Development and validation of creative thinking skills test in the project of laboratory apparatus modification

by Chansyanah Diawati

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Development and validation of creative thinking skills test in the project of laboratory apparatus modification

C. Diawati
Universitas Lampung, Lampung, Indonesia

L. Liliasari & A. Setiabudi
Universitas Pendidikan Indonesia, Bandung, Indonesia

B. Buchari
Institut Teknologi Bandung, Bandung, Indonesia

ABSTRACT: This study reports on the development and validation of test assessments designed to measure students' creative thinking skills in a Visible Spectrophotometer (VS) and Atomic Absorption Spectrophotometer (AAS) apparatus modification project. The test form was an essay that was arranged based on Torrance's Framework of creative thinking skill indicators. A preliminary draft of the test instrument was validated by three experts in the field of chemical education. The instrument was administered to third-year undergraduate students in the chemistry education study program in Province Lampung. The results showed that the internal consistency of the instrument was fairly good, which indicates that the instrument can be used to measure the acquisition of students' creative thinking skills. This result is highly recommended for future empirical research in developing a creative thinking assessment, especially on the topic of a particular subject matter.

1 INTRODUCTION

Creative thinking skills are a major goal of science education, because school leavers and graduates who think creatively will contribute positively to the personal, social, technological, and economic world that they will inhabit as adults in the 21st century (Wellestrand & Tjeldvoll, 2003; Diawati, 2016; DeHaan, 2009; Trnova, 2014). However, sufficient emphasis has not been given to the measurement of creative thinking skills, in particular in science domains such as chemistry. Creativity is very difficult to define and measure (Runco, 1993). To estimate creative thinking potential, divergent thinking tests are often used. The term and the measures of divergent thinking were invented by Guilford (Hong & Milgram, 2010; Hong et al., 2013). Currently, there are two types of creative thinking measurements that have been developed by researchers. The first is the measurement of creative thinking in the general domain; the second is a specific domain measurement.

In the beginning, the instrument that was most often used to measure creative thinking over the years was an instrument measuring creative thinking ability, that is, the divergent thinking test, which always includes the measurement of ideational fluency (for example, Torrance, 1974, 1999). In the measurment of general domain creative thinking, the problem posed to the respondents to be completed is very different from the type of problems that people encounter in everyday life. For example, when responding to the ideational fluency measure, respondents were asked to name all the ways in which to use a newspaper. Although they have long been considered reliable measures of creative thinking ability (Runco, 1990), divergent thinking tests have been criticized for their low correlation with real-world performance, because the generalization from general domain creative thinking scores based upon ideational fluency measures to creative thinking in practical life situations is not entirely justified (Hong & Milgram, 2010; Okudo 1991).

Measurements designed to assess specific domain creative thinking have been developed (for example, Okudo 1991). *Real Life Problem Solving*, for example, provides respondents with the opportunity to utilize their creative thinking abilities in a variety of specific domain real life situations (Hong & Milgram, 2010). However, the problems that are provided to the respondents on the specific domain creative thinking measurement are general real life problems to be solved, not those for specific science-oriented domains, such as chemistry. For example, a test item is as follows, "Your friend Teddy sits next to you in class. Teddy likes to talk to you a lot and often bothers you while you are doing your work. Sometimes the teacher scolds you for talking, and many times you don't finish your work because he is

bothering you. What are you going to do? Remember to give as many answers as you can" (Okudo, 1991).

In relation to a visible spectrophotometer (VS) and atomic absorption spectrophotometer (AAS) modification practice that is being developed, we need a specific domain creative thinking skills test. Therefore, this article aimed to develop and validate the specific domain creative thinking skills test instruments of VS and AAS modification in project-based learning.

2 LITERATURE REVIEW

2.1 *Creative thinking skills*

Creative thinking is a skill to develop, to find, or to create new constructive combinations based on the data, information, or elements that already exist, with a different perspective that appears as a manifestation of their perceived problems, so as to produce a useful solution (Al-Suleiman, 2009; Lawson, 1979).

Although there are different concerns, creativity is considered as an essential life skill, which must be fostered through education (Shen & Lai, 2014). The previous research has shown that creative thinking is influenced by various circumstances, including whether collaboration works and the extent to which individuals are motivated to solve problems (Brophy, 2008; Zhou et al., 2010; Doppelt, 2009; Cheng, 2010). Most research suggests that there are differences in creativity and that students' gain achievement when the classroom environment is manipulated (Baker 2001; Sternberg, 2003).

