



Bibliometric Analysis of Creativity and Creative Thinking Skills of Vocational School Students

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ABSTRACT

The results of research or review papers on creativity and creative thinking skills have been widely carried out. However, no preliminary studies have been conducted to see how the development and specific research mapping on vocational school students' creativity and creative thinking skills are broad. The descriptive method in this study uses a bibliometric study with the VOS viewer desktop application sourced from the Scopus database. This research was conducted using co-authorship, co-occurrence, and citation analysis. The research results can be used as state of the art or provide information about the performance, development, and research trends of creativity and creative thinking of school students. The research results show that the development of the number of research publications on creativity and creative thinking skills of vocational high school students seems to increase significantly until 2021. The research trends that are mainly carried out have subjects including social science, engineering, arts and humanities, psychology, and computer science. Meanwhile, the issue of optimization, mechanisms, mechatronics, human-computer interaction, teaching models, and information technology began to be studied around 2018.

Keywords: *Bibliometric, VOS Viewer, Creativity, Creative thinking skills, TVET.*

1. INTRODUCTION

One of the ways to meet the 4.0 industrial revolution demands is to prepare superior and competent human resources through changes in the Vocational High School education sector. Education to build competence requires students to combine cognitive, affective, and psychomotor skills using a scientific approach based on learning and innovation skills [1].

One of the competencies needed in competency-building education is High Order Thinking Skills (HOTS). HOTS is a thinking ability in which a person must understand, analyze, classify, manipulate, create new creative methods, and apply them to become the latest solutions and innovations [2]. A study shows that the ability of Indonesian students to HOTS is still low due to a lack of application of communication, collaboration, critical thinking, and creativity (4Cs) in learning [3].

On the other hand, to face 21st-century learning, students must have the ability to be creative and think creatively so that they can become superior human resources. SMK is expected to be able to create students who can be creative and think creatively to become superior human resources in the industry. In this regard, a lot of research has been conducted regarding vocational students' creativity and creative thinking abilities. Some of them are: (1) Creativity and educational research is an emerging field of study whose interest has grown exponentially over the previous two decades [4]. (2) The impact of digital technology products on student creativity varies and depends on teaching strategies and learning behaviour [5]. (3) Additional measurement tools are needed for middle and high school levels in Mathematical Creative Thinking [6].

Regarding the author's analysis, no research has been found that maps the development of research publications on creativity and creative thinking skills of SMK students in mechanical engineering. For this reason, this research

was conducted to find out the performance, development, and research trends on creativity and creative thinking skills of Vocational High School students in mechanical engineering using the bibliometric method with the VOSViewer application.

2. METHOD

The method used in this research is a quantitative descriptive research method with bibliometric analysis. The data source in this study is empirical research publications on the creativity and creative thinking skills of mechanical engineering vocational students. Data source comes from Scopus database without year limitation. The Scopus database was chosen because of its more comprehensive range of indexing articles and included many leading journals [7].

Data mining is carried out to obtain information about author data, author affiliations, and citation relationships with other authors. In addition, research trends were investigated based on the research area and the corresponding inter-keyword relationships. The results of this study are expected to be used as a state-of-the-art or preliminary study to find research gaps or to produce preliminary research for future researchers, which can be used in research on the creativity and creative thinking of students.

3. RESULTS AND DISCUSSION

Based on the data collection, restriction, and screening process using keywords (TITLE-ABSKEY ("creative thinking" OR "creativity") and TITLE-ABS KEY ("vocational school OR "vocational education" OR "mechanical engineering" OR "refrigeration and air conditioning")), found 524 Scopus indexed documents that met the analysis criteria.

3.1. The number of publications by year

Figure 1 shows the number of publications on creativity and critical thinking skills year by year. Based on it, publications on creativity and critical thinking skills first appeared in 1973. The development of the number of publications seemed to increase gradually, starting in 2014 and reaching its peak in 2020. The decline in publications occurred in 2021 due to the COVID-19 pandemic, where research focuses more on the pandemic [8].

