Higher Education Studies; Vol. 12, No. 3; 2022
ISSN 1925-4741 E-ISSN 1925-475X
Published by Canadian Center of Science and Education

The Development of a Scientific Creativity Test in Science for High School Students of Northeastern Princess Chulabhorn Science High Schools

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Received: June 13, 2022 Accepted: July 28, 2022 Online Published: July 31, 2022

doi:10.5539/hes.v12n3p105 URL: https://doi.org/10.5539/hes.v12n3p105

Abstract

The purposes of the research were to: (1) create a scientific creativity measure for high school students; (2) examine the quality of the science creativity scale of the created test; (3) establish a benchmark for scientific creativity scores for high school students; and (4) study a scientific creativity level of students in the senior high school of the three Northeastern Princess Chulabhorn Science High schools. Data were collected in three phases. The first test was implemented with a sample of 96 students to determine the appropriate time to complete a scientific creativity measurement. The second stage, the test was used with a sample of 96 students to find out the Index of difficulty (P), Discrimination(r), and Reliability of the whole scientific creativity scale. For the last phase of the study, a sample of 360 students was tested to create the norms of the science creativity scale for high school students and to study their scientific creativity.

The results of this research were as follows: 1) the scientific creativity test for high school students consists of 8 questions. The measurement covers 3 areas: originality, flexible thinking, and scientific imagination. The optimal measurement time is at 7 minutes. It was found that the created test had the Index of Congruence (IOC) ranging from 0.60 - 0.82; 2) the Index difficulty (P) was from 0.387 to 0.677, the discrimination (r) was from 0.208 to 0.448, and the confidence (α) of the conceptual aspects: originality, flexibility, and scientific imagination were 0.747, 0.704, and 0.786 respectively; 3) the normalized T-score of scientific creativity for upper secondary school students had 5 levels of creativity: very high, high, moderate, low, and very low; 4) the study of scientific creativity level of students in the upper secondary level of 360 students from three Northeastern Princess Chulabhorn Science High Schools indicated that the students' scientific creativity was at a low, moderate, high, very low and very high level (30.56, 29.45, 26.94, 8.61 and 4.44 percentage respectively).

Keywords: creativity science, originally, flexibility, imagination science, normalized T-score

1. Introduction

Princess Chulabhorn Science High Schools were established according to the Cabinet resolution passed in the meeting on November 25, 2010. This made all twelve Princess Chulabhorn Science High Schools become a regional science school with missions as follows: to be a boarding school which provides education with a specific curriculum for students with high abilities in mathematics and science, to provide opportunities for students with high potential in mathematics and science in each service area covering all regions of the country, and to develop learners to be creative with a spirit of being a researcher, inventor, investor and developer in mathematics, science and technology at the same level as leading science schools of many countries (Office of the Basic Education Commission, 2010b). Inventors are people who create things that arise from the need for using them to facilitate the comforts of daily life and benefit people in that society; one of important skills of an inventor is creativity (Office of the Basic Education Commission, 2018). Therefore, the development of learners to become researchers and inventors do need creative thinking. When examining the curriculum, the researcher found that it emphasizes teaching and learning in science and mathematics, as well as organizing various activities in science to encourage students to be researchers and inventors. The past developments, however, also lack tools to measure creativity in science.

The researcher, thus, had the idea to develop a scientific creativity measure based on the Scientific Structure

Creativity Model (SSCM, Hu & Adey, 2020) which focuses on creating a comprehensive measure of all three dimensions including trait, scientific process, and product so as to be used to measure the scientific creativity of students who are competent in science and mathematics. To develop learners to become researchers or inventors who create science projects and innovations, this designed scientific creativity tool consisted of measuring three conceptual concepts: originality, flexibility, and scientific imagination.

2. Method

In conducting this research, three phases of data collection were performed as follows:

2.1 Phase I

A development of a scientific creativity test and finding the appropriate time for students to complete it.

