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Scientific Creativity In More Than 60 Years: A Bibliometric Analysis

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Abstract

Although research on student scientific creativity can be found easily on the literature, it is difficult to get articles on how scientific creativity is presented for some decades. This article report scientific creativity from 1960 to 2022 which mined from Scopus database. 181 articles were analyzed using a bibliometric analysis. Publish or Perish (PoP), Mendeley and Vos Viewer were used to find the map of literature on scientific creativity. Keyword used in this research was merely "Scientific Creativity". The results of the analysis using Vos Viewer show some interesting findings. First, although there have been publications published since 1960 on scientific creativity, from 2008 to 2022 the number of studies on this topic increased significantly. This may be due to the increasing attention of researchers to 21st century skills, creativity and other skills. Second, several findings from Vos Viewer show that there is no collaboration among researchers on scientific creativity that should be able to improve the quality and productivity of research around the topic. Third, the topics about the model and the effectiveness of scientific creativity are increasing. This matter can be taken into consideration by researchers to be used as the next research.

ientific Creativity, Bibliometric Analysis, Vos Viewer

INTRODUCTION

Creativity has not a single definition. In 2004, Plucker et. al in (Beghetto & Kaufman, 2014) examined 90 articles in two major journals on creativity and found that only 38% of articles wrote down the definition of creativity. Creativity is not just being different from others. But it still has to be contextual and useful. Everyone has creativity. What is different is the level of creativity and focus. In the context of classroom learning, many teachers feel they have not been able to promote creativity in students (Mullet et al., 2016). Most of the learning process is still limited to activities such as practice questions and has not been able to make my students free and independent in showing their creativity. This is supported by the finding (Schacter et al., 2006) which explains that most of the teachers involved in their research do not use an approach that is able to increase students' creativity. (Beghetto & Kaufman, 2014) p. 53, explains that some activities in schools ignore creativity, but creativity cannot be completely "killed". It will still exist and can reappear even though someone is faced with conditions where creativity is suppressed.

The next question is what can teachers do to increase the creative potential of a student? Writing (Beghetto & Kaufman, 2014) p. 54 finds the answer. One important aspect that supports the emergence of students' creative potential is a supportive learning environment. (Beghetto & Kaufman, 2014) page 64 provides a summary of what teachers can do in creating a learning environment that supports student creativity, namely: Incorporating creativity in the teacher's daily teaching activities, Provide opportunities to choose, imagine and explore, The teacher monitors carefully every lessons that can be taken from every student activity in the classroom, especially students' intrinsic motivation, Viewing creativity is not only a matter of individual competence but also being able to make changes in school and in the community, Teachers provide examples as creative figures

Studies on teacher perceptions of student creativity are also widely carried out researcher. (Bereczki & Kárpáti, 2018; Craft, 2003; Mullet et al., 2016; So & Hu, 2019). Teachers' perceptions of creativity are important for preparing classes that provide activities that encourage students' creativity (Mullet et al., 2016). The findings of Mullet et al., 2016 also explain that teachers believe in the importance of creativity, however, they have a concept of creativity that is not in line with what is written by experts and researchers. Many teachers define attitudes such as stubbornness and impulsive behavior as bad behavior. Furthermore, Muller found that teachers feel unprepared in teaching and identify creativity in the classroom. Another interesting finding is that teachers consider creativity to be the same as aesthetic and linguistic products but at the same time do not recognize creativity in the domains of science and mathematics.

Many researchers explain what scientific creativity is. Scientific Creativity is an integrated perspective of product, person and process (Simonton, 2003). Furthermore, scientific creativity is: "Any thought or behavior in science that is both novel and useful; with creative thought or behavior in science being manifested throughout the scientific process, from theory construction and hypothesis formation, research and study design, to publication and communication of results" (Feist, 2011). Moreover, Feist explained the four main studies of creativity in science, namely neural complexity, development of science talent and achievement, creative personality in science and creative cognition. In terms of Neural Complexity, Feist argued that Creative people have more complex and connected neural than less creative ones. He also stated that the combination between talent and training which is a long process. In General, Feist wrote that creative people in science tend to be "more open and flexible, driven and ambitious, and although they tend to be relatively asocial, when they do interact with others, they tend to be somewhat prone to arrogance, self- confidence, and hostility".

