The Development of Scientific Creativity Test for Grade Twelve Chemistry Students

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Abstract

This study aimed to develop a creativity test for the science grade 12th chemistry students. The test includes five factors, i.e. Sensitivity to problem, fluency, flexibility, originality and elaboration & redefinition. The developed test administered to grade 12 students in Khyber Pakhtunkhwa Pakistan (n=80). The reliability coefficient of this test was estimated at 0.87 by passing through the test-retest method. To calculate the test reliability the same developed test was administered twice to the same group within a proper interval of time. The recorded scores were correlated through SPSS-17. The coefficient value (*r*-0.87) provided measure of stability. Rubrics are the standardized marking scheme for assessing student outcomes and performances of the assigned task. Therefore, rubrics were used for scoring of items. The entire procedure seized 25 days. The creativity test was also checked by experts. The experts were those who had command over scientific creativity. The analysis was accomplished to substantiate and check on item discrimination, internal consistency, and agreement between scores. The analysis of the data showed adequate reliability and validity.

Keywords: *Creativity, Scientific Creativity Tests (SCT), Rubrics*

1. Introduction

Creativity which occupies the most key and essential position in today education that leads the students to their high and indispensable thinking has always remained the main focus for the researchers. Creativity not only acquires the expression of great thinkers, scientists that designing the creation of high productive machines but also gets articulation and expression of the educational researchers to accomplish the potentialities of students. To use hidden potentialities is commendable, credible and admirable. This will give a creative

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student. A creative student is the need of the society that produces new ideas and thoughts in every walk of life. According to Robert (1982), students' creativity is an imperative and central aspect and feature in instructional process, particularly to science education where students gain knowledge by ability. It passes on the individuals' propensity to create or be acquainted with high thoughts and possibilities to resolve the problems. Similarly, Gardner (1993) is of the opinion that a person with high quality creative mind always solves the problem regularly.

Converging and diverging thinking are the two aspects of creativity. In converging thinking one can focus on the familiarities that are already known, i.e. a readymade answer as the given MCQs. In such type of thinking the students only recollect the stored information already exist in their long term memory, while diverging thinking means to produce multiple answers from much possible information stored in both long term and short term memories. In other words, it is the combination and recognition of information.

Due to its mundane level and exploration of new ideas, solution of the problem and to envisage the direction to the solution creativity is beyond existing knowledge and technique. That is why creativity has drawn its worthy and valuable attention in the educational environment for students that work as scientists for their general understanding of societal needs. But one can observe many times that all students may not be intelligent in their studies but they may have the command, domination and interest in the production of new things. Such type of students is God gifted. Their uniqueness, individualities and exceptionality can be ignored. Since scientific creativity more important element in higher secondary education especially in higher secondary education, therefore, a standardized test as an instrument for creativity may be developed that could be exercised for influential purposes in teaching-learning process. Therefore, the foremost objective of this research is to develop a new and innovative test of creativity for science for grade twelve students.

1.1 Objective of the Study

This study had a single objective:

- To develop a creativity test for 12^{th} grade chemistry students.

1.2 Significance of the Study

This research article is significant for several reasons.

This study is likely to direct the curriculum designers to include such type of material in a curriculum which increases the creative thinking of the higher secondary students. This will make the curriculum more successful, fascinated for the learners and science educators as well. As this study is mostly based on

activity-based approach therefore, it will help the teachers and students to enhance the laboratory activities. Owing to this research article the contributions of educational research regarding to the promotion of students creativity will be increased.

2. Literature Review

As creativity is one of the main features of students in teaching-learning process. Therefore, various creativity tests have been instigated and launched to evaluate and quantify the creativity of the learners at various levels for the successful accomplishment of the students' creative thinking. Such as Muhammad (2006), Philip (2008), Sansanwal and Sharma (1993), Liang (2002), Sinha and Singh (1987), Taylor (1975), Besemer and O'Quinn (1987) and Hany (1994) developed creativity tests. Most of the available tests on Scientific Creativity have incorporated divergent items.

Muhammad (2006) investigated and corroborated scientific creativity test for fifth- grade learners. The corroborated test was included four factors i.e., Fluency, Flexibility, Originality, and Complexity. The reliability of this test was 0.89. Likewise, Philip (2008) has created a test for computing the scientific creativity of higher secondary school students. This test consists of five factors, i.e. fluency, flexibility, originality, elaboration and redefinition and sensitivity to the problem. Scientific awareness was the main feature of this test that was expected from the students of higher classes.