The sample group used in this phase was students in the second year of the second semester of the academic year 2021, Princess Chulabhorn Science High School, Buriram. The sample size was determined using the percentage criteria (a sample of 15-30% from a population of 432 students). Using stratified sampling, a sample of 96 students was chosen. An 8-item written answer scale of scientific creativity was created based on the creative structure of each item, 2 items out of a total of 4 issues. In each question, students are encouraged to find answers and solve problems; to answer, scientific principles must be used in explaining concepts which emphasize new ideas and demonstrates scientific imagination supported by theoretical principles. After this procedure, scoring criteria were created and presented to the thesis advisory committee to verify the initial correctness and make adjustments accordingly. When the review was completed, the created measurement was sent to 5 experts to check the Index of Item – Objective Congruence (IOC) and the content validity. Finally, the scientific creativity test was used with a sample of 96 people to determine the optimal time to complete the test.

2.2 Phase II

Analysis of quality of the scientific creativity test

The sample group used in this phase of the study was students in the second year of the second semester of the academic year 2021, Princess Chulabhorn Science High School, Buriram. The sample size was determined using the percentage criteria (a sample of 15-30% from a population of 432 students). Using stratified sampling, a sample of 96 students was chosen. The preliminary quality analysis was carried out after the scientific creativity scale was used with 96 students of Princess Chulabhorn Science School, Buriram. The difficulty of the exam based on the formula of Whitney & Sabers (Whitney & Sabers) was adopted. The formula D of Whitney & Saber was analyzed for discrimination. Reliability was analyzed using Cronbach's alpha coefficient (α-Coefficient) modified from the formula KR-20.

2.3 Phase III

Establishing the norms of the scientific creativity test and separating the students' levels of the scientific creativity

The sample group in the final phase of this research study was 360 senior students in the second semester of the academic year 2021 from three Princess Chulabhorn Science High Schools, Northeastern Region. The multi-stage random sampling method was used. The sample size was determined using a ready-made table by Krejcie and Morgan. The sample size was 360 students from Princess Chulabhorn Science High School Mukdahan, Princess Chulabhorn Science High School Loei, and Princess Chulabhorn Science High School Buriram. Stratified random sampling and cluster random sampling were then adopted. The province as a group in each school was divided into 3 grade levels, which are students in Mattayom Suksa 4, students in Mattayom Suksa 5, and students in Mattayom Suksa 6. Students in each level then were randomly selected. At this stage, the variable used to divide the landscape is the grade level that the student is studying. Each school randomly selects students. A simple random sampling method is 80% classified as follows.

- Students of Princess Chulabhorn Science High School Mukdahan

  80% randomly from 18 rooms, 14 rooms

- Students of Princess Chulabhorn Science High School Loei

  80% randomly from 18 rooms, 14 rooms

- Students of Princess Chulabhorn Science High School Buriram, the number of students remaining from the

experiments in Phase 1 and Phase 2, 8 rooms

As a result, 360 students who are a sample group from the classroom were randomly assigned in this phase by the simple random sampling method.

The scientific creativity measure was used to test 360 high school students of Princess Chulabhorn Science High School Mukdahan, Princess Chulabhorn Science High School Loei, and Princess Chulabhorn Science High School Buriram in order to establish criteria of scientific creativity scores. Percentiles were compared to normal T-scores. The values of vertical T-scores represent the ten digits and the horizontal ones represent the unit digits. The calculated percentile was compared with the percentile value in a table with 2 decimal places considering the match (if there is no match, use the closest value). Then, the T-score 10 from the vertical combined with the main unit was read. Finally, the levels of scientific creativity of students who participated in the Science Creativity Scale were separated.

3. Results

The researcher has divided the analysis of the data into three parts according to the objectives as

follows:

Part 1 Developing a scientific creativity test and finding a suitable time for taking the scientific creativity test.

