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# Strategies in promoting creative thinking skills in science classroom: A systematic review

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**Abstract**

There is an abundance of studies investigating the effects of teaching strategies on promoting students' creative thinking skills. However, most of the teaching strategies only focus on divergent thinking as a sub-skill to promote creative thinking among secondary school students. Besides, no systematic review has been carried out to propose a teaching strategy and approach that focus on three creative thinking sub-skills namely associative thinking, visual thinking and divergent thinking. Hence, to achieve this research objective, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were used. This research systematically review forty articles obtained from seven electronic databases: Web of Science, Scopus, EBSCOhost, ProQuest, Taylor & Francis, Google Scholar, and Google. These articles were traced from 2010 until 2022. This research found that the majority of these articles highlighted digital storytelling as a project-based learning teaching strategy that can be used to promotes these three creative thinking sub-skills. In addition, the review also found that the science scenario task-orientation was the predominant approach taken to incorporate students' creative thinking skills in the science classes. Overall, the contribution of this research has identifies project-based digital storytelling with science scenario approach as a comprehensive teaching strategy that can promote students' creative thinking skills in secondary science classes.

Keywords: Creative thinking, sub-skills, teaching approach, teaching strategy, systematic review

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## 1. Introduction

Organizations and societies worldwide are increasingly reliant on innovation and creative talents to handle new challenges, making innovation and creative thinking skills more important than ever (Foster & Schleicher, 2022; World Bank, 2021; UNESCO, 2021). Every individual is believed to have the ability to think creatively, either at a high or low level (OECD, 2019). According to Ramalingam et al. (2020) and Amabile et al. (1996), creative thinking skills can be enhanced through training. Moreover, there is a consensus among psychologists and educators that creative thinking skills are associated with the improvement of one's problem-solving skills and academic achievements (Rosli & Phang, 2021; Gupta & Kumar, 2020).

There are various definitions of creative thinking skills. For example, Guilford (1950), Runco and Jaeger (2012) define creativity as the ability to generate valuable ideas to solve problems practically and uniquely. Meanwhile, Torrance (1979) suggests that creative thinking means generating new ideas, such as students generating more ideas (i.e., fluency), and incorporating a variety of different ideas (i.e., be flexible) and unique ideas (i.e., original ideas). Those ideas need to be specific, detailed, and valuable (elaboration). Recently, the Programme for International Student Assessment (PISA) 2022 defines creative thinking skills as "coming up with new ideas and solutions" (Foster & Schleicher, 2022). Although the terms of definition differ, the concepts are similar in the process of thinking to produce a novel solution to the problem.

Next, Guilford (1956) also stated that the production of a novel solution is influenced by the skill of generating ideas known as divergent thinking. According to Mednick (1962), divergent thinking is highly dependent on an individual's associative thinking. Moreover, Ackerman (1974) stated that the process of associating ideas between ideas can only be achieved through the involvement of visual thinking, which is the ability to connect ideas through mental imagery. Therefore, the involvement of these three sub-skills is important to promote creative thinking skills effectively (Suyundikova et al., 2021; Masadeh, 2021). However, most of the past research that investigated the effect of teaching strategies toward promoting creative thinking skills only focused on one sub-skill which is divergent thinking (Zahro & Mitarlis, 2021; Supratman et al., 2021; Wijayati et al., 2019; Ahmad Adnan et al., 2019; Hanif et al. al., 2019; Safitri & Suparwoto, 2018; Siew et al., 2017; Lou et al., 2017 & Lamb et al., 2015). Thus, the past research does not provide much information about teaching strategies that involve all creative thinking sub-skills.

An equally significant aspect to promote creative thinking skills other than teaching strategies is the teaching approach taken by the teacher to direct students' focus on a task. The types of task-focus orientation also determine the success of incorporate all creative sub-skills into the regular classroom (Yang & Zhao, 2021). According to Cheng (2010), there are three different teaching approaches to include creative thinking skills in regular science lessons in the context of the science classroom. The science process-based approach comes first. The most vital and widely applied open inquiry strategy to foster creativity in science classrooms is this one. Through activities like asking students to come up with new hypotheses, this method involves students in the open-ended discovery and scientific inquiry process that aids in the development of new ideas.