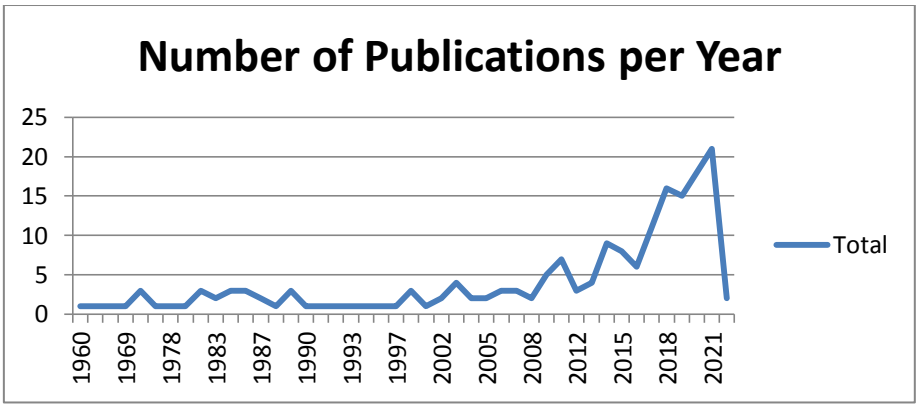
(Hu & Adey, 2002) in his research concluded several definitions of Scientific creativity, namely: Scientific creativity is different from other creativity since it is concerned with creative science experiments, creative scientific problem finding and solving, and creative science activity, Scientific creativity is a kind of abilities. The structure of scientific creativity itself does not include non-intellectual factors, although non-intellectual factors may influence scientific creativity, Scientific creativity must depend on scientific knowledge and skills, Scientific creativity should be a combination of static structure and developmental structure. The adolescent and the mature scientist have the same basic mental structure of scientific creativity but that of the latter is more developed. Creativity and analytical intelligence are two different factors of a singular function originating from mental ability.

Some interventions have been found to improve students' scientific creativity. (Bi et al., 2020) explained that there are four interventions to increase students' creativity which are the most widely studied, namely Problem Solving, Scientific Reasoning, Collaborative Learning and Conceptual Construction. The order of effectiveness of the four approaches is as follows: problem-solving > scientific reasoning > collaborative learning > conceptual construction. This study found that problem solving based approach was the most effective approach in increasing students' creativity followed by scientific reasoning. Interventions aimed at cultivating the product dimension of scientific creativity were probably most effective in terms of students' scientific creativity, followed by those based on the nature of the training and the dimensions of the process. The meta-analysis concluded that interventions aimed at cultivating the product dimension of scientific creativity were probably most effective in terms of students' scientific creativity, followed by those based on the nature of the training and process dimensions.

RESEARCH METHODS

Analysis of scientific creativity in the literature uses a lot of systematic literature reviews. However, this method has several weaknesses, including the limited number of documents that can be analyzed. In addition, this method also requires quite a lot of time to find patterns and conclusions to be reached. In addition to this method, bibliometric analysis can be used as an option for researchers. This study was a Bibliometric analysis to map the literature of scientific creativity. The data were extracted from Scopus over 62 year period, from 1960 to 2022. This study was conducted in February 2022. Harzing's Publish or Perish (PoP) was utilized to mine data articles from Scopus Database. "scientific creativity" was put on the title word as key search. It yields at 181 papers. Finally, the articles were save to CSV and RIS formats. The CSV data was run with Microsoft Excel to identify the most cited Journals, Authors and to draw timeline of citations every year. Moreover, the RIS format was imported to Mendeley. The Authors of this report read the title and abstract of each articles and group them into categories.

RESULTS AND DISCUSSION



Number of publications is presented above. The graph shows the number of publications from 1960 to 2022. From the table above it can be seen, Since 2008, the number of publications has increased almost 5 times to 2021. One reason is the attention to 21st century skills. Search results on the Scopus database produce a list of the most popular journals. widely cited by researchers from all over the world. The table below shows a list of the most cited journals processed using Microsoft Excel. In the first place there is the Psychological Bulletin with a total of 451 citations. The articles cited are those written by (Simonton, 2003). Next is the International Journal of Science Education with a total of 188 citations. There are two articles that contributed to the citation, namely (Hu & Adey, 2002) and (Liu & Lin, 2014). Furthermore, in third place is the Journal of Baltic Science Education with 137 citations. The journal reports six articles on scientific creativity written from several countries (N. Siew, 2017; NM Siew, 2015; Suyidno, 2018; Wicaksono, 2017)