The test consists of 8 questions:

1.1 2 questions of artificial design

1.2 2 questions of selection methods/processes of science

1.3 2 questions of reasoning (if…then)

1.4 2 questions of correlation

The results of content validity checking by the Index of Congruence: IOC

Table 1. Content Validity Examination Results with Index of Congruence (IOC) from 5 experts

Item	Index of Congruence	Item	Index of Congruence
1	0.80	5	0.60
2	0.80	6	0.80
3	0.60	7	0.80
4	0.80	8	0.80

Table 1 showed the results of the Index of Congruence (IOC) review from 5 experts, demonstrating that the scientific creativity test for high school students have appropriate content consistency.

All 8 items had the Index of Conformity (IOC) between 0.6 - 0.8

The results of the test to determine the optimal time to complete the scientific creativity test for high school students from a sample of 96 people

Table 2. Results of the first test to determine the optimal time to complete the scientific creativity test for high school students

The time it takes the scientific creativity test (minute)	quantity	percent
6	2	2
7	90	94
8	4	4

Table 2 showed the results of the test to find the right time to complete the scientific creativity test for students at the high school level from doing a scientific creativity measure. It was found that the time it took the participants to complete the scientific creativity scale was between 6-8 minutes, with 92 percent taking 7 minutes to complete the test.

Part 2 Results of the second test to analyze Difficulty (p) Discrimination (r) and Reliability (α) of the scientific creativity test set for high school students

Table 3. Difficulty (p) Discrimination Effectiveness (r) and Reliability (α) of item on Originality by using program RTAP developed by the Department of Educational Research and Evaluation, Mahasarakham University

Item	difficulty	discrimination	Criteria	Reliability
1	0.552	0.229	medium discrimination medium	0.747
2	0.451	0.292	medium discrimination medium	
3	0.465	0.347	medium discrimination medium	
4	0.587	0.354	medium discrimination medium	
5	0.517	0.201	medium discrimination medium	
6	0.476	0.438	medium discrimination very good	
7	0.632	0.222	easy discrimination medium	
8	0.604	0.278	easy discrimination medium	

Table 3 showed results of analysis on Originality. It can be concluded that the confidence analysis of the 8 selected subjective exams have difficulty values ranging from 0.451 to 0.632 and discrimination values ranging from 0.201 to 0.438, which all pass the criteria, and this subjective exam has the Reliability (α) at 0.747.

Table 4. Difficulty (p) Discrimination Effectiveness (r) and Reliability (α) of item on Flexibility by using program RTAP developed by the Department of Educational Research and Evaluation, Mahasarakham University

Item	difficulty	discrimination	Criteria	Reliability
1	0.420	0.285	medium discrimination medium	0.704
2	0.378	0.410	difficult discrimination very good	
3	0.601	0.382	easy discrimination medium	
4	0.608	0.299	easy discrimination medium	
5	0.622	0.285	easy discrimination medium	
6	0.563	0.278	medium discrimination medium	
7	0.524	0.285	medium discrimination medium	
8	0.462	0.340	medium discrimination medium	

Table 4 showed results of analysis on Flexibility. It can be concluded that the confidence analysis of the 8 selected subjective exams have difficulty values ranging from 0.378 to 0.622 and discrimination values ranging from 0.278 to 0.410, all passing the criteria, and this subjective exam has the Reliability (α) at 0.704.

Table 5. Difficulty (p) Discrimination Effectiveness (r) and Reliability (α) of item on Scientific Imagination by using program RTAP developed by the Department of Educational Research and Evaluation, Mahasarakham University

Item	difficulty	discrimination	Criteria	Reliability
1	0.609	0.240	easy discrimination medium	0.786
2	0.542	0.354	medium discrimination medium	
3	0.568	0.281	medium discrimination medium	
4	0.583	0.229	medium discrimination medium	
5	0.667	0.208	easy discrimination medium	
6	0.599	0.448	medium discrimination very good	
7	0.677	0.375	Easy discrimination medium	
8	0.609	0.344	easy discrimination medium	

Table 5 showed results of analysis on scientific imagination with the conclusion of the confidence analysis of the 8 selected subjective exams have difficulty values ranging from 0.542 to 0.677 and discrimination values ranging from 0.208 to 0.488, which all pass the criteria, and this subjective exam has the Reliability (α) at 0.786.

