

# Scientific Creativity in Relation to Achievement of Senior Secondary School Students in Physical and Biological Sciences

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## Abstract

The present study aimed to find the relationship between Scientific Creativity and Achievement of Senior Secondary School Students in Physical and Biological Sciences. The objectives of the study were a) to study the status of Scientific Creativity among Senior Secondary School Students; b) to study the influence on Scientific Creativity of Senior Secondary School Students having different levels of Achievement; and c) to study the relationship between Scientific Creativity and Achievement of Senior Secondary School Students. The sample comprised of 300 class XII students belonging to physical and biological sciences from 4 CBSE and 4 M P Board schools. The data was collected using a) Majumdar Scientific Creativity Test developed by S. K. Majumdar; and b) Cognitive Style Inventory developed by Dr. Praveen Kumar Jha. The marks obtained by the students in Class XI in Physical and Biological Sciences were also collected and these were considered as their achievement. The findings of the study are - a) more than half of the senior secondary school students have an average level of scientific creativity; b) almost half of the senior secondary school boys and almost three-fifths of the senior secondary school girls have an average level of scientific creativity; c) three-fifths of the senior secondary students from C.B.S.E schools and almost half of the senior secondary students from M P Board have an average level of scientific creativity; d) almost half of the students from biological and physical sciences have an average level of scientific creativity; e) The senior secondary level school students having a high level of achievement have the most scientific creativity; and f) senior secondary school students who have whose achievement is better to have better scientific creativity and the senior secondary level school students who have low achievement have poorer scientific creativity. The implications of the study were also discussed.

**Keywords:** Scientific Creativity, Achievement, Physical Sciences, Biological Sciences

## Introduction

With the advent of technology, the present world has become increasingly complex and technical. It is essential that a minimum level of technical understanding or creativity is inbuilt in the present age individual. Creativity has become not only necessary but an imperative part of the present life. Creativity has become important for not only survival but also sustainability. Bach (1973) has defined creativity as the ability to integrate creative elements into new combinations, which correspond to some requirements or are otherwise useful. The multifarious society, being specialized and logical, needs a decent number of scientifically

tempered and talented people who may successfully contribute to its progress. These prerequisites of the general public recommend the significance of encouraging creative thinking in the field of science. Students are the future citizens of the country and the possibility of this significant resource impacts the development of the nation considerably. Although most of the earlier researches on creativity recognized it as domain independent, learning-related creativity is domain-specific by nature; its functioning in one domain is unique and psychologically differs from that of in other (Feldhusen, 1994; Diakidoy & Constantinou, 2001).

Science is a specialized body of knowledge; knowledge of several facts, phenomenon, laws, theories and their applications, etc. which, a learner is to acquire accepting the truth established already, recognizing science as a product. At the same time, science is also a process, a way of establishing the truth exploring new areas of knowledge. For creativity and science learning being closely associated, there is enough scope in science education to foster and encourage scientific creativity (Meador, 2003).

### **Scientific Creativity**

According to Feist, (1998) the capacity to have novel-original and useful-adaptive ideas in the domain of natural and social sciences is scientific creativity. Misra (1986) defined scientific creativity as a process of becoming sensitive to problems related to science; deficiencies, gaps, missing elements, disharmonies and so on scientific knowledge; identifying the difficulty; searching for solutions; making guesses or formulating hypotheses about deficiencies; testing and retesting of these hypotheses and possibly modifying and retesting them, and finally communicating the result. According to Moravesik (1981), scientific creativity is the comprehension of new ideas and concepts added to scientific knowledge, in formulating new theories in science, finding new experiments, preventing the natural laws, in recognizing new regulatory properties of scientific research and scientific group, in giving the scientific activity plans and projects originality and many other ideas.

Kocabas (1992b) names seventeen different major research tasks involved in scientific research. These are: Formulating research goals, selecting research goals, defining research framework, gathering knowledge, organising knowledge, selecting research strategies, methods, tools and techniques, proposing experiments, designing experiments and selecting experiment materials, setting expectations, conducting experiments, data collection, data evaluation, hypothesis formation, theory revision, theory formation, goal satisfaction control, and producing explanations.