Most Cited Journal of Scientific Creativity

Name of Journal	Sum of Cites
Psychological Bulletin	451
International Journal of Science Education	188
Journal of Baltic Science Education	137
Creativity Research Journal	129
Journal of Creative Behavior	115
Thinking Skills and Creativity	103
Proceedings of the National Academy of Sciences of the United States of America	102
Psychological Science	97
International Journal of Instruction	42
Research in Science Education	39
Journal of the American Psychoanalytic Association	33
Scientific Reports	31
Educational Psychology Review	28
Journal of Informetrics	22
Affect, Creative Experience, and Psychological Adjustment	19
Scientometrics	19
Journal of Environmental Psychology	19
Journal of Physics: Conference Series	16
History of Science	15
Bulletin of the history of medicine	14
International Journal of Emerging Technologies in Learning	13
American sociological review	10

Search results on Publish of Perish (PoP) yielded the most cited authors. (Simonton, 2003) is the author with the most citations with 451 citations and then followed by (Hu & Adey, 2002) with 163 citations. Next (Jones, 2011) ranks third with 102 citations. New publications that are less than 5 years old have also received quite a number of citations, including (Huang et al., 2017; Suyidno, 2018) with 37 and 32 respectively citations.

Most Cited Author of Scientific Creativity Articles

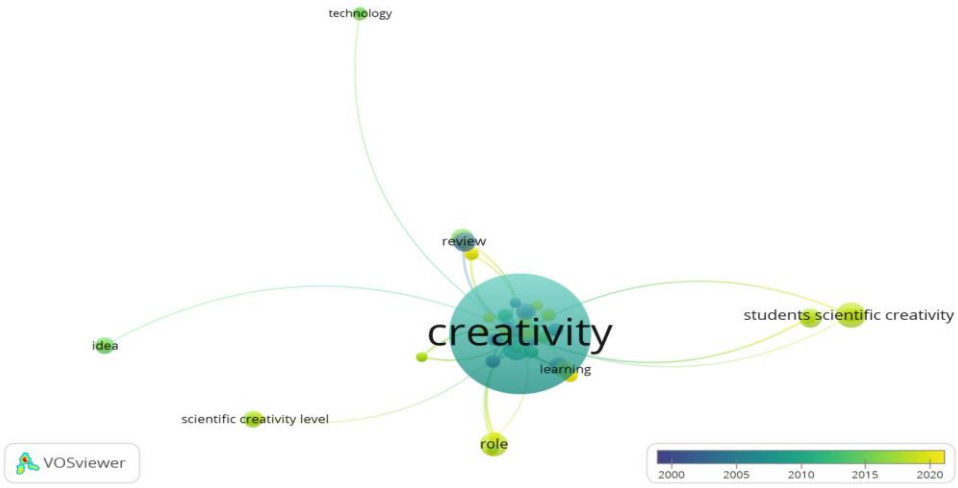
Cites	Authors	Title	Year	Source
451	D. Simonton	Scientific Creativity as Constrained Stochastic Behavior: The Integration of Product, Person, and Process Perspectives	2003	Psychological Bulletin
163	W. Hu	A scientific creativity test for secondary school students	2002	International Journal of Science Education
102	B.F. Jones	Age dynamics in scientific creativity	2011	Proceedings of the National Academy of Sciences of the United

				States of America
97	G. Park	Ability differences among people who have commensurate degrees matter for scientific creativity	2008	Psychological Science
61	C. Charyton	General, artistic and scientific creativity attributes of engineering and music students	2007	Creativity Research Journal
59	W. Hu	Increasing students' scientific creativity: The "Learn to Think" Intervention Program	2013	Journal of Creative Behavior
38	P. Huang	The relative influences of domain knowledge and domain-general divergent thinking on scientific creativity and mathematical creativity	2017	Thinking Skills and Creativity
37	M. Ayas	Objective measure of scientific creativity: Psychometric validity of the Creative Scientific Ability Test	2014	Thinking Skills and Creativity
36	C. Lin	The influence of CASE on scientific creativity	2003	Research in Science Education
33	A.I. Miller	Scientific Creativity: A Comparative Study of Henri Poincare and Albert Einstein	1992	Creativity Research Journal
32	Suyidno	Effectiveness of creative responsibility based teaching (CRBT) model on basic physics learning to increase student's scientific creativity and responsibility	2018	Journal of Baltic Science Education
31	S. Astutik	The practicality and effectiveness of Collaborative Creativity Learning (CCL) model by using PhET simulation to increase students' scientific creativity	2018	International Journal of Instruction
31	B. Shi	Different brain structures associated with artistic and scientific creativity: A voxel-based morphometry study	2017	Scientific Reports
30	I. Wicaksono	The effectiveness of virtual science teaching model (VS-TM) to improve student's scientific creativity and concept mastery on senior high school physics subject	2017	Journal of Baltic Science Education
28	H. Stumpf	Scientific creativity: A short overview	1995	Educational Psychology Review
26	M. Bush	Psychoanalysis and scientific	1969	Journal of the American