Part *3* Normalized T-score of the scientific creativity test and differentiating the levels of scientific creativity of the learners

1. Normalization results of the scientific creativity test

To normalize the scientific creativity test for high school students, the researcher created normal criteria using data from a sample of 360 people to find the raw score to calculate the percentile and compare it to the normalized T-score.

Students' creativity can be divided into 5 levels as follows:

T_{65} or upper very high level of scientific creativity.

T_{55} - T_{64} high level of scientific creativity.

T_{45} - T_{54} moderate level of scientific creativity.

T_{35} - T_{44} low level of scientific creativity.

T_{34} or very low level of scientific creativity.

Percentile Rank Interpretation

When comparing a student's grades in percentiles, it means that they have a very high level of scientific creativity than other students. Being in the “percentile” percentage of the total number of test subjects, i.e., a student's scientific creativity score is in the 75 percentiles, meaning that student has a very high level of scientific creativity than other test takers 75% of the total number of test takers

Normalization of the scientific creativity scale for high school students is shown in Table 6**.**

Table 6. Shows the normal criteria for the Science Creativity Scale for students in the upper secondary level

Level of scientific creativity	Score	PR	T
very low	3	3	32
	8	5	34
	11	10	37
low	15	20	41
	19	33	46
	23	45	49
medium	25	53	51
	27	63	53
	30	74	56
high	35	87	62
	38	94	66
	40	98	70
very high	44	98	71
	49	99	74
	54	100	89

Table 6 showed criteria for the scientific creativity test set of science high school students divided into five levels of creativity:

3 - 11 very low creativity and T- normal from $T_{32} – T_{37}$
15 - 23 low creativity and T-normal from $T_{41} – T_{49}$
25 – 30 Moderate creativity and T-normal from $T_{51} – T_{56}$
35 – 40 high creativity and T-normal from $T_{62} – T_{70}$
44 – 54 very high creativity and T-normal from $T_{71} – T_{89}$

Separation of scientific creativity level

Table 7. Showed the results of the separation of scientific creativity levels of 360 high school students of three Princess Chulabhorn Science High Schools, Northeastern region

Level of scientific creativity	Score	Quantity (Person)	Percent
very low	3	8	8.16
	8	7	
	11	15	
low	15	27	
	19	40	30.56
	23	43	
medium	25	33	29.45
	27	35	
	30	38	
high	35	44	26.94
	38	33	
	40	19	
Very high	44	6	4.44
	49	6	
	54	5	
Total		360	100

Table 7 showed the students' levels of scientific creativity: 30.56% of students had a low level of scientific creativity, 29.45% had a moderate level of scientific creativity, 26.94% had a high level of scientific creativity, 8.16% had a very low level of scientific creativity, and 4.44 percent had a very high level of scientific creativity.

4. Discussion

From the creation of a scientific creativity measurement model for students at the high school level, the main points that can be discussed are as follows:

1. Developing a measure and finding the optimal time to conduct a scientific creativity measurement for high school students.

The scientific creativity test containing 8 questions is a subjective model that measures creative thinking in originality, flexibility, and scientific imagination.

The results of the Index of Congruence (IOC) values ranged from 0.6 -to 0.8, indicating that the questionnaire was consistent with what was intended to be measured, according to Paisan Worakam (2015) who stated that if the calculated Index of Congruence (IOC) is greater than or equal to .50, then the question is consistent with what you want to measure. However, if the Index of Congruence (IOC) is less than .50, the question has to be removed or improved. It shows that the scientific creativity test is consistent with what it wants to measure. Also, when studying the optimal time to complete the individual scientific creativity measurement questionnaire, it was found that the duration used was 7 minutes. The time was in line with what Pichit Ritjarun's (2013) suggestion for subjective questions to specify the time required to answer each question because scheduling each test will allow respondents to determine the correct scope for their response. This will enable them to complete the other exams promptly, avoiding the opportunity to be selective on one or the other.

