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How Are Self-Regulation and Creative Thinking Addressed in Science Learning? A Research Trend Analysis Using the Scopus Database

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Abstract. Self-regulation and creative thinking skill are of the highly essential skills. This research aims to analyze trends in self-regulation and creative thinking research in science learning, visualize these trends, and their contributions to education in Indonesia. The research was conducted in September 2023 using the Scopus database. Keywords used were self-regulation OR self-control OR Creative thinking AND Science learning for multi years. A total of 107 documents were retrieved, and relevant ones were sorted, resulting in 96 documents. Data were analyzed using the VOSViewer and Biblioshiny applications. The analysis indicates a strong connection between self-regulation and creative thinking in science learning. Aldrige, Sajidan, and Velayutham are the most prolific authors producing research on this topic. Indonesia stands out as the most productive country in researching self-regulation and creative thinking in science learning. In terms of affiliations, Universitas Sebelas Maret emerges as the institution with the best output on this topic. Research on self-regulation and creative thinking in science learning makes a significant contribution to Indonesia, emphasizing the need for further in-depth studies related to other domains like critical thinking and motivation.

Key words: self-regulation, creative thinking, science learning, bibliometric

INTRODUCTION

Self-regulation and creative thinking are skills that must be possessed in the 21st century [1]–[4]. Self-regulation is the ability where an individual can systematically focus their thoughts, feelings, and actions to achieve goals [5]. Self-regulation can help students manage their thoughts, behaviors, and emotions to successfully direct their learning experiences [6]. Self-regulation consists of three stages: the first is anticipation before knowledge, which includes task analysis and goal setting; the second is performance control, involving the use of cognitive strategies like practice and elaboration; the third is self-reflection, where students evaluate and develop the reasons for their predetermined learning behaviors [7] (see Figure 1). Self-regulation is also described as the ability to assess and develop the dynamic, cyclical, active, and constructive learning behavior of students [8], [9]. Self-regulation is the result of a student's decision in learning to acquire information [10]. It is said that self-regulation is a metacognitive process, motivation, and dynamic behavior in learning that involves four main elemental processes: planning, learning, self-assessment, and monitoring [11], [12]. Given the importance of self-regulation, this skill is crucial to be nurtured throughout one's life [9]. Self-regulation cannot be acquired naturally; instead, it must be taught and continuously developed [13]. Numerous studies have shown that self-regulation correlates positively with academic performance [7], [14], [15].

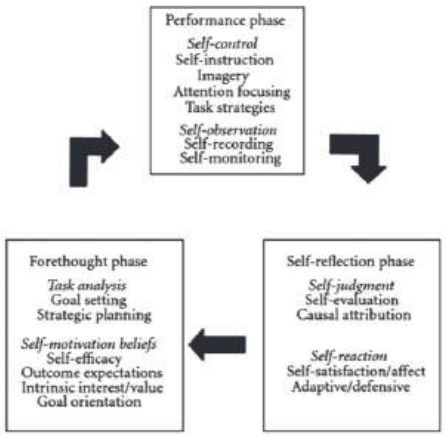

FIGURE 1. Cylic Process' self regulation [5], [12]

The self-regulation process in each phase has a different role. In the forward-thinking phase, students set goals, engage in strategic planning, and have a sense of self-efficacy to achieve the set goals. During self-reflection, students engage in self-evaluation and make attributions about their performance [5], [16]. Self-evaluation is comparing the results of self-observation with the standards/performance of other people. Positive self-evaluation makes students feel confident about learning and motivates them to continue to be diligent because they believe they are able to make better progress. Meanwhile, attribution is a belief about the causes of successful results [5].