Second, knowledge content and examination predominate in the science content-based approach. When using a science content-based approach, teachers can encourage creative thinking by having students apply science knowledge to tasks specified in the curriculum. For instance, assigning creative writing exercises based on the science concept being taught. The science scenario-based approach comes in third. Offering students the chance to "work with open-ended problems or tasks that require creative solution" is the goal of this strategy (Park & Seung, 2008).

All three of these approaches, though, face unique issues and conundrums. For instance, Cheng (2010) claimed that because they were less constrained by the rigid content in the syllabus, teachers and students felt that the science scenarios-based approach and science process-based approach were more approachable to initiate than the science content-based approach. However, teaching creative thinking through the science process-based approach might not work well with concurrent science concept learning. Students with weak science knowledge and poor creative skills may find applying scientific principles to be too complex. Apart from that, creative thinking is divergent and open-ended in nature. So, it is challenging to restrain students from a fixed-ended science content in developing creative thinking skills.

To sum up, based on these argumentations there are two main objectives in this reseach. The first objective of this article attempted to identify the teaching strategy that promote three creative thinking sub-skills. To fulfil this aim, the indicators set by Hu and Adey (2002) was taken as a guidance in this article. The selection of these indicators was made following the nature of study that used the sample of secondary science schools with three aspects of indicators: tret, process and product. To give further details, this article will list out examples of suggested activities based on previous studies. For the second objective, this article attempted to highlight the predominant teaching approach taken to incorporate these skills in the science classroom. Three approaches to incorporate creative thinking skills in the regular science classroom were referred as proposed by Cheng (2010), consisting of science process-based, science content-based and science scenario-based.

In the process of formulating research questions in this systematic literature review, we were guided by the PICO model that helped organize and focus on achieving the research objective. In this model, P stands for Population, which was, in this case, mainly targeting the secondary school students. In contrast, I is for Intervention, specifically aiming to enhance creative thinking skills. C is for Comparison, which was alternative instructional strategies. Lastly, O is for Outcome, covering creative thinking skills indicators in the science classrooms. As a result, four research questions have been identified as follows:

1. What teaching category is commonly used to promote creative thinking skills?
2. Which teaching strategy comprehensively focuses on all three sub-skills to promote creative thinking skills?
3. What teaching activities should be emphasized during teaching in promoting creative thinking skills?
4. What teaching approach taken to incorporate student's creative thinking skills in the science classroom?

## 2. Methodology

### *2.1. Research Design*

This article used PRISMA guidelines to conduct systematic literature review as indicated in Figure 1. PRISMA offers three key advantages, according to Subramaniam et al. (2022). First, it provides specific research topics that enable systematics research. Second, it creates exclusion and inclusion criteria, and third, it aims to analyse a large scientific database publication within a specific time frame. The reviewing process involved four steps: identification, screening, eligibility, and quality appraisal.