Some of the researchers have used the Diverging Thinking test. Likewise Liang (2002) has applied this test in three Biology classes of 11^{th} grade. The total number of respondents was 130 male.

Majority of the investigators like Sansanwal and Sharma (1993) had applied the creativity test developed by Majumdar (1975). Similarly, Sinha and Singh (1987) have also exercised creativity test for secondary school students. 84 items were included in this test for 54 students. The analysis was created on the source of reliability test like split-half, test-retest. Difficulty level Discrimination value was also the bases on which analyses were made

Xinfa (2008) constructed a scale on creativity. Constructed test was planned to evaluate and quantify the verbal and figural creativity; this leaded two subtests– with one item each.

The most validated and reliable creativity test has been constructed by Torrance (1988) and Guilford (1956), therefore, most of the researchers have followed that pattern with minor changes, such as William (2017) has presented Torrance test of creativity factors i.e., Fluency, Originality, Elaboration, Abstractness of Titles and Resistance to Premature Closure for scoring. The researcher concluded that any effort to evaluate and encourage creativity take

two domain i.e. adaption and innovation, into consideration to acquire and obtain a practical assessment and valuable promotion of creative thinking capability and capacity of the individuals.

Guilford (1967), one of the pioneers of the creativity has worked on the intellectual factors of creativity in his research. These factors are i) Fluency with sub-themes such as word fluency, associational fluency and expression fluency) (ii) Flexibility with sub-themes such as spontaneous flexibility and adoptive flexibility) (iii) Originality (iv) Elaboration and Redefinition (v) Sensitivity to the problems. Philip (2008) has constructed a creativity test on the base of Guilford's theory for higher secondary school students. Creative thinking ability is a major feature of this theory.

Majority of the researchers likewise Besemer and O'Quinn (1987) and Taylor (1975) have accessible and presented a variety of dimensions to evaluate and appraise the creativity of learners. Taylor (1975) has mentioned many aspects as creativity product inventories that are further divided in a variable such as Generation, Reformulation, Originality, Relevancy, Hedonics, Complexity and Condensation, in creativity test.

Hany (1994) has worked on technical creativity and given the fundamental cognitive components for the development of creativity. The researcher has comprehensively furnished the longitudinal comparison of the youth and children with intelligence.

3. Research Methodology

3.1 Research Design

This was an experimental research. Many experiments were performed by the researcher himself. Modifications were made by students themselves. Moreover, there were some threats (extraneous variables) which could affect the experimental study. The researcher controlled these threats, because any uncontrolled extraneous variable could affect the performance on the depending variable to the validity of an experiment. The most important internal threats were mortality, instrumentation, testing and differential selection of participants.

3.2 Sample and Sampling technique

This was a convenient sample technique. Therefore, 80 students ranging from age 16 to 18 years studying in XI and XI classes were non-randomly selected from Oxford Education Academy Bat Khela. The sample group consisted of 40 males and 40 females. All of these belonged to the same race and religion and were of middle socioeconomic status.

3.3 Procedure of Test development and its Administration

For the development of the creativity test the investigator himself visited the sample institution and discussed the purpose of the visit with the Principal and the concerned lecturers who taught chemistry to higher secondary portion. With the proper permission of the principal the Chemistry lecturers allotted two periods per day. Being a subject specialist in chemistry, the investigator attended the allotted periods on a regular base. The students were taught through activity based approach because this was imperative for developing of creativity test. And then the proposed creativity test was administered. As this was lengthy process therefore, the school administration has strictly advised the students to attend the classes regularly. The collected data were analyzed using SPSS-17. The detail is given later in section 4. (Item analyses) Brief description of the test is given below.

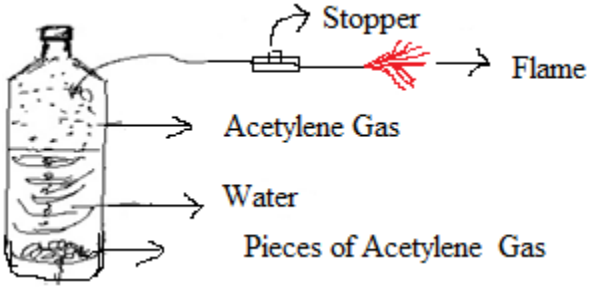
3.4 Designing and Brief descriptions of the developing creativity test (Instrumentation)

This test has five parts i.e. from part A to part E

3.4.1 PART- A Sensitivity to the problem

Apparatus testing (Suggestion for the upgrading of apparatus)

For the chemical production of Ethyne ($C_2 H_2$) which is commonly called acetylene gas, the following apparatus can be used. When Calcium Carbide CaC_2 reacts with cold water then the massive quantity of gas is formed that can cause the apparatus to burst. Keeping in mind this statement, attempt the following items, No.1 to 3.without losing time.