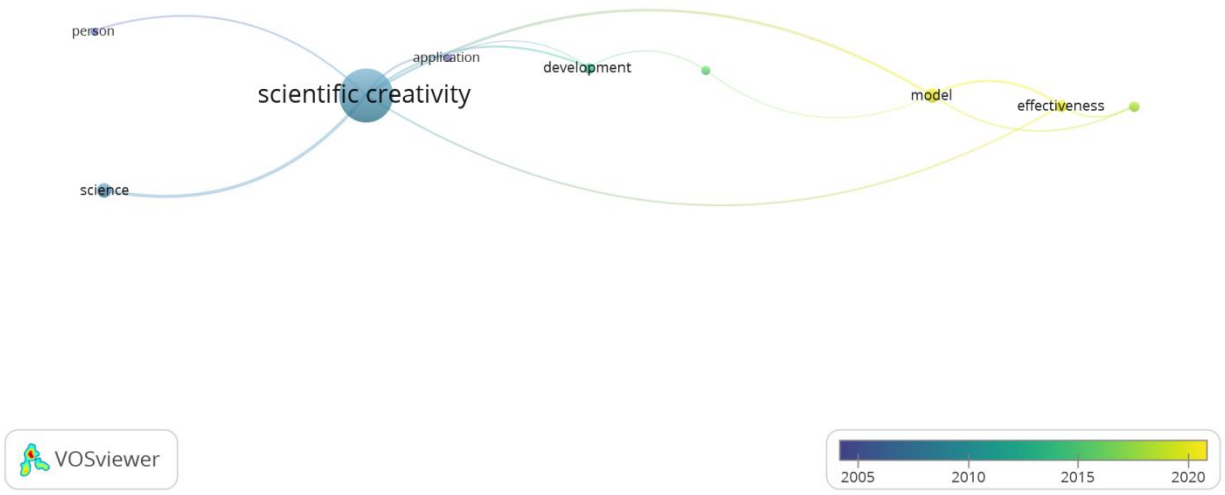
		creativity: With Special Reference to Regression in the Service of the Ego		Psychoanalytic Association
25	S. Liu	Primary Teachers' beliefs about Scientific Creativity in the Classroom Context	2014	International Journal of Science Education
22	H.B. de Vries	Scientific Creativity: Divergent and Convergent Thinking and the Impact of Culture	2019	Journal of Creative Behavior
22	J. Soler	A rational indicator of scientific creativity	2007	Journal of Informetrics
19	G. Feist	Affect in artistic and scientific creativity	2015	Affect, Creative Experience, and Psychological Adjustment
19	P. Suedfeld	Enhancement of scientific creativity by flotation rest (restricted environmental stimulation technique)	1987	Journal of Environmental Psychology
16	N.M. Siew	The effects of problem based learning with cooperative learning on preschoolers' scientific creativity	2017	Journal of Baltic Science Education
15	R. Qiang	Critical Thinking Disposition and Scientific Creativity: The Mediating Role of Creative Self-Efficacy	2020	Journal of Creative Behavior
15	N.M. Siew	Fostering fifth graders' scientific creativity through problem-based learning	2015	Journal of Baltic Science Education
15	F. Holmes	The fine structure of scientific creativity	1981	History of Science
13	M. Sun	Effects of divergent thinking training on students' scientific creativity: The impact of individual creative potential and domain knowledge	2020	Thinking Skills and Creativity
13	W. Zhu	Convergent Thinking Moderates the Relationship between Divergent Thinking and Scientific Creativity	2019	Creativity Research Journal
13	Wahyudi	The effect of scientific creativity in inquiry learning to promote critical thinking ability of prospective teachers	2019	International Journal of Emerging Technologies in Learning
13	A. Laius	Impact on student change in scientific creativity and socioscientific reasoning skills	2011	Journal of Baltic Science Education