Apart from self-regulation, creative thinking skills are important skills in the 21st century [17]–[21]. Creative thinking skill is one aspect of higher order thinking skills [22], [23]. Liu, et al explained that creativity is an indicator of students' cognitive development and is the core output of learning [24]. Lin, et al. stated that creativity is a skill that students need and is a skill that must be focused on in learning. It was explained that creative thinking skills help students in solving everyday problems and help students produce creative ideas needed in various activities [25]. Creative thinking skills are seen as a synthesis between lateral and vertical thinking introduced by De Bono [26]. Lateral thinking refers to discovering new ways of thinking to discover ideas, while vertical thinking relates to developing ideas and comparing those ideas with objectives. This thinking starts from initial generative ideas, not fixed classifications, which then ends in a systematic and selective nature obtained from an approach to finding the most appropriate solution. Meanwhile, lateral thinking produces a wide variety of alternative approaches in generating ideas, it does not have to be correct at every step and does not use fixed categories [26]. Creative thinking skills have several indicators according to Greenstein [27], namely *curiosity*, *fluency*, *originality*, *elaboration*, *imagination*, *flexibility*. Suryandari, et al divide aspects of creative thinking skills into four, namely *fluency, originality, elaboration*, and *flexibility* [28]. Other literature states that creative thinking skills can be measured using the Creative Thinking Scale (CTS) adapted from Barak & Doppelt [29].

Many studies in the world have examined the role of self-regulation and creative thinking skills in education. For example, in Indonesia, such as research conducted by Suryandari in 2021, Sajidan in 2018, Hidayat & Aurelia in 2023, Santoso, et al in 2022, Rizki, et al in 2022 [30]–[34]. In China researched by Li, et al in 2023, Liu & Xiadong in 2023, and Hu, et al in 2023, Bai & Wang in 2020, Sun et al in 2022 [7], [35]–[38]. In the USA researched by Zheng, et al in 2019, Hilpert, et al in 2023, Lu et al in 2022 [39]–[41]. In Canada researched by Daniel, et al in 2023, Aloysius, et al in 2023, Marilyn & Lee in 2023 [18], [42], [43]. In Korea researched by Lee & Kwon in 2023, Kate et al in 2021, Park & Kim in 2022, Han & Suh in 2022 [44]–[47]. In Germany researched by Wild & Grassinger in 2023, Fan et al in 2022, Holzapfel et al in 2022 [48]–[50].

Research Questions

This research focuses on the trends in self regulation and creative thinking in science learing with five research questions:

a. To what extent is the publication profile of self regulation and creative thinking in science learing?
b. To what extent is the distribution of publications on self regulation and creative thinking in science learing among countries and affiliations worldwide?

c. Who are the most productive authors in self regulation and creative thinking in science learing research worldwide?
d. What is the visualization of the trends in self regulation and creative thinking in science learing?
e. To what extent does self regulation and creative thinking in science learing research contribute to education in Indonesia?

METHODS

This research conducts a systematic review of published empirical studies to identify research on self regulation and creative thinking in science learing. This systematic review uses a bibliometric analysis adapted from Kulakli & Osmanaj; Yang, dkk; Bonilla-Chaves & Palos-Sánchez [51]–[53].

FIGURE 2. Five steps in conducting bibliometric analysis [54], [55]

The literature search was conducted in September 2023 using the Scopus database. This research used three search terms in titles, abstracts, and keywords self-regulation OR self-control OR Creative thinking AND Science learning in multi years. The literature search yielded a total of 107 documents. Of the 107 documents, 96 met the search criteria. The data were documented in a (.csv) format. Then, this data was processed and analyzed using VOSViewer and Biblioshiny applications to examine research trends in self regulation and creative thinking in science learing.

RESULT AND DISCUSSION

1. Result

The publication profile of self regulation and creative thinking in science learning

Search results for scientific articles relevant to research on self-regulation and creative thinking in science learning in the Scopus database resulted in 96 documents. This publication focuses on publications in each year which can be seen in Figure 6 which shows that research on self-regulation and creative thinking in science learning started in 1996 and continues to produce until 2023. 2021 is the year when the number of research on self-regulation and creative thinking in science learning was the highest compared to other years, namely 16 documents (see figure 3).