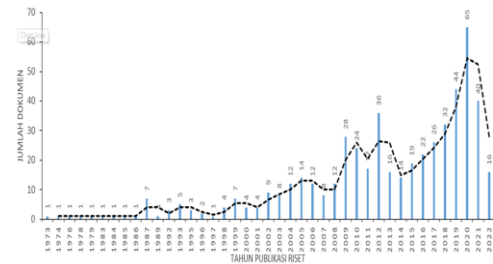


Figure 1. The number of publication on creativity and critical thinking skills by year.

From 524 Scopus documents analyzed, the article's topic was dominated by the engineering of 35%, social science of 20%, and computer science of 13%. This percentage value indicates that related research publications on engineering, social science, and computer science are carried out to improve innovation and vocational school graduates' quality. The high level of competition in the globalization era requires vocational students to have creative adaptation abilities and imaginative solutions for all problems in various subjects.

3.2. Co-authorship analysis by countries

524 publications of documents on creativity and critical thinking skills are spread across 79 countries, as shown in figure 2. The 79 countries mapped in Figure 2 show 47 clusters. However, there are 42 countries whose clusters are separate and do not collaborate with other countries. The other 37 countries that have collaborated are grouped into 12 clusters. The three most significant clusters are as follows. The first cluster in red connects the three countries dominated by the United States with 144 publications. Then, the second green cluster connects five countries, namely China, Italy, Iran, Taiwan, and Thailand, dominated by China, with 33 publications. The third cluster is blue, connecting five countries, namely Australia, Indonesia, Malaysia, Nigeria, and the Philippines, dominated by Indonesia with 53 publications.

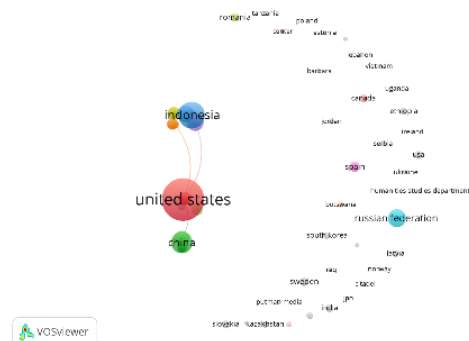


Figure 2. Countries researching on creativity and creative thinking skills.

Next, the five countries with the highest number of research publications are shown as shown in Table 1.

entitled The Development and implementation of project management skills in vocational institutions [10].

Table 1. The five countries with the highest number of research publications.

Countries	Number of publication	Number of citation
United States	144	782
Indonesia	53	94
Malaysia	20	71
United Kingdom	19	271
United States	144	782

A study conducted by the Trend International Mathematics and Science Study (TIMSS) states that students' creative thinking ability in Indonesia is relatively low [9]. However, Indonesia occupies the second position in the number of publications after the USA. This is one of the proofs that Indonesia is trying to increase students' creativity and creative thinking abilities.

3.3. Co-authorship analysis by author

From the 524 documents, the total number of contributing authors was 1241. Then determined, the criteria that the minimum limit had been to write two documents, 85 authors were obtained. The 85 authors were then mapped, as shown in Figure 3. There were five authors with the highest number of research publications, presented in Table 2.

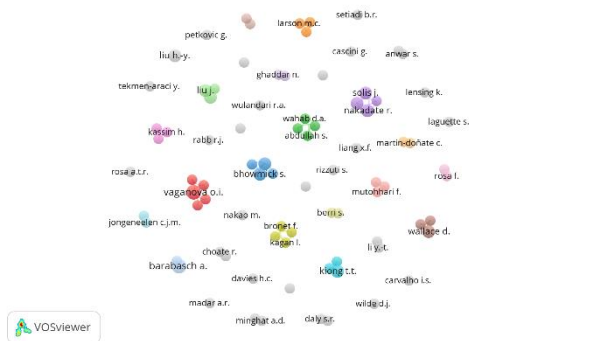


Figure 3. Co-authorship analysis by author.

The most prolific authors are Vaganova, Barabasch, Bhowmic, Kershaw, and Nakadate. Most of the researchers used educational subjects, one of them

3.4. Keyword mapping by publication year

From a total of 524 documents collected, 605 keywords were obtained. Furthermore, the data is reduced to get a set of keywords that appear in at least six articles; data obtained as many as 98 keywords. The mapping of 98 keywords based on the year they appear is presented in Figure 4.