2.2 *Assessment of creative thinking skills*

Many researchers have developed test assessments to measure creative thinking skills. The term and the measures of divergent thinking were originated by Guilford (Hong & Milgram, 2010; Hong et al., 2013) to measure the potential of creative thinking. The Torrance Creative Thinking Test (TCTT) has become a standard for assessing the ability of creative thinking. TCTT often requires considerable testing time, as it covers the figural and verbal forms. Torrance, Wu, and Ando created the Torrance Form Demonstration Test (D-TCTT), which requires less testing time, in 1980. The success of the short form when working with adults led to the current developments of the Abbreviated Torrance Test Adults (ATTA) (Shen & Lai, 2014). The development of measurements was designed to assess specific domain creative thinking (for example, Okuda 1991), which provides respondents with the opportunity to utilize their creative thinking abilities in a variety of specific domain real life situations (Hong & Milgram, 2010). Doppelt (2009) applies four layers as an assessment criteria of the Creative Thinking Scale (CTS) to assess the creative work of high school students. CTS includes, layer 1: awareness; layer 2: observation; layer 3: strategy; and layer 4: reflection.

3 RESEARCH METHODS

The method used in this research was descriptive. This article attempted to describe systematic, factual, and accurate information on the development and validation of the creative thinking skills test instruments in the chemistry domain during the VS and AAS modification project.

3.1 *The development of test instruments*

Tests were aimed to assess specific creative thinking skills in the VS and AAS modification project. Test items have been constructed so that such domain emerged. Tests were developed in an essay form, and based on creative thinking skills indicators using Torrance's Framework, that is, fluency, flexibility, originality, and elaboration (Al-Suleiman, 2009). Once the test was developed, then rubrics and scoring were created. The rubric was developed with four levels of gradation. The highest gradation level was scored 4, and the lowest level was scored 1.

3.2 *Expert judgment*

The test instrument was validated by three experts in the field of chemical education. Assessment aspects for the tests construction validation included: (1) the sentence is easy to understand, (2) does not waste words; (3) accordance with the concept scope; (4) the truth of concept, and (5) accordance with creative thinking skills indicators. Scores obtained from experts on the five aspects were analyzed using Intraclass Correlation (ICC) Two-Way Mix ANOVA that emphasizes the similarities of the assessment between raters. In addition, to examine the inter-rater reliability, the ICC correlation result was used to determine the validity of an assessment instrument based on the consistency of assessment among experts (ICC consistency).

3.3 *Testing the instrument*

A validated test instrument was administered to third-year students in the Program Studi Pendidikan Kimia in Province Lampung (N = 35). The test results were analyzed using Product Moment Pearson correlation: it is a type of correlation test to determine the empirical validity. Reliability was also analyzed using the Cronbach-Alpha formula.

4 RESULTS AND DISCUSSION

The developed test instrument consisted of 21 items. Examples of indicators and creative thinking skills test items are shown in Table 1.

Table 1. Examples of indicators and creative thinking skills test items.

The creative thinking skills indicators	Test items
Propose alternative ideas of VS/AAS component replacement and its modification (originality)	What are the VS components that can be modified? What is the reason? What is an alternative to its modification?
Describing work process flow of modified VS/AAS using images/charts in detail (flexibility and elaboration)	Describe work process flow of modified VS/AAS, using picture/charts in detail
Propose the idea of how to prove modified VS/AAS (fluency, originality)	How do you prove that the VS/AAS modified components work as expected?

The summary of the output analysis of the intraclass correlation coefficient (ICC) consistency between experts using SPSS 20.0 is shown in Table 2.

Based on the statistical analysis of the Two-Way Mixed ANOVA, the ICC consistency between experts on all the aspects is as follows: (1) the sentence is easy to understand is adequate (ICC = 0.756), (2) does not waste words is adequate (ICC = 0.658); (3) accordance with the scope concept is adequate (ICC = 0.669); (4) the truth of concept is good (ICC = 0.884), and (5) accordance with creative thinking skills indicators is good (ICC = 0.801). These analyses were conducted at the significance level of 95%. It indicates that the test instrument is valid and can be used to assess student creative thinking skills.