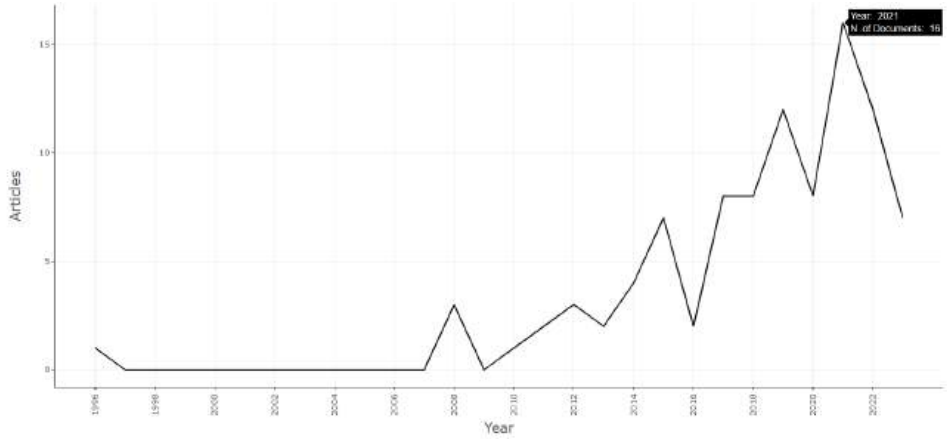

FIGURE 3. Number of research documents on self regulation and creative thinking in science learning

Figure 3 shows the production of self-regulation and creative thinking in science learning research each year. It is known that research on this topic began to be published in 1996 with 1 document. Meanwhile, in 1997-2007 there was no research on this topic.

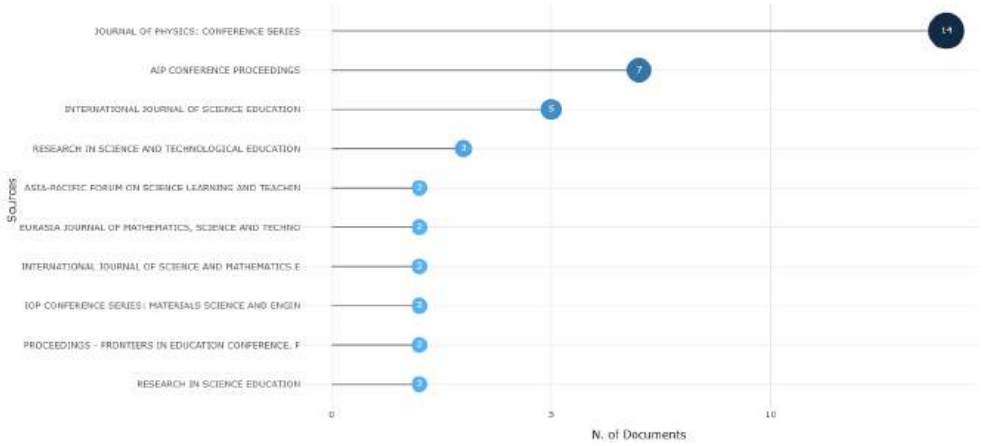

FIGURE 4. Top 10 most relevant sources of research self regulation and creative thinking in science learning

Figure 4 shows that the most research on self-regulation and creative thinking in science learning was published in the journal of physics: conference series, namely 14 documents. Continuing in second place is the AIP conference proceedings with 7 documents, and in third place is the international journal of science education with 5 documents.

Distribution of publications on self regulation and creative thinking in science learning among countries and affiliations worldwide

Based on the number of documents between countries, it is clear that Indonesia is ranked first. Followed by the USA in second place, and Australia in third place.

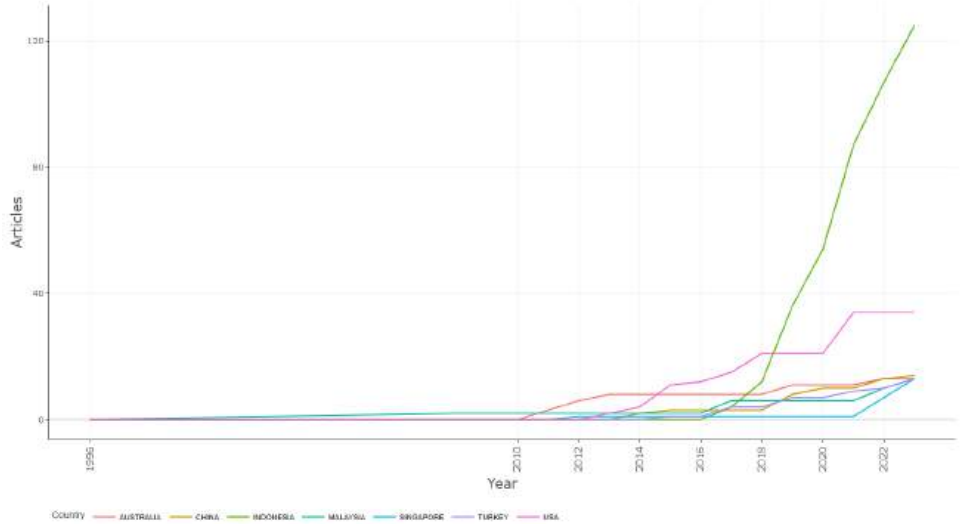

FIGURE 5. Number of research documents on self regulation and creative thinking in science learning by country

