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Exploring University Students' Creative Thinking Through Digital Mind Maps

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Abstract

Creative thinking is an unorthodox way of thinking to produce fresh and new ideas. Creative thinking can be trained using innovative learning strategies. This study aimed to explore creative thinking aspects in the Digital Mind Maps (DMM) created by Universitas Islam Riau, Indonesia, students who were enrolled in Human Anatomy and Physiology course. A rubric containing four aspects of creative thinking, namely fluency, flexibility, originality, and elaboration. The result of the analysis showed that fluency obtained the highest score (95.64) of all aspects, and the lowest score was reported by elaboration (61.43). Findings from this study suggest that students' DMM can be used to determine their creative thinking level because DMM contains distinguished creative thinking details. Based on the results, it can be concluded that the participants' creative thinking has been properly developed. Therefore, it is advisable for lecturers to use DMM to monitor the development of their students' creative thinking.

Keywords: Ccreative thinking, education, digital mind maps, human anatomy and physiology course, university students

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Abstract

Creative thinking is an unorthodox way of thinking to produce fresh and new ideas. Creative thinking can be trained using innovative learning strategies. This study aimed to explore creative thinking aspects in the Digital Mind Maps (DMM) created by Universitas Islam Riau, Indonesia, students who were enrolled in Human Anatomy and Physiology course. A rubric containing four aspects of creative thinking, namely fluency, flexibility, originality, and elaboration. The result of the analysis showed that fluency obtained the highest score (95.64), and the lowest score was reported by elaboration (61.43). Findings from this study suggest that students' DMM can be used to determine their creative thinking level because DMM contains distinguished creative thinking details. Based on the results, it can be concluded that the participants' creative thinking has been properly developed. Therefore, it is advisable for lecturers to use DMM to monitor the development of their students' creative thinking.

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INTRODUCTION

The most recent education system is mainly focused on educating university students as creative individuals. Organisation for Economic Co-operation and Development (OECD) even lists creative thinking as one of the important goals of the 21st century learning (Lucas et al., 2013). Learning at various levels of education aims to equip the students with creative thinking so that they can generate creative ideas in solving their life problems. Therefore, an appropriate learning environment is mostly targeted at improving the students' creative thinking (Katz & Stupel, 2015; Tsai, 2013).

Creative thinking is used to solve problems that cannot be solved using conventional methods. Creative thinking refers to the ability to produce new and different concepts, solutions, or ideas (Sternberg, 2003). The thought process underlying creative answers is based on the person's skills, knowledge, understanding, motivation, and emotions (Ferrari et al., 2009). In psychological research, creative thinking is usually defined as a process that leads to new, original, useful, and effective products. A creative mind is characterized by its flexibility that encourages someone to imagine innovative answers to a question (Runco & Jaeger, 2012).

Creative thinking is associated with the concept of lateral thinking, divergent thinking, and free thinking (Bacanlı et al., 2011). Lateral thinking is thinking to find new ways of solving problems based on intelligence and logic. Divergent thinking is performed by rearranging directly received information and memory-system information so that athe quantity of ideas can be created (Silvia et al., 2008). Divergent forms of thinking do not follow routines and explore answers from many aspects (Chena et al., 2015). Free thinking is an individual's skill to create his own thinking without being bound by the thoughts of authority or the thoughts of others (Bacanlı et al., 2011).

Creative thinking is portrayed as the ability to innovate and make a difference in an ongoing process (Hürsen et al., 2014), realize imagination, express ideas easily, diagnose problems, and produce solutions (Ersoy & Başer, 2014). The development of creative thinking goes through a process that appears as a result of interrelated reactions and influenced by teaching approaches influenced by teaching approaches (Batlolona et al., 2019; Hu et al., 2016) and inquiry modules (Dewi & Mashami, 2019). Therefore, learning needs to facilitate the students to be able to express themselves efficiently, so they can find similarities or differences infrom the problems they face (Ersoy & Başer, 2014).

Creative thinking aspects include fluency, flexibility, originality, and elaboration. Fluency is the ability to produce new solutions to new problems in a short time (Lucchiari et

al., 2018). Fluency is associated with intelligence because the production of a large number of ideas highly depends on intelligence (Batey & Furnham, 2006). Flexibility is defined as the ability to simultaneously propose different perspectives on a problem. On the other hand, originality is closely related to personality factors such as openness to new experiences (Batey & Furnham, 2006). Originality helps an individual produce ideas that have never been developed before. Elaboration is the ability to systematize and organize the details of an idea and use the information to perform a task (Siew & Chong, 2014).

Rapid changes and increased competitiveness have made creative thinking as one of the most needed skills in the current era. There is no progress without creative thinking because the same pattern will repeat itself (Lucchiari et al., 2018). Creative thinking has become a driving force for technical innovation and scientific discovery (Hennessey & Amabile, 2010). In addition, on a personal level, creative thinking also plays a crucial role in helping someone to overcome everyday problems and challenges (Collard & Looney, 2014; Newton, 2014). In the business sector, creative thinking acts as an important resource to be innovative and competitive in the global market (Caniëls & Rietzschel, 2015; Mueller et al., 2012). Students need to be creative in order to acquire and integrate new knowledge. Thus, learning needs to be designed in such a way to promote creative thinking in the classroom so that the students are prepared to study, work, and live their personal lives effectively (Gu et al., 2019).

The fundamental role of creative thinking in higher education is not directly proportional to the students' achievement. Research by Rizki (2018), Rosy & Pahlevi (2015), and Suparman & Husen (2015) has revealed university students' lack of creativity. Likewise, Suriyani (2015) discovered that the majority of students in university performed poorly in creative thinking. When students weare given tests that require the ability to think creatively, they weare unable to do. If the forms and examples of questions given weare different from what they weare used to doing, students will become felt confused. They found that the performance of the students needed to be improved using appropriate learning strategies. They found that the performance of the students needed to be improved using appropriate learning strategies. Other related studies discussed how to foster university students' creative thinking through various innovative learning strategies (Batlolona et al., 2019; Hung et al., 2008; Kong et al., 2014). Innovative learning strategies provide opportunities for students to independently construct knowledge and transform new information. The use of mind maps is an example of innovative learning (Noonan, 2012; Ravindranath et al., 2016).