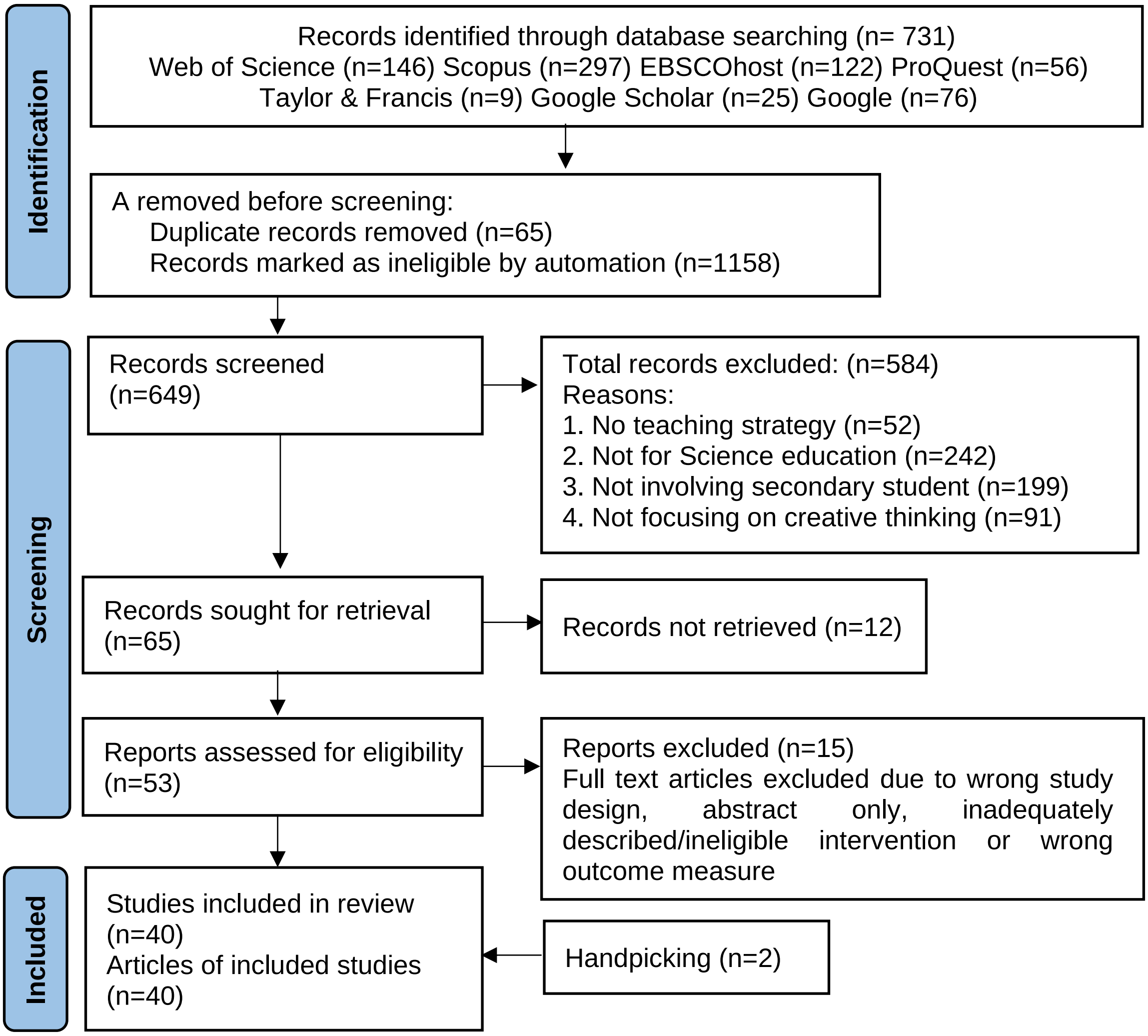


Figure 1. A flow diagram illustrating the study selection process adapted from the PRISMA diagram (Page et al., 2021)

### *2.2. Searching procedure*

The two main search methods used in this study were manual Google search and advanced search (Web of Science, Scopus, EBSCOhost, Proquest, Taylor & Francis, Google Scholars). To combine keywords in their advanced search, the researcher also used the phrase searching feature and the Boolean operator OR or/and AND. Handpicking, backward tracking, and forward tracking were the three main manual searching methods used in this study. As described in the following subsections, there were four steps in this reviewing process.