Based on the number of documents analyzed spread across all institutions, it can be seen in Figure 5. It can be seen that Sebelas Maret University/University of Sebelas Maret is the institution that has produced the most research on self-regulation and creative thinking in science learning, namely 22 documents. Followed by Curtin University with 8 documents, and the University of North Carolina at Chapel Hill with 7 documents.

TABLE 1. The institution that has produced the most research on self regulation and creative thinking in science learning

No	Affiliation	Articles
1	Sebelas Maret University/Universitas Sebelas Maret	22
2	Curtin University	10
3	University of North Carolina at Chapel Hill	7
4	Nanyang Technological University	6
5	Postgraduate Lambung Mangkurat University	6
6	UIN Raden Intan Lampung	6
7	Universitas Pendidikan Indonesia	6
8	Universitas Negeri Malang	5
9	Peter the Great St. Petersburg Polytechnic University	4

Most productive authors on self regulation and creative thinking in science learning

In terms of the most productive authors researching self-regulation and creative thinking in science learning, Figure 6 shows the number of authors who produce the most on this topic. The blue dots indicate the number of publications, the larger the circle size the greater the number of publications. Meanwhile, the density of the color shows the number of citations, the darker the color, the greater the number of citations. Aldrige, Sajidan, and Velayutham are the most productive authors producing research on self-regulation and creative thinking in science learning, namely 3 documents.

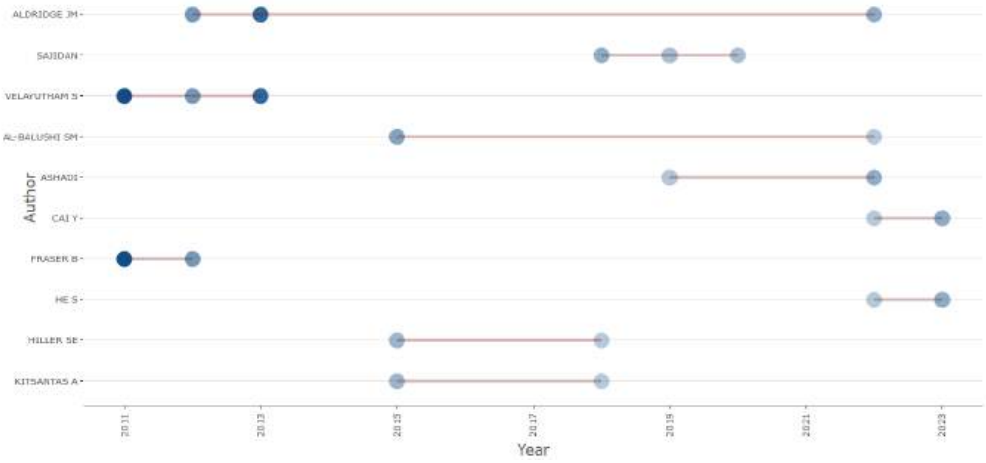

FIGURE 6. The most productive authors in self regulation and creative thinking in science learning

In terms of the number of citations, the top author is Velayutham with 225 citations, followed by Fraser ranked 2nd with 150 citations, and Aldridge 119 citations.

TABLE 2. Top citation of article/document

No	Author	∑citation
1	Velayutham	225
2	Fraser	150
3	Aldridge	119
4	Albalushi	24
5	Sajidan	19

Visualization of the trend self regulation and creative thinking in science learning

Based on the results of the analysis of 96 articles related to self-regulation and creative thinking in science learning in the Scopus database, researchers can produce findings about thematic maps through the biblioshiny application. This research analyzes the thematic map by dividing it into four theme quadrants based on density and

centrality. Themes in the upper right quadrant should be developed and studied further because of their high density and centrality. In contrast, specific, rare, but highly developed themes with high density and low centrality are above the upper left quadrant. Furthermore, themes with a downward trend are in the lower left quadrant, while fundamental themes with high centrality but low density are in the lower right quadrant. The Thematic Map shows that there is a connection between three themes, namely science learning, creative thinking, students. Further research regarding the relationship between these three things has great opportunities to be developed and studied. This means that further research can examine students' creative thinking in science learning.

