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Scientific Research Trend on Creativity in Physics Learning

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ABSTRACT
This paper aims to describe the scientific research trend on creativity in physics learning. Bibliometric analysis was used in this study to explore more about creativity in physics learning in the Scopus database (2011-2020). The total sample is 179 documents—no more research on creativity in physics learning until 2018. A significant increase occurred in 2019 (54 documents) then decreased in 2020 (42 documents). All data is then stored in the form of RIS for bibliometric analysis using VOSviewer software. The trend of top co-author based on the entire documents lead by Gunawan. Based on the total citation, the top five authors are Kao et al., Xing et al., Lou et al., Cady, and Suyidno et al. The map result shows four main clusters, namely red, blue cluster, green cluster, and yellow cluster. Based on the bibliometric analysis, there are some recommendations. The general advice for further research is to explore and conduct a meta-analysis on creativity in physics learning. Besides, it needs research views on approaches/strategies, tests, instruments, thinking processes, and characteristics of students and subject matter that must be considered as a whole in carrying out physics learning to increase creativity in realizing SDGs in Society 5.0.

Keywords: *Creativity in physics learning, Research trend, Scopus database*.

1. INTRODUCTION

Sustainable development (SD) is an issue that is being intensively echoed to save the next generation. SD is also one of the biggest challenges in the 21st century [1]. At the same time, the development of SD issues was also accompanied by the story of information and communication technology (industrial revolution 4.0) and continues to this day. Today, we are in the society 5.0 era and are still trying to realize sustainable development goals (SDGs).

Society 5.0 is the new super-intelligent society where the different occupations are finely differentiated and fulfilled [2]. It is estimated to promote competitive development and solve social problems by evolving capable localities or super-cities (Smart-cities) [3]. Society 5.0 aiming for a new human-centred society, the frameworks and technology developed here will no doubt contribute to resolving societal challenges [4]. Figure 1 shows the concept of Society 5.0 for SDGs.

System thinking competence, interpersonal competence, strategic competence, normative competence, and anticipatory competence are the fundamental competencies of sustainability [5]. Research during the last decade has demonstrated how new social practices evolve due to the increased use of new digital technologies. Such practices create preconceptions of critical competencies and skills, not defined from a systems level but the everyday lives of people in our societies [6].

The competencies need some skills or complex thinking skills. Zeltina integrated ESD with design thinking (DT) criteria (empathy, creativity, collaboration, responsibility, and interdisciplinary approach) to develop socially responsible and environmentally sustainable products and services [7]. Efforts to realize the SDGs in this era of society 5.0 require 21st-century skills, often known as 7 C's (Critical Thinking, Creativity, Communication, Collaboration, Career & learning self-reliance, Cross-cultural understanding, Computing/ICT literacy) [8-9]. Based on the Scopus database, the number of publications that examine the seven competencies of the 21st century can be traced. Table 1 shows the record of the Scopus database about 21-st century skills for all years that accessed on August 06 2021.

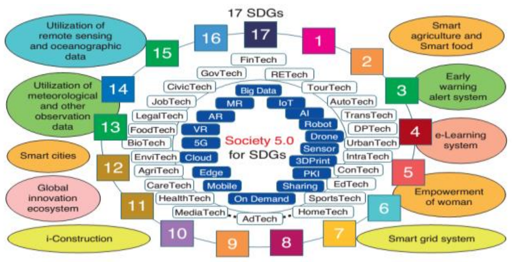


Figure 1 Society 5.0 for SDGs [4]

Based on Table 1, we know the number of publications in physics learning about 21st-century skills. Some of the basic principles and stages of DT, such as empathy, creativity, collaboration, responsibility and interdisciplinary approach, have been tested by evaluating students' project work regarding integrated ESD and DT criteria [7]. One of the 21st-century competencies that need to be considered to realize the SDGs is creativity. Several studies have shown a link between creativity and efforts to realize the SDGs [10]

Table 1. The number of Scopus documents about the 21st-century skills (7C's) for all year

7 C's century skills		7 C's in physics learning		
Skills	The number of documents	Skills	The number of documents	Percentage (%)
Critical thinking	38,635	Critical thinking in physics learning	383	0. 99
Creativity	72,751	Creativity in physics learning	233	0.32
Communication	2,131,142	Communication in physics learning	900	0.04
Collaboration	323,391	Collaboration in physics learning	451	0.14
Career & learning self-reliance	20	Career & learning self-reliance in physics learning	0	0
Cross-cultural understanding	7,756	Cross-cultural understanding in physics learning	2	0.03
Computing/ICT literacy	143	Computing/ICT literacy in physics learning	9	6.23

Creativity is an essential part of learning for sustainability [11]. Creativity is also a multidimensional ability influenced by various factors of specific social environments [12]. However, not too many studies in physics learning. For this reason, efforts are needed to foster student creativity in every learning activity, including physics subjects [13].