Mind maps are diagrams that reveal significant relationships between terms. Mind maps transform linear texts into graphical representations (Buzan, 2005) by placing one main concept in the middle surrounded by branches representing lower categories (Budd, 2004). Mind maps combine all the concepts that exist in one's brain, including logic, sequences, procedures, words, and numbers in the left brain, as well as images, imagination, color, and space in the right brain (Buzan, 2005). Mind maps can also be used as visual tools to help individuals develop complex conceptual schemes as well as think and process new knowledge. Mind maps are marked by a radial structure, where the linear text content is reorganized by placing the central theme of the text in the middle. Some related main text ideas radiate out in the form of branches. These main branches become other smaller branches representing more detailed ideas (Merchie & Keer, 2016).

Mind maps have been proven effective in facilitating the students to get actively involved in the learning process (Akinoglu & Yasar, 2007; Morse & Jutras, 2008). They were also effective in improving the long-term memory of medical students (Farrand et al., 2002), immediate achievement and retention (Bawaneh, 2019). Furthermore, through the use of colors and images in mind maps, information could last longer in the students' memory (Şeyihoğlu & Kartal, 2013). Mind maps were also applied to enrich students' knowledge or used as a medium for providing feedback (Simonova, 2015). As a result, both the teacher and the students could benefit from the implementation of mind maps in the classroom (Buran & Filyukov, 2015). Numerous research has shown that mind maps can improve students' creative thinking (Dell et al., 2012; Mahmud et al., 2013; Papushina et al., 2017). Mind maps are also available in a digital form; they were are called Digital Mind Maps (DMM). There is various software that allows the creation of electronic-based mind maps. The advancement of technology and electronic devices provides the opportunity to engage students in a creative learning process (Kisicek et al., 2010; Lin & Wu, 2016).

Digital mind maps (DMM) consist of digital graphics arranged hierarchically. A digital mind map is composed of a main idea which is then develop into branches that are equipped with colors, numbers, fonts, or images (Papushina et al., 2017; Simonova, 2015). Digital mind maps (DMM) allow students to be more flexible in creating mind maps (Yeong, 2013) because they can easily move objects and concepts by merely dragging and dropping. In addition, DMM can also depict a general description and details of the concept that is being created because the contain 'minimize' and 'maximize' features (Simonova, 2015). DMM allow students to insert hyperlinks or e-mail links and attach videos or images. The other

advantage of DMM is that they provide facilities for copying and pasting, and can be easily exported as images or *pdf* files (Papushina et al., 2017).

Many studies have attempted to investigate the effectiveness of mind maps in improving students' learning outcomes (Noonan, 2013; Radix & Abdool, 2013), problem-solving skills (Ismail et al., 2010), creative thinking (Widiana & Jampel, 2016; Zubaidah et al., 2017), and various other skills. However, these studies generally involved paper-based instead of digital-based mind maps. There have been indeed a few studies conducted on the implementation of digital mind maps in learning, yet the aspects of creative thinking, including fluency, flexibility, originality, and elaboration have not been thoroughly examined. Therefore, this study aimed to find out more about creative thinking based on Digital Mind Maps that have been created by university students.

METHODS

Design

This study was an experimental study that involved treatment in the form of Digital Mind Maps (DMM) implementation in the classroom. The type of experimental study used was pre-experimental designs. Treatment of research subjects without a control group. The study was conducted at *Universitas Islam Riau* (Riau Islamic University) and involved students who were enrolled in the 'Human Anatomy and Physiology' course. All students taking the human anatomy and physiology course were sampled. The number of students is 31 people. The first step of this study was to introduce Digital Mind Maps (DMM) to the participants who were not familiar with them. The use of DMM can be successful in the classroom when the students are taught how to use and make them. It is also useful for giving feedback to the students on the use of the DMM so that the DMM can be fully and properly utilized. The name of the software used to create the DMM in this study was *Mindomo*. The steps to creating a digital mind map can be seen in Table 1.

Instruments

The participants' creative thinking was measured based on the DMM they created. The rRubric which used to evaluate the students' creative thinking was adapted from Rahayu et al. (2018), such as presented in Table 2. Creative thinking aspects consist of fluency, flexibility, originality, and elaboration.

Data Analysis

A descriptive quantitative approach was used to analyze the data. The participants' achievement in creative thinking was examined using the following formula. The category for the students' creative thinking achievement referred to Table 3.

$$P = \frac{SC}{SM} x100$$

Note:

P = achievement

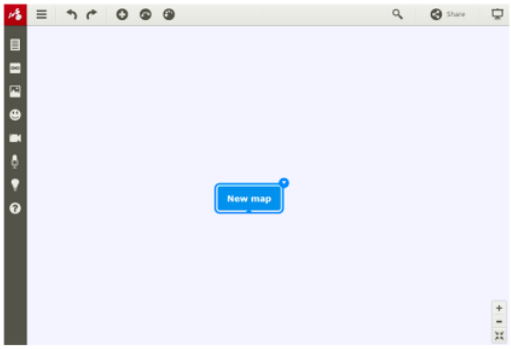
SC = achievement score

SM = maximum score

In addition to the quantitative data analysis, the students' digital mind maps were also analyzed descriptively. The descriptions of the students' DMM would provide a clearer picture of exemplary or non-exemplary digital mind maps.

