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Assessing the Creative Thinking Level of In-Service Chemistry Teachers Using a Case Study Test

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Abstract: In the 21st century is an urge that teachers are not only required to change teaching methods but also have a role and responsibility to be able to motivate students' reasoning and logic to think critically, creatively, and innovatively. This study was conducted to assess the level of creative thinking skills of high school chemistry teachers in one of the districts/cities in Yogyakarta Province. As a survey with a quantitative approach, this study involved 24 in-service chemistry teachers as respondents. All of the population became the respondents in this study so that saturated sampling technique was applied. Creative thinking skills were measured using the creative thinking skill test (CTST). The results of the Aiken content analysis validity show that the instrument was suitable to apply with a score of 0.92. Six out of 10 test items are empirically valid with a reliability value of 0.697. CTST was filled in by respondents at the chemistry teachers' meeting forum. Data analysis was carried out using descriptive statistics to answer the categories of in-service chemistry teachers' creative thinking. Based on the results of CTST, it was 3.20 related to a sufficient creative thinking level category. The current research result suggests professional training for teachers to optimize their creativity in chemistry teaching strategy.

Keywords: chemistry learning, creative thinking, in-service chemistry teacher.

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INTRODUCTION

Currently, the teaching-learning activity adheres to a student-centered paradigm and demands the importance of transferable skills, called 4Cs critical thinking, creative thinking, communication, and collaboration (Trilling & Fadel, 2009; Wagner, 2010). The results of the 21st-century competency evaluation show that knowledge through the core subjects is not enough, it must be equipped with the ability to think critically, think creatively, have strong character, and be supported by information and communication technology capabilities. Learning experiences in the classroom need to be designed to develop student competencies in terms of collaboration, problem-solving, self-control, critical thinking, creativity, innovation, communication, and information and communication technology (ICT) skills (Rahmawati, 2017). The importance of creative thinking is not only prominent in rapid globalization (De Alencar et al., 2017), but also related to the role of the teacher which is still important in the learning process. As a facilitator, teachers must plan teaching-learning activities so that students are active in acquiring knowledge. The role of the teacher as a facilitator makes the teaching process run well under the teaching objectives (Pane & Darwis Dasopang, 2017).

Nowadays, based on the results of previous research, it is known that students' creative thinking abilities in Indonesia still need to be (Ernawati et al., 2019; Mulyanti et al., 2022; Nusowati, 2015; Nuswowati et al., 2017). It is urgent that teachers be not only required to change teaching methods, but also have a role and responsibility (Borodina et al., 2019) to familiarize students with applying 4C in

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everyday life to create learning activities that can motivate students' reasoning and logic to think critically, creatively, and innovatively, and can argue scientifically in solving a problem (Wagner, 2010). The results of the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) reveal that Indonesian students are very skilled when facing theoretical and rote questions, but do not get optimal results when facing questions that reveal high-level cognitive aspects, namely questions that require logical and reasoning (Salirawati, 2012). Thinking using logic and reasoning is included in critical and creative thinking skills. This fact shows that teaching in Indonesia is relatively unable to encourage students to use logic and reasoning when solving problems. Students' creativity can develop well if it is supported by several factors, such as providing good mental stimulation, creating an environment that is conducive to the emergence of students' creativity, and the role of teachers in developing teaching strategies related to exploring students' creativity (Septikasari & Frasandy, 2018).

Ideally, a teacher has creative thinking skills that can make students able to solve simple to complex problems. It will affect the usefulness of chemistry learning and its implementation in everyday life. Especially in chemistry teaching, the teacher's role cannot be ignored in gaining knowledge, both as a transfer of chemistry material and as a facilitator. Achieving students' transferable skills through learning will not be optimal if it is not supported by the teacher's ability to design teaching that shows vivid teaching methods to make students interested in learning (Smith et al., 2022). Student creativity will be formed if teachers can also deliver material that initiates students' creative ideas. Therefore, it is necessary to reveal the level of creative thinking abilities of high school chemistry teachers. This will support further research regarding the relationship between teachers' creative thinking abilities and their effect on students' creative thinking. The research questions asked to answer the research objectives are as follows.

1. What does the feasibility of the creative thinking skills test (CTST) to be used to measure the creative thinking skills of high school chemistry teachers look like?
2. Which level of in-service chemistry teachers' creative thinking skills is based on the results of CTST?

METHOD

Research Design

This research was conducted as a survey with a quantitative approach. The research was conducted on the level of creative thinking skills of high school chemistry teachers in one of the districts or cities in Yogyakarta Province. A total of 24 in-service chemistry teachers participated in this study. All of the sample from the population became the respondents in this study so the saturated sampling technique was applied.

