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SCIENTIFIC CREATIVITY OF SECONDARY SCHOOL STUDENTS WITH PARTICULAR REFERENCE TO FLUENCY, FLEXIBILITY, ORIGINALITY AND ELABORATION

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Abstract
Scientific Creativity plays a pivotal role for career progression of students pursuing education in science and technology. In the present investigation an attempt was made to study the scientific creativity of secondary school male and female students in terms of Fluency, Flexibility, Originality and Elaboration. A total of 100 students of class IX, studying in Government Schools of Mahendergarh were taken as a sample of the study by random sampling technique, out of which 50 were male and 50 were female students. The researcher used self-developed tool to study the scientific creativity of students. Data was analysed by calculating mean, S.D.s and t-test. Findings of the study indicates that male students were having higher scientific creativity in comparison to female students in the terms of fluency, flexibility and elaboration while in terms of originality both male and female students had similar scientific creativity.

Keywords: Science Education, Scientific Creativity, Secondary school students

Introduction

The concept of scientific creativity has been developed alongside general theories of creativity and has also been influenced by different conceptual frameworks and shifts in the philosophy of science. Much like creativity itself, scientific creativity can be interpreted through multiple constructs and viewed upon from different perspectives. Torrance (1962) described creativity as "a successful step into the unknown, getting away from the main track, breaking out of the mold, being open to experience and permitting one thing to lead to another, recombining ideas or seeing new relationships among ideas." In a similar vein, Misra (1986) aligned with Torrance's perspective, defining 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"

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Importance of Scientific Creativity

In recent past, surging of knowledge economy and technical advances in the field of science and technology made modern society more technical and complex. This has created unprecedented multidimensional challenges and unpredictable demands which can be matched by an individual who has a strong scientific outlook, agility to adept these changes in the world and also possess creativity. Therefore, it becomes mandatory for the policy makers to devise the means for identification and nurturing of scientific creativity in its citizens more specifically in students at a young age. Subsequently, it is the duty of the academia to study this domain and develop a clear and comprehensive understanding of scientific creativity.

In India, committees and commissions constituted to draft national education policies have also given recommendations to develop an ecosystem for development of scientific creativity. The reputed Kothari Commission mentioned that, *"one of the primary objectives of science education is to foster creative thinking"*. Other state government reports related to science education in the country have similar observation on the issue. The national curriculum framework, 2005 constituted for systemic reforms and curriculum revamping emphasized the importance of scientific creativity and given its observation as follows: *"The principal goal of education is to create individuals who are capable of doing things, not merely repeating what earlier generations have done individuals who are creative, inventive, and capable of discovery. The second goal is to cultivate minds that think critically, verify information, and do not accept everything at face value. We must develop individuals who can resist, question, and distinguish between what is proven and what is not."*

National education policy (2020), a comprehensive and transforming framework for complete reforms of education system in India also mandated to develop skills, nurture scientific creativity and appreciate originality in students instead of traditional rote learning which encouraging them for out of box thinking and innovation. It is the only way a nation remains relevant, competent and excel in this world knowledge economy.

Dimensions and Models of Scientific Creativity

Scientific structure creativity model developed by Hu and Adey (2002) has mentioned following three dimensions of scientific creativity:

1) **Scientific Process**:
   "*The integration of scientific thinking with scientific imagination"*
2) **Personality Traits**:
   "*Characteristics such as fluency, flexibility, and originality"*
3) **Scientific Product**:
   "*Encompassing technical products, scientific knowledge, phenomena, and problems"*

Similarly, Cole (1970) defined scientific creativity as a process through which an individual acquire, organize, generalize, apply, and construct knowledge in a creative manner. Liang (2002)

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and Meador (2003) further enumerated the **"***scientific process"* skills such as to identify, formulate, and analyze a problem, after that generate and test hypotheses. They identify these abilities as core qualities of a creative individual.

Later on Jang (2009) further elaborated this domain and highlighted important criteria for scientific creativity within web-based learning environments in addition to fluency, flexibility, and elaboration**.** He mentioned that scientific creativity also involves abilities such as visualization or generation of mental images, combining of objects and ideas in unconventional ways, finding alternative uses of objects, finding solutions of problems, designing new devices and solving puzzles. He also considered fantasizing, dreaming and pretending as abilities related to scientific creativity. In the present study, the following components of scientific creativity were considered:

a) Fluency: It is the capability to have a large number of relevant and non-repetitive ideas to solve a particular problem. The ease and speed by which ideas can be generated and articulated also matters.

b) Flexibility: It is the capability to generate diverse ideas in response to a particular problem/ stimulus by adopting diverse approaches and thought patterns. In other words, it can be termed as divergent thinking.

c) Originality: It is the quality to generate rare, unique, and novel ideas in response to a particular problem/ stimulus out of spontaneity. Guilford considered originality as the fundamental and mandatory trait of creative thinking.

d) Elaboration: It is the capability to further enrich a simple idea by adding more details, new dimensions and transform it into a more comprehensive and descriptive construct.