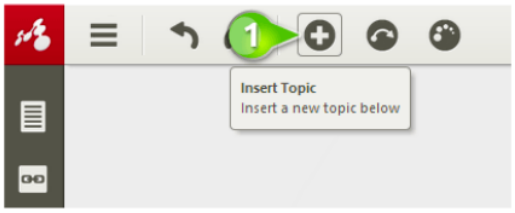
Table 1

Steps to Creating a Digital Mind Map

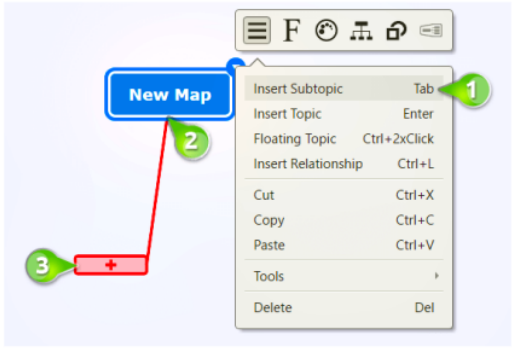
Steps	Remarks
1. Open the application (*Mindomo* application). After clicking "create", you will be presented with the *Mindomo* display.	
2. On the display, you can see four topics, namely central topic, main topic, subtopic, and floating topic. a. To name a topic, click topic. Then, the color of 'topic' will change into blue. Click again to insert texts in the topic marked in blue. Now, you can insert words.	

b. To insert a new line of text into a topic, place the mouse cursor at the end of the current line and hold down the SHIFT key and then press ENTER.

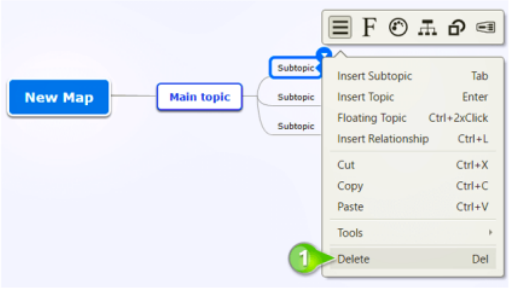
3. To create a topic, use PLUS button on the toolbar.



4. Or you can select several alternatives to creating a topic, including:
   a. Click the arrow icon in the upper right corner of the main topic and select "Insert Subtopics" from the context menu.
   b. Use keyboard shortcuts for faster topic creation: keep the mouse cursor in the central topic and press ENTER
   c. Hover over a topic, click on the triangle that appears inside and drag to enter a new topic



5. To delete a topic, click the arrow icon in the upper right corner of the topic and tap "Delete" button from the context menu. You can also delete a topic by tapping "Delete" button on the keyboard.



6. To save your work, you can find the "Auto Save" function in the top toolbar by clicking on the first icon. This function is already activated, so you do not need to click "Save" every time you want to back up your work.

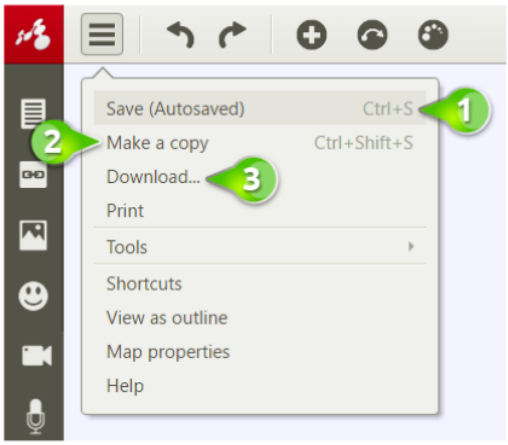


Table 2

Rubric for Evaluating Creative Thinking

Fluency		
Aspect	Criteria	Score
Central Idea	Writes the main idea	1
	Places the main idea in the middle of the map	1
Keyword	Selects and arranges node with the number of keyword(s):	
	X > 20	4
	10 < X ≤ 20	3
	5< X ≤ 10	2
	0 <X ≤ 5	1

	Percentage of keywords conformity	
	X>75%	2
	X ≤ 75%	1
Colors	Uses colors in the mind map (including the central idea, branches, cross-links, and illustrations), under one of the following conditions:	
	9<X ≤12	4
	6<X ≤9	3
	3<X≤6	2
	0<X≤3	1
Branches	Uses curvy or wavy branches	1
	Involves a lot of branches	1
	Uses the same color for the same hierarchical branch	1
	Uses different colors for different hierarchical branches	1

Table 3

Category of Creative Thinking

Score Range	Category
0-25	Not Creative
26-50	Almost Not Creative
51-75	Creative
76-100	Very Creative

Table 4

Creative Thinking Achievement of The Students

Creative Thinking Aspect	Average Score	Category

1. Fluency	95.54	Very Creative
2. Flexibility	79.74	Very Creative
3. Originality	71.67	Creative
4. Elaboration	61.43	Creative
Total Score	77.10	Very Creative