Mapping was carried out using bibliometric analysis assisted by VOS viewer software to further map research trends in creativity in physics learning. This research focuses on obtaining information on the development of creativity in physics learning research. The implication is that this research will show a mapping that can be followed up with experimental study or other types of research. This research was conducted as an initial stage before continuing the investigation to the next step.

2. METHODS

This type of library research aims to analyze research trends in creativity in physics learning for ten years (2011-2020) using bibliometric analysis with a qualitative approach [14-16]. The qualitative approach in this study is to describe secondary data from the Scopus database on August 06, 2021, with the category of the article, title, abstract. Total documents for all years based on the keywords "creativity in physics learning" is 423 documents. For the analysis of trend research on physics learning, the searching category used the strategy on Scopus search engine:

TITLE-ABS-KEY (creativity AND in AND physics AND learning)

There are 235 documents for all years of publication. Then, choose the years from 2011 until 2020 to limit the year of publication. There are 179 documents. The database is saved in the form of .csv and .ris for further analysis. Microsoft Excel and the VosViewer application visualize raw data into tables, graphs and maps [17-19]. The mapping results by the VOSviewer software are then used to analyze the mapping of creativity research in physics learning. The analysis of bibliometric based on indicators, including the area of study, source documents, publications, source documents, distribution of countries and institutions, authors, number of citations, and author keywords, have been frequently used to analyze trends [20-22]. But, this paper, limited to the source documents, authors, institution, the number of citations, and the keywords.

3. RESULTS AND DISCUSSION

The search results of the keyword strategy presented in the method are 179 documents. Figure 2 shows the trend of the publication number during ten years (2011-2020). Research related to creativity in physics learning has not become a trend or is not much in demand by international researchers until 2018 (less than 20 documents per year). There was a drastic increase in 2019 with 54 papers and a less significant decrease in 2020 with 42 articles.

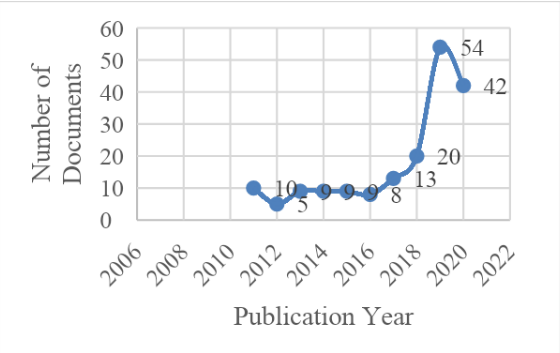


Figure 2 Research trend on the number of publications during ten years later.

All of these documents come from Conference Paper (106), Article (48), Conference Review (10), Book Chapter (6), Book (4), Note (2), Review (2) and Editorial (1). Journal of Physics Conference Series (64) is the most significant contributor to creativity in physics learning. Followed by Physics Teacher (5), AIP Conference Proceedings (4), IOP Conference Series Materials Science and Engineering (4), Physics Education (4), ASEE Annual Conference And Exposition Conference Proceedings (3), European Journal of Physics (2), International Conference on Information Science and Communications Technologies Applications Trends and Opportunities ICISCT 2019 (2), International Journal of Scientific and Technology Research (2), International Journal of Scientific and Technology Research (2), and Journal for The Education of Gifted Young Scientists (2). Gunawan has five documents of creativity in physics learning. Four papers owned by Harjono, Herayanti, and Sunarno. Amir, Festiyed, Gregorcic, and Prahani have three papers each other. Then, Astutik and Bentri have two papers each other. The top five contributor in the research on creativity in physics learning areUniversitas Negeri Surabaya (10), Universitas Negeri Padang (10), Universitas Pendidikan Indonesia (8), Universitas Sebelas Maret (7), and Universitas Mataram (6). Besides the top authors based on the entire document, we also analyze the principal author's total citation—the following are the top five citations on the research of creativity in physics learning. Kao et al. Dominate the authority in the published documents in creativity in physics learning (34 citations). Followed by Xing et al. (31), Lon et el. (31), Cady (31), and Suyidno (29). All of them discussed and studied creativity as a skill that is very important in 21st-century skills [23-27].