Of the results of the scores analysis obtained by students from the 24 test items of the preliminary version, 21 test items are valid and 3 test items are invalid. The three invalid test items were not used further. Therefore, the number of revised version test items is 21. Analysis using the Cronbach-Alpha formula at the significant level of 95% indicates that the test is a good internal consistency (α = 0899). These results indicated that the test instrument was valid and reliable, therefore, it can be used to assess student creative thinking skills.

The VS and AAS modification project requires students to apply knowledge and to train high-order thinking skills, such as creative thinking skills. Students formulated the problems, sought the replacement apparatus alternative, designed and constructed apparatus, tested and evaluated. These creative thinking activities are very specific, therefore they cannot be assessed using a creative thinking skills instrument of the general domain. Considering the importance of developing students' ability to think creatively in the specific domain of science, especially chemistry, researchers and practitioners should create test instruments

Table 2. The results of the analysis of intraclass consistency between expert judgments.

Aspects		Intraclass correlation[b]	95% Confidence interval Lower bound	Lower bound
The sentence is easy to understand	Single Measures	.110[a]	.001	.001
	Average Measure	.756[c]	.028	.028
Doesn't waste words	Single Measures	.071[a]	–.011	.821
	Average Measure	.658[c]	–.364	.991
Accordance to the concept scope	Single Measures	.075[a]	–.010	.825
	Average Measure	.669[c]	–.322	.992
The truth of concept	Single Measures	.234[a]	.045	.932
	Average Measure	.884[c]	.539	.997
Accordance to creative thinking skills indicators	Single Measures	.139[a]	.101	.888
	Average Measure	.801[c]	.208	.995

[a]The estimator is the same, whether the interaction effect is present or not.
[b]Type c intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.
[c]This estimate is computed, assuming the interaction effect is absent, because it is not estimable otherwise.

that are valid and reliable to evaluate the effectiveness of various learning efforts.

Both qualitative and quantitative data analysis was conducted and showed that the initial stage of this test instrument can be used to properly assess the students' creative thinking skills. Content experts were involved in reviewing the items during the item development stage, which provided evidence that the test items were clear and elicited the targeted specific domain creative thinking of VS and AAS modification.

Quantitative evidence showed that, in the stage of theoretical validation, the test instrument produced sufficient inter-rater consistency between the experts on aspects of ease of sentence to understand, do not waste words, and appropriateness with the concept scope; and good inter-rater consistency on aspects of the truth of concept and accordance to creative thinking skills indicators. This evidence indicates that the instrument is valid to assess student creative thinking skills.

In the empirical validation stage, quantitative analysis of the students' test scores showed that, of the 24 test items to have been developed, 21 test

item were valid, so therefore the number of items on the revised version of the test instrument was 21. The analysis also showed that the test instrument for creative thinking skills produced a good reliability coefficient ($\alpha = 0.899$), which means that the test instrument has good reliability to assess students creative thinking skills.

The development of the creative thinking skills tests described in this study were largely in line with the recommended guidelines for the preparation of the test and other performance tests (for example, Adams & Wieman, 2011; Aydın & Ubuz, 2014; Benjamin et al., 2015; Tiruneh et al., 2016). Although the procedure is based on the guidelines established from previous studies, this study has proposed a framework for assessing creative thinking skills that can be used to measure creative thinking skills in the specific domain of chemistry. It is hoped that creative thinking skills tests can be used as a good basis for future empirical research as well as for teaching purposes assessment focusing on the integration of creative thinking skills in a particular subject matter instruction. The test can be used to answer the research questions involving the assessment of the effectiveness of learning on the acquisition of the specific creative thinking skills of chemistry.

5 CONCLUSION

The instrument for measuring creative thinking skills during the VS and AAS modification project has been developed. The test consists of 21 items. Intraclass correlation coefficient (ICC) consistency between experts was adequate and good. This indicates that the test instrument was valid. Analysis for the Cronbach-Alpha formula indicates that the test had a good internal consistency ($\alpha = 0899$). These results indicate that the developed test instrument is valid and reliable, therefore it can be used to assess students' creative thinking skills. This result is highly recommended for future empirical research in developing a creative thinking assessment, especially on the topic of a particular subject matter.

