A Pilot Study on Chemistry Creativity Test for Malaysian Science Students

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Abstract

This study describe the adaptation of the scientific creativity test developed by Hu & Adey (2002) into Malay Language, and its validity and reliability analysis. This Chemistry Creativity Test (CCT) consist of 4 different items based on a Scientific Creativity Structure Model derived from theoretical accounts of the nature of scientific creativity. Some questions of the original test have been modified according to Malaysia context. In this study, the validity of the test was established by content and linguistic experts. While, the reliability of the CCT was established through the test-retest procedure. The researcher administrated the test within two different times involving 27 of Form Four science stream students. The values for the test-retest reliability coefficient were .845. The measurement of CCT is based on three dimension, which is product, trait and process. All of these dimensions, including the description of the test items and the scoring procedure will also be discussed in this paper.

Keywords: Scientific creativity, creativity, scientific creativity test, creativity in science, science education.

Introduction

Creativity is one of the important skills required for the development of a country to be sustainable, especially in an increasingly complex social environment (Hennessey and Amabile 2010; Molly, 2015). Today, the needs of creative ideas is important in order to get benefit to solve problems in our lives (Marx, 2006). Furthermore, creativity is also considered as one of the key components for the development of Science and Technology (Robinson, 2006) and it plays a crucial role in fulfilling the unpredictable needs of the future (Kind and Kind, 2007). Creative thought and behaviour happen in any and all domains of life, from cooking, building, and surviving to Science (Feist, 2011). The proclamation of the Year of Creativity and Innovation in the European Union, in 2009, and in Malaysia, 2010 (Azrina, 2011) further signified the importance of creativity, which has also been a major focus in the development of national education, especially in Science (Park, 2011, 2012; Chumo, 2014). In fact, creativity has been proven to be a catalyst in educational reform in most countries (Siew, Chong and

Chin, 2014). Scientific creativity, in particular, may be defined as the ability to produce ideas or products relevant to the context which has scientific usefulness or significance (Sak & Ayas, 2013). It is commonly associated with some factors including problem solving, problem finding, formulating hypotheses, using analogies along with some personality factors such as motivation (Grosul, 2010; Liang, 2002; Dunbar, 2000). A study by Usta & Akkanat (2015) stated that, scientific creativity can be defined as, "depending on previous experiences and knowledge", "sensitivity to problems and their solutions", "understanding the nature of science and getting fascinated with it", and "development of new, extraordinary and useful scientific knowledge, experiments, theories and products".

Scientific creativity should be taught to students in an ordinary Science curriculum, as it is not a special thought process for special students, according to Park (2011). Past researches revealed that, students who are used to making scientific experiments on their own attempts during their school times are likely to be more creative in their professional lives later (Mumford, Supinski, Baughman, Costanza and Threlfall, 1997; Simonton, 2008). However, research on creativity has been criticized for using creativity tests that have, theoretically, too general items to measure such a multi-dimensional construct (Kaufman, Plucker, & Baer, 2008). Generally, those instruments used in general creativity are still been being used in the measurement of scientific creativity. According to Mohamed (2006), this can lead to errors and it may not give correct results when scientific creativity is gauged by measures prepared for general measuring creativity (Liang, 2002). Zeng, Proctor & Salvendy, (2011) revealed in their study that, a test that uses creativity problems in a specific field is more appropriate as compared to a general creativity test to measure scientific creativity. The use of domain-specific tests of creative ability (Kaufman et.al, 2008), thus was suggested. In promoting the idea for domain-specific assessment of creativity, Hu and Adey (2002) developed prototype tests of scientific creativity as criterion measures of scientific creativity. The tests produced satisfactory reliability and validity evidences in preliminary studies. Hu and Adey applied a Scientific Creativity Structure Model in their studies to develop the scientific creativity test for secondary school students. The model includes both general creativity skills, such as fluency and flexibility and science-related skills, such as imagination and thinking. Relying on this basis, this paper discussed Chemistry Creativity Test (CCT) adapted from the scientific creativity test developed by Hu and Adey (2002), as one of the initiatives to provide more creativity instruments on specific domains, specifically in the Malaysian context.