Based on the Scopus database stored in the RIS extension, bibliometric analysis was performed using VOSviewer software. Figure 3 shows the network visualization for the research on creativity in physics learning. It shows that there are four main clusters. The first is a red cluster, then a green, blue, and yellow cluster. The red cluster discussed the approach, paper, knowledge, understanding, concept, curriculum, work, role, issue, etc. The blue one addressed the implementation of creativity in physics, high school students, instruments, systems, quality, science process skills, etc. The green cluster discussed the test of creativity in physics learning related to scientific creativity, responsibility, students creativity, aspect, effect, group, increase, etc. At the same time, the yellow cluster discussed the tool, the use, competency, science learning, learning tool, etc. The bigger the circle on the map, the more discussion about it. Each keyword has the networking with the other one. If this data of keywords show in the density visualization, it looks like in Figure 4.

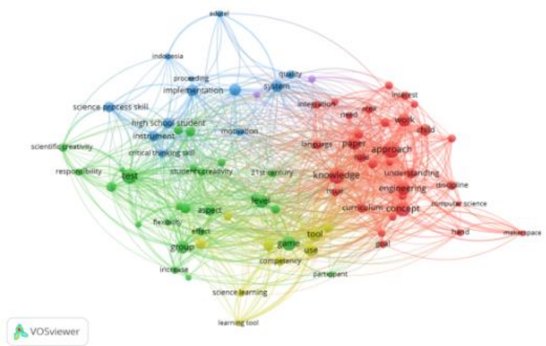


Figure 3 Network visualization on the research of creativity in physics learning.

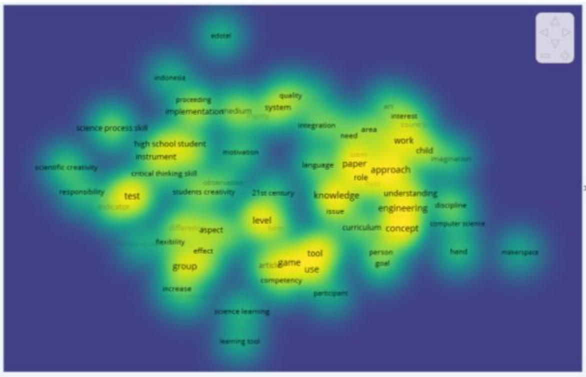
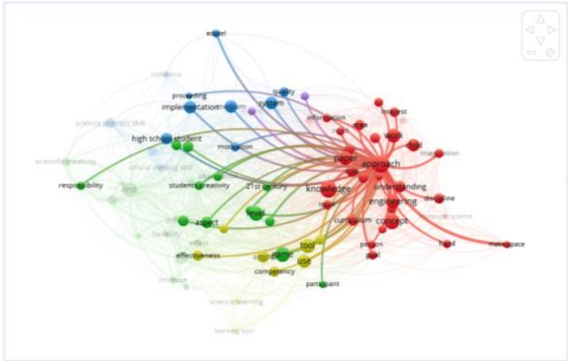
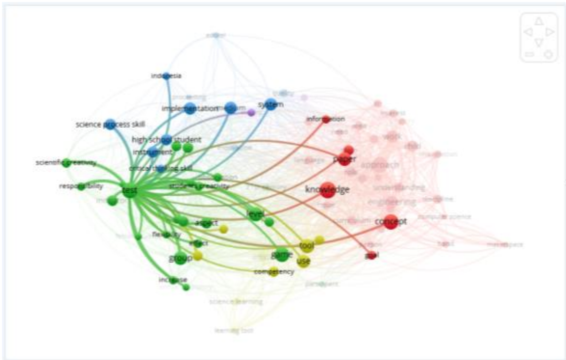


Figure 4 Density visualization on the research of creativity in physics learning.