Fig; 1

Item- 1: How would you control the huge amount of produced gas in the bottle? Mark and present your information to make the apparatus more effective. Suggested figure-?.....

Activity 2; After sometime due to the consumption of water in the bottle, more water is necessitated, while the inlet of the equipment is closed with lid. What

fixation you would generate to triumph over this problem? Suggested figure-? ……

Item 3; It is very difficult to drop Calcium Carbide CaC_2 into the apparatus directly containing water that creates acetylene gas in an enormous amount. How would you overcome this problem?

Suggested Figure? ----

The above items were asked to find out the scientific process skills, and also producing new ideas, being sensitive to problems and seeing the deficiencies in the apparatus as scientific creativity components (Check out the method that makes the representative plan or activity more effective).

The assigned task is the students' capacity to create new ideas which are technologically accepted. Students will use low-cost material such as plastic bottle and cans in their life for solving the problems that the students may face during the performing of activities in the science laboratories.

3.4.2 Part-B Fluency

Item 4

In the above presented low-cost apparatus, numerous scientific words that start with Elec. Inscribe more supplementary scientific words that instigate (suffix) with terms…….

(i) Electr…… (ii) Rea….. (iii) Cromi….. (iv) Chem…. (v) Eva…….

Item 5

Write prefix with the following scientific words

a) ___tion. (b) __ous (c) ___oric (d) ___ate

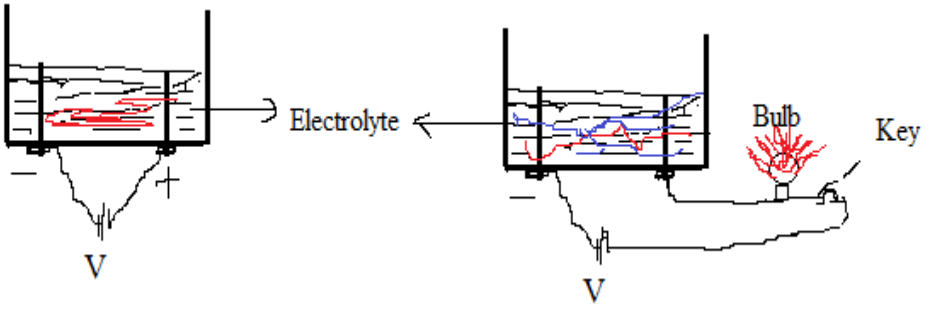
(e) ____oide (f) ____nce (g) ___ sion

The purpose of this task is to measure students' ability to produce the number of original ideas

3.4.3 Part. C Flexibility

- **Semantic spontaneous**

In the following low-cost activity various vegetable and fruits have been used for the conduction of current. Having the concept of the above activity in mind give the answer of the given item No. 6



Item 6

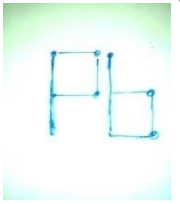
In the above activity the electric bulb is on due to the flow of electrons.
Mention the common and unusual utilization of dry cell in our daily life.
Ans……
……

The purpose of this item is to determine the new method if required. This assesses the creative experimental ability of the students and connects them with the scientific creative activity that leads them to the true scientific products.

- **Figural Adaptive flexibility**

Item 7

The following symbol of Plumbum (Pb) has been drawn with the help of match sticks. Try to make as many symbol of elements given in the periodic table.



The purpose of such type of item is designed to measure the creative products of the learners. These products could be the vision as the realization and accomplishment of innovative, fresh and new steps in understanding and realizing the targeted objectives of the science learning. Scientific creativity can manifest itself "in the conception of new ideas contributing to scientific knowledge itself, in the formulation of new ideas.