#### *2.2.1. First step: identification*

In step one, the identification step, we used more keywords for selecting and enriching the selected keywords so that more potential articles can be retrieved and to ensure the selected keywords would obtain the more relevant article. The primary keywords were obtained from the research question, and the researcher categorized the research question into three specific domains as recommended by Kitchenham and Charters (2007): teaching strategy, creative thinking skills, and secondary science education. These keywords ensured the adequacy through the identification step to identify synonyms, related terms, and variations. During the step, all databases were searched using the following terms identified in the title, abstract, or keywords: ("teaching strategy" OR "instructional strategy" OR "teaching approach" OR didactic OR Intervention OR Impact OR approach OR promote OR enhance) AND ("creative thinking skills" OR "creative imagination" OR "scientific imagination" OR "creative visualization" OR "creative in Science" OR "creative thinking" OR "creative in STEM"). The search results were then subjected to the inclusion and exclusion criteria outlined in Table 1.

Table 1. The inclusion and exclusion criteria

| **Criterion type** | **Inclusion** | **Exclusion** |
|---|---|---|
| Language | In either English or Malay | Non-English or Non-Malay |
| Document type | Journal articles or dissertation or theses | Conference proceeding or book |
| Topic | In the title, abstract, or keywords, the words "teaching strategy or approach", "creative thinking" and "Science" appear | Other words or terms stated |
| Recency | Published between 2010 and 2022 | Before 2010 |
| Finding | They present their findings regarding the impact of teaching strategy on creative thinking skills in the science classroom | No impact reported on their findings |

*2.2.2. Second step: screening*

The second step continued with the screening process based on the criteria shown in Table 1. This study included the publication timeline between 2010 and 2022. Only article journals and dissertation/theses that used English or Malay language were included, focusing on teaching strategies for promoting creative thinking skills. For the first screening process, from 649 articles, 584 articles were excluded.

*2.2.3. Third step: eligibility*

In step three, the eligibility, we evaluated the full article text in the eligibility step by reading the title and abstract and focused on four eligibility inclusion reasons as follows: 1) the articles should clearly state the teaching strategies as an intervention to promote creative thinking skills, 2) the teaching strategy is mainly targeted within secondary science education curriculum, and 3) the article evaluates the indicators of creative thinking skills to assess secondary science students' creative thinking. The selection of articles only involved secondary school students because each educational stage has different thinking characteristics compared to the primary to tertiary education students (Hu et al., 2013). Hence, in this study, we only selected article that targeted secondary school students. This final eligibility step has narrowed the study to 40 articles to be reviewed.

*2.2.4. Fourth step: eligibility*

For step four, quality appraisal, two reviewers appraised each of the remaining articles individually, paying particular attention to the abstract, methodology, and main findings. According to Petticrew and Roberts (2008), reviewers should assign each article a quality rating, ranging from low, moderate, or high. Only articles of a high or moderate quality were included.

The reviewers were directed by these five criteria for their quality assessment, which they adapted from the guidelines provided by Hong et al. (2018): 1) Are teaching strategies for promoting creative thinking skills among the articles' primary objectives? 2) Do the articles offer all the methodologies required to recognise the indicators of creative thinking skills? 3) Do the articles clearly state the approach taken to incorporate creative thinking skills to the researchers? 4) Does each piece of advice on developing creative thinking skills in the articles have a strong enough justification? 5) Are the articles providing any recommendation or suggested guidance on activities that promote creative thinking skills? The reviewers had three options for the response for each criterion: yes, no, or cannot tell. 40 articles were unanimously agreed upon by the reviewers for this study to satisfy the minimum requirement (high or moderate).

## 3. Results

This article's primary purpose was to present a comprehensive analysis of teaching strategies and pedagogical approaches to incorporate creative thinking skills into the science classroom. Therefore, a review of 40 studies were conducted on this topic. The data extraction answered the four research questions in this review as shown in Table 2, which compared all forty articles according to the creative thinking skills indicators used and teaching approaches taken to incorporate creative thinking skills in the science classroom. By addressing these questions, this review sought to summarize the current teaching intervention involving the indicators of creative thinking skills and to point out important aspects that were not covered.

