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LEVEL OF CREATIVE THINKING AMONG PROSPECTIVE CHEMISTRY TEACHERS

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ABSTRACT

Creative thinking is one of the skills considered in facing the 21st-century era. Similar to other science domains, creative thinking is also crucial in chemistry learning. The variety of problems in chemistry makes students must be creative thinkers to solve chemistry problems faced. In the classroom, a chemistry teacher has a role in encouraging students' creative thinking. Other than that, this role also applies to prospective chemistry teachers who will have the same responsibility in the future. Therefore, this study aims to identify the level of creative thinking among prospective chemistry teachers, and identify the aspect of creative thinking that needs to improve. The research design used in this study was a quantitative approach with descriptive research. There were 92 prospective chemistry teachers in Pekanbaru, Riau-Indonesia selected using simple random sampling. Data were collected using open-ended questions and analyzed using the rubric of scoring. Once scoring was done, the score obtained was presented in form of a percentage of score to determine the level of creative thinking. The finding reveals that the level of creative thinking of prospective chemistry teachers was moderate (percentage score of 35.43). The prospective chemistry teachers were at a low level of flexibility and fluency with a percentage score of 27.29 and 27.42 respectively. This finding could be a consideration for any stakeholder to improve the quality of education by taking steps to improve creative thinking among prospective chemistry teachers. With the hope, that none of the students in the future found is at a low level of creative thinking because the students have been taught by competent teachers.

Keywords: 21st-century learning; chemistry; creative thinking; prospective teacher

INTRODUCTION

The emergence of Industrial Revolution 4.0 makes the demand of the world has been changed. Many aspects are changed, one of them is its impact on education which refers to the demands 21st-century skills. It is also called 21st-century learning, these skills included critical thinking, collaboration, communication, and creativity (Chusni et al., 2020). The education system must emphasize students' ability in facing the demand of 21st-century learning. In 21st-century learning, there are demands on all schools that must change their learning to student-centered learning, so this learning can support inductive, critical, and creative (Vong & Kaewurai, 2017).

In the classroom, the teacher must encourage 4Cs ability, especially considering any kind of creativity. That is because the teacher isn important person in preparing the students to face the demands of the era and to enhance the quality of learning (Kurniawan et al., 2019). According to Wiyarsi et al. (2018), creative thinking is one of the 21st-century skills that students must have. In this case, the teachers' performance influences encouraging students' creativity with the hope of students can learn to solve the problem (Sternberg, 2003).

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Creative thinking is useful to create the idea or find the solution to overcome problems in daily life and this skill is also crucial to real working as a foundation by students (Hadzigeorgiou et al., 2012). Lynch et al. (2019) also stated that creative thinking skills are the same as other subjects, in chemistry, the cognitive ability also considered creative thinking. It is also stated by Wiyarsi et al. (2018) that in learning chemistry, creative thinking among students is a crucial skill because it is useful to observe all things such as chemical representation. Creative thinking can be called a trait consisting of fluency, flexibility, and originality (Hu & Adey, 2002; Sumarni et al., 2021). According to Hadzigeorgiou et al. (2012), creative thinking skill is an ability as a foundation by students.

Creative thinking skills must be implemented in all topics such as mathematics, science, and technology to have a new idea (Lynch et al., 2021). It is the same with other subjects, in chemistry, the cognitive ability also considers creative thinking (Hadzigeorgiou et al., 2012). It is also stated by Wiyarsi et al. (2018) that in learning chemistry, creative thinking among students is a crucial skill because it is useful to observe all things such as chemical representation. The focus of chemistry education in learning is to make students understand the chemistry concept and relate to real situations. In chemistry, phenomena, problems, and processes related to chemical representation (Treagust et al., 2003). Chemical representation makes chemistry different from other science domains (Wimbi et al., 2021). Thus, creative thinking in chemistry learning is considered an essential skill.

Previous studies found that level of creative thinking of students in chemistry learning is low and tried to enhance the creativity level of students (Murtiningrum et al., 2013; Magdalena et al., 2014; Kusumawardani et al., 2015; Siregar et al., 2021; Zulkarnaen et al., 2022). A low level of creative thinking cannot be separated from the role of the teacher. That is because they potentially foster the creative potential of each student by facilitating the development of knowledge, skills, and attributes related to creativity in the context of formal education (Andiliou & Murphy, 2010).