Data Collection Technique

Table 1. CTST-Case Study Grid

Creative Thinking Aspects		Indicators	Item Number	Σ
A	fluency	generate lots of ideas and ways to solve problems	1	2
		provide analogies/illustrations for abstract concepts	2	
B	flexibility	answer questions according to the character of the questioner.	3	2
		replace old ways with new ways	4	
C	elaboration	explain the concept in detail	5	2
		explain the concept in a more interesting way	6	
D	originality	generate new and unique ideas	7	2
		think of unconventional ways	8	
E	sensitivity	take advantage of everything around you	9	2
		change strategy according to conditions	10	
		Total Number of Items	10	10

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Creative thinking skills are measured using an essay test called the Creative Thinking Skill Test (CTST)-based case study questions. It was adapted from five aspects of creative thinking skills, namely fluency of thinking, flexibility of thinking, elaboration, originality, and sensitivity (Guilford, 1957). The CTST consists of 10 essay questions. CTST was validated theoretically by experts through the delta-phi validation technique and was tested for empirical validity and reliability. The test grid can be seen in Table 1.

Suggestions from the experts were used to improve the CTST on the aspects of material, construction, and language. Three validators in the assessment field provided suggestions for improvement to suit the creative thinking measurement concept. All input/suggestions from the three validators were used as materials for improving the CTST quality. The improvements made can be seen in Table 2 below.

Table 2: CTST Improvement Based on Experts' Validation Results

No.	Validator	Suggestions
1.	Expert 1	Corrections are needed on several editorial errors.
2.	Expert 2	Statement 25 is added as an alternative to overcome learning boredom, namely by studying outside the classroom. Several statements should be presented as negative statements to check the consistency of the respondents' answers.
3.	Expert 3	Statements 10 and 12 should be emphasized so as not to cause misunderstanding.

Data Analysis

To answer questions that support the research objectives, the researcher conducted the data analysis using descriptive statistics to answer the categories of in-service chemistry teachers' creative thinking. This analysis was performed on CTST data. The category criteria are of five categories, namely very good, good, sufficient, poor, and very poor. Calculation of category criteria is carried out as follows.

Table 4. In-service Chemistry Teachers' Level Criteria

Profile Level	Criteria
Very Good	$\bar{X} > Mi + 1.8\ SDi$
Good	$Mi + 0.6\ SDi < \bar{X} \leq Mi + 1.8\ SDi$
Sufficient	$Mi - 0.6 < \bar{X} \leq Mi + 0.6\ SDi$
Poor	$Mi - 1.8 < \bar{X} \leq Mi - 0.6\ SDi$
Very Poor	$\bar{X} \leq Mi - 0.6\ SDi$

(Widyoko, 2009).

FINDINGS AND DISCUSSION

Results

The feasibility of creative thinking skills test (CTST) instrument

Three experts reviewed the CTST. The scores obtained from the three experts were then analyzed using the Aikens program. The result of the three experts' assessments using the Aiken formula analysis is presented in Table 5 below.

Table 5. CTST Aiken Test Results

Item Number	Material Aspect				Construct Aspect			Language Aspect		
	a	b	c	d	a	b	c	a	b	c
1	1.00	1.00	1.00	1.00	0.92	1.00	1.00	0.92	0.92	0.92
2	1.00	1.00	0.92	1.00	1.00	1.00	1.00	0.92	0.92	0.92

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Item Number	Material Aspect				Construct Aspect			Language Aspect		
	a	b	c	d	a	b	c	a	b	c
3	0.92	0.92	0.92	1.00	1.00	1.00	1.00	0.92	1.00	0.92
4	0.92	1.00	1.00	0.92	0.92	0.92	0.92	1.00	0.92	0.92
5	1.00	1.00	0.92	1.00	1.00	1.00	1.00	1.00	0.92	1.00
6	0.92	0.92	0.92	1.00	1.00	1.00	1.00	1.00	0.92	1.00
7	0.92	0.92	0.92	1.00	1.00	1.00	1.00	1.00	0.92	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.92	0.92	0.92
9	1.00	0.92	0.92	1.00	0.92	0.92	0.92	1.00	0.92	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00
Indicator Average	0.97	0.97	0.95	0.99	0.98	0.98	0.98	0.97	0.93	0.96
Aspect Average	0.98				0.98			0.95		
Total Average	0.97									

According to the standards, the index is above 0.92. It was declared fit for testing and met content validity. Based on the calculations of the Aiken index, both the average/indicator and the average/aspect obtained a value above 0.92, which means that the case study instrument for creative thinking skills developed is worthy of being used because it has fulfilled content validity. The empirical validity and reliability test results of the CTST instrument are presented in Table 6 below.