All 40 studies reviewed in this article measured the effectiveness of teaching strategies on the creative thinking skills involving secondary school students aged 13 to 17 years old. The analysis found that 22 (55%) studies used 'Tret' as the only indicator of creative thinking skills. The indicator of 'Tret' represents the characteristic of a creative person proposed by Guilford (1950), consisting of four sub-indicators: fluency, flexibility, originality, and elaboration. Meanwhile, 15 (37.5%) articles included 'Process' as a creative thinking skills indicator, and 13 (32.5%) articles included 'product' as a creative thinking skills indicator. This result of analysis reflected that few articles considered 'process' and 'product' as the creative thinking skills indicators that were equally important to be considered in developing creative thinking skills. Moreover, including 'process' and 'product' as the creative thinking skills indicators could provide more holistic information regarding the most efficient teaching strategies (Rhodes, 1961).

Table 2. Data extraction table

| **Authors/Year/ Teaching Strategies** | **Creative Thinking Skills Indicators** | | | | | | | | | | **Creative Thinking Skills Approaches** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Trait** | | | | **Process** | | | **Product** | | | | | |
| | **F** | **Fl** | **Or** | **El** | **Im** | **Th** | **TP** | **SK** | **SPr** | **SPh** | **PS** | **SC** | **SS** |
| Hu et al. (2013) - PBL | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Lee et al. (2013) - Inquiry | ✓ | ✓ | | ✓ | ✓ | | | | | | | ✓ | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lin (2014) - PBL | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Lamb et al. (2015) - PjBL | ✓ | | | | | | | ✓ | | | | | ✓ |
| CrĂciun et al. (2016) - PjBL | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Sripongwiwat et al. (2016)- PBL | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Batlolona et al. (2019) - PBL | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| Abdul Kadir (2017) - PBL | ✓ | ✓ | | ✓ | ✓ | | | | | | ✓ | | |
| Karaca & Koray (2017) - Inquiry | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | | | ✓ | |
| Lou et al. (2017) - PjBL | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Siew et al. (2017) - PjBL | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Vidergor (2018) - Inquiry | ✓ | | | | ✓ | ✓ | | | | | ✓ | | |
| Wicaksono et al. (2017) - Inquiry | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Doa et al. (2018) - Hands-on | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Kumdang et al. (2018) - Inquiry | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| Safitri (2018) - PjBL | ✓ | ✓ | ✓ | ✓ | | | | | | | | ✓ | |
| Srikoon et al. (2018) - Inquiry | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Uğraş (2018) - STEM | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Hanif et al. (2019) - PjBL | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| Hernita & Djamas (2019) - PBL | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | ✓ |
| Nur et al. (2019) - Inquiry | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Ozkan & Topsakal (2019) - STEAM | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| Peng (2019)- PBL | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Mohd Shukri (2019) - PjBL | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| Wijayati et al. (2019) - PjBL | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Halim & Syahrun (2020) - PBL | ✓ | ✓ | ✓ | ✓ | | | | | | | ✓ | | |
| LO (2020) - STEAM | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| Muñoz (2020) - Hands-on | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Sun et al. (2020) - PBL | ✓ | ✓ | ✓ | ✓ | | | | | | | ✓ | | |
| Amida (2021) - Hands-on | ✓ | ✓ | | ✓ | | | | | | | | ✓ | |
| Aris et al. (2021) - Hands-on | ✓ | ✓ | ✓ | | | | | | | | | | ✓ |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Doğan (2021) - STEM | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| Furqon (2021) - Inquiry | ✓ | ✓ | ✓ | ✓ | | | | | | | ✓ | | |
| Bakırcı & Kırıcı (2021) - STEM | ✓ | ✓ | ✓ | | | | | | | | | | ✓ |
| Michalsky (2021) - PBL | ✓ | ✓ | ✓ | | | | | | | | ✓ | | |
| Putri et al. (2021) - PjBL | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Saregar et al. (2021) - PBL | ✓ | ✓ | ✓ | | | | | | | | | ✓ | |
| Supratman et al. (2021) -PjBL | ✓ | | | | | | | | | | | ✓ | |
| Zahro & Mitarlis (2021) - PjBL | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ✓ |
| Delawanti & Lutfi (2022) - Inquiry | ✓ | ✓ | | ✓ | | | | | | | | ✓ | |

F = Fluency; Fl = Flexibility; Or = Originality; El = Elaboration; Im = Imagination; Th = Thinking; TP = Technical Product; SK = Science Knowledge; SPr = Science Problem; SPh = Science Phenomenon; PS = Process Science; SC = Science Content; SS = Science Scenario.

