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Systematic Literature Review of Chemistry Learning to Improve Students' Creative Thinking Skills

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Abstract: The purpose of this study is to discuss novel approaches to teaching chemistry that enhance students' creative thinking skills (CTSs), as well as the kinds of research that are conducted and the tools that are used to measure CTSs. . This research use the PRISMA paradigm in conjunction with a systematic literature review approach. This method was employed by searching for Google Scholar. The analysis results of eight relevant journals and proceeding articles show five articles discussing the implementation of chemistry learning strategies to improve students' CTSs, with the distribution as follows: problem-based learning-scaffolding, STEAM-PjBL, case-based Learning, STMCpE textbooks based on chemo-entrepreneurship, and students' worksheet with the mind mapping strategy which amounts to 20.00% each. The types of research used were experimental methods (37.50%), research and developmental methods (12.50%), survey research (12.50%), ex post facto research (12.50%), and qualitative research (descriptive approach) (25.00%). Instruments for measuring CTSs are in the form of a CTS test with indicators developed by Torrance (75.00%), non-test (interview and observation) (12.50%), and unclear instrument (12.50%).

Keywords: Chemistry learning; Creative thinking skills; Literature review

Introduction

In the era of globalization, the development of science, technology, and information is growing very fast (Zan et al., 2023) and is competitive, which presents increasingly complex life challenges. To face this challenge, CTSs are very important to solve problems, generate new ideas, and create innovative solutions. CTSs can make people more productive and improve their quality of life (Sudrajat et al., 2023). These competencies provide the foundation for the creative problem-solving skills that are critical to the progress of science and necessary for students' future employment and economic growth. (Sukarso et al., 2022). CTSs emphasize idea generation, the creation of diverse skills, and alternative approaches to an issue (Feranie et al., 2023; Darussyamsu et al., 2019). CTSs are the foundation of science, including chemistry (Hadzigeorgiou et al., 2012; Zubaidah et al., 2017).

The CTSs of the pupils are still not ideal, nevertheless. The CTSs of the students at SMP Negeri 1 Jateng in Karanganyar, Central Java, Indonesia, demonstrate this as they continue to score poorly on three factors, such as originality, elaboration, and fluency, and only one indicator in the medium category, such as flexibility indicator (Pratiwi et al., 2019). Additionally, junior high school pupils in Jember, East Java, Indonesia, exhibited the similar thing (Amaliyah et al., 2023), grade VII students on SMPN 11 Teluk Keramat (Pabrianto et al., 2023), class XI MIPA students at Adabiah 2 High School Padang (Purwati & Alberida, 2022), and Chemistry Education students, Jambi University (Ernawati et al., 2019) where the CTSs was in the low category. Low students' CTSs will make it difficult to solve the problems or answer the questions given by teachers and to be less trying to find alternative answers (Madyani et al., 2020).

Low student CTSs are caused by a number of causes, one of which is the learning style that the students adopt. The primary emphasis of science (chemistry) education in Indonesia is memorization of scientific principles (Zubaidah et al., 2017) and the

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establishment of an innovative educational procedure in the classroom that is more focused on developing intelligence than CTSs (Feranie et al., 2023). Students' CTSs are still ignored in the educational process. (Saputri et al., 2023). This learning is less trained students' CTSs, especially in chemistry learning.

Several researchers have been working to improve students' CTSs in chemistry learning. These efforts are traced through systematic literature review research. Specifically, the research objectives are to describe innovative chemistry learning strategies to improve students' CTSs, types of research, and CTS instruments used.