3.4.4 PART –D Originality

Novelty; Remote consequences

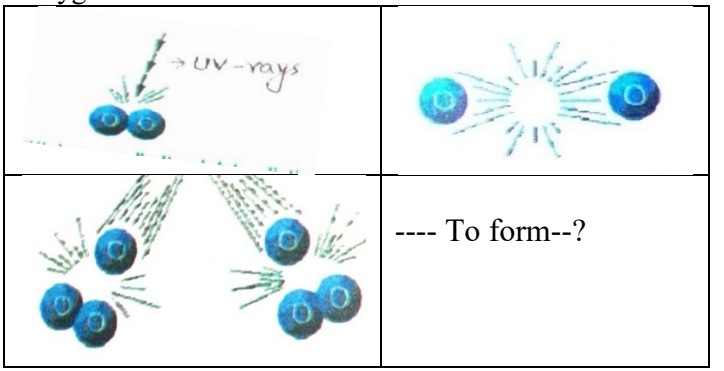
Item 8 what will you expect when

a) The sun lost its sunlight

b) The entire plants stopped to produce oxygen.
c) The Ozone depletion occurred

Item Novelty Picture Completion

Item 9; Try to complete the last cell in the following figure. The sphere of the ball represents oxygen.

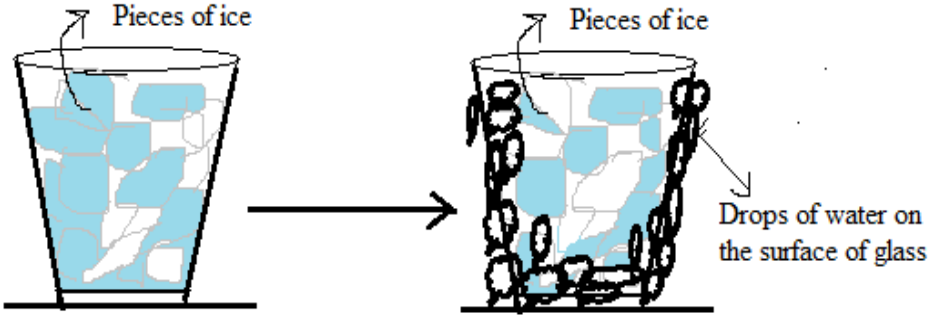


Originality gives the ideas that are exclusive, fashionable, remarkable and innovative. Originality is one of the factors given in Torrance's creativity tests. Originality is the creation of brainstorm that comes occasionally and answers all those things which are unusual and exceptional.

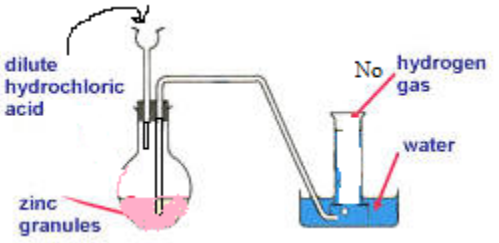
3.4.5 PART-E Figural and Redefinition

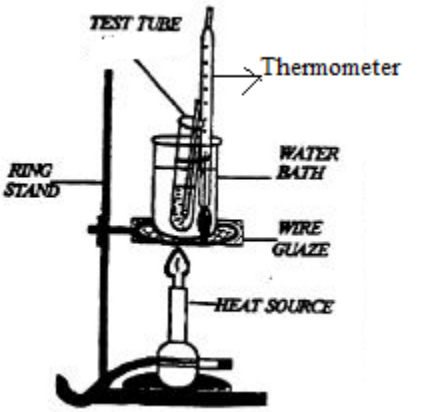
Item 10

Both the glasses are filled with the pieces of ice and cold water due to which drops of water formed. Give the scientific cause without losing time.



Scientific Cause……...





Scientific Mistake……..
Scientific Mistake……

Science students face problem to get an accurate result due to unscientific manipulation in the laboratory during science activity. Therefore, to assess their capability to overcome such type of problem the item. No 10 was asked. In the creativity test for science (CTS), this encompasses the capability of scientific manipulation, problem-solving, seeking further solutions to the problems and identifying difficulties. This also gives creativity components such as making prediction and imagination and designing further experiments which lead to more production of creative thinking.

3.4.5 Scoring procedures

For scoring the item in the present study the researcher used rubrics to trail the new instrument. Rubrics are guide lines for marking a test for the assessment of student achievements and performances.

The following table shows the category of responses of respondents that reckoned into a different scoring scale for 1, 2, 3, and 8 items. While for items 4, 5, 6, 7.9 and 10 there were four marks for each item depending on answer accordingly.