FINDINGS AND DISCUSSION

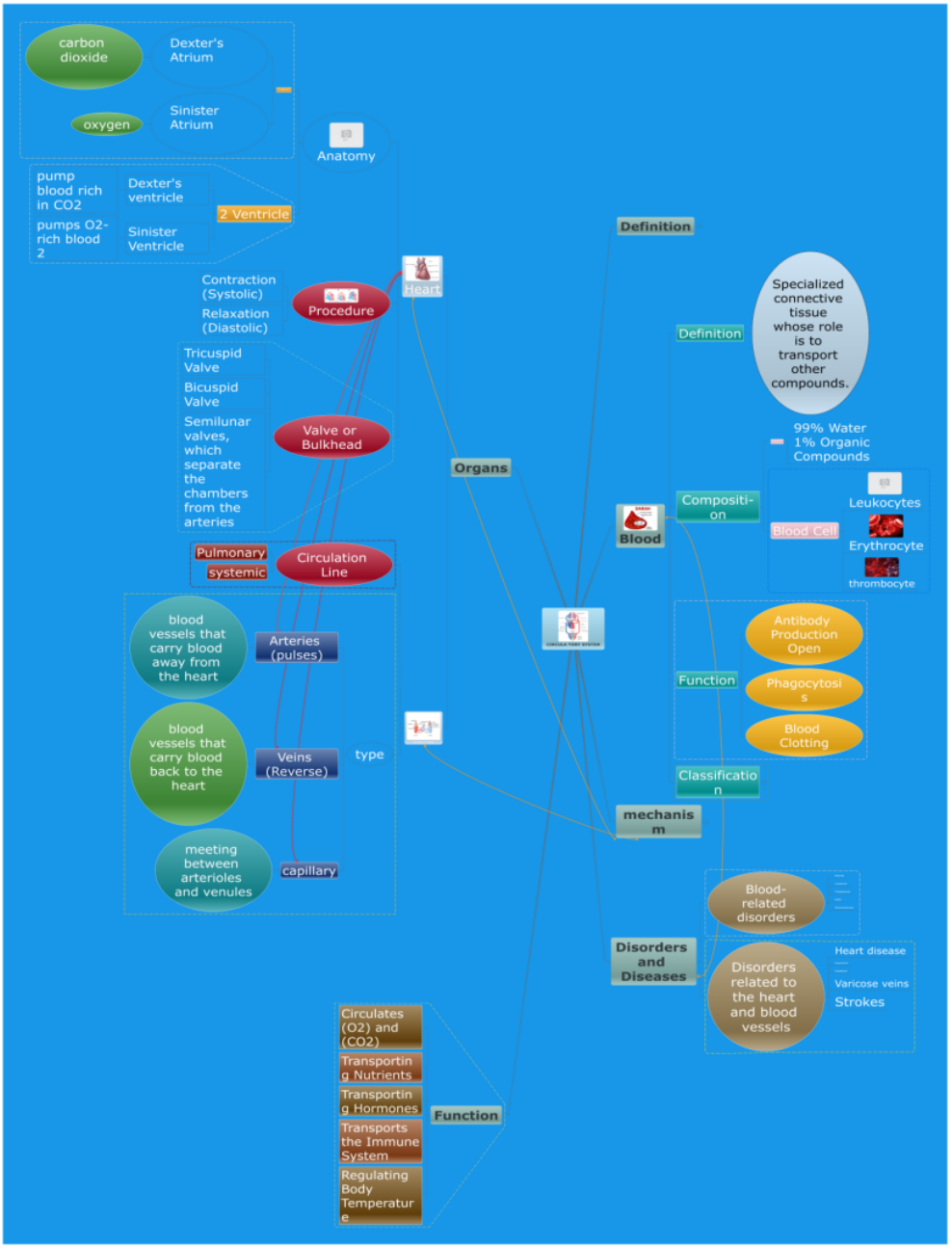
The participants' creative thinking was described based on the digital mind maps (DMM) they created (Table 4). Table 4 showed that the participants' creative thinking belonged to the 'very creative' category (77.10). A digital mind map contains a variety of features; therefore, it provides flexibility in thinking and as a result, supports the development of students' creative thinking. When elaborating on the main topic, students should add various keywords to form a lot of branches and hierarchies. The process of creating digital mind maps (DMM) can help the students express their ideas and creativity. They are thus expected to be able to relate a new keyword to the existing keywords that can be equipped with either images or videos. Through this process, the students are allowed to explore their abilities and prevent learning from being becoming monotonous. Digital mind maps (DMM) can also assist the students in generating many ideas through keywords or illustrations as the details. When elaborating on the main concept and supporting details, previously unknown connections have become detectable (Aykac, 2015). Another reason why DMM can improve the students' creative thinking is because DMM provide flexibility to think with an unrestricted structure. The addition of ideas and links is also not limited so as to encourage brainstorming (Davies, 2011).

Fluency achieved the highest score (95.64) among all aspects of creative thinking. Fluency was able to score higher than the other aspects of critical thinking because the participants were able tocould generate ideas in large numbers. The ideas generated were identified from the number of keywords, the use of various colors/illustrations, and the number of branches formed. Fluency refers to the ability to produce a large number of ideas by understanding concepts rather than remembering information. To clarify the definition of fluency, we can compare Figure 1 and Figure 2. Figure 1 is an example of a digital mind map that demonstrates excellent fluency, while Figure 2 shows a digital mind map with poor fluency.

Figure 1 shows a digital mind map with excellent fluency. One way to examine fluency in a DMM is to count the number of keywords displayed on it. The DMM presented in Figure 1 contains a very large number of keywords (> 20), where one main topic (circulatory system) is elaborated into six sub-topics, namely organs, understanding, blood, mechanisms, functions, and disorders/diseases. Each subtopic is also associated with other keywords forming a hierarchy. The DMM is also equipped with images so that theto make the concepts displayed are easier to understand. In addition, fluency can also be assessed from the use of different colors and branches. In Figure 1, it appears that the student applied the same color in the same hierarchy and different colors in different hierarchies. Mind maps allow for a more complex representation of text relationships through the addition of numbers, images, arrows, or connectors to branches. Interrelated elements are grouped using particular settings. Adjacent or more related concepts use similar colors and shapes (Merchie & Keer, 2016).

Figure 1

An Example of Digital Mind Map with Excellent Fluency



Unlike Figure 1, Figure 2 shows a digital mind map with a lack of concept explorations, indicated by a few keywords found. The main topic in the DMM is broken down

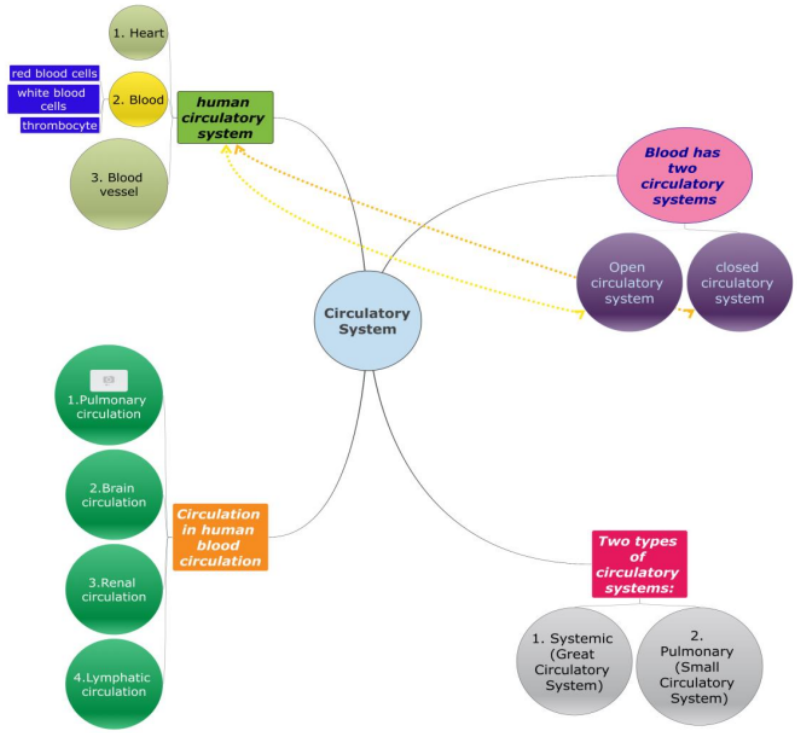
into four sub-topics, namely the mechanism of blood circulation, circulatory device, type of blood circulation, and blood circulation. After writing subtopics, the student was unable to proceed to other subtopics, so that there is a lack in the student's ability to connect one keyword to another. In addition, some of the keywords used are inappropriate to describe the human circulatory system. Overall, it can be informed that the DMM in Figure 2 has a poor fluency. Ideally, reference reading can help students find important information that can be used as keywords in creating a digital mind map. According to Kotcherlakota et al. (2013), mind maps help students clarify their thoughts and lay the foundation for a deeper conceptual framework and expertise.