In Figure 4, the darker the yellow colour, the more discussion about these keywords in creativity research in physics learning. Based on the density visualization in Figure 4, we know the topic frequently discussed in creativity in physics learning. The keywords approach, knowledge, and concept is in the red cluster (see Figure 3). Creativity refers to the abilities that are most characteristic of creative people [28]. There are creativity as effect (works of art, physical theories, etc.), creativity as the cause (psychological factors that give rise to creativity), and creativity as interaction, the degree to which one's environment fosters creativity) [29]. Creativity is the first step of innovation [30]. Creativity as a thinking skill needs the way to encourage or implement in the learning. Some researchers develop many approaches or models of learning to increase these skills. Including CRBT, CRBL, CCL, and the others [27, 31-33].



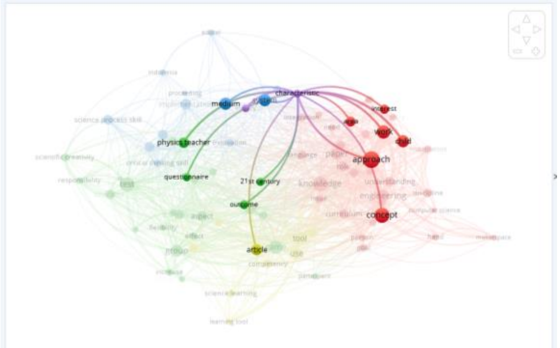
(a)



(b)

Figure 5 Network visualization from (a) the keyword approach in the red cluster, (b) the keyword test in the green cluster.

The strategies to encourage creativity in physics learning include networking to some keywords in some clusters, not only with the red group (see Figure 5 (a)). Interestingly, this visualization network map is that the approach is not only related to blue, green, and yellow clusters. A small purple cluster is also associated with the approach in the red cluster—namely, characteristic and inquiry (see Figure 6). As we know from the visualization, each keyword has the network to other clusters. It is interesting to search deeply about the relationship between each keyword on the groups. We recommend the following study explore the metadata through meta-analysis to research creativity in physics learning—for example, the relationship between approach and characteristic (See Figure 6a). There we can find another network formed by characteristic. We can examine this based on educational psychology theory regarding how we understand the characteristics of the approach associated with student characteristics, material characteristics, and teacher characteristics to recommend the most appropriate approach to train creativity in physics learning. In another example, we found a relation between the inquiry and students' creativity (see Figure 6b). We recommend further study to explore the extent to which inquiry plays a role in student creativity. How does it compare with the implementation of other learning models if you want to increase student creativity?



(a)

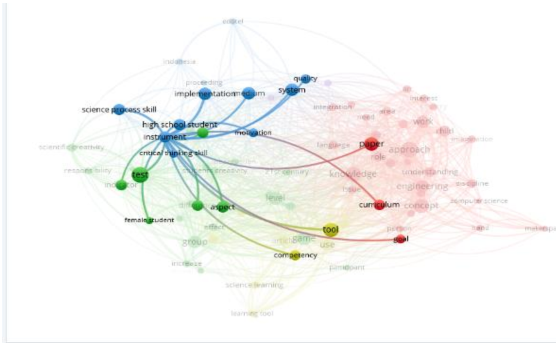
(b)

Figure 6 The network visualization for the keywords (a) characteristic and (b) inquiry.

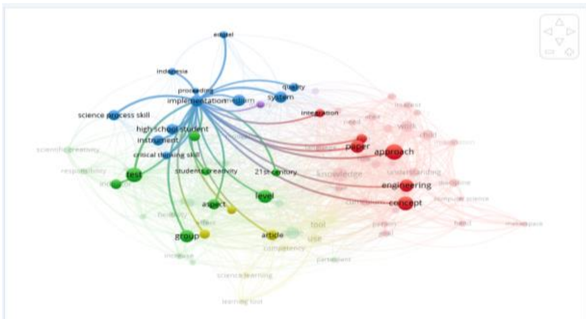
The densest topic in the green cluster is the test. Based on Figure 5 (b), we know the network visualization of its issue. Test also has networking to all clusters. The test has networking to knowledge, concept, paper, information, and goal in the red cluster. It means that before we develop the creativity test, we must understand the knowledge, concept, information, goal of the creativity test through reading the paper. Then, the test has networking to the use, tool, and competency in the yellow cluster. If we want to develop the creativity test, we must notice the competency of creativity in physics learning. Do we also see the use of the test? Is it a tool to measure creativity or not? We found system, high school students, science process skills, critical thinking skills, implementation, medium, and Indonesia in the blue cluster.