Objectives

1. To study the scientific creativity of secondary school students
2. To compare the scientific creativity of male and female students at secondary school stage in terms of fluency, flexibility, originality and elaboration

Hypotheses

1. There is no significant difference between male and female students in their scientific creativity
2. There is no significant difference between male and female students in terms of fluency
3. There is no significant difference between male and female students in terms of flexibility
4. There is no significant difference between male and female students in terms of originality
5. There is no significant difference between male and female students in terms of elaboration

Delimitations of the study

1. The present study was limited to the scientific creativity of secondary school students of the class IX students of Mahendergarh District of Haryana State.
2. The present study was confined to 100 students studying in government schools of Mahendergarh District

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Research Methodology

In the present study descriptive survey method was used. It is most commonly used methods of descriptive research. It is also known as non- experimental research or co-relational research.

Sample

The researcher confined this investigation to study the Scientific Creativity of Secondary school students in terms of fluency, flexibility, originality and elaboration. Students of class IX, studying in Government Schools of Mahendergarh were considered in the population of the present study. The researcher selected 100 class IX students as a sample of the study. Out of those 100 class IX secondary school students, 50 were males and 50 were females. In this context, the investigator followed the random sampling technique

Tool Used

The researcher used self-developed tool to study the scientific creativity of students. The tool of Scientific Creativity is based on the test pattern of Guilford (1956) and Torrance (1967). The following sub-tests are used to measure dimensions of Scientific Creativity i.e. Fluency, Flexibility, Originality and Elaboration:

1) Consequences
2) Unconventional Uses
3) Explore the Relationship
4) Problem Solving

Discussion of the Result

In the present study, t - test was used to examine the significance difference between mean score of fluency, flexibility, originality and elaboration - dimensions of scientific creativity of male and female students. The same has been presented in the following tables:

Table 1: Scientific Creativity of Male and Female students

Variable	N	Total Score	Mean	SD	Calculated 't' value	Remarks at 5% level
Males	50	13259	265.18	11.16	20.93	Significant
Females	50	11277	225.54	7.38		

*The value of 't' for df = 98 at 0.05 level of significance is 1.98

Interpretation:

The results of table-1 shows that the mean score of scientific creativity of male and female students at secondary school level are 265.18 and 225.54 respectively. The standard deviation for male students is 11.16 while for female students is 7.38. The calculated 't' value is 20.93; which is greater than the critical 't' value (1.98 at 0.05 level of significance). It shows that the null hypothesis i.e. "There is no significant difference between boy and girl students in their scientific creativity" is not retained. It indicates that male students had higher scientific creativity than female students.

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Table 2: Scientific Creativity of Male and Female students in terms of Fluency, Flexibility, Originality and Elaboration

Dimensions of scientific creativity	Fluency		Flexibility		Originality		Elaboration	
Variable	Males	Females	Males	Females	Males	Females	Males	Females
N	50	50	50	50	50	50	50	50
Mean	92.06	78.34	73.78	63.94	3.88	3.36	95.46	79.90
SD	6.16	3.17	5.51	2.55	2.03	2.11	4.64	3.29
t – statistics value	13.97		11.45		1.25		19.32	
Remarks at 5% level	Significant		Significant		Non- Significant		Significant	

*The value of 't' for df = 98 at 0.05 level of significance is 1.98

Interpretation:

The table-2 shows that the mean score for fluency among male and female students are 92.06 and 78.34 respectively. The standard deviation for male students is 6.16 while for female students it is 3.17. The calculated 't' value is 13.97; which is greater than the critical 't' value (1.98 at 0.05 level of significance). It indicates that the 't' value is significant. Hence the null hypothesis i.e. "There is no significant difference between male and female students in term of fluency" is not retained. It indicates that male students had higher fluency than female students.

Further, the table reveals that the mean score for flexibility among male and female students are 73.78 and 63.94 respectively. The standard deviation for male students is 5.51 while for female students it is 2.55. The calculated 't' value is 11.45; which is greater than the critical 't' value (1.98 at 0.05 level of significance). It indicates that the 't' value is significant. Hence the null hypothesis i.e. "There is no significant difference between male and female students in term of flexibility" is not retained. It indicates that male students had higher flexibility than female students.

The also reveals that the mean score for originality among male students and female students are 3.88 and 3.36 respectively. The standard deviation for male students is 2.03 while for female students it is 2.11. The calculated 't' value is 1.25; which is smaller than the critical 't' value (1.98 at 0.05 level of significance). It indicates that the 't' value is non-significant. Hence the null hypothesis i.e. "There is no significant difference between male students and female students in term of originality" is retained. It indicates that male students and female students had similar scientific creativity in terms of originality.

The mean score for elaboration among male students and female students are 95.46 and 79.90 respectively. The standard deviation for male students is 4.64 while for female students it is 3.29. The calculated 't' value is 19.32; which is greater than the critical 't' value (1.98 at 0.05 level of significance). It indicates that the 't' value is significant. Hence the null hypothesis i.e. "There is no significant difference between male and female students in term of elaboration" is not retained. It indicates that male students had better elaboration than female students.

Conclusion

Based upon the findings of the current study, it can be concluded that male students showed higher level of scientific creativity in comparison to female students in the terms of fluency, flexibility and elaboration while in terms of originality both male and female students had similar scientific creativity. It may be due to the lack of exposure and access of female students to the information. So, in case of female students there is a need to nurture the scientific creativity of female students which may be achieved by motivation, sensitization and encouragement. A positive learning environment will also improve science learning. Scientific Creativity is of utmost importance for helps teachers, curriculum developers and policy makers to develop strategies for improvement of learning capacity and interest of student toward science and technical education

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