Similar to the teacher, a prospective teacher also possesses an important role in developing creative thinking. It is supported by (Demir, 2015; Kaçan, 2015), who reveal that prospective teachers are equally important to the teacher and that they must be a creative thinker. That is because they will develop students' creative thinking in the future. Unfortunately, a study of creative thinking among prospective chemistry teachers is limited. Even though, this phenomenon will be found the root cause in the future if prospective teachers' performance is not considered. In other words, the prospective teachers need to be a creative thinker and their level of creative thinking needs to be investigated as soon as possible to give an overview of their skill before teaching. Therefore, this study aims to identify the level of creative thinking among prospective chemistry teachers, and identify the aspect of creative thinking that needs to improve.

METHODS

This study is a quantitative approach with descriptive research. The population in this study is 4th year chemistry education students in Pekanbaru, Riau-Indonesia. The technique of sampling used in this study is probability sample-simple random sampling. In determining sample size in this study, a simple size table by (Krejcie & Morgan, 1970) was used. Thus, as many as 92 prospective chemistry teachers were involved in this study. The following Figure 1 shows the research stages for this research.

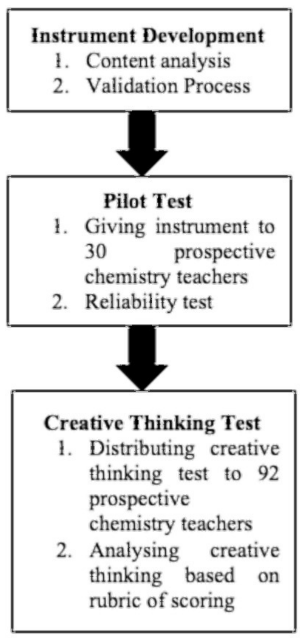

Figure 1. Research Stages

This study was begun with the development of the instrument. In this stage, content analysis was carried out to make sure the content provided in the instrument was in line with the curriculum. After that, the instrument developed was validated by three experts in chemistry education.

Furthermore, valid instrument obtained was distributed to 30 prospective chemistry teachers to check the reliability of the instrument. The prospective chemistry teachers' responses were analysed using SPSS to check alpha Cronbach. Lastly, a valid and reliable instrument was given to 92 prospective chemistry teachers. The responses obtained further were analysed using the rubric of scoring.

Research instrument used in this study is open-ended questions ((alpha Cronbach= 0.636 (reliable)). The questions are developed based on the rate of reaction as chemistry content. To collect data, a set of open-ended questions is given to prospective chemistry teachers. Data collected is analysed using the rubric of scoring adapted from (DeHaan, 2011; Omar et al., 2017) as Table 1 below.

Table 1. Rubric of Scoring

Creative Thinking Aspect	Scoring Criteria	Score
Fluency	No relevant idea	0
	1 – 4 ideas	1
	5 – 8 ideas	2
	More than 8 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	Ideas stated ≥50% as compared to the overall sample	0
	One or more ideas are between 20%- 49% as compared to the overall sample	1
	One or more ideas is ≤19% as compared to the overall sample	2
	At least one idea that is unique or common to more than 10% of the population	3

After scoring, the score is further changed in form of a percentage to identify the level of creative thinking of prospective chemistry teachers. Kaur et al. (2018) stated that percentage is every other way of describing a proportion as a fraction of a hundred. In this study, the total score of prospective chemistry teachers on is analyzed in form of a percentage of the score. Furthermore, to determine the level of creative thinking, the percentage of the score is compared to level criteria as Table 2 below.

Table 2. Criteria Level of Creative Thinking

Percentage of Score	Level of Creative Thinking
68 - 100	High
34 – 67.99	Moderate
0 – 33.99	Low

RESULTS AND DISCUSSION

The result of this study shows that the prospective chemistry teachers' creative thinking is still at a moderate level. According to Siew (2013), a moderate level means that prospective teachers are not yet capable of generating large numbers of ideas with different categories at one particular time and the ideas were mostly neither unique nor novel. In this case, moderate level shows that prospective chemistry teachers still do not have high creative thinking which can be seen from the limited ideas, and the categories of ideas that are conveyed are not varied.

In this study, the determination of the level of creative thinking was identified from the overall score obtained, and further was converted to the percentage of score to determine the criteria of level. The result obtained was discussed to observe what is extent of the level of creative thinking among prospective chemistry teachers and it would be discussed for each aspect of creative thinking (fluency, flexibility, and originality). The detail can be seen in Table 3.