### **Steps in Scientific Creativity**

In concise, scientific creativity involves the five steps that are mentioned in the lines that follow. The first and foremost step in scientific creativity is the motivation to conduct systematic scientific research; the second step is the ability to correctly identify the area of study and to formulate research problems within that specific body of knowledge; the third step involves the ability to identify and create a comprehensive search area for

the solution of a scientific problem; the ability to assemble and implement one's own knowledge that has been acquired by discovering things themselves and learning from their own experiences to reduce the search space; and lastly having the fortitude and endurance for the pursuit of a meticulous search for solving the scientific problem within the constrained search space and not stopping until the most feasible solution is obtained. Therefore a creative researcher is one who realizes how to accurately define research problems, can produce a broad quest space for a selected problem, can gather or detail the vital methodological information to decrease the quest space into reasonable measurements, and can direct a thorough pursuit in the constrained inquiry space.

### **Components of Scientific Creativity**

According to Guilford (1956) creativity is mostly associated with divergent thinking which leads to several solutions of a particular problem. He related divergent thinking to certain well-known ability factors, namely: fluency (ability to produce a number of valid responses), flexibility (ability of producing a wide variety of responses), originality (ability to generate rare and uncommon responses), and elaboration (ability to construct complex object based on simple construct). Later he also included two other abilities namely redefinition (seeing known in a new way) and sensitivity to the problem (ability to tell when something is wrong or is likely to go wrong) belonging to convergent thinking.

### **Scientific Creativity and Achievement**

Achievement is important for the successful development of young people in society. Today the world is more of application. It is important to know the why and how of it rather than just knowing the what of any fact. The students need to understand that just having knowledge is not enough, they must know how to apply this knowledge in a meaningful manner to obtain desired results. The recent trend of questions papers being set for regular and competitive exams emphasis on testing the ability of the students to apply their knowledge in the right direction to bring out the results. Hence creativity is a major factor which affects the achievement of the students to a great deal. Science being a subject which provides ample opportunities to develop creativity, it is considered that students who are studying science should have the requisite scientific creativity. Students who do well in school are better able to make the transition into adulthood and to achieve occupational and economic success.

### **Rationale for the study**

Achievement during academic life is considered as the hallmark to success in future. There are a number of factors affecting achievement. Children who master basic reading, writing and mathematics skills are less likely to fail in school and more likely to develop the thinking skills they need for higher education (Regier,

2011). In evaluations of the reasons for accomplishment and failure in academics, creativity appears to have replaced intelligence as the focus of interest (Smith and Carlson, 1990). Scientific creativity helps in deductive learning which is the core of science learning. It helps in learning as mentioned by Hurley (1993) when he conceptualized scientific creativity as an individual and social capacity for solving complex scientific and technical problems innovatively and productively. In science, it is necessary that answers are such that they are formed as a result of certain reasoning due to already known facts. This idea is expressed by Liang (2002) when suggested that scientific creativity is the ability to find and solve new problems and the ability to formulate hypotheses; it usually involves some addition to our prior knowledge.

Singh (2006) in his study concluded that the academic achievement of students was significantly related to creativity. He found that highly creative students' achievement was higher as compared to low creative students. One of the most important factors contributing to achievement is the knowledge of the subject matter Hu, and Adey (2002). To get good achievement in science subjects, one has to use knowledge effectively and reason abstractly. Thus, knowledge in science is an indicator of achievement and creativity (Metz, 2000). Although studies have been conducted where the influence of creativity on achievement is seen but no studies have been conducted to see the influence of scientific creativity on the achievement of students from biological and physical sciences. This research gap needs to be filled and hence the investigator has taken up this study to find the relationship between scientific creativity and achievement of Senior Secondary School Student in Physical and Biological Sciences.