In the previous explanation, it is said that the aspect of fluency occupied the highest place of all aspects of creative thinking, yet elaboration was placed in the lowest rank (61.43). The unfavorable elaboration score is caused by the inability of the students to filter important information in detail based on references that have been read. Important information is used as a keyword when compiling a digital mind map. The more concepts students can find, the more hierarchies in a DMM can be built. In the creation of DMM, students intentionally rearrange the information that has been read by searching for and interpreting associations between concepts (Brinkmann, 2003; Farrand et al., 2002). This strategy is carried out by highlighting important information, for example, by paraphrasing, making connections with prior knowledge, and linking texts with images (Weinstein et al., 2011).

Besides that, the low elaboration score also indicated that the students were facing a great deal of difficulties in connecting one keyword to another. The students' elaboration skill was also identified by the number of cross-links generated. A cross-link is a line that connects two different concepts simultaneously (Evrekli et al., 2010). The number of cross-links created in a digital mind map has a linear correlation with students' elaboration skills. Students will be able to make a cross-link if they understand the relationship between one keyword with another so that the resulting DMM become more detailed and rich in information. Elaboration is the ability to add necessary details to make something more understandable and look aesthetic (Vasilyeva & Erdyneeva, 2016). Figure 3 shows an example of DMM that contains plenty of details and cross-links, suggesting the student's high elaboration ability.