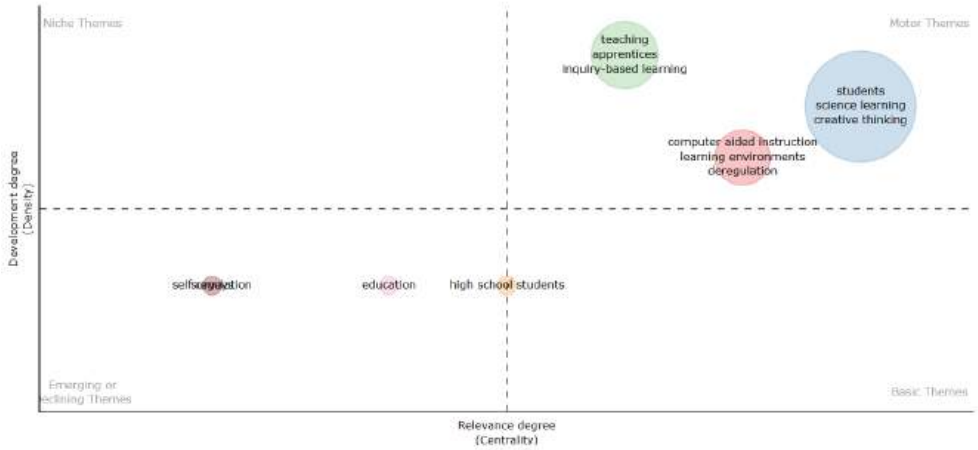

FIGURE 7. Thematic map

From the data above, additional testing will be carried out via the VOSViewer application. This helps to confirm the results data from biblioshiny regarding the novelty of research in this domain. Figure 8 shows the overall picture of research on self-regulation and creative thinking in science learning. Researchers around the world produced three clusters (red, green and blue). The first cluster (red) is the relationship between self-regulation and creative thinking in science education with other domains such as motivation, self-efficacy, and so on. The second cluster (green) is the application of self-regulation and creative thinking in science education such as impact, inquiry, teaching, and so on. The third cluster (blue) shows several indicators of self-regulation and creative thinking in science education such as fluency, originality, and so on.

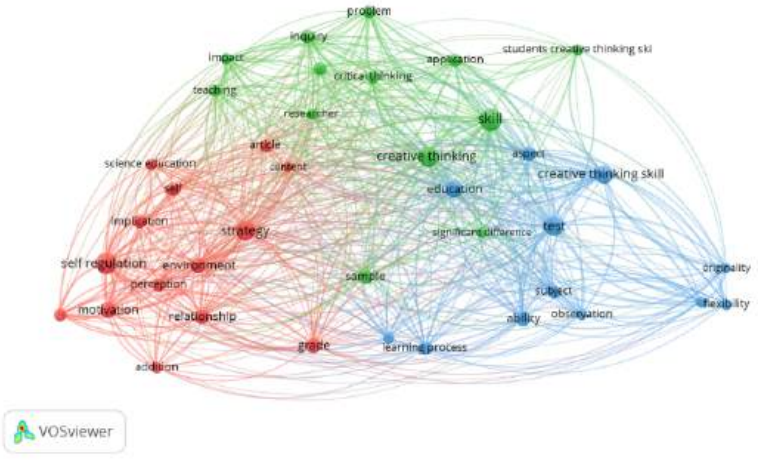

FIGURE 8. The whole picture of research on self regulation and creative thinking in science learning

To determine the novelty of research on self-regulation and creative thinking in science learning, it can be done by describing the specific relationships between variables. Figure 9 reveals this picture.