### **Objectives**

1. To study the status of Scientific Creativity among Senior Secondary School Students.
2. To study the status of scientific creativity among boys and girls of senior secondary schools.
3. To study the status of Scientific Creativity among Senior Secondary School Students studying in C.B.S.E. and M. P. Board schools.
4. To study the status of Scientific Creativity among Senior Secondary School Students from Physical and Biological Sciences.
5. To study the influence on Scientific Creativity of Senior Secondary School Students having different levels of Achievement.
6. To study the relationship between Scientific Creativity and Achievement of Senior Secondary School Students.

### **Research Questions**

1. What is the status of Scientific Creativity among Senior Secondary School Students?
2. What is the status of Scientific Creativity among boys and girls of Senior Secondary Schools?
3. What is the status of Scientific Creativity among Senior Secondary School Students studying in C.B.S.E. and M. P. Board schools?

4. What is the status of Scientific Creativity among Senior Secondary School Students from Physical and Biological Sciences?

### **Hypothesis**

1. There is no significant difference in the mean Scientific Creativity scores of Senior Secondary School Students having different levels of Achievement.
2. There is no significant correlation between Scientific Creativity and Achievement of Senior Secondary School Students.

### **Methodology**

The present study is an ex-post-facto study where survey method has been utilized. As sample 4 C.B.S.E. and M. P. Board secondary schools each was selected. Such schools were selected which provided education to both boys and girls together. Also, it was made sure that they offered biological and physical science streams to the students in class XII. Stratified random sampling technique was used to select the sample for the present study. From the CBSE schools, 160 students of whom 67 belonged to the biological sciences group and 93 belonged to the physical sciences group were selected. Among these among the students belonging to biological sciences 34 were boys and 33 were girls, similarly among the students belonging to physical sciences group 57 were boys and 36 were girls. From the schools affiliated to the M P Board, 140 students of whom 69 belonged to the biological sciences group and 71 belonged to the physical sciences group were selected. Among these among the students belonging to biological sciences 25 were boys and 44 were girls, similarly among the students belonging to physical sciences group 33 were boys and 38 were girls. Hence the sample for the present study consisted of 300 students. The demographic differences in the sample need to be highlighted in the study hence the differences in the type of school, gender and stream of study have been considered separately. The data for the present study was collected using a) Majumdar Scientific Creativity Test developed by S. K. Majumdar: and b) Cognitive Style Inventory developed by Dr. Praveen Kumar Jha. Along with the above tools the marks obtained by the students in Class XI in Physical and Biological Sciences were also collected and these were considered as their achievement.

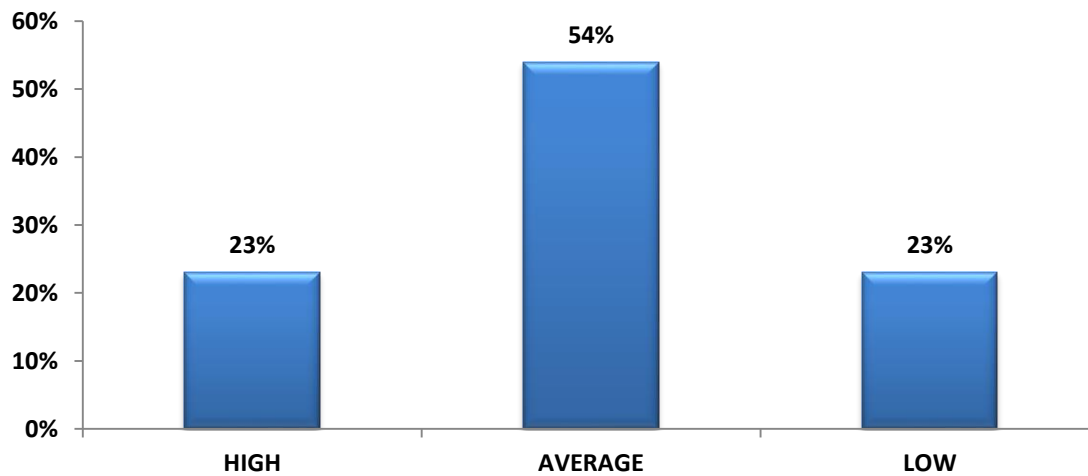
### **Analysis, Interpretation and Discussion**

In the lines that follow the analysis and interpretation are done objective wise.