The Structure of Scientific Creativity

The proposed structure was designed as a theoretical foundation on which the measurement of scientific creativity, scientific research into creativity, and the cultivation of scientific creativity may be based. In summary, and in the light of the exploration of creativity in the literature, Hu and Adey (2002) defined scientific creativity as a kind of intellectual ability or trait producing or potentially producing a certain product that is original and has social or personal values, designed with a certain purpose in mind, using the information given. This definition may be elaborated with a set of hypotheses about the structure of scientific creativity:

(1) Scientific creativity differs from other creativity as it is concerned with creative science experiments, creative scientific finding and problem solving, and creative science activity.

(2) Scientific creativity is a kind of ability. The structure of scientific creativity itself does not include non-intellectual factors, although non-intellectual factors may influence scientific creativity.

(3) Scientific creativity must depend on scientific knowledge and skills (Park, 2011; 2012).

(4) Scientific creativity should be a combination of static structure and developmental structure. Adolescent and mature scientists have the same basic mental structure of scientific creativity but that of the latter is more developed.

(5) Creativity and analytical intelligence are two different factors of a singular function originating from mental ability.

The three-dimensional model of scientific creativity cells described above provides 24 items (3 trait dimension x 4 product dimension x 2 process dimension) for each item.

Description of the CCT

This CCT was adapted from the Scientific Creativity Structure Model (SCSM) by Hu & Adey (2002). The reliability of SCSM was determined by previous researchers (Siew, Chong and Chin (2014), Ceran, Gungoren & Boyacioglu (2013), Pekmez, Aktamiz and Taskin (2009). SCSM is a model that focuses on 3 main dimensions, namely, traits, products and processes. Torrance (1990) considered fluency, flexibility, and original thinking as central features of creativity. Fluency means the number of original ideas produced, flexibility is the ability to 'change tack', and not to be bound by an established approach after that approach is found no longer to work efficiently. Originality is interpreted statistically: an answer which is rare, which occurs only occasionally in a given population, is considered original. Table 1 shows the distribution of items based on dimensions. The first dimension, traits, are creative individual characteristics demonstrated through fluency, flexibility and originality. Fluency means the number of ideas generated. In this study, the more the scientific ideas were presented, the higher the fluency increased. Whereas, flexibility means the ability to give ideas encompassing a variety of categories and are not tied to only one category. In this study, the more categories or approaches proposed, the flexibility also increased. Originality means, the extent to which ideas produced differ from those commonly used. The ability of students to provide bright ideas, different from answers given by their peers show their higher level of originality characteristics.

Chemistry involves abstract concepts and this causes difficulties for students to understand the topics mainly Acid and Base (Ozmen, 2004; Norasekin, 2008). The study by Chiu (2005) found that among the weaknesses of students in this topics are the students failed to clearly explain the neutralization process. Furthermore students will be considered the strength of an acid is higher if there are a high number of hydrogen atoms. By taking account on that findings, therefore, this CCT will covers topic Acid and Base. Table 1 shows the distributions of item in CCT based on dimensions. Next is the further description of the 7 items consists in the CCT.

Table 1 Distribution of Items Based on Dimensions

Item/ Dimension		**1**	**2**	**3**	**4**
Traits	Fluency	/	/	/	/
	Flexibility	/	/	/	/
	Originality	/	/	/	/
Product		Science Knowledge	Science Problem	Technical Product	Science Phenomena
Process	Thinking	/	/	/	
	Imagination		/	/	/

Item 1

The first task was about unusual uses. Based on the model of Torrance's Unusual Test (1962), this task was designed to measure the fluency, flexibility, and originality in using an acid for a scientific purpose. Within CCT, this covers Science knowledge (in the product dimension), fluency, flexibility and originality (in the trait dimension) and thinking (in the process dimension).

Item 2

To raise new questions, new possibilities from a new angle, requires imagination and it is necessary to make real advances in Science. The purpose of the second task was to measure the degree of sensitivity to Science problems. Within CCT, this covers Science problem (in the product dimension), fluency, flexibility and originality (in the trait dimension) and thinking and imagination (in the process dimension).

Item 3

Technical production is a key component of creativity in science. The third task was designed to measure students' ability to improve a technical product. In the present study, considering the age and character of the students and the purpose of measurement, a toothpaste, familiar to most secondary school students and contains many scientific principles was used as an object. Within CCT, this covers technical product (in the product dimension), fluency, flexibility and originality (in the trait dimension) and thinking and imagination (in the process dimension).

Item 4

The purpose of this task was to measure students' scientific imagination about acid rain phenomena. Within CCT, this covers Science phenomena (in the product dimension), fluency, flexibility and originality (in the trait dimension) and imagination (in the process dimension).