2. Quality Assurance of the scientific creativity test for high school students.

The difficulty values of the scientific creativity test for high school students of Northeast Princess Chulabhorn Science High Schools had values from 0.387 to 0.677, meeting the selection criteria. The questions with difficulties of 0.20 or more, when considering the criteria, it was found that the scientific creativity scale had difficulty according to the relatively easy to moderate difficult standards because the students who take the scientific creativity test are a selected group of scientific and mathematical talents.

The item discrimination values of the scientific creativity thinking test ranged from 0.201 to 0.448, which were within all valid criteria, indicating that the researcher-generated scientific creativity test could classify students with creative thinking as high and low creative groups. As it is the scientific creativity measure, there is a detailed clarification on how to complete the creativity measurement. There is a clear scoring criterion for each scientific creativity and the scores from reviewers and score reviewers. To determine the accuracy of scoring, students with knowledge of the subject can take the test, which is different from students who do not understand

the subject matter (Paisan Worakham, 2015)

The confidence values of the entire version of the scientific creativity test for high school students in the Northeast Princess Chulabhorn Science High Schools are from 0.704 to 0.786, which is considered high confidence. Because the scientific creativity test was reviewed for validity by 5 experts, it was be able to use to measure the students' scientific creativity, consistent with Songsak Phusee-on (2015: 90-91). The confidence value analysis of the whole test should be close to 1 to be considered. The tool has the quality of reliability and is suitable for use in data collection for future research purposes.

3. Normalization criteria of scientific creativity scores of high school students of Northeast Princess Chulabhorn Science High Schools.

The researcher established the norm in the form of the Normalized T- Score, which allows each student's skill level to be immediately known without having to compare the scores to other students to find the norm, which is consistent with what Somnuk Phatthiyathanee (2008:269) mentioned that the sample must have a large number enough to be a good representative of the population. Otherwise, the norm cannot be trusted. The normative in this study used a sample of 360 people from a population of 1,296. The raw scores for scientific creativity scores were from 3 to 54, and the percentile positions were from 3 to 100. When the raw scores are interpreted to create T-normal score criteria, it can be divided into 5 levels of creative thinking (very low, low, moderate, high, and very high) which is in line with what Chawan Praaratkul (1977:20) suggested translating the raw scores to create a normal T-score from very low to very high.

However, to apply the normal criteria created by the researcher, it can be only for students in the Northeast Princess Chulabhorn Science High Schools, who are students with special abilities in mathematics and science and are taught with a curriculum that focuses on mathematics and science, the students who are similar in ability to the sample used to create the norm in this research.

4. A study of scientific creativity levels of students in the upper secondary level at Northeast Princess Chulabhorn Science High Schools.

The results of a study on the scientific creativity level of the upper secondary students of Northeast Princess Chulabhorn Science High Schools indicated that most students had a low level of creativity; 30.56 percent and a moderate level; 29.45 percent. The development of the researcher's scientific creativity measure has emphasized measuring the scientific competence of experimental learners and solving problems using the scientific process of finding answers. Pupils who have the knowledge and high-level scientific process skills will be able to do a good measure of scientific creativity, Hu & Adey (2020) said that scientific creativity is a specific idea to science which depends on knowledge and scientific process skill.

In collecting this data, however, the sample was students from Princess Chulabhorn Science High School Mukdahan, Princess Chulabhorn Science High School Loei, and Princess Chulabhorn Science High School Buriram. This means that the process of teaching and learning to promote skills and the scientific method depends on the teacher's learning management design. As a result, learners have skills and different scientific processes. Another reason is that the sample students are from three levels: Mathayom Suksa 4, 5, and 6. Students in Mathayom 4 and 5 have not yet developed their knowledge and scientific process skills to complete the course. As a result, students have low to moderate creativity scores.

Acknowledgment

I would like to thank the Faculty of Education, Mahasarakham University to encourage and support this research. I also would like to thank for the research samples and the experts who checked the quality of tools, as well as the students who helped collect the data. Finally, I would like to thank Mr. Songsak Phusee-orn for recommending the journal and manuscript preparation.

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