#### **a) Status of Scientific Creativity among Senior Secondary School Students**

According to the scores of scientific creativity obtained, the students were categorised as having low, average and high scientific creativity. The category wise scientific creativity of all the senior secondary school students is presented in figure 1.1.



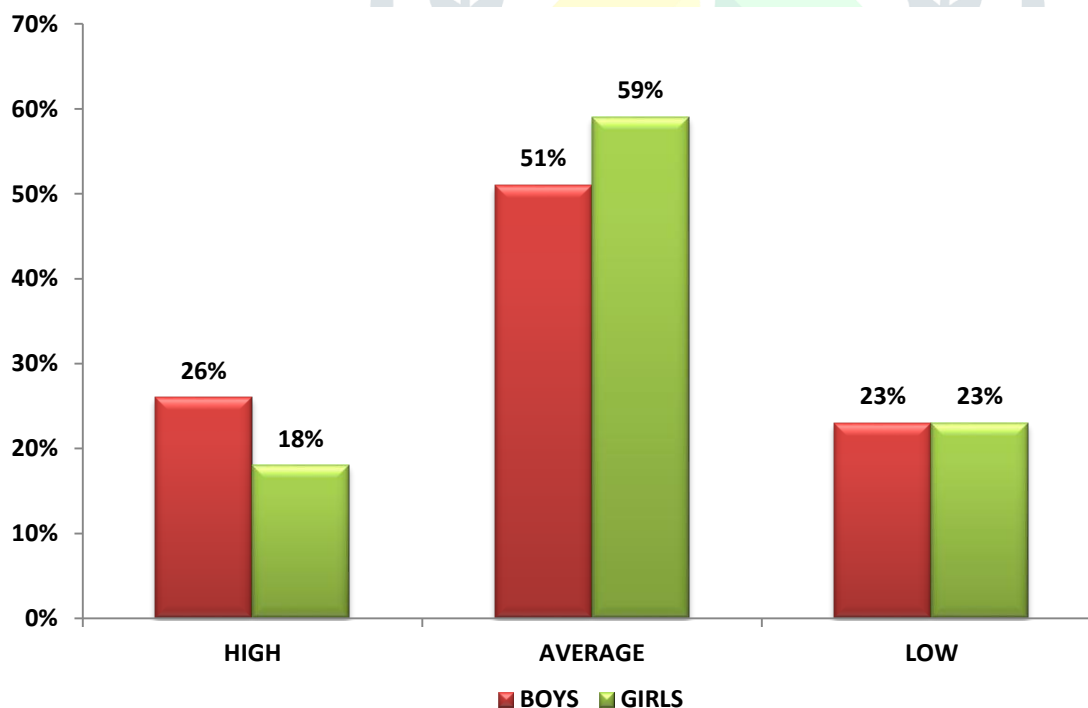


**Figure 1.1 Status of Scientific Creativity among Senior Secondary School Students**

From figure 1.1 it can be seen that 23% of the senior secondary school students have a high level of scientific creativity, 53% have an average level of scientific creativity and 24% have a low level of scientific creativity. From above it can be stated that more than half of the senior secondary school students have an average level of scientific creativity.

**b) Status of Scientific Creativity among boys and girls of Senior Secondary Schools**

According to the scores of scientific creativity obtained, the boys and girls were categorized as having low, average and high scientific creativity. The category wise scientific creativity of boys and girls is presented in figure 1.2.