Scoring Procedure

The scores of Items 1 to 4 are the sums of fluency score, flexibility score, and originality score. The fluency score is obtained simply by counting all of the separate responses given by the subjects. The flexibility score for each task is obtained by counting the number of approaches or areas used in the answer. The originality score is developed from a tabulation of the frequency of all of the responses obtained. Table 2 shows the scoring procedure for *CCT*.

Table 2 Scoring Procedure (Adapted from Hu and Adey, 2002 and De Haan, 2011)

Traits	Scoring Criteria	Score Awarded
Fluency	No idea is stated/ Number of ideas are 0%-4% as compared to overall ideas	0
	Number of ideas are 5%-49% as compared to overall ideas	1
	Number of ideas are 50-99% as compared to overall ideas	2
	Number of ideas are ≥100% as compared to overall ideas	3
Flexibility	All of the ideas are in the same category/ One category is produced	0
	Two categories are produced	1
	Three categories are produced	2
	More than three categories are produced	3
Originality	The idea produced is ≥ 50% as compared to the whole sample	0
	One or more idea is between 20%-49% as compared to the whole sample	1
	One or more idea is ≤19% as compared to the whole sample	2
	One or more idea is ≤10% as compared to the whole sample	3

Purpose of the study

The purpose of this study was to test the validity and reliability of the *CCT*. According to Creswell (2014), validity refers to the ability of an instrument to measure a concept or construct matches for its proposed use, while reliability refers to the stability of the score of the instrument. In this study, validity referred to content validity and linguistic validity. The content validity gave more focus on the suitability of the contents of the Chemistry curriculum of Malaysia, while the linguistic validity focused on the format and the linguistic requirements. The reliability of the *CCT* was established through the test-retest procedure.

Respondents

This study involved experts and students. The experts comprised a total of three lecturers and two teachers with 5-25 years of experience. The experts were assigned to evaluate the content and linguistic validity. The students, comprising Form Four Science stream students, were assigned to evaluate reliability through test-retest procedure. The details of the number of respondents for each analysis are as shown in Table 3.

Table 3 Respondents involved in the pilot study

Type of Analysis	No of respondents	Role of the respondents
Linguistic Validity	2	To validate the instrument in terms of meanings of items, language, instruction and etc.
Content Validity	3	To validate the instrument in terms of suitability with the research objectives, respondents' cognitive level and etc.
Reliability	27	To evaluate the reliability of the test through test-retest procedure

Methodology

In this study, the draft of *CCT* was referred to the experts for validation. The first step taken was the linguistic validation, focusing on the spelling, the instruction, the clarity of the meaning of each item and the learning objectives. After improvements were made, the draft was prepared for the content validity. The draft of *CCT* was referred to the content experts to make sure that the content of this test was in line with the Form Four Chemistry Syllabus. Upon completion of the validity test, the improvised draft of *CCT* was analysed for its reliability. For this study, the reliability values were established through test-retest procedure, administered by the researcher at two different times on all the students at a sufficient time interval. In this test-retest procedure, all the respondents completed the *CCT* twice. The validity and reliability processes are as shown in Figure 1.