Figure 2

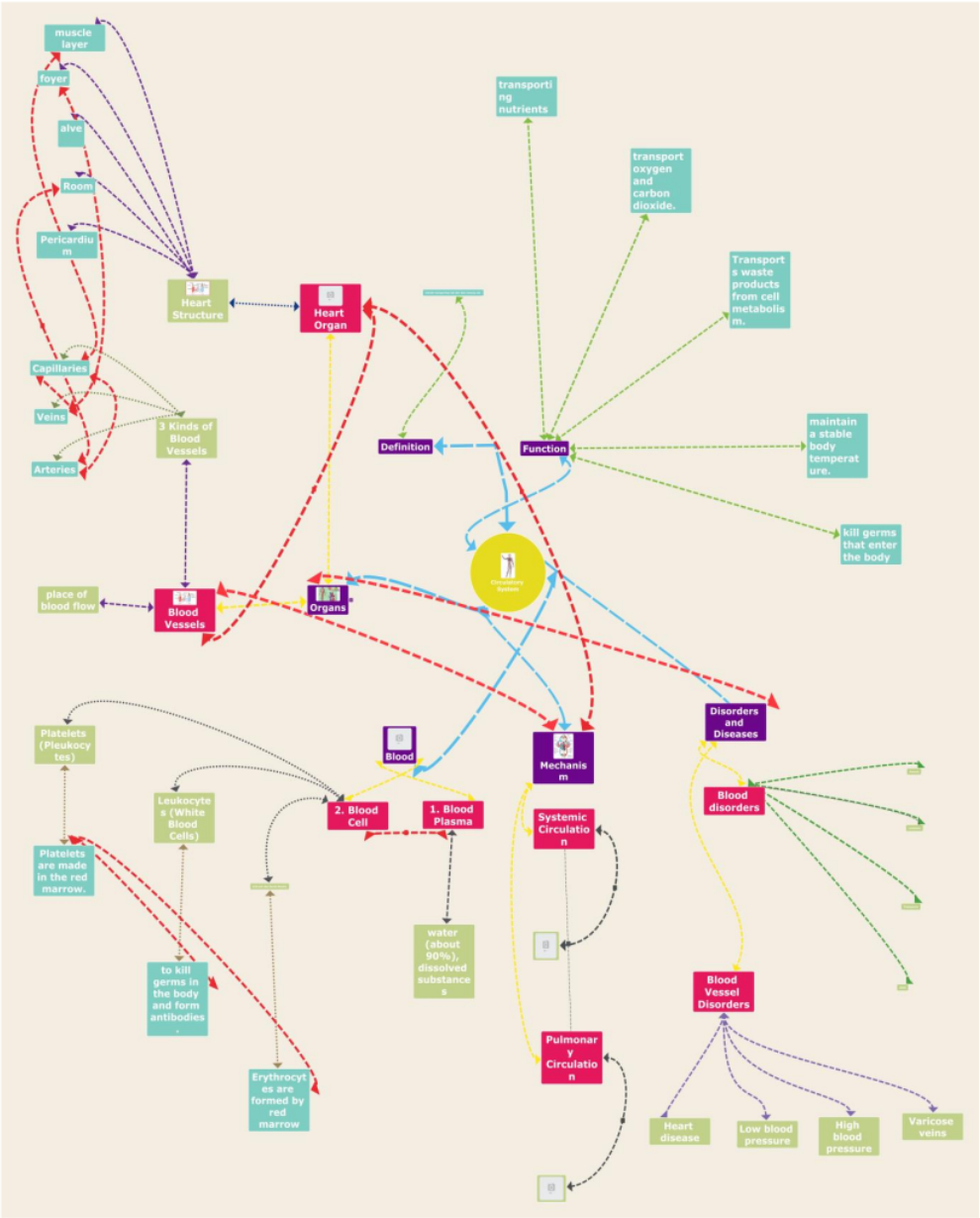
An Example of DMM with Poor Fluency



The DMM shown in Figure 3 has a high elaboration score because it is composed of several hierarchies and contains a great deal of cross-links. Four hierarchies are formed in the DMM. The first hierarchy is marked in purple (explaining five5 sub- topics from one main topic). The second hierarchy is marked in red which is a branching of the subtopic. The third hierarchy, marked in green, is a continuation of the second hierarchy, and the fourth hierarchy marked in blue, is the last branch of the DMM. The large number of hierarchies that can be formed indicates that the student who compiled the DMM was able to elaborate on all information obtained from his reading. Mind maps can help students think, learn, and remember effectively and bring up different innovative thoughts. Educators can utilize mind maps to facilitate the students to quickly understand the subject matter, hierarchical structures, and logical relationships between concepts (Liu et al., 2018).

Figure 3

An Example of DMM with High Elaboration

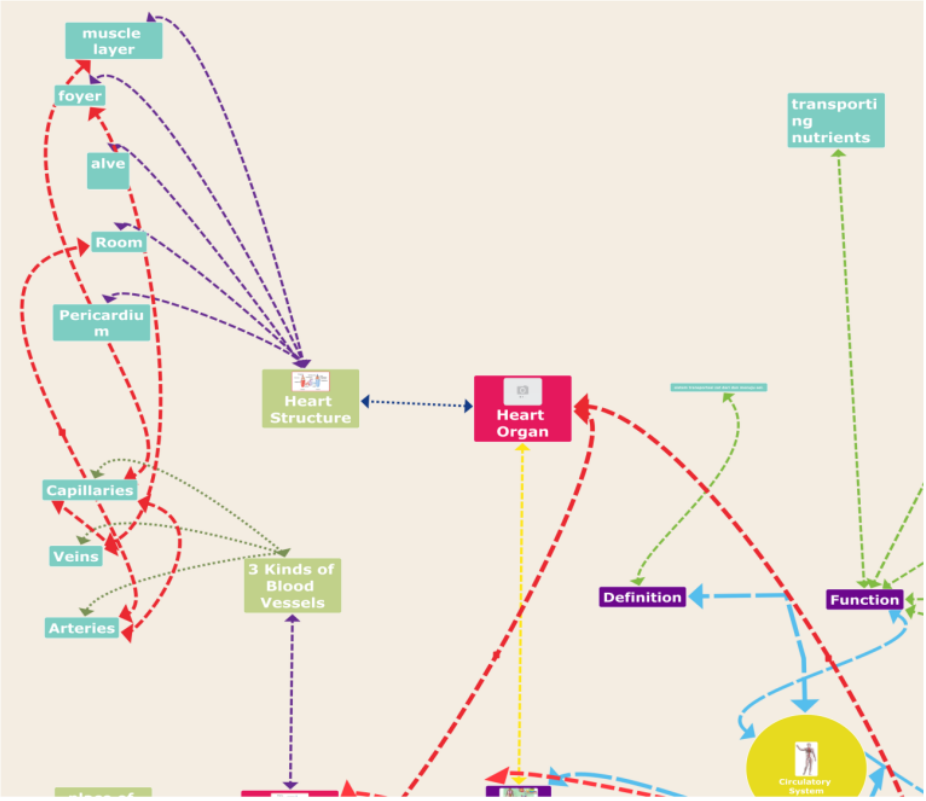


In addition to the number of hierarchies, Figure 3 also shows an example of digital mind maps that has an adequate number of cross-links. The addition of these cross-links makes the digital mind map in Figure 3 rich in information sources. The cross-links in the

digital mind map are indicated by red-dash lines. The atria, for example, is connected with veins, ventricles with arteries, arteries with capillaries, and veins with capillaries. To see the cross-links more clearly, one part in Figure 3 is zoomed-in and presented in Figure 4.