## 4. Discussion

### *4.1. Common teaching category used to promote creative thinking skills*

According to Sidek et al. (2020), incorporated STEM-based learning, collaborative learning, ICT-based learning, and Project-Based Learning (PjBL) were common teaching categories used to cultivate students' creative thinking skills. Meanwhile, based on comparative analyses in Table 2, the most common teaching category used to promote creative thinking skills was Project-Based Learning (PjBL), with 11 out of 40 studies (27.5%) implementing PjBL as their intervention. This was followed by other teaching categories, such as inquiry (9; 22.5%), Problem-Based Learning (PBL) (8; 20%), multi-disciplinary integration STEM/STEAM (7; 17.5%), and hands-on (5; 12.5%). These teaching categories are summarized in Table 3.

Table 3. Teaching categories

| Teaching categories | Authors |
|---|---|
| PjBL | CrĂciun et al. (2016), Hanif et al. (2019), Lamb et al. (2015), Lou et al. (2017), Mohd Shukri et al. (2019), Putri et al. (2021), Safitri & Suparwoto (2018), Siew et al. (2017), Supratman et al. (2021), Wijayati et al. (2019), Zahro & Mitarlis (2021) |
| PBL | Abdul Kadir (2017), Batlolona et al. (2019), Hu et al. (2013), Lin (2014), Michalsky & Cohen (2021), Saregar et al. (2021), Sripongwiwat et al. (2016), Sun et al. (2020) |
| Multi-disciplinary Integration (STEM/STEAM) | Halim & Syahrun (2020), Bakırcı & Kırıcı (2021), Doğan & Kahraman (2021), LO (2020), Ozkan & Topsakal (2019), Peng (2019) Uğraş (2018) |

| | |
|---|---|
| Hands-on | Amida & Nurhamidah (2021), Aris et al. (2021), Doa et al. (2018), Hernita & Djamas (2019), Muñoz (2020) |
| Inquiry | Delawanti & Lutfi (2022), Furqon & Novita (2021), Karaca & Koray (2017) Kumdang et al. (2018), Lee et al. (2013), Nur et al. (2019), Srikoon et al. (2018), Vidergor (2018), Wicaksono et al. (2017) |

PjBL is a common intervention to promote creative thinking skills, and is driven by the fact that it is a systematic teaching category. It consists of five stages to further develop students' creativity, including curiosity and imagination. The five stages of PjBL are 1) preparation, 2) implementation, 3) presentation, 4) evaluation and 5) correction (Lou, 2017). During the PjBL stages, the students need to solve the problems related to daily-life scenario, which can bring to long-term knowledge acquisition (Zahro, 2021). Through this relevant problem scenario in PjBL, students can get an idea of actual concepts and their application so that they can individually practise and apply concepts that they have acquired (originality) to be used in obtaining various ideas (fluency) related to material that is reviewed from various influencing aspects (flexibility) to be more detailed (elaboration) (Torrance, 1979).

Project-Based Learning entails focusing on meaningful questions to solve a problem, decision making, and many sources of search procedures, allowing students to collaborate, and concluding with an actual product presentation (Machmudi Isa & Abdullah, 2013). Students are trained to solve problems and conduct searches from diverse sources by focusing on questions and difficulties. Students are encouraged to think outside the box and experiment with new ways of thinking in order to meet the requirements of fluency, flexibility, elaboration, and originality. As a result of the contributions of each stage in PjBL, students can be guided in strengthening their creative thinking skills, making PjBL a common teaching technique employed in prior studies.