Table 3. Level of Creative Thinking

Creative Thinking Aspect	Overall Score	Percentage of Score	Level criteria
Fluency	2.47	27.42	Low
Flexibility	2.46	27.29	Low
Originality	9.57	51.57	Moderate
The average percentage of score = 35.43			Moderate

Creative thinking is based on the experience and existing knowledge used to help people find a variety of input ideas in multiple perspectives and dimensions to create a new idea (Daud et al., 2012). According to Susanto (2011), students who have high creative thinking skills will more easily accept new concepts and students with creative thinking skills have creative ways of understanding a concept.

Referring Table 3, it reveals that in general, flexibility is the lowest aspect of creative thinking had by the prospective chemistry teachers (overall score = 2.46, percentage of score = 27.29). Flexibility is the ability related to the number of ideas or answers generated, not only having many answers but the answers must be varied. This also relates to the way students solve problems where sometimes students can produce more than one answer (Ernawati et al., 2019). The low level of flexibility in this study was in line with Wartono et al. (2018); Umar & Ahmad (2019) who also found that flexibility is the worst aspect belonged by students and prospective teachers.

In this study, the responses given by the prospective chemistry teachers for each question indicate that the flexibility level of producing ideas is low. The following Figure 2 shows an example of prospective chemistry teachers who are lacking in flexibility.

Answer:
In collision reaction A there is no collision reaction.
In collision reaction B, no reaction occurs and the collision is ineffective
In reaction C, there is an effective reaction and collision

Figure 2. Example of Respondent's Answer (R49)

Based on Figure 2, respondent R49 gave ideas with the same category, namely effectiveness collision, for all reactions as shown by the figure given. Therefore, the score obtained is 0 because only one category idea was produced. The low ability of students on the flexibility aspect is due to several factors, namely 1) many students who are not able to solve questions and are only fixated on one way, 2) many students are not able to or lack motivation in solving open-ended questions, and 3) students only see a problem from one point of view (Faizah, 2018). Furthermore, according to Ernawati et al. (2019), the low flexibility is caused by the students' answers coming from the same or less varied concepts. In this study, the low level of flexibility among the prospective chemistry teachers due to fewer chemistry concepts related to collision theory so the category idea produced tends to the same.

Next, another aspect of creative thinking with a low level is fluency. Fluency is the ability to produce a large number of ideas, the way students represent their answers also included flexibility and originality (Wiyarsi et al., 2018). According to Siswono (2011), fluency is indicated for someone to produce an appropriate idea to fluently answer questions. In this study, the prospective chemistry teachers must answer test questions as much as possible. However, the answers proposed by the prospective teachers were still inadequate. In other words, they were still not fluence enough to answer the questions so it impacts their creative thinking, for instance, the prospective chemistry teachers had a low level of fluency in answering all questions. The following Figures 3 and 4 show the answers from the prospective chemistry teachers.

Answer:
A. Ineffective collision
B. Effective collision
C. Ineffective collision

Figure 3. The Responses from Respondent R40

If both answers as shown by Figures 3 and 4 are compared, respondent R80 obtained a higher score than respondent R40. That is because respondent R80 produced more ideas than respondent R40.

Answer:

In collisions A and B, there are ineffective collisions. The possibility that occurs in collisions A and B is that the collision does not have sufficient activation energy when breaking bonds or forming all new bonds, thus causing no product to be formed. Therefore, this collision is not successful and cannot increase a reaction rate. Meanwhile, in collision C, there is an effective collision. The collision has sufficient activation energy at the time of breaking bonds or forming all new bonds, so that a reaction product is formed. Therefore, the collision is successful and cannot increase the rate of a reaction.

Figure 4. The Responses from Respondent R80

Even though both explained the effectiveness of collision occurred among molecules NO and O_3, respondent R80 explained the idea proposed by adding other ideas instead of only mentioning effective or ineffective collision. The comparison shows that the more ideas produced will impact their fluency level. Based on the ability of the prospective chemistry teachers in producing ideas, it can be concluded that they were not fluent enough to produce a large number of ideas in answering the question provided.

The third creative thinking aspect is originality. Originality is the ability to produce unique ideas or unpredictable ideas (Ernawati et al., 2019). In this study, referring to Table 3, the percentage score for originality is 51.57, which is higher than other aspects. It indicates that the prospective chemistry teachers have been able to produce slightly uncommon ideas in answering questions. Based on the score of originality obtained, the prospective chemistry teachers have been at a moderate level. It can be seen from how they answered all questions which always be at a moderate level. Thus, originality is the best aspect possessed by prospective chemistry teachers among other aspects of creative thinking.