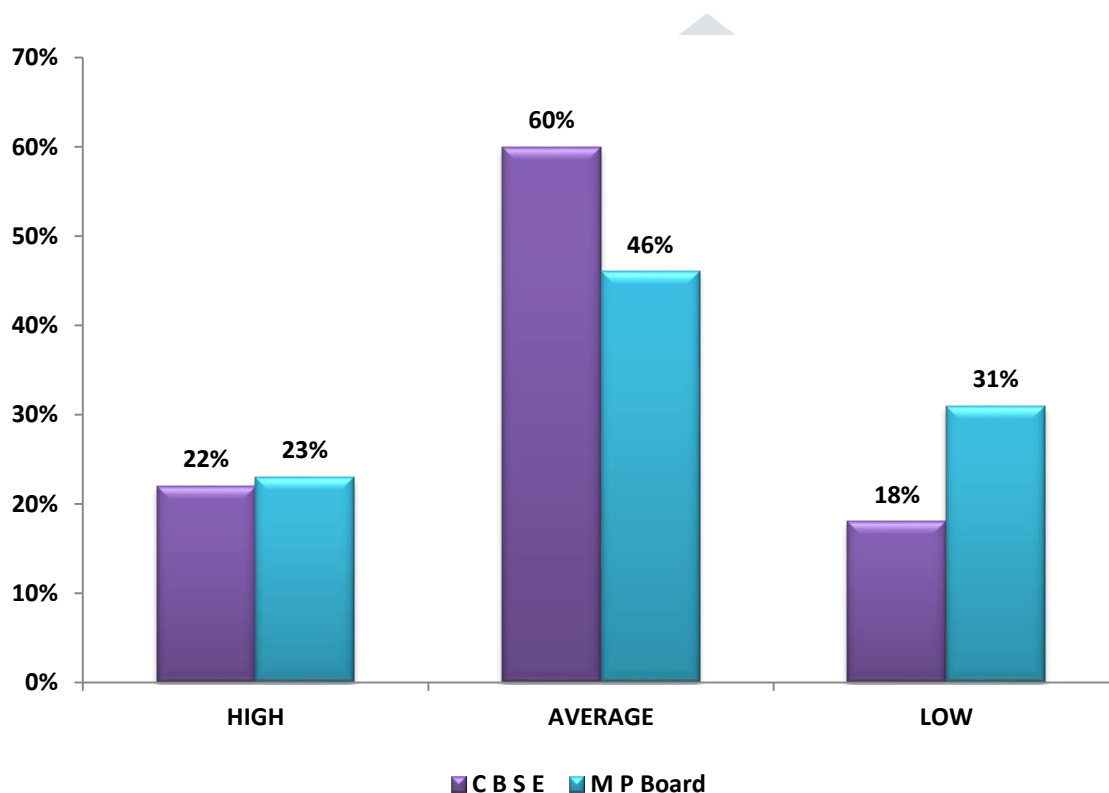
**Figure 1.2 Status of Scientific Creativity among boys and girls of Senior Secondary Schools**

From table 1.2 it can be seen that among the boys 26% have a high level of scientific creativity, 51% have average and 23% have a low level of scientific creativity. Likewise, among girls 18% have a high level of

scientific creativity, 59% have average and 23% have a low level of scientific creativity. From above it can be inferred that almost half of the senior secondary school boys and almost three-fifths of the senior secondary school girls have an average level of scientific creativity.

**c) Status of Scientific Creativity among Senior Secondary School Students studying in C.B.S.E. and M. P. Board schools**

According to the scores of scientific creativity obtained, the senior secondary school students studying in C.B.S.E. and M. P. Board schools were categorised as having low, average and high scientific creativity. The category wise scientific creativity of students from C.B.S.E. and M. P. Board schools is presented in figure 1.3.