### *4.2. Teaching strategy that comprehensively focuses on three sub-skills in promoting creative thinking skills*

According to Aguilera & Ortiz-Revilla (2021), it is found that interventions in the form of teaching strategies would be a determining factor in the development of students' creative skills. In this research, analyses of the 40 studies also found that the most comprehensive teaching strategy involving all three creative thinking sub-skills were teaching strategies that incorporated the elements of technology utilization and project-based learning with a science scenario-based approach. For example, studies carried out by Putri et al. (2021) and CrĂciun et al. (2016) used digital storytelling as an intervention to promote creative thinking skills in the regular science classroom. According to Cheng and Chuang (2019), digital storytelling helps to improve student subs-creative thinking skills through its implementation steps. He further explained that digital storytelling focused on imagination and thinking, helping students understand scientific concepts. Thus, imagination is a crucial element in promoting creative thinking skills that is usually not emphasized in the rest of the studies.

### *4.3. Suggested teaching activities should been emphasized to promote creative thinking skills in the classroom.*

Table 4 summarizes the activities proposed to develop creative thinking skills during science teaching. These activities have similar attributes, such as activities carried out in small group work and research-based activities through brainstorming that focus on divergent thinking (Sripongwiwat et al., 2016; Wicaksono et al., 2017). This statement is supported by Peng (2019), whereby brainstorming is one of the creative thinking activities that effectively promotes the students 'creative thinking in science learning (see Figure 2). For example, Peng (2019) argued that group members who recognized the practice of brainstorming would generate more ideas than those who avoided this strategy. Therefore, brainstorming orientation can help foster innovation in the organization by focusing the members 'attention on the goal of generating creative ideas (Dominggus et al., 2021).

Table 4. Suggested activites to promote creative thinking skills

| **Authors** | **Activities Suggested in the Articles** |
|---|---|
| 1. Hu et al. (2013) | - activities of image conversion and association |
| 2. Lee et al. (2013) | - orally present the new application of science concept learned |
| 3. Lin (2014) | - based on element of technological design |
| 4. Lamb et al. (2015) | - science concepts using personal computer platform |
| 5. CrĂciun et al. (2016) | - create and present own digital stories |
| 6. Sripongwiwat et al. (2016) | - brainstorming, making connection between prior knowledge |
| 7. Abdul Kadir (2017) | - relate existing experience to new concepts are learned |
| 8. Karaca & Koray (2017) | - group discussion |
| 9. Lou et al. (2017) | - mixed-gender groups-based research activities |
| 10. Siew et al. (2017) | - group activities involving initiation, brainstorming & association |
| 11. Vidergor (2018) | - mutual dialoque between students and teacher |
| 12. Wicaksono et al. (2017) | - brainstorming to formulate alternative problem solving |
| 13. Doa et al. (2018) | - solving daily life problem by appyling science knowledge |
| 14. Kumdang et al. (2018) | - argumentation between group of students |
| 15. Safitri & Suparwoto (2018) | - project of creating prototaip by applying science concept |
| 16. Srikoon et al. (2018) | - research group activities |
| 17. Uğraş (2018) | - solving daily life problem by applying multidiscipline knowledge |
| 18. Batlolona et al. (2019) | - give problem to associate prior knowledge with new knowledge gained |
| 19. Hanif et al. (2019) | - design & draws product in group and apply multidiscipline knowledge |
| 20. Hernita & Djamas (2019) | - worksheet and brainstorming based activities |
| 21. Nur et al. (2019) | - practical learning by using virtual media |
| 22. Ozkan & Topsakal (2019) | - design based activities made by group through worksheet |
| 23. Peng (2019) | - brainstorming activities in each phase of science instruction |