Table 6. Result of validity and reliability test

Instrument	Aspects	Item Number	Reliability Test Result
CTST	fluency	1, 2*	0.697 (Reliable)
	flexibility	3*, 4	
	elaboration	5*, 6	
	originality	7*, 8	
	sensitivity	9, 10	

*) incompatible with the validity criteria

Based on the results of empirical validity and reliability analysis, six questions were valid with a reliability value of 0.697. The results of this test show that the instrument is reliable enough to be used in research.

Level of in-service chemistry teachers' creative thinking skills

The results of data collection on solving creative thinking skills questions in the form of CTST case studies by 24 high school chemistry teachers were analyzed using descriptive statistics. The results of a brief recapitulation of the creative thinking skills of high school chemistry teachers based on the ideal values for each aspect are presented in Table 7.

Table 7. Descriptive statistics of in-service chemistry teachers' creative thinking skills based on CTST

	Creative Thinking Aspects	Average	Level
A	fluency	4.38	Very High
B	flexibility	2.96	Medium
C	elaboration	3.21	Medium
D	originality	2.46	Low
E	sensitivity	3.00	Medium
	Average	3,20	Medium

Table 7 shows that there is only one aspect that is in the very high category, namely fluency of thinking, which gained an average score of 4.38, and the lowest one is the originality aspect. Overall, the level of creative thinking skills of in-service chemistry teachers is in the medium category. These findings are discussed in the next section.

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Discussions

Based on the recapitulation analyzed from the results of the CTST case study, there is one aspect that meets the requirement value of a very high category, namely fluency. Fluency is the ability to generate lots of ideas so the case given in this aspect is to ask the teacher to design as many as possible simple experiments at home about the effect of concentration on reaction rates using tools and materials found in everyday life for their students. Because the topics that were asked are found in everyday life, both materials and tools, most teachers could answer very well, clearly, and completely. It is not difficult if the teacher can use their logic and reasoning ability so that ideas or thoughts emerge to answer it (Dyer et al., 2009). These results are supported by the teacher's statement written in the answer sheet, which reads: "When a chemical ran out in the laboratory even though the labwork had to continue, I thought about looking for alternative chemicals in the laboratory as a replacement." This is relevant to the teacher's ability to generate many ideas and ways of solving problems. Following the reality in the field, teachers are often faced with the problem of lacking certain chemicals for practical implementation (Zulirfan et al., 2022).

In the aspects of flexibility, elaboration, and sensitivity, the category gains medium criteria. Flexibility is the ability to look at something from a different angle or point of view, shifting to an opposing viewpoint (Wagner, 2010). As is known, chemistry content can be represented at three levels, namely macroscopic, microscopic, and symbolic, requiring a framework of specific teaching design efforts (Johnson, 1991). This leads the teaching-learning activity to construct, such as special strategies used by teachers to encourage the development of ideas in the chemistry classroom. Through this flexibility, teachers need to find as many as possible alternative learning media that are relevant to certain chemistry content. For example, in this research, the research content tested is to provide various communicative ways to explain the definition of atoms and their differences from elements and their symbolization. Teachers use various ways of communicating, one of which is by providing visual design images about atoms and elements and explaining them in simple language. Apart from that, the teacher has tried to provide relevant issues related to it. These alternatives show the teacher's way of thinking flexibly, showing something abstract that might direct students by directing their points of view and imagining the implementation of chemical concepts in a real way. Fluency in a series of key skills is providing clear and operational direction to students so they can understand real chemical content (Yani & Widiyatmoko, 2023) because creative thinking is a part of the higher thinking process (Wibowo & Laksono, 2015). It is likely that students inevitably face challenges and uncertainty when carrying out group projects and writing individual essays. To help students succeed, teachers must sometimes use strategies that require flexibility in abilities.

Elaboration is part of fleshing out the ideas in a group of collaborators, carrying an idea to fruition, and adding the details to make something real, understandable, or aesthetically pleasing. Elaboration takes an inspiring or original idea and completes it (Wagner, 2010). In this research, it consists of two indicators, namely the ability to develop ideas/ideas to broaden horizons and the ability to explain concepts in detail. In the context of chemistry learning in the classroom, elaboration can be demonstrated by the teacher's ability to update chemistry material through actual discoveries, explain chemical concepts down to the details, apply joyful learning in chemistry learning, and explain chemical material in a relaxed but engaging way, showing videos, animation, and other ways to make learning chemistry interesting. It is related to the meaning when creativity exists in the classroom, there will be a more conducive environment to learning chemistry through joy and happiness. Some possibilities may remain the same, no matter how strong the theory presented and introduced to chemistry teachers in their training, there is no guarantee that teachers will know how to do creative teaching when they start working in schools (Veerasinghan et al., 2021).