Table 1
Distribution of Marks according to Rubrics

Creativity	4 =Excellent	3= Good	2= Average	1= Poor	0 =Nil
Respondent	Extremely creative, accessible to originality and an Exceptional approach to solution.	creative, accessible to originality and Exceptional approach to a solution.	Few touches to improve but lack of integration throughout	Little creative, Plan, thoughts and improper use of energy and poor approach to solving the problems in time.	No interest in the solution of the problem, passive minded

Those respondents were exceptionally creative and accessible with originality and utilized outstanding approaches that really solve the problem were awarded four marks. This was an excellent category. While those respondents who were simple creative as mentioned in the table;1, put in the second category, honored with three marks. Two marks were awarded the students of second category holders who had simple and few touches to the project. The respondents of the fourth category have used their energy blandly during to solve the problem therefore, they secured only one mark while the last category holders that were not interested and did not attempt to solve the problem.

4. Item Analyses

The difficult and poor items may have an effect on the reliability of any test. Weak items have a propensity to lessen reliability while good items have a propensity to standardize the reliability; item analysis is reasonably practical in the selection of test items. Consequently, to have high quality of items the investigator particularly used item difficulty and discrimination in this process. SSPS -17 was used for the dependable and unwavering result of the item analysis of the items, ie, item difficulty and discrimination, for the creativity test.

Table 2
Items Analysis of Test of Creativity

Item No;	Difficulty	Discrimination	Item No;	Difficulty	Discrimination
1	0.58	0.53	6	0.58	0.54
2	0.66	0.36	7	0.55	0.17
3	0.65	0.25	8	0.18	0.16
4	0.59	0.45	9	0.67	0.51
5	0.46	0.28	10	0.17	0.13

The following formula given by Ebel (cited in Courville, 2004) was successfully applied for discrimination values. The formula shows four guidelines as indicated in Table; 3

Table 3
Formula for difficulty level

Difficulty level score	$D \geq 40$	$30 \leq D \leq .39$	$20 \leq D \leq .29$	$D \leq .19$
Position required	No revision required	Little/no revision needed	Item revision is needed	Complete revision required or may be eliminated

Items No. 8 and 10 were the most difficult. Therefore, these items were abandoned and analyses and were expelled from the item analysis. Consequently, both the items were modified while the remaining items left unchanged.

4.1 Reliability of the Creativity Test

The reliability coefficient of this test was estimated at 0.87 by passing through the test-retest method. To calculate the test reliability the same developed test was administered twice to the same group within a proper interval of time. The recorded value *"r"* indicates that the test is a reliable one.

The reliability and validity of this test show that the developed test is suitable and can be opted to compute and quantify the creativity of higher secondary science students, especially for Chemistry students.

Table 3

S.No	Factors	Reliability
1	Sensitivity to the problem	.88
2	Fluency	.86
3	Flexibility	.92
4	Originality	.91
5	Elaboration and Redifinition	.89

4.2 Internal consistency

The internal consistency was found based on interrelatedness of items that is the extent to which all of the items on the test measure on the same construct.

Table 4

Inter-correlation of the factors of the developed Creativity test

	Fluency	Flexibility	Originality	Elaboration & Redefinition
Sensitivity to the problem	.625	.753	.688	.693
Fluency		.769	.617	.734
Flexibility			.725	.821
Originality				.758

Pearson Correlation

Table; 4 justifies the validation of the selected factors because all correlations are positive and significant.

4.3 Validity

For such type of creativity test face validity was determined. 20 people (10 education researchers and 10 science teachers were asked to review the creativity test. On the bases of their suggestions changes were made in the form of modification in the statement of items.

5. Conclusion

In this study the researcher developed the creativity test for higher secondary science students with the hope that more experiential efforts of this nature will be taken up by interested researchers and science teachers to promote the inventive skill and creativity of the students that are the primary and foremost goal of education. The internal consistency and validity of this test were found to be satisfactory. The items of the test measured the diverging thinking ability which is essential for learning science. Items had been selected from the basic

concept of chemistry text book of grade 12. The students did not show their ability of rote memorization but indicated their ability based on the basic information, facts and concepts. This test not only encouraged the students but also explored the scientific knowledge in chemistry. Although a wide variety of creative dimensions were considered but still the test was not too long to solve.

6. Recommendations

Following recommendation is drawn on the basis of the findings and conclusion of this study. The reliability coefficient of this test was estimated at 0.87. Consequently, it is recommended that this test may be useful and helpful in evaluating and assessing the students' creativity at the higher secondary level. Therefore, this test may be used by the authorities, curriculum designers and researchers. Moreover, this creativity test might have importance to the teachers in higher secondary schools in identifying creative talents in chemistry and fostering these subsequently.

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