Figure 4

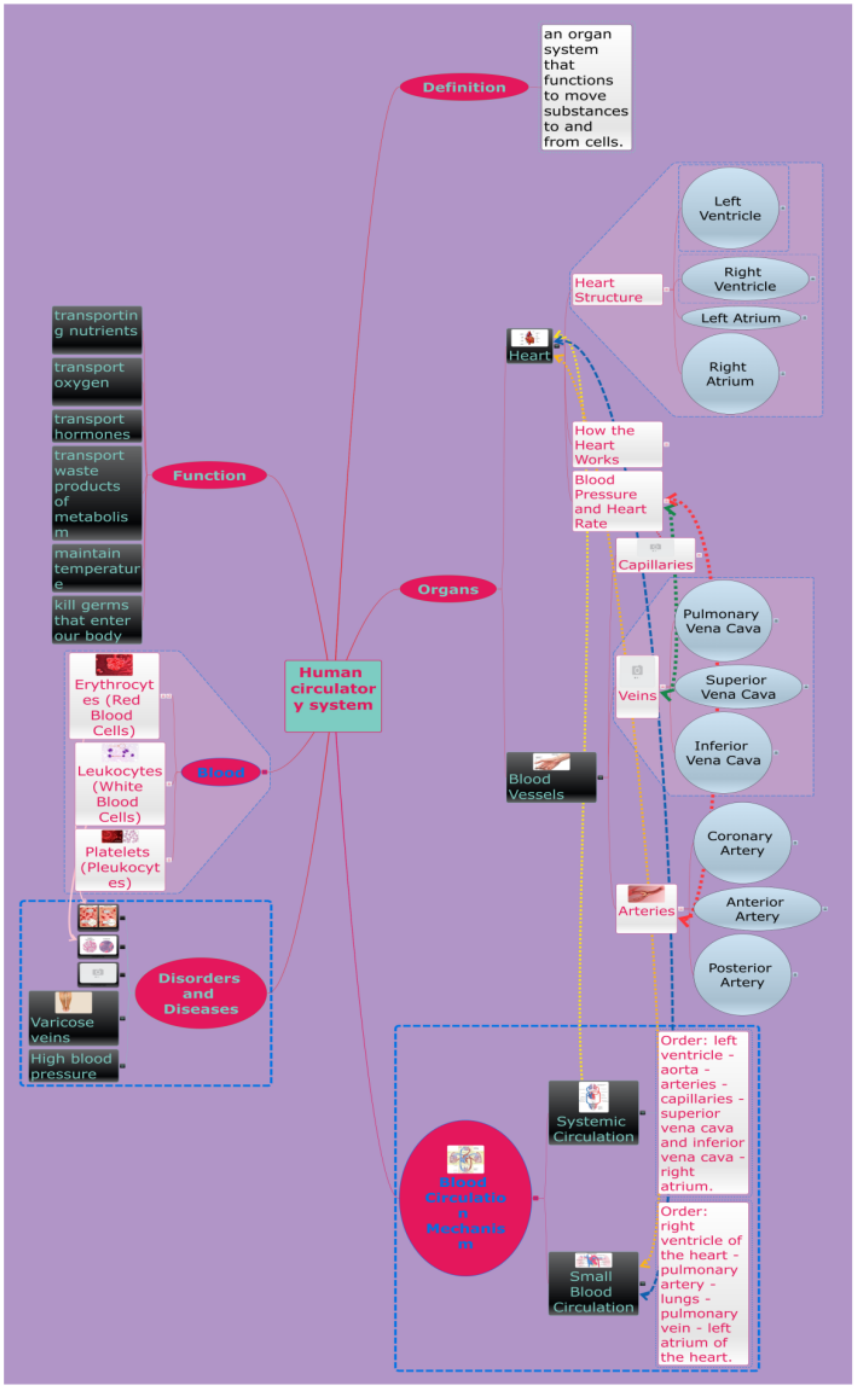
An Example of DMM with Cross-Links



The next aspect of creativity is flexibility. In this study, flexibility was assessed from the number of ideas and branches formed in the students' DMM. Kenett et al. (2018) explain that someone who has flexibility can produce ideas based on possibilities surrounding the situation and see things from different points of view. The fFollowings are two examples of DMM with different flexibility values. Figure 5 is an example of DMM with exemplary flexibility, while Figure 6 is an example of DMM with poor flexibility.

Figure 5

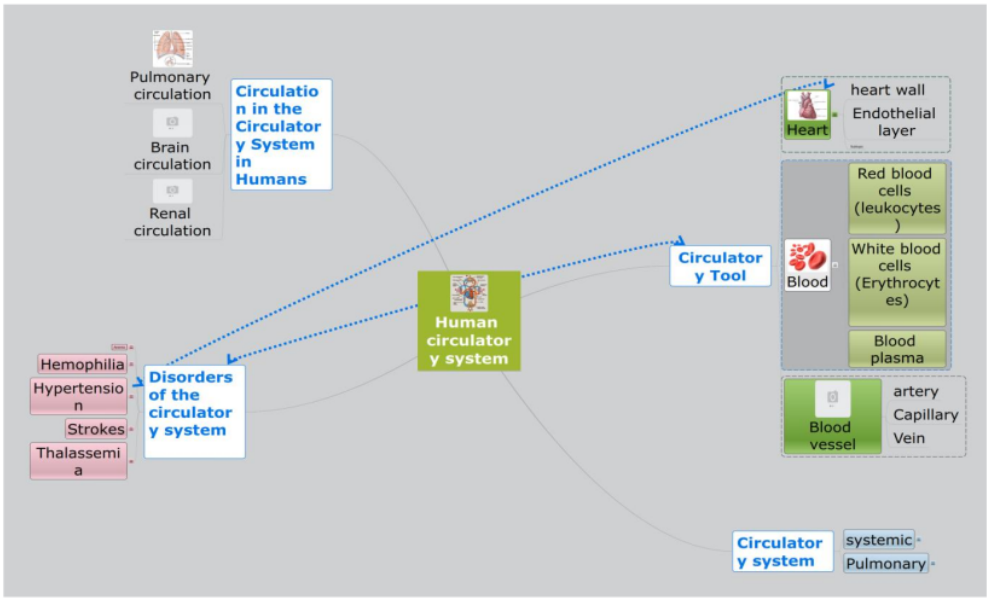
An Example of DMM with Exemplary Flexibility



The digital mind map presented in Figure 5 consists of six basic ideas with many branches and sub-branches. A branch is a more detailed concept drawn from the main topic. A supporting branch is the extension of a branch. For instance, the basic idea of "circulatory organs" branch off into the heart and blood vessels. The hHeart can be broken down through helper branches into the structure of the heart, how the heart works, and the heart's blood pressure. Subsequent auxiliary branches can still be continued from the heart structure to the right atrium, left atrium, left ventricle, and right ventricle. On the other hand, the digital mind map shown in Figure 6 only contains 4 four basic ideas with a little branching. Even, the DMM only consists of one hierarchy representing every basic idea. AThe large number of branches is an illustration of keywords that can be understood by studentsstudents can understand. Students are asked to draw up a digital mind map based on the references they read. After reading, the students can determine which main concepts and keywords to be used in in digital mind maps so that they can easily understand and remember the information that has been read. This is consistent with the explanation of Buran & Filyukov (2015), who states that it is easier to remember ten keywords from a text rather than remember the entire page. In addition, students can also consider some creative ideas by including pictures and other illustrations so that their DMM can be appealing.