Sensitive creativity is a unique combination of creativity and sensitivity to see the surrounding environment as something that can give ideas that are unique or different from other people's ideas (Uno, 2022). Teachers think deeply and often have heightened awareness, which makes them highly attuned to their surroundings and the people around them. Such as in classroom learning, teachers have relatively maximized efforts to utilize current technology as a teaching mode. A teacher should have the effort to utilize whatever is in the surrounding environment to demonstrate chemical phenomena or carry out practical work, the teacher's ability to change models/methods/media so that students can receive an

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explanation of a concept, and the teacher's ability to change strategies to make chemistry learning more interesting (Korableva et al., 2019; Safiullin* & Akhmetshin, 2019) If it is trained and optimized, this technology can help teachers find ways of teaching that help students understand chemistry concepts more easily. Apart from that, the maximum role of the teacher is to demonstrate experiments to clarify chemical concepts empirically. Encouragement for teachers to have the courage to modify their teaching models and combine various talents to create interesting learning needs to be increased. If the implementation of this technology can be carried out in the field, it means that teachers can think creatively and mobilize their abilities, talents, and courage so that learning becomes meaningful.

Meanwhile, the lowest category was in the originality aspect. It mainly falls on the indicators of the ability to explain concepts more interestingly and the ability to think in unconventional ways (Dudek et al., 1993). In this section, the teacher was asked to develop certain chemical concepts creatively, such as combining chemistry concepts with art. As is known, chemistry is a part of science that requires mathematical skills, speaking skills, logic, and reasoning (Chang, 2010). This ability is related to left brain function which is related to logical things, facts, numbers, or mathematics for analysis (Kadir, 2010). The right brain is generally related to imagination, art, creativity, and music. In general, people who work in the field of chemistry use the left brain more dominantly (Shichida, 2013). Concerning this, the age is also possible that when they received their education, they were not trained in creative thinking skills. As a result, when teachers do not practice or rarely take part in training on creative thinking skills, they tend to have relatively less creative thinking skills. This should be overcome if they routinely or periodically read professional literature so they can show a better or even higher level of creativity. However, teachers have tried to implement varied or new teaching methods. This is stated through one of their answer statements: “When there is a trend in models/methods, new teaching approaches, I try to study and see how appropriate they are to the material and characteristics of students, then try to apply them.” This statement is translated from indicators of the ability to replace old ways with new ways. This statement shows that although teachers generally try to apply new models/methods and approaches that are trending, not in the meaning of always but often.

Overall, this research has revealed the level of creative thinking skills of chemistry teachers. The results of this study can be used as material for consideration for policymakers relating to improving the quality and competence of teachers, that high school chemistry teachers still need guidance to improve the skills that are the demands of the 21st century, especially creative thinking. The teacher's role is very large in the development and formation of students' creativity, starting from creating a learning atmosphere that is conducive to the emergence of creativity, to good mental stimulation so that students are not afraid to have different answers as their original ideas. There are several ways that teachers can improve their creative thinking, not only bringing knowledge to teaching but also using their interests as a learning experience for students, for example applying a musical hobby as a learning medium. So far, chemistry teachers have been connected in a forum called the Subject-Matter Teachers' Forum (MGMP), discussions in a group can create various inspirational references for teaching experiences. To gather creative ideas for teaching, teachers can search for the latest information from various available tools and curation. Based on several teachers' experiences, they began to be able to describe teaching ideas after having conversations with other teachers and leading a discussion. Meanwhile, barriers to thinking such as feeling unsure of one's abilities will become potential obstacles. As time goes by, teachers who try to learn new things to implement in teaching will become more accustomed to creating a creative atmosphere in chemistry classes. This needs to be followed by reflection from students, such as providing their responses to the natural learning process, and then readjusting by the teacher for further learning (Corazza, 2016; Miller, 2014; Mumford, 2003; Scheffer et al., 2017). Training and habituation are very necessary because developing a person's creative thinking abilities is the same as developing other cognitive abilities.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the CTST-based case study is suitable for measuring the creative thinking of in-service chemistry teachers based on expert judgment and empirical tests. In addition, the results of this research suggest considerations for further research as a means of improving teacher quality and competency. High school chemistry teachers in

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Indonesia still need guidance to improve skills that are demands of the 21st century, especially creative thinking skills. For chemistry teachers, this can be done by providing workshop activities, for example holding green chemistry-based chemistry labwork using environment-friendly tools and chemicals, or training in implementing teaching approaches using local wisdom as the context for chemistry.

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