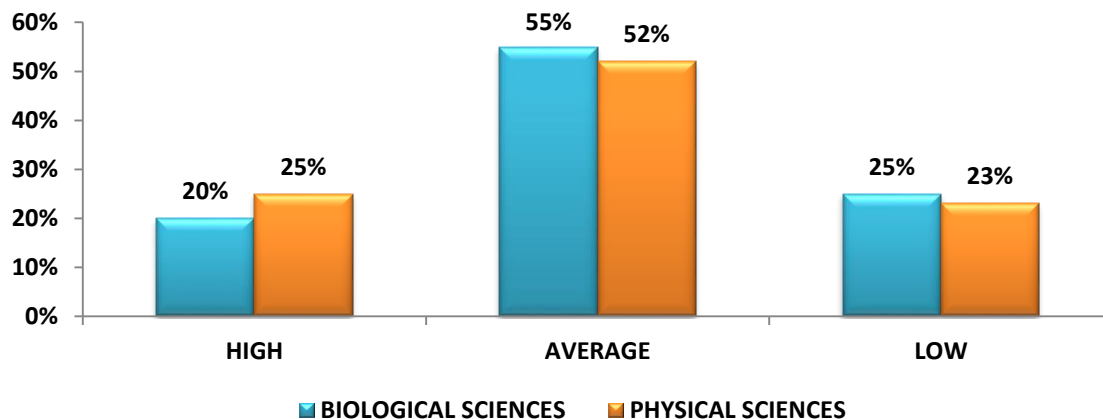


**Figure 1.3 Status of Scientific Creativity among Senior Secondary School Students studying in C.B.S.E. and M. P. Board schools**

From figure 1.3 it can be seen that among students from C.B.S.E schools 22% have a high level of scientific creativity, 60% have average and 18% have a low level of scientific creativity Likewise among students from M P Board schools 23% have a high level of scientific creativity, 46% have average and 31% have a low level of scientific creativity. From above it can be inferred that three-fifths of the senior secondary students from C.B.S.E schools and almost half of the senior secondary students from M P Board have an average level of scientific creativity.

#### d) Status of Scientific Creativity among Senior Secondary School Students from Physical and Biological Sciences

According to the scores of scientific creativity obtained, the senior secondary school students from Physical and Biological Sciences were categorised as having low, average and high scientific creativity. The category wise scientific creativity of students from physical and biological sciences is presented in figure 1.4.



**Figure 1.4 Status of Scientific Creativity among Senior Secondary School Students from Physical and Biological Sciences**

From figure 1.4, it can be seen that among students from biological sciences 20% have a high level of scientific creativity, 55% have average and 25% have a low level of scientific creativity while among students from physical sciences 25% have a high level of scientific creativity, 52% have average and 23% have a low level of scientific creativity. From above it can be inferred that almost half of the students from biological and physical sciences have an average level of scientific creativity.

#### e) Scientific Creativity of Senior Secondary School Students having different levels of Achievement

The mean scores of scientific creativity were analysed with the help of one way ANOVA to find the influence of levels of Achievement namely, high, average and low levels of achievement on the scientific creativity of the senior secondary school students. The results are presented in table 1.1.

**Table 1.1**

**Summary of ANOVA for Scientific Creativity of Senior Secondary School Students having High, Average and Low levels of Achievement**

	SS	df	MSS	F-Value
<b>Among</b>	15315.297	2	7657.648	25.654**
<b>Within</b>	88652.900	297	298.495	
<b>Total</b>	103968.197	299		

\*\* Significant at 0.01 level



Table 1.1 indicates that that the F-value for scientific creativity of higher secondary level school students is 25.654, which is significant at 0.01 level with df equal to 2/297. The F-value indicates that there is a significant difference in scientific creativity of senior secondary school students having high, average and low levels of achievement. Therefore, the hypothesis, namely, 'there is no significant difference in the mean Scientific Creativity scores of Senior Secondary School Students having different levels of Achievement.' is rejected. Thus, it can be inferred that the scientific creativity of senior secondary school students is dependent upon the level of achievement of senior secondary school students.

Since there is found to be a significant difference in the mean scientific creativity scores of students having different levels of achievement, there is need to find the difference between the various groups. This is shown in Table 4.4.

**Table 4.4**  
**Significance of Difference of Means between Higher Secondary Level School Students having different level of Achievement in respect of Scientific Creativity**

Category 1	Category 2	df	Mean Difference	t – value	Significance
<b>High (M=62.46)</b>	<b>Average (M=52.14)</b>	221	10.321	3.734	p<0.01
<b>High</b>	<b>Low (M=41.96)</b>	144	20.503	7.032	p<0.01
<b>Average</b>	<b>Low</b>	229	10.182	4.38	p<0.01

Table 4.2 indicates that there is significant difference in the mean scores of scientific creativity of senior secondary school students having high, average and low levels of achievement. The mean scientific creativity scores of students having a high level of achievement (M=62.46) is significantly higher than the students having an average level of achievement (M=52.14) and low level of achievement (M=41.96) at 0.01 levels of significance. Further, the students mean scientific creativity scores of students having average level of achievement is significantly higher than the students having low levels of achievement. Hence it can be concluded that the senior secondary level school students having high level of achievement have the most scientific creativity.