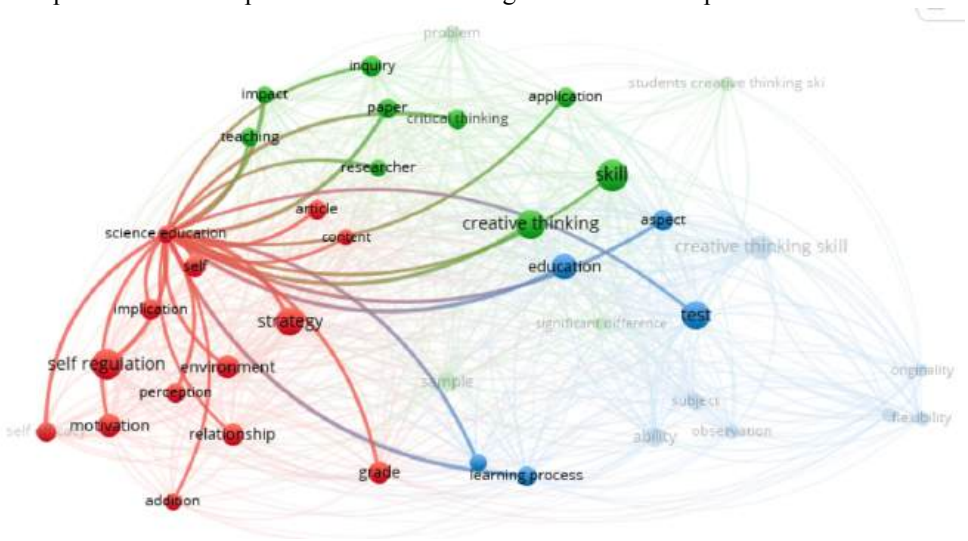

FIGURE 9. The relationship of self regulation and creative thinking in science learning with other domains

Figure 9 shows that research on self-regulation and creative thinking in science learning is related to teaching, education, inquiry, problems, motivation, and so on. Apart from the education domain, research on self-regulation and creative thinking in science learning is also related to other variables such as critical thinking, motivation, perception, and so on.

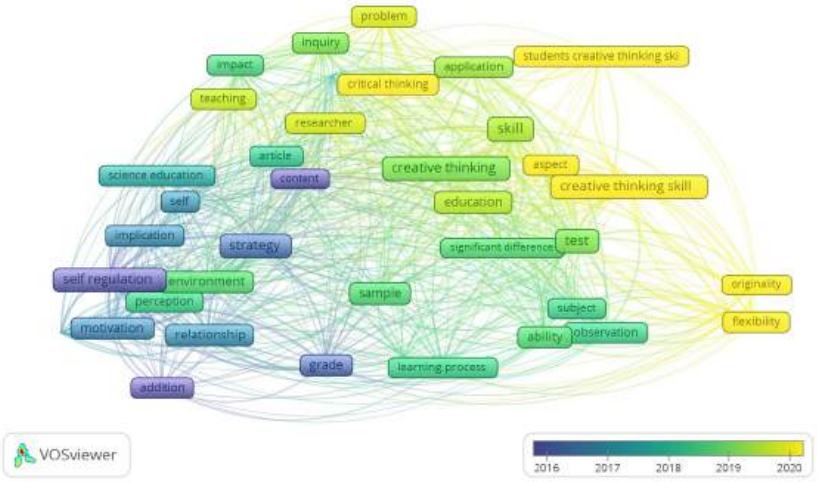

FIGURE 10. Thematic Map VOSViewer

Figure 10 shows that keywords related to self-regulation and creative thinking in science learning are widely used by researchers. In 2023 (in yellow) there are several themes that are still interesting issues to research today. Future research can follow current topic trends, one of which is studying science learning that measures creative thinking skills.

Contribution of self regulation and creative thinking in science learning in Indonesia

Based on the number of research documents on the topic of self-regulation and creative thinking in science learning in Indonesia, there are 32 documents. The lack of research that examines self-regulation and creative

thinking in science learning makes it a great opportunity to conduct studies on this topic in Indonesia. Table 4 is an overview of research that shows the relationship between self-regulation and creative thinking in science learning based on the Scopus database.