In Figure 4, it can be seen that the keywords are visualized in dark blue, green, and yellow. The dark blue indicates that these keywords are found in research published from 2008 to 2011. This means that the keywords visualized in dark blue are no longer widely used after 2011.

Keywords visualized in green (2011-2018) rarely appear in creativity publications, and creative thinking skills include design methods, project management, and decision making. Meanwhile, the keywords visualized in bright yellow include higher education, e-learning, apprenticeship, learning process, and critical thinking, which have been researched since 2018. The results of mapping keywords based on the year of publication allow future researchers to obtain topic predictions, which are the future research trends.

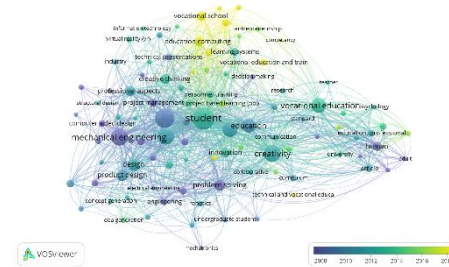


Figure 4. Keyword mapping by publication year.

Table 2. The 5 authors with the highest number of publications.

Author	Number of publication	Number of citation
Vaganova, O.I.	4	22
Barabasch, A.	4	11
Bhowmick, S.	3	28
Kershaw, T.C.	3	28
Nakadate, R.	3	25

Table 3. Grouping keywords by topic.

Topic	Description
Other skills	mechanical engineering, entrepreneurship, machine design, design, product design, apprenticeship, psychology, management, robotics, industry, structural design, industrial engineering
Learning strategies	learning systems, active learning, education computing, e-learning, active learning, problem-based learning, engineering education, human experiment
Learning media	artificial intelligence, surveys, article, questionnaire
Learning component	assessment, learning process, curricula, student, first year, teaching, vocational education, mechanical engineering education, university, humans, curriculum
Factors influencing creativity and creative thinking	innovation, idea generation, creativeness, skills, decision making, technical presentation, communication

3.5. Co-occurrence analysis by topics

This grouping is done by categorizing which keywords belong to other skill topics such as learning strategies, learning media, learning components, and other factors related to creativity and creative thinking of vocational school students in mechanical engineering and refrigeration & air conditioning. The results of the

Table 3 shows that there are still few publications on the latest learning media, such as media based on Android applications and artificial intelligence. This indicates that there are still great opportunities to research the use of instructional media in enhancing students' creativity and creative thinking skills.

3.6. Keyword relatedness based on co-occurrence analysis

From the results of mapping by VOSViewer, 44 keywords were found related to mechanical engineering and air conditioning refrigeration, with a minimum number of appearances in 6 articles.

Based on the data, there is still very little research related to optimization, mechanism, mechatronics, human computer interaction, teaching models, and information technology. These words only started to appear on average in 2018. This shows that research trends related to mechanical engineering and air conditioning refrigeration used these keywords, starting in 2018.

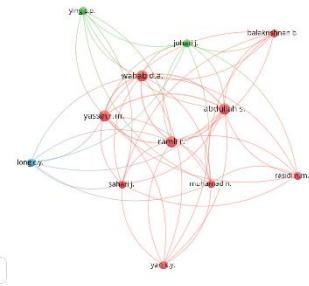
Table 4. Keywords related to mechanical engineering and air conditioning refrigeration

Keywords	Number of appearances	Keywords	Number of appearances
student	176	machine design	10
engineering education	133	robotics	10
curricula	94	active learning	10
teaching	77	idea generation	9
education	67	research	9
design	45	design method	8
product design	43	Manufacture	8
problem solving	39	design process	8
professional aspects	33	collaborative	8
innovation	27	decision making	8
education computing	26	artificial intelligence	8
project management	20	computer simulation	7
learning systems	19	computer software	7
engineering design	18	conceptual design	7
mechanical engineering student	17	first year	7
engineers	16	communication skills	7
computer aided design	15	optimization	6
product development	15	mechanism	6
societies and institutions	15	mechatronics	6
e-learning	14	human computer interaction	6
undergraduate student	11	teaching model	6
engineering research	11	information technology	6

3.7. Author distribution map using citation analysis

From the 24 documents, the total authors contributed 1236. The data is then reduced to obtain data from authors cited by others at least 20 times; data is obtained from 76 authors, as shown in Figure 5.