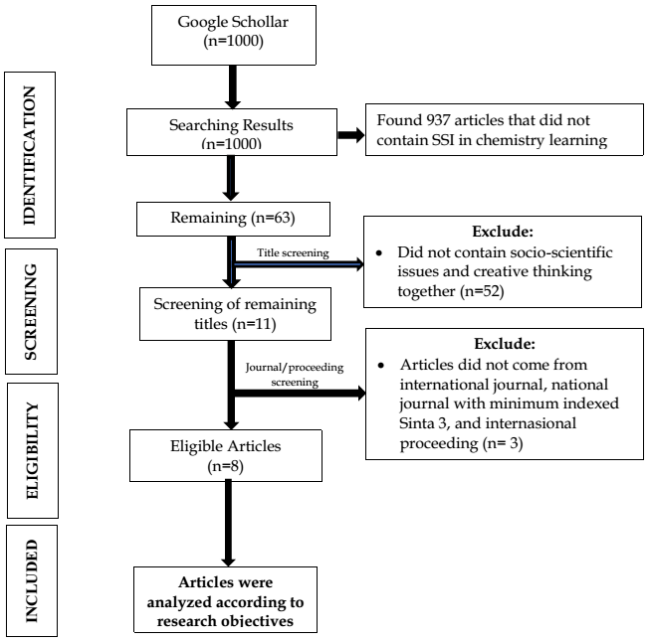

Figure 1. Model of articles screening

Method

This research of Systematic Literature Review was done using Selected Reporting Items for Systematic Review and Meta-Analyses (PRISMA) (Sohrabi et al., 2021) to analyze chemistry learning in improving students' CTSs. The flow of article collection went through the stages of identification, screening, eligibility, and fulfilling the specified requirements. The search for articles used the Google Scholar databases in the 2014-2023 range. The search process used the keyword "creative thinking." Search results were filtered to eliminate articles not meeting the inclusion criteria. The following were the inclusion criteria for reviews, including open access articles, articles published in Indonesian or English, articles published in international and national journals indexed at least in Sinta 3, international proceedings, and articles concerning chemistry learning and assessment of CTSs.

The search resulted in 1000 articles, and then the criteria for selecting article units were implemented, as shown in Figure 1. Eight articles met the inclusion criteria, and these articles were related to learning chemistry to improve CTSs. The data collected was analyzed qualitatively-descriptively. The data were presented in percentages to describe the distribution of learning strategies to enhance students' CTSs, types of research, and instruments used to measure CTSs.

Result and Discussion

Research Findings in Chemistry Learning

Table 1 showed that there were eight articles analyzed; five of them discussed students' CTSs in chemistry learning. These five learning models included the problem-based learning (PBL) model with scaffolding, the STEM (Science, Technology, Engineering, Art, and Mathematics) model with a project-based learning (PjBL) model, the case-based learning (CBL) model, the textbook on chemo-entrepreneurship based on Science, Technology, Engineering, Mathematics, and Contextual Problems (STMCpE), and a worksheet with a mind mapping technique for the students. The distribution of the use of each model was the same, that was 20%. All these models can improve students' CTSs in chemistry learning. An article discussed the connection between past knowledge and the capacity for creative thought. The profile of students' CTSs was presented in two papers.

Research findings in improving students' CTSs through PBL were also stated by other researchers (Kardoyo et al., 2020; Madyani et al., 2020; Nuswowati et al., 2017; Wartono et al., 2018). The PBL stage trained students' CTSs. For example, in the early stage, students were presented with open-ended problems that stimulated students to analyze the problems from different perspectives and think about solutions relevant to the issues identified. Similar findings also occurred for the PjBL model (Biazus & Mahtar, 2022; Putri et al., 2019; Wijayati et al., 2019; Yamin et al., 2020), STEM/STEAM_PjBL (Adriyawati et al., 2020; Lestari et al., 2018; Pramesti et al., 2022; Sumarni & Kadarwati, 2020), and mind mapping strategy (Miranti & Wilujeng, 2018; Pratama et al., 2020). The PjBL model improved students' CTSs by getting ideas and conveying them while working on projects (Chintya et al., 2023). Students had possibilities for chemistry learning engagement and the development of many thinking skill areas because to the STEAM integration

in the project-based learning paradigm (Rahmawati et al., 2019).

Table 1. Research Findings in Chemistry Learning to Improve CTSs

Researchers	Result
Ernawati, Sudarmin, Asrial, Damris, Haryanto, Nevriansyah, Fitriani, and Putri	In contrast to the traditional learning model and the problem-based learning model alone, students' CTSs were taught through a problem-based learning model combined with scaffolding in chemistry learning (Ernawati et al., 2022).
Rahmawati, Ridwan, Hadinugrahaningsih, and Soeprijanto	Project-based learning, which has the potential to foster CTSs, was used to incorporate STEAM into the teaching of acid and base composition. The combination of STEAM with chemical principles, time and resource management, teacher empowerment, and student engagement were hurdles for the study. The STEAM integration gave the studentsds chances to engage in chemistry lessons and strengthen their critical thinking abilities in a number of areas (Rahmawati et al., 2019).
Vani, Stephen, Anjana, Sreekala, Eranholi, and Rema	The first batch of Bachelor of Medicine and Bachelor of Surgery (MBBS) students' CTSs were aided by case-based learning. (Vani et al., 2022).
Sutarto, Nuriman, Budiarso, and Hasanah	Students' CTSs who studied with STMCpE-based chemo-entrepreneurship textbooks were higher than those with conventional learning (Sutarto et al., 2021).
Wardani and Mitarlis	The worksheet that the students completed using a mind mapping technique was doable and enhanced their CTSs and learning objectives for the stoichiometry materials (Wardani and Mitarlis, 2019).
Ahmar, Ramlawati, Masri, and Ahmar	There was a positive correlation between the two variables—prior knowledge and capacity for creative thought in chemistry (Ahmar et al., 2017).
Perdana, Budiyono, Sajidan, and Sukarmin	The CTSs of male students (mean score 46.95) were better than those of female students (mean score 44.31). The students' CTSs were low (Perdana et al., 2019)
Ernawati, Muhammad, Asrial, and Muhaimin	Less than 50.00 percent of the students' CTSs in bio-chemical materials fell into the excellent category. The following metrics showed improvement: 44.70 percent for sensitivity, 41.50 percent for fluency, 40.40 percent for flexibility, 43.10 percent for originality, and 39.40 percent for elaboration (Ernawati et al., 2019).