TABLE 3. Research on self regulation and creative thinking in science learning

No	Author	Year	Title	Result
1	Wiyanto, et al	2022	Review of learning strategies to improve creative thinking skills	Through the literature review, problem-based learning is the most widely studied model for improving creative thinking skills, especially in high school students.
2	Usman	2022	ICT Thematic Science Teaching Material With 5e Learning Cycle Model To Develop Students' 21st-Century Skills	Integrated thematic science learning with the 5E learning cycle model has been proven to have a positive effect on 21st century skills, namely critical, creative and communication.
3	Suryandari	2021	The effect of scientific reading based project model in empowering creative thinking skills of preservice teacher in elementary school	The Scientific Reading Based Project (SRBP) model has been proven to have a positive effect on improving the creative thinking abilities of prospective elementary school teachers.
4	Suchyadi, et al	2021	Using a multimedia as an effort to improve creative thinking skills of elementary teacher education college student	The use of multimedia has been proven to improve the creative thinking skills of prospective elementary school teachers.
5	Widyasmah & Herlina	2020	Implementation of STEM Approach Based on Project-based Learning to Improve Creative Thinking Skills of High School Students in Physics	The application of the STEM learning approach improves high school students' creative thinking skills and there are differences in the increase in students' creative thinking skills before and after the implementation of STEM learning.
6	Dewi, et al	2019	The implementation of PODE worksheet to improve students' scientific attitude, analysis ability and self-regulation	The application of PODE worksheets has been proven to improve junior high school students' scientific attitudes, analytical skills and self-regulation.

Of all the articles that examine the importance of self-regulation and creative thinking in science learning in Indonesian education, this is a great opportunity for researchers to study and develop this topic. From the article explanation, it is also explained that there are many learning models that can be used to improve creative thinking and self-regulation skills in science contexts such as STEM, projects, and so on. In summary, self-regulation and creative thinking skills in science learning in Indonesia are still interesting topics to study.

2. Discussion

The field of research on self-regulation and creative thinking in learning began in 1996 and continues to develop until 2023 and has the opportunity to continue to develop. It is proven that in 2024 someone will publish on this topic, this is based on a review of the Scopus database, namely 4 documents written by Bendel-Stenzel, et al; Moreno-Lianos, et al; Kamber, et al; and Jackman, et al [56]–[59].

Research on self-regulation and creative thinking skills has developed in various worlds. Based on the results of the analysis, Indonesia is the country that produces the most self-regulation and creative thinking in learning. Such as research conducted by Suryandari in 2021, Sajidan in 2018, Hidayat & Aurelia in 2023, Santoso, et al in 2022, Rizki, et al in 2022 [30]–[34]. Many studies state that self-regulation and creative thinking skills are essential

abilities that students must have. This ability is an ability that needs to be developed in the 21st century. Apart from that, self-regulation and creative thinking skills have been proven to have a significant influence on academic performance, as researched by Li et al in 2023, Lawson et al in 2019, and Yu et al in 2023 [7], [14], [15]. Aldrige, Sajidan, and Velayutham were the most productive authors producing research on self-regulation and creative thinking in science learning, namely 3 documents. Aldrige is known to have started researching this topic in 2012, and in 2013 he was recorded still producing this research, then producing it again in 2022. Sajidan produced research on this topic starting in 2018, 2019 and 2020. Meanwhile, Velayutham produced this research starting in 2011, 2012, and 2013.

Self-regulation and creative thinking skills in learning have a big contribution to the Indonesian state. This is proven by the production of research on this topic from various authors and agencies. In Indonesia itself, Sebelas Maret University is the institution that produces the most research on this topic. Some of the studies researched on this topic are the use of learning models or media in improving self-regulation and/or creative thinking skills in science learning. Like research by Dewi, et al in 2019 which proved that the application of PODE worksheets was proven to improve students' scientific attitudes, analytical skills and self-regulation [60]. Suryandari in 2021 researched the Scientific Reading Based Project (SRBP) model which was proven to have a positive effect on increasing the creative thinking abilities of prospective elementary school teachers [30]. Other authors from Indonesia also develop it into other domains such as the importance of self-regulation in distance learning [33], and also online learning during Covid-19 [34], [61]–[63]. Indonesian researchers have also studied the role of self-regulation on students' academic performance [64].

CONCLUSION

The analysis indicates a strong connection between self-regulation and creative thinking in science learning. Aldrige, Sajidan, and Velayutham are the most prolific authors producing research on this topic. Indonesia stands out as the most productive country in researching self-regulation and creative thinking in science learning. In terms of affiliations, Universitas Sebelas Maret emerges as the institution with the best output on this topic. Research on self-regulation and creative thinking in science learning makes a significant contribution to Indonesia, emphasizing the need for further in-depth studies related to other domains like critical thinking and motivation.

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