There are no direct studies related to the present find but Devi and Raja (2016) found that scientific creativity helps in logical, step by step sequential approach to thinking, learning, problem-solving and decision making which helps to attain more academic scores. Also, according to Ai (1999) creativity is hardly correlated with academic achievement. Nami, Marsooli, and Ashouri (2014) found that there are positive significant between components of creativity such as flexibility components, components of the initiative as creativity and academic achievement of students.

It is found that the students who have a high level of achievement have more scientific creativity. This may be due to the fact that scientific creativity is the step by step process finding solution to a problem by means of regular removal of unrealistic solutions. In studying sciences the phenomenon must be understood properly to master the concepts. If the concepts are mastered properly it usually leads to better achievement, hence the students who have higher achievement may be having better scientific creativity.

#### f) Relationship between Scientific Creativity and Achievement

The relationship of the scientific creativity and achievement of senior secondary school students was found out using Pearson's product moment correlation. The value of 'r' is presented in Table 1.2.

**Table 1.2**  
**Value of 'r' for Scientific Creativity and Scientific Creativity**

Variable	N	Mean	SD	r
Scientific Creativity	300	51.90	18.647	0.433**
Achievement	300	199.48	40.480	

\*\* Significant at 0.01 level.

Table 1.2 shows that the value of 'r' is 0.433 which is significant at 0.01 level of significance. Since the value is significant hence the hypothesis namely "there is no significant relationship between scientific creativity and achievement of senior secondary school students" is rejected. There is a positive correlation between scientific creativity and achievement of senior secondary school students, therefore it can be inferred that higher the achievement of the senior secondary level school students higher will be their scientific creativity. A higher score of achievement shows good achievement and a lower score of achievement shows poor achievement. On the other hand, higher scores of scientific creativity show good scientific creativity and lower scores show poor scientific creativity. Hence the results state that senior secondary school students whose achievement is better have better scientific creativity and the senior secondary level school students who have low achievement have poorer scientific creativity.

The present result is in conformity with the findings of Ahrens (1962), Cline, Richards and Needham (1963), Diseth (2003) and Farsides and Woodfield (2003) who found that high creative's performed better in school achievement. The study is also in agreement with the findings of Surapuramath (2014) who found a positive relationship between creativity and academic achievement.

Creativity is composed of many components of which originality, fluency and flexibility are the major components. People who are more creative tend to think out of the box and may find solutions to problems more efficiently and hence their achievement may be better. In sciences, questions are such that they require the implementation of a number of phenomena together. It is seen that those who have good achievement, tend to form these relationships easily using their flexible and fluent approach. They try to come out with original ideas and apply these in enhancing their achievement.

## Conclusion

More than half of the senior secondary school students have an average level of scientific creativity.

Almost half of the senior secondary school boys and almost three-fifths of the senior secondary school girls have an average level of scientific creativity.

Three-fifths of the senior secondary students from C.B.S.E schools and almost half of the senior secondary students from M P Board have an average level of scientific creativity.

Almost half of the students from biological and physical sciences have an average level of scientific creativity.

The senior secondary level school students having a high level of achievement have the most scientific creativity.

Senior secondary school students whose achievement is better, have better scientific creativity and the senior secondary level school students who have low achievement have poorer scientific creativity.

## Implications

Since it is found that more than half of the senior secondary school students have an average level of scientific creativity, there is an urgent need to devise pedagogical practices to foster scientific creativity among the students. Further, it is also found that senior secondary level school students having a high level of achievement have the most scientific creativity, there is urgent need of developing content transaction in such a way that the achievement of the students is enhanced and thus there will be improvement in the scientific creativity of the students.

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