REFERENCES

Adams, W.K. & Wieman, C.E. (2011). Development and validation of instruments to measure learning of expert like thinking'. *International Journal of Science Education*, *33*(9), 1289–1312.

Al-Suleiman, N. (2009). Cross cultural studies and creative thinking abilities. *Journal of Educational and Psychology Science*, *1*(1), 42–92.

Aydın, U. & Ubuz, B. (2014). The thinking-about-derivative test for undergraduate students: Development and validation. *International Journal of Science and Mathematics Education*, *13*(6), 1279–1303.

Baker, M. (2001). Relationships between critical and creative thinking. *Journal of Southern Agricultural Education Research*, *51*(1), 173–188.

Benjamin, T.E., Marks, B., Demetrikopoulos, M.K., Rose, J., Pollard, E., Thomas, A. & Muldrow, L.L. (2015). Development and Validation of Scientific Literacy Scale for College Preparedness in STEM with Freshmen from Diverse Institutions.

Brophy, D.R. (2006). A comparison of individual and group efforts to creatively solve contrasting types of problems. *Creativity Research Journal*, *18*(3), 293–315.

Cheng, V.M.Y. (2010). Teaching creative thinking in regular science lessons Potentials and obstacles of three different approaches in an Asian context. *Asia-Pacific Forum on Science Learning and Teaching*, *11*(1).

DeHaan, R.L. (2009). Teaching creativity and inventive problem solving in science. *CBE Life Sci. Ed, 8*, 172–181.

Diawati, C. (2016). Students' conceptions and problem-solving ability on topic chemical thermodynamics. In T. Hidayat et al. (Eds.), *Mathematics, science, and computer science education* (pp. 040002). *AIP Conference Proceedings* (Vol. 1708, No. 1, p. 040002). AIP Publishing.

Domain generality and specificity. *Creativity Research Journal, 22*(3), 272–287.

Doppelt, Y. (2009). Assessing creative thinking in design-based learning. *International Journal of Technology and Design Education*, *19*, 55–65.

Hong, E. & Milgram, R.M. (2010). Creative thinking ability:

Hong, E. et al. (2013). Domain-general and domain-specific creative thinking test: Effects of gender and item content on test performance. *The Journal of Creative Behavior*, *47*(2), 89–105.

Lawson, A.E. (1979). *AETS. Yearbook the psychology of teaching for thinking and creativity. Clearing house for science, mathematics, and environmental education*. The Ohio State University College of Education.

Okudo, S.M. (1991). Creativity and finding and solving of real-world problems. *Journal of Psychoeducational Assessment*, *9*, 45–53.

Runco, M.A. (1990). The divergent thinking of young children: Implications of the research. *Gifted Child Today*, *13*, 37–39.

Runco, M.A. (1993). Divergent thinking, creativity, and giftedness. *Gifted Child Quarterly*, *37*, 16–22.

Shen, T. & Lai, J. (2014). Exploring the relationship between creative test of ATTA and the thinking of creative works. *Procedia Social and Behavioral Sciences*, *112*, 557–566.

Sternberg, R.J. (2003). Creative thinking in the classroom. *Scandinavian Journal of Educational Research*, *47*(3), 325–338.

Tiruneh, D.T. et al. (2016). Measuring critical thinking in physics: Development and validation of a critical thinking testing electricity and magnetism. *International Journal of Science and Mathematics Education, Advanced online publication* doi:10.1007/s10763–016–9723–0.

Torrance, E.P. (1974). *The torrance tests of creative thinking*. Bensenville, IL: Scholastic Test Services.

Torrance, E.P. (1999). *Torrance test of creative thinking: Norms and technical manual*. Beaconville, IL: Scholastic Testing Services.

Trnova, E. (2014). IBSE and creativity development. *Science Education International*, *25*(1), 8–18.

Welle-strand, A & Tjeldvoll, A. (2003). Creativity, curricula and paradigms. *Scandinavian Journal of Educational Research*, *47*(3), 359–372.

Zhou, C. et al. (2010). Creativity development for engineering students: Cases of problem and project based learning. *Joint International IGIP-SEFI Annual Conference 2010*. Trnava, Slovakia.

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