Figure 6

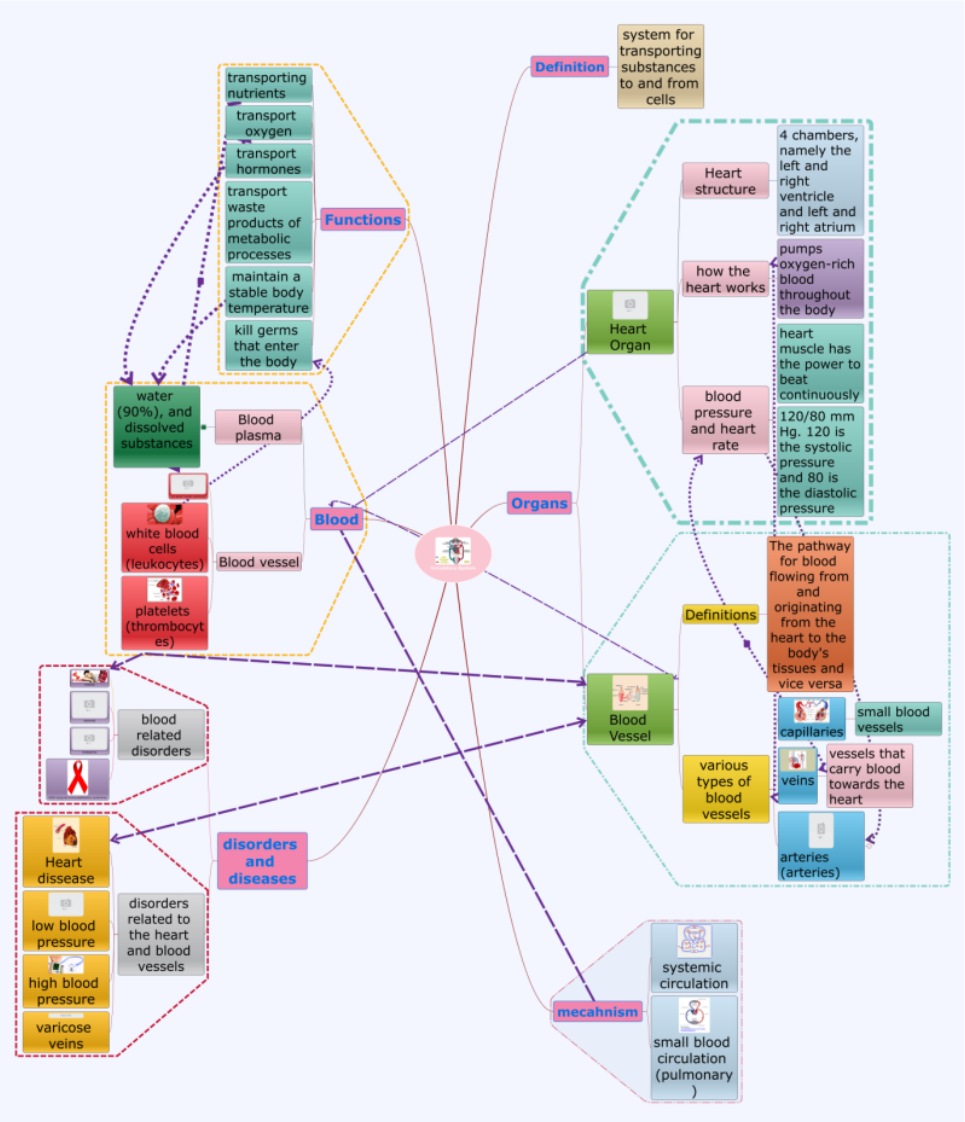
An Example of DMM with Poor Flexibility



The last aspect of creative thinking discussed in this study is originality. Originality in the students' digital mind maps (DMM) was evaluated based on the suitability of the keywords with the main topic being discussed, the suitability of the images with the concepts represented, and additional highlights or boundaries showing important information. The findings of this study revealed that the students' digital mind maps scored 71.67 in originality. An example of DMM that contains originality is shown in Figure 7.

Figure 7

An Example of DMM with Exemplary Originality



Based on Figure 7, it can be seen that the keywords used are in accordance with the main topic. The main topic is the main theme that is discussed in the DMM and is always put in the middle of the DMM. Figure 7 shows that the DMM consists of one main topic, that which is the circulatoryion system. Examples of suitable keywords used to describe the circulatoryion system are the heart, blood vessels, blood, blood cells, plasma, erythrocytes, leukocytes, platelets, anemia, thalassemia, and so forth. In addition to keywords compatibility, the DMM in Figure 7 is also equipped with images that support the keywords. The pictures are selected according to the intended purpose so that it helps in understanding the message conveyed. Illustrations in the form of pictures or videos can represent information, making it easier for someone to understand the DMM. This is in line with research conducted by D'Antoni et al. (2010), who suggest that mind maps that are equipped with colors and images can facilitate the acquisition of information from short-term to long-term memory.

The DMM in Figure 7 is also equipped with boundaries so that the important information is categorized into the same group. Boundaries are information that is marked by a circle and functions to indicate a certain conclusion so that it helps in storing information more effectively (Bystrova & Larionova, 2015). Figure 7 presents a digital mind map that contains seven boundaries,; each of which has been differentiated according to sub-topics and keywords. Different keywords that have a link are then grouped into one boundary. For instance, disorders related to the heart and blood vessels are categorized into heart disease, high blood pressure, low blood pressure, and varicose veins (as shown by the arrow in Figure 7).

The process of creating digital mind maps has provided the students with the opportunity to explore their ideas. It was shown in this study that the students were able to use all the available features so that they could produce different digital mind maps. When using linear learning strategies for example, by reading, the students were unable to think creatively and remember information effectively. Therefore, digital mind maps can be used by the students to learn independently, improve memory, and connect ideas. In addition, digital mind maps (DMM) can also be used to measure students' creative thinking and improve other skills such as problem-solving skills, concept mastery, and various other skills.

CONCLUSIONS

In this study, Digital Mind Maps (DMM) wereas used to determine students' creative thinking. The students' creative thinking score based on their DMM was categorized into the 'very good' category (77.10). Fluency achieved the highest score (95.54, very good), and elaboration obtained the lowest score 61.43 (good), among the other creative thinking aspects. In conclusion, this study provides evidence that, besides tests and creative projects, digital mind maps can also be used as a tool to assess students' creative thinking. Further studies can be conducted on the link between creative thinking and other variables so that they can make a substantial contribution to the learning process.

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AUTHORS' NOTE

Nurkhairo Hidayati

The last five studies, place and date of publication are presented as follows

No	Studies	Place of Publication	Date of Publication
1	The PBL vs. Digital Mind Maps Integrated PBL: Choosing Between the two with a view to Enhance Learