7190	11.5183	-5.8347	8.0781	-7.9452	<0.01	S
Post-test	72.5537	12.0782					

From the above Table, it is clearly seen that, a difference between pre-test (mean=66.7190) and post-test (mean=72.5537) science achievement scores of secondary school students in experimental group is found to be statistically significant (t=-2.0221, p<0.05, S) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the post-test science achievements scores are higher compared to pre-tests scores of secondary school students in experimental group. The mean and SD values are also presented in the following diagram.

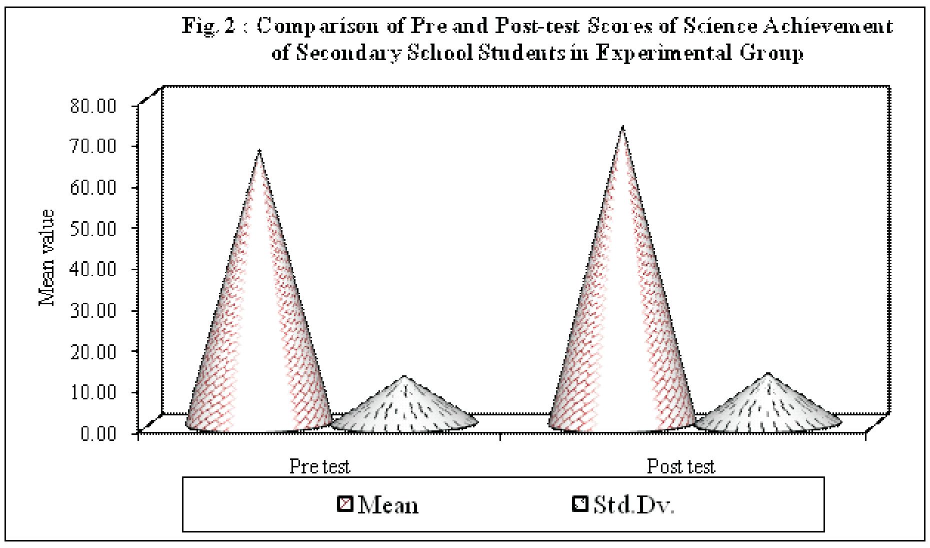

Table 3 :The Results of Unpaired t-Test Between Control and Experimental Group with Respect to Pre-Test and Post-Test Scores of Science Achievement of Secondary School Students

Variable	Group	N	Mean	SD	Unpaired t-value	P-value	Signi.
Pre-test	Control	79	67.1519	11.3047	-0.3127	>0.05	NS
	Experiment	120	67.8000	15.9656			
Post-test	Control	79	73.8734	12.2614	1.9000	>0.05	NS
	Experiment	120	70.1833	14.1040			

From the above Table, it is clearly seen that,

1.The control group (mean=67.1519) and experimental group (mean=67.8000) do not differ significantly with respect to pre-test scores of science achievement of secondary school students (t=-0.3127, p>0.05, NS) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that, the students of secondary school belong to control and experimental group have similar pre-test science achievement scores.

2.The control group (mean=73.8734) and experimental group (mean=70.1833) do not differ significantly with respect to post-test scores of science achievement of secondary school students (t=1.9000, p>0.05, NS) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that, the students of secondary school belong to control and experimental group have similar post-test science achievement scores. The mean values are also presented in the following diagram.

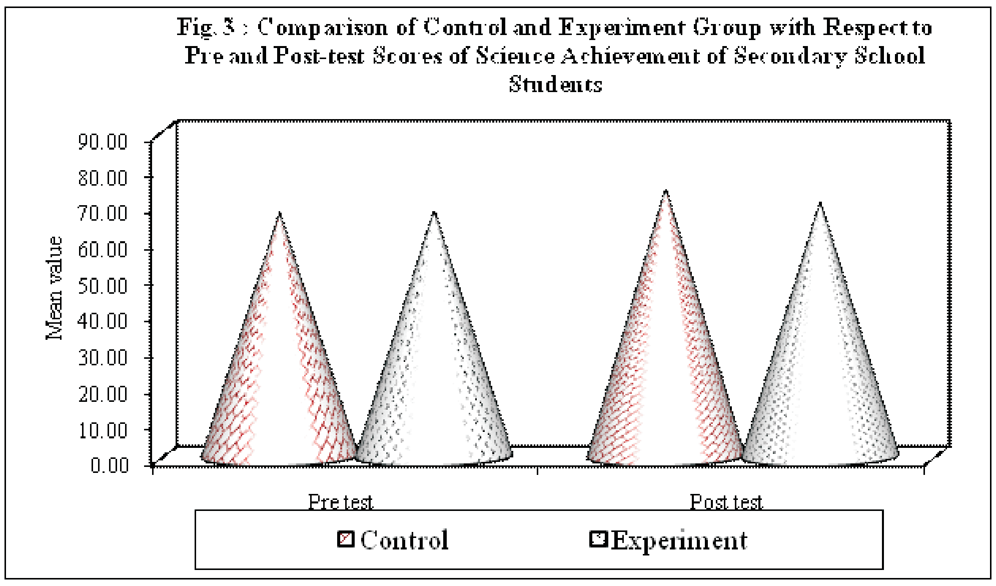

Table 4 :The Results of Unpaired t-Test Between Control and Experimental Group with Respect to Scientific Aptitude Scores and Problem Solving Ability Scores of Secondary School Students

Variable	Group	n	Mean	SD	Unpaired t-value	P-value	Signi.
Scientific aptitude	Control	79	44.3291	7.5034	3.1486	<0.05	S
	Experiment	120	37.0667	19.5619			
Problem solving ability	Control	79	13.1519	2.6989	0.9749	>0.05	NS
	Experiment	120	12.4583	5.9280			

From the above Table, it is observed that,

1.The control group (mean=44.3291) and experimental group (mean=37.0667) differ significantly with respect to scientific aptitude scores of secondary school students ($t=3.1486$, $p<0.05$, S) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the students of secondary school belong to control group have higher scientific aptitude scores compared to experimental group students.

2.The control group (mean=13.1519) and experimental group (mean=12.4583) do not differ significantly with respect to problem solving ability scores of secondary school students ($t=0.9749$, $p>0.05$, NS) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that, the students of secondary school belong to control and experimental group have similar problem solving ability scores. The mean values are also presented in the following diagram.

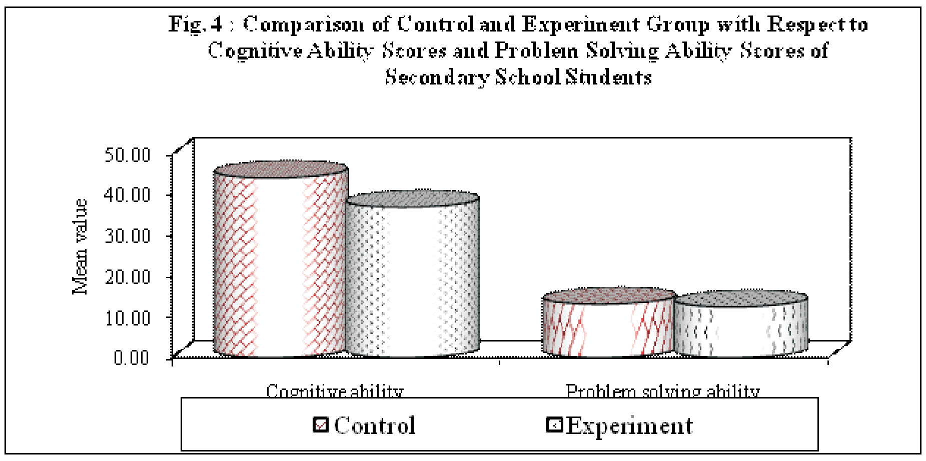

Table 5 :The Results of Unpaired t-Test Between Boy and Girl Students of Secondary Schools with Respect to Scientific Aptitude Scores and Problem Solving Ability

Variable	Sex	n	Mean	SD	Unpaired t-value	P-value	Signi.
Scientific aptitude	Boy	112	37.2946	16.9942	-2.8706	<0.05	S
	Girl	129	42.9147	13.3651			
Problem solving ability	Boy	112	12.2143	5.0161	-1.6048	>0.05	NS
	Girl	129	13.1473	4.0021			

From the above Table, it clearly observed that,

Boy (mean=37.2946) and girl (mean=42.9147) students of secondary schools differ significantly with respect to pre-test scores of Scientific aptitude ($t=-2.8706$, $p<0.05$, S) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the girl students of secondary schools have higher scores of Scientific aptitude compared to boy students.

Boy (mean=12.2143) and girl (mean=13.1473) students of secondary schools do not differ significantly with respect to pre-test scores of Problem solving ability ($t=-1.6048$, $p>0.05$, NS) at 0.05 level of significance. Hence, the null hypothesis is accepted and alternative hypothesis is rejected. It means that, the boy and girl students of secondary schools have similar scores of Problem solving ability. The mean values are also presented in the following diagram.

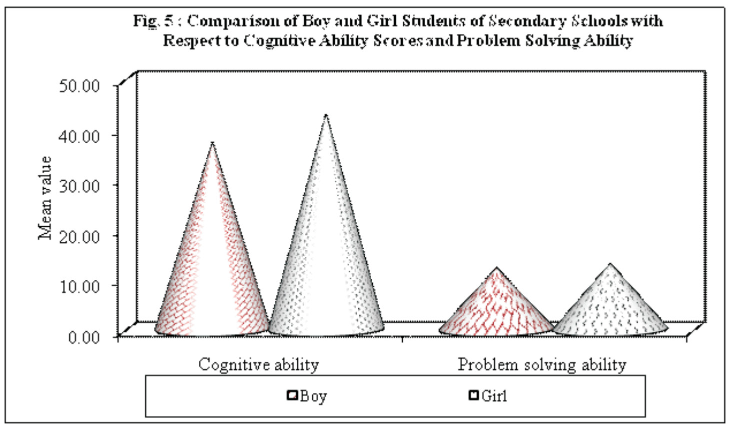

Table 6 :Correlation Coefficient Between Concept Mapping, Scientific Aptitude and Problem Solving Ability and Science Achievement of Secondary School Total Students

Variables	Science achievement of total students			
	Correlation coefficient	t-value	p-value	Signi.
Concept mapping	0.1747	2.7436	<0.05	S
Scientific aptitude	0.5573	10.3777	<0.05	S
Problem solving ability	0.4545	7.8889	<0.05	S

From the results of the above Table, we clearly observed the followings:

1.A significant and positive relationship is observed between concept mapping and science achievement of secondary school students (r=0.1747, t=2.7436, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the concept mapping increasing (decreasing) with increasing (decreasing) in the science achievement of students of secondary schools as a whole.
2.A significant and positive relationship is observed between scientific aptitude and science achievement of secondary school students (r=0.2420, t=3.8551, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the scientific aptitude increasing (decreasing) with increasing (decreasing) in the science achievement of students of secondary schools as a whole.
3.A significant and positive relationship is observed between problem solving ability and science achievement of secondary school students (r=0.4545, t=7.8889, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the problem solving ability increasing (decreasing) with increasing (decreasing) in the science achievement of students of secondary schools as a whole.

THE FINDINGS OF THE PRESENT STUDY

The findings of the present study are as follows:

The post-test science achievement scores are higher compared to pre-tests scores of secondary school students in control group.
The post-test science achievements scores are higher compared to pre-tests scores of secondary school students in experimental group.
The students of secondary school belong to control and experimental group have similar pre-test science achievement scores.
The students of secondary school belong to control and experimental group have similar post-test science achievement scores.
The students of secondary school belong to control group have higher scientific aptitude scores compared to experimental group students.
The students of secondary school belong to control and experimental group have similar problem solving ability scores.
The girl students of secondary schools have higher scores of Scientific aptitude compared to boy students.
The boy and girl students of secondary schools have similar scores of Problem solving ability.
The concept mapping increasing (decreasing) with increasing (decreasing) in the science achievement of students of secondary schools as a whole.
The scientific aptitude increasing (decreasing) with increasing (decreasing) in the science achievement of students of secondary schools as a whole.
The problem solving ability increasing (decreasing) with increasing (decreasing) in the science achievement of students of secondary schools as a whole.

DISCUSSION AND CONCLUSIONS

The present study was intended to study the effect of concept mapping strategy on achievement in science in relation to scientific aptitude and problem solving ability of secondary school students. The present study revealed the concept mapping strategy is effective in improving the achievement in science and in fostering scientific aptitude and problem solving ability.

Research conducted by Bacons and Novak (1985) and Cliburn (1987) agreed with the findings of the present study that the effect of concept mapping strategy on achievement science of experimental group was significantly higher than of the control group.

Allen (1989) and Nicolus (1987) also agreed with the findings of the present study that the achievement of experimental group was significantly higher than the control group in respect of achievement in science, scientific aptitude and problem solving ability. The investigator concluded that the concept mapping is an innovative strategy for teaching science which was effective in fostering not only achievement in science and also in improving problem solving ability and scientific aptitude of secondary school students. Hope that the findings of the present study would help in improving the teaching strategy and could be used as a tool and also self leaning tool. Concept mapping tool proves in improving the scientific aptitude, problem solving ability and achievement in science at secondary school level.

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