From it networking, we can interpret that the test on creativity in physics learning is a system. Not only the final product. As we know that creativity is as the effect, creativity as the cause, and creativity as interaction [3], we need a system to implement creativity skills. So, the hope of creativity as the essential skill to realize the SDGs in the Society 5.0 can come true [10-11]. Until now, creativity tests are still being carried out in high schools students if we look at the metadata in the visualization of Figure 5 (b). The recommendation that can be given is that creativity in physics learning can be implemented at every level of education. It considers students' material characteristics and characteristics to contribute to realizing the SDGs in the era of Society 5.0. We also need to understand other thinking skills when compiling creativity tests. Creativity and critical thinking differ from each other [30]. Of course, it is different too with another skill. Each skill has its characteristics. If we understand its characteristics, we will be able to distinguish between creativity and other thinking skills.

We need the instrument to do the test creativity in physics learning. Figure 7 (a) shows the visualization from the keyword of the instrument. Instruments are closely related to tests. In developing test instruments, we must pay attention to several things related to tests, as discussed earlier. Therefore, Figure 7 (a) shows some of the same networks as the test. Other things that need to be considered in preparing the instrument apart from explaining the network test are quality and motivation (from the blue group). The network instruments on the red cluster are curriculum, goals, papers. Meanwhile, for the yellow cluster are competencies and tools, and for the green cluster are aspects and female students.



(a)



(b)

Figure 7 The network visualization in the blue cluster: (a) the keyword instrument and (b) the keyword implementation.

The visualization in Figure 7 (a) means that when compiling the creativity test instrument in physics learning, you must pay attention to quality. If creativity is still in the stage of growing creativity, it is necessary to pay attention to the motivation that is built so that students can have good creativity. Of course, we must analyze the curriculum and determine goals based on the curriculum and physics learning materials before compiling the instrument. Thus, instrument compilers must understand what aspects and competencies need to be measured to determine the extent to which their abilities measure students' creativity. For example, what has been done is based on gender. The study of the characteristics of this section can be further expanded. For example, based on the level of education, socio-cultural background, and so on. So that, the results of measuring creativity in students can also be linked to other 21st century competencies, such as cross-cultural understanding or career & learning self-reliance.

Duli Pllana found that six countries gave a lot of space to curricula creativity even though they failed to materialize it in the school districts [30]. Let's see Figure 7 (b) to explore the implementation of creativity in physics learning. The implementation has networking to all of the clusters. It means that we must pay attention to a whole system when implementing creativity in physics learning. Not only the concept of creativity in physics learning as in the red cluster, but also system, the other skills (21st-century skills), the learning process (science process skills), the student characteristics (high school student or the different level), the assessment (student's creativity, test, instrument, level, aspect), and all of the components that related to the implementation of learning to increase students' creativity in physics learning. So, we can not only submit the creativity in the curricula. But also plan the strategies/methods/approach appropriate to the characteristics of the creativity itself, the students, and the subject materials then implement it in a whole system assess the learning process and the learning product based on the goals.

4. CONCLUSION

The conclusion of this study is about the trend of the research on creativity in physics learning, the top author based on the documents and citations, and the finding of literature study based on the bibliometric analysis. The trend of the research on creativity in physics learning was almost flat until 2018 (is in the range of 10) and started to rise to 20 documents in 2018, then increased drastically in 2019, then decreased slightly in 2020. The findings of the bibliometric analysis based on text data visualized by VOSviewer are the main groups, that is, four main clusters (namely red cluster, blue cluster, green cluster, and yellow cluster). The exploration is more about the approach, test, instrument, and implementation studied and recommendations based on the four clusters. The advice is to explore the metadata through meta-analysis to research creativity in physics learning, especially the characteristics and inquiry. The test on creativity in physics learning is a system. The recommendation is creativity in physics learning can be implemented at every level of education by taking into account the characteristics of the material and the characteristics of students to contribute to realizing the SDGs in the era of Society 5.0. Instruments are closely related to tests, so we must plan the instrument as a whole based on the curriculum, process, and competencies. Whereas for the implementation, we must look at it as a whole system so that the planning of creativity in physics learning can be implemented and assess properly.

AUTHORS' CONTRIBUTIONS

MNR Jauhariyah: conceptualization, method, data visualization, and drafting manuscript. T. Sunarti & Wasis: Review of manuscript; W Setyarsih & A Zainuddin: data curation, S Fatimah, K Syahidi, N S Safitri: Review and suggestion.

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