		from teacher collaboration and gains from professessional in-service		
12	M. Frigotto	A few special cases: Scientific creativity and network dynamics in the field of rare diseases	2011	Scientometrics
11	K. Yang	Exploring the significant predictors of convergent and divergent scientific creativities	2019	Thinking Skills and Creativity
11	Zulkarnaen	Feasibility of creative exploration, creative elaboration, creative modeling, practice scientific creativity, discussion, Reflection (C3PDR) teaching model to improve students' scientific creativity of junior high school	2017	Journal of Baltic Science Education
11	B. Chen	The Effect of Mood on Problem Finding in Scientific Creativity	2016	Journal of Creative Behavior
10	L. Datta	Family religious background and early scientific creativity.	1967	American sociological review

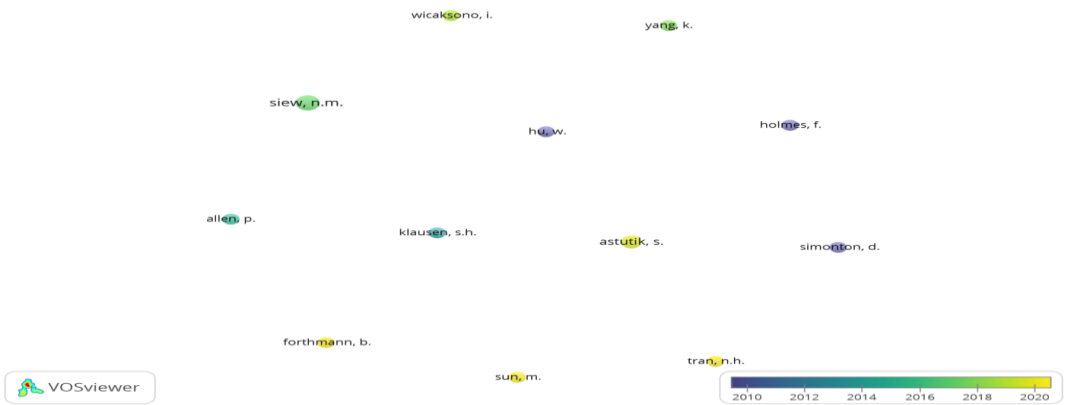
This literature mapping study aims to see the position of the study of scientific creativity in research in the Scopus database. The mapping begins by looking at the position of scientific creativity among studies that discuss creativity. The figure below describes some of the research focuses around the topic of creativity in general. The results of the analysis using the VOS Viewer show that there are several research topics including learning promoting creativity, scientific creativity level, review of creativity, the use of technology on promoting creativity and the role of creativity. Students' scientific creativity is also the center of attention of researchers who publish their research reports in journals indexed by Scopus. In the picture below, it can be seen that students' scientific creativity has received attention in the last few decades. Similar to the use of technology on creativity, students' scientific creativity is not yet in a position close to the Creativity circle as shown in the image below. This shows that although it has received attention since the last few decades, the intensity of the research has not been so great.



Publications around scientific creativity are also shown by Vos Viewer. In the picture below, you can see some of the topics that have been studied by previous researchers. Among them the most are about application and development of scientific creativity. Next is about science and person. Of the 181 papers analyzed in this report, the topic of model and effectiveness has not been studied much. This can be brought to the attention of researchers as a bibliographic map of the conditions of scientific creativity research.



The results of the Vos Viewer analysis also show interesting results from the side of collaboration among researchers. From the picture below, it can be seen that since the study on students' scientific creativity was published and indexed by Scopus, there has been no collaboration between researchers. Collaborating with fellow researchers provides an opportunity to share knowledge, methodologies, experiences and resources (Hernández-Torrano & Ibrayeva, 2020). Furthermore, this collaboration can also produce quality research. In addition, collaboration is also expected to increase productivity. Collaboration is also expected to be carried out not only within the same institution or country, but also collaboration between countries and nations is expected to produce research that considers cultural differences regarding scientific creativity.



CONCLUSION

Although this study reports important things about the development of research on student scientific creativity from 1960 to 2022, several weaknesses need to be considered in generalizing. First, this study only uses Scopus as a database. This research will be more perfect if it can use combined data from most of the available databases, so that the conclusions obtained will be more generalizable. Next, the keyword used in this research was merely "Scientific Creativity". The results of this study will be more comprehensive if the keywords used also consider a more complete thesaurus so as to produce articles that are more complete and comprehensive.

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