Authors who have cited one another are mapped, as shown in Figure 6. The most cited documents are presented in tabular form, as shown in Table 5.

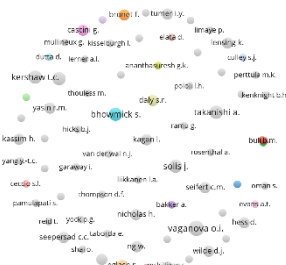


VOSviewer

Figure 6. The mutual quotations between authors.

Table 5. The most cited documents.

Authors	Title of article	keywords	Number of citation
Hicks B.J., Culley S.J., Allen R.D., Mullineux G [11]	A framework for the requirements of capturing, storing and reusing information and knowledge in engineering design (2002)	Creativity; Decision making; Information; Knowledge	186
Thompson D.F., Callen E.C., Nahata M.C. [12]	New indices in scholarship assessment (2009)	Assessment; Evaluation; Literature; Research	68
van Dam K., Schipper M., Runhaar P. [13]	Developing a competency-based framework for teachers' entrepreneurial behaviour (2010)	Adaptability; Competencies; Entrepreneurship; Teachers; Vocational education	58
Yang, Y. [14]	Virtual CEOs: A blended approach to digital gaming for enhancing higher order thinking and academic achievement among vocational high school student (2015)	Applications in subject areas; Cooperative/collaborative learning; Improving classroom teaching; Secondary education; Simulations	49
Wang, E. [15]	Teaching freshmen design, creativity and programming with legos and labview (2001)	Creativity; Freshmen; Labview; LEGO; ROBOLAB	44



VOSviewer

Figure 5. Seventy-six authors with at least 20 citations.

The number of citations obtained by a publication shows the impact of the publication on other publications [16]. The most cited documents are entitled A framework for the requirements of capturing, storing and reusing information and knowledge in engineering design, with the keywords creativity, decision making, information, and knowledge [11] discussing the overall framework for requirements for capturing, storing, and reusing information and knowledge in engineering design. The high number of citations in the article is also influenced by the year of publication which has been going on for 20 years.

Some documents have good publication quality because, within seven years, they got 49 citations. The document title is Virtual CEOs: A blended approach to digital gaming for enhancing higher order thinking and academic achievement among vocational high school students [17] with the keywords: applications in subject

areas, cooperative/collaborative learning, improving classroom teaching, secondary education, and simulations. This article discusses empirically verified digital game-based learning (DGBL) instruction that significantly improves creative thinking, critical thinking, and problem-solving skills.

A high citation of an article indicates that the article has good publication quality. In addition, authors who cite each other provide an overview of the publication's relevance with other relevant and recent publications. In addition, doing citations provides a comparison of his research ideas with other people's research ideas. Researchers cite work in addition to acknowledging or appreciating the contributions of others and acknowledging that the manuscript is helpful for the study they are conducting [18].

4. CONCLUSION

The development of the number of creative research publications and creative thinking for vocational high school students began in 1973 and increased significantly until 2020. Then it decreased until 2022 due to the Covid-19 pandemic. Research trends primarily carried out include social science, engineering, arts and humanities, psychology, and computer science. The keywords optimization, mechanism, mechatronics, human-computer interaction, teaching model, and information technology just started to appear in 2018 on average. Five countries publish in large numbers, one of which is Indonesia. The large number of publications on creativity and creative thinking skills by Indonesian writers shows that Indonesia is working to improve these two skills, especially for vocational high school students. Bibliometric analysis can also map the quality of a piece of writing, where the number of other pieces that cite it indicates a good piece of writing. Publications are important for academics because the more publications they produce, the more other people know about the latest developments on a topic, which leads to the birth of innovation.

AUTHORS' CONTRIBUTIONS

F.H.A. conceptualization designed the research procedure and created the original manuscript draft, E.T.B. and W.M. processed and analyzed data, H.S. manuscript preparation, and I.H. writing-reviewing and editing the manuscript.

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