The other model improving CTSs was CBL. CBL stimulated students' CTSs by involving students in the case preparation stage (Vani et al., 2022). Students' develop CTSs with generating and assessing knowledge, elucidating notions, searching for opportunities, weighing options, and resolving issues. Additionally, CBL can enhance their communication and analytical abilities (Ciraj et al., 2010), and the learning environment's effectiveness in improving learning outcomes (Nair et al., 2013).

Furthermore, CTSs can be improved through mind-mapping strategies. These strategies brings out the consequences of freedom of expression that stimulates students' CTSs (Wardani et al., 2019). Mind mapping strategies train CTSs using imagination, connecting ideas, and flexibility (Zubaidah et al., 2017).

Research Type in Chemistry Learning

The research types used in chemistry learning research to improve critical thinking skills included quantitative research (experimental method, research and developmental method, survey, ex post facto) and qualitative research (descriptive approach). The distribution of these research types is shown in Table 2.

Table 2. Distribution of Research Type in Chemistry Learning

Quantitative Research (%)				Qualitative Research (%)
Experimental Method	Research and Development	Survey	Ex-post Facto	Descriptive
37.50	12.50	12.50	12.50	25.00
75.00				25.00

Table 2 shows that the most widely used research type is quantitative research, which is the experimental method. In this case, it uses a quasi-experiment design. These findings align with Walser's statement that experimental and quasi-experimental methods are increasingly being used to evaluate educational programs (Walser, 2014). The quasi-experiment design is similar to randomized controlled trials (Maciejewski, 2020). The selection of samples in the quasi-experimental design is carried out through the class or cluster random sampling technique because students are already grouped into classes, which are difficult to randomize student or class arrangement.

Instruments for Measuring CTSs in Chemistry Learning

The instrument for measuring students' CTSs researchers use refers to Torrance indicators and unclear instruments. They used are shown in Figure 2.

The instrument for measuring CTSs that researchers most widely use is a test using Torence indicators: sensitivity, fluency, flexibility, originality, and elaboration. E. Paul Torrance created the Torrance Tests of Creative Thinking in the 1960s (Alabbasi et al., 2022). The most often utilized tests are the Torrance Tests of Creative Thinking-Figural and Verbal (TTCT-F and V); TTCT-F is a more thorough, dependable, and legitimate measure of creativity (CTSs) than TTCT-V (Kim, 2017).

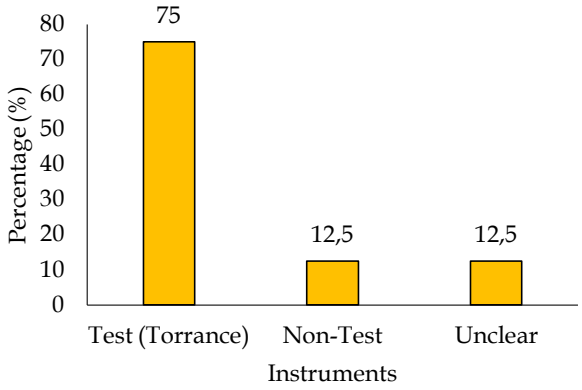

Figure 2. Distribution for measuring CTSs

Conclusion

The analysis article journal results and proceeding through the Systematic Literature Review show that the learning strategies to improve students' CTSs were problem-based learning-scaffolding, STEAM-PjBL, case-based learning, STMCpE textbooks based on chemo-entrepreneurship, and students' worksheet with the mind mapping strategy with 20.00% each. The type of research used was quantitative research (75.00%) [experimental method (37.50%), research and developmental method (12.50%), survey (12.50%), ex post facto (12.50%)] and qualitative research (descriptive approach) (25.00%). Instruments for measuring CTSs are in the form of a CTS test with indicators developed by Torrance (75.00%), non-test (interview and observation) (12.50%), and unclear instrument (12.50%). Further studies are to develop and test innovative chemistry learning tools to optimize students' CTSs.

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Author Contributions
I Nyoman Suardana searched for articles and wrote the manuscript. I Wayan Redhana reviewed and submitted the manuscript. Kompyang Selamat analyzed data and reviewed the manuscript. The published version of the work has been read and approved by all of the writers.

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Conflicts of Interest
No conflicts of interest are disclosed by the writers.

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