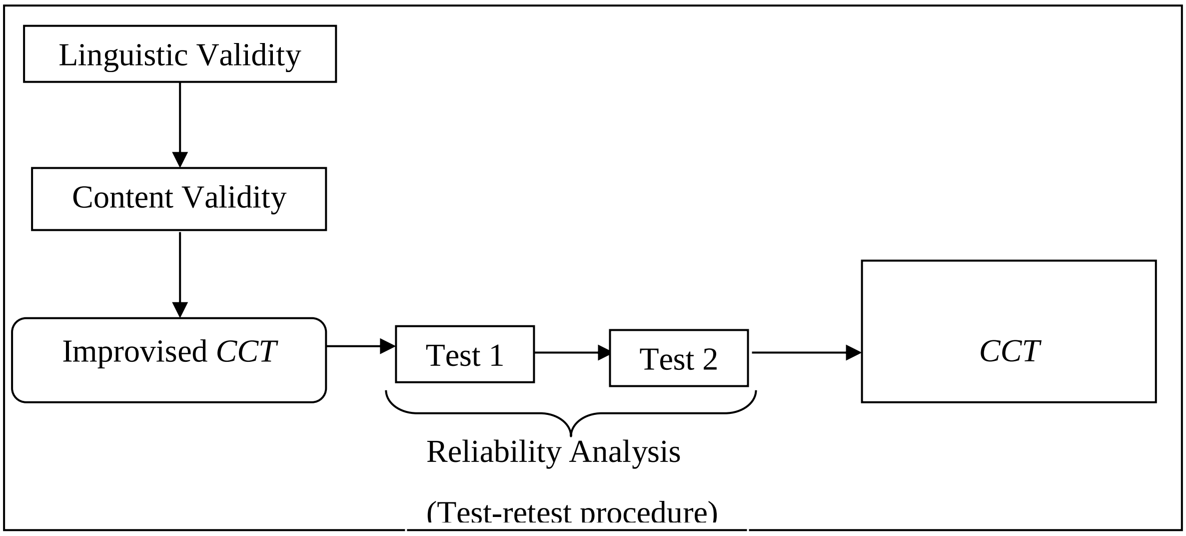

Figure 1: The process of pilot study for *CCT*

Results and Discussion

To determine the validity and reliability of *CCT*, the comment and suggestion from the experts and the result from the test-retest were utilized and the following results were revealed:

Validity

Impara (2010) stated that, each type of the instrument has a different type of validity which depends on the purpose of the particular instrument. In this study, the validation of the *CCT* was more focused on the content and linguistic validity. Table 4 below shows the views from the experts regarding the language used in the *CCT*. All of the experts agreed that there was no spelling error, that the font used was suitable and that, the language used was easy to be understood. However, there were a few comments on the instruction given by the experts, especially on how the instructions were written. The experts suggested that, each of the items would be better understood if written in the contextual form. Other than that it is also suggested for a new line to be provided for each task in the item. All of these comments were taken into account during the correction and improvement of the *CCT*.

Table 4 Views of linguistic experts

No	Item	Percentage Given by Experts (n=2)		Comments
		Yes (%)	No (%)	
1	The format of the study is suitable and interesting	50	50	The stimulus and the task must be in the same pages
2	The meaning of each item is clear	50	50	Too much information is given in a particular item
3	The language used is easy to be understood	100		Suitable
4	The size of the fonts is suitable	100		Suitable
5	The instructions given are clear	50	50	Each figure or table must be labelled, so the instructions become clearer
6	The font spacing is suitable	50	50	Each of the task must be written in a new line
7	The indicators for measurement scale are clear	100		Satisfactory
8	There are no spelling errors	100		Satisfactory
9	The objectives stated are clear	100		Satisfactory

Table 5 below shows the views from the content experts. All of the experts gave a positive response about the content of the *CCT*. In addition, for the content validity, the two teachers were also asked to evaluate whether the content of the *CCT* suited the Form Four

Chemistry Syllabus endorsed by the Minister of Education of Malaysia, 2012. The results showed that, the content of the *CCT* suited the suggested curriculum and was suitable to be used for Form Four science stream students.

Table 5 Views of content experts

No	Item	Percentage Given by Experts (n=3)		Comments
		Suitable (%)	Not suitable (%)	
1	Suitability with the research objectives	100		
2	Suitability of the language used	100		
3	Suitability with the cognitive level of the respondents	100		
4	The accuracy of construct and dimension used	100		
5	The clarity of the meaning of each item	100		
6	Alignment of the construct	100		

Reliability

For the reliability analysis, the *CCT* was administrated by the researcher at two different times, involving a total of 27 Form Four Science stream students. The value for the test-retest reliability coefficient, determined by using *Statistical Package for Social Sciences* software was .845. Table 6 below shows the results of the reliability analysis.

Table 6 The test-retest reliability coefficient for *CCT*

		Test 1	Test 2
Test 1	Pearson Correlation	1	.845**
	Sig. (2-tailed)		.000
	N	27	27
Test 2	Pearson Correlation	.845**	1
	Sig. (2-tailed)	.000	
	N	27	27

**Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation test results above showed that, for this group of subjects (n=27), the test-retest correlation value for the *CCT* was .845. This means that, the *CCT* was suitable for obtaining reliable data from other subjects with the same characteristics, namely, Form Four Science stream students.

Conclusion

This study reported an analysis of validity and reliability of *CCT* for Form Four Science students, especially those taking Chemistry subject. The *CCT* demonstrated a high degree of content and linguistic validity. The study also showed that, the *CCT* had high reliability values and was suitable to be used among Form Four science students especially in Malaysia context. This research can be considered as one of the initiatives to provide more creativity instruments on specific domains, specifically in the Malaysian context.

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