For example, as shown by Figure 5 that many the prospective chemistry teachers tend to give ideas about the effectiveness of collision between two compounds, in fact, many components can be ideas such as the energy used, the reaction occurred, the product of the reaction occurred, and giving an illustration of how a collision occurred. The moderate level of originality is caused by some of the prospective chemistry teachers who proposed at least one idea that is unique or common to more than 10% of the population so which affected their scores obtained. Figure 5 shows an example of answers which obtained a score of 3.

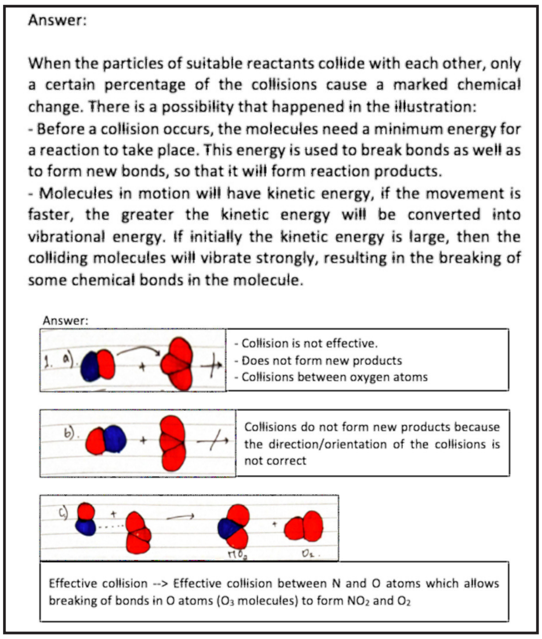

Figure 5. Example of Answers which Obtained a Score of 3 from Respondents R102 and R23

Based on Figure 5, the response from R102 predicts the possibilities that occur in terms of kinetic energy, molecular movement, and chemical bonds in molecules are related to the illustration given in the question. Furthermore, respondent R23 gave a unique idea by drawing an illustration of how molecules react and form products. In this case, the responses given by respondents show that they can give an uncommon idea to solve the chemistry problem given.

From the responses obtained in this study, prospective chemistry teachers' creative thinking is still at a moderate level. Specifically, flexibility and fluency are still at a low level, while originality is adequate (moderate level). Many factors affected to performance of creative thinking. Based on a study conducted among prospective teachers, the creative thinking of prospective physics teachers is suspected to be due to lecture activities that do not provide opportunities to practice creative thinking skills (Rizal et al., 2020). According to Meintjes and Grosser (2010), barriers to creative thinking in an academic setting can be due to a lack of tacit and explicit encouragement to think.

Furthermore, DeHaan (2011) stated that at the university level, the level of creative thinking is influenced by the ability of the faculty in developing creative thinking skills, encouraging the students to take part in a training program to empower and develop their positive teaching skills and the development of their skills. In addition, Huda et al. (2013) also revealed that creative thinking performance is influenced by the inappropriateness of the education environment.

Based on potential factors that affected the unsatisfied creative thinking among prospective chemistry teachers, the low level of fluency and flexibility and a moderate level of originality could be triggered by those things. Therefore, it needs improvement which can be carried out through training or any kind of treatment given which is beneficial to enhancing creative thinking at the university level. It is supported by Cherkasov & Smigel (2016); Kotluk & Kocakaya (2018) who stated that teachers' creative thinking depends on the quality of teachers' professional training which affects how creative they become in numerous ways.

These findings give an overview of creative thinking performance among prospective chemistry teachers, which educational stakeholders, universities, and government have an overview of the current situation and prepare training or treatment to improve creative thinking. It can be the first step to preventing future students with a low level of creative thinking.

CONCLUSION

Creative thinking is the ability that must be possessed by individuals in facing 21st-century learning demands. As future teachers who will develop creative thinking in chemistry, prospective chemistry teachers must be creative thinking first. The finding of this study shows that level of creative thinking of prospective chemistry teachers is moderate. In detail, the level of fluency and flexibility is still low, and a moderate level of originality aspect. It means prospective chemistry teachers in this study need to improve creative thinking because their ability in producing many categories of ideas is still low. The level of creative thinking found in this study needs to be concerned because it probably will affect future students' creative thinking. Hence, educational stakeholders, universities, and government need to take part in finding solutions to develop creative thinking appropriately, such as providing professional training or treatment. Through information on creative thinking levels found and efforts that will be taken, it hopefully can be the first step to preventing students with a low level of creative thinking in the future.

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