| | |
|---|---|
| 24. Mohd Shukri et al. (2019) | - design based activities |
| 25. Wijayati et al. (2019) | - project of creating prototype by applying science concept in group |
| 26. A Halim & Syahrun (2020) | - cooperative learning |
| 27. LO (2020) | - project involving imagination, creation, play, sharing and reflecting |
| 28. Muñoz (2020) | - watching videos and visualize model |
| 29. Sun et al. (2020) | - divergent thinking worked in small groups |
| 30. Amida & Nurhamidah (2021) | - students using guided worksheet to find answers and develop concepts |
| 31. Aris et al. (2021) | - investigation activities and application of knowledge learned |
| 32. Doğan & Kahraman (2021) | - using imagination skills, make innovative designs in group |
| 33. Furqon & Novita (2021) | - problem inquiry with hypothesis formulation and testing |
| 34. Bakırcı & Kırıcı (2021) | - worksheet based activities involving multidiscipline & brainstorming |
| 35. Michalsky & Cohen (2021) | - collaborative scientific problem-solving tasks |
| 36. Putri et al. 2(021) | - digital storytelling |
| 37. Saregar et al. (2021) | - connecting, organizing, reflecting, and extending science concepts |
| 38. Supratman et al. (2021) | - classroom interactions that allow students to work together |
| 39. Zahro & Mitarlis (2021) | - using worksheet that is oriented on the stages of a project-based task |
| 40. Delawanti & Lutfi (2022) | - guided worksheet involving inquiry learning |


Figure 2. Brainstorming as one of creative thinking activities that effectively encourage students' creative thinking skills in learning science (Peng, 2019)

In addition, activities that focused on student centralization by giving autonomy to students to explore the content of knowledge using the help of technology to facilitate the learning process were also recommended (CrĂciun et al., 2016; Hu et al., 2013; Lamb et al., 2015; Muñoz, 2020; Putri et al., 2021). Besides that, the students' understanding of concepts can be further strengthened through dialogues, argumentation or presentation, to help them master science concepts through the process of challenging the proposed ideas (Kumdang et al., 2018; Lee et al., 2013; Vidergor, 2018). Finally, the activities in all forty studies were mainly focused on applying the students' knowledge in daily life, which could contribute to meaningful learning at the end of the learning process.

### *4.4. Teaching approach taken to incorporate student's creative thinking skills in the Science classroom*

Based on data extraction in Table 2, a science scenario-based teaching approach is a predominant task-focus orientation taken to incorporate creative thinking skills in science classrooms. From the analysis of 40 studies, 18 studies used a science scenario-based approach compared to science process-based and science content-based approach, with 13 and 9 studies, respectively. This result can be further explained by referring to the study conducted by Cheng (2010), which states that the science scenario-based approach is frequently used as an approach to incorporate creative thinking skills in the science classroom because it is easier to begin with since it is less constrained by the rigid content in the syllabus. He also added that the science scenario-based approach requires the students to analyze ideas and decide on a creative solution to the open-ended problems in the task (Cheng, 2010).

## 5. Conclusion

In conclusion, to effectively promote creative thinking skills in the secondary science classroom, teachers can use Project-Based Learning (PjBL) such as digital storytelling together with science scenario-based task-focus orientation as a teaching strategy and approach. Among suggested activities that can be carried out during this approach are brainstorming, small teamwork assignments, research-based work, utilization of technology, student-centric methods such as dialogue, argumentation or worksheet, and problem-solving activities related to the daily life phenomena.

## 6. Recommendations

We reviewed some of the research associated to this study. Firstly, this systematic study provides information to the secondary school science teachers about the teaching strategies that can promote all sub-skills of creative thinking. Secondly, this study gives the example of teaching activities that can be carried out to stimulate students, and creative thinking during the lessons. Last but not least, this study identifies science scenario-based teaching approach as a predominant task-focus orientation that can be used by teachers to incorporate creative thinking skills in their classes. Based on the findings of this study, future research is needed for different educational levels, particularly in the science classrooms. Apart from that, to give more convincing data regarding the effectiveness of the teaching strategy in promoting creative thinking, future studies can also conduct meta-analyses presenting effect size of each compared teaching strategies to add more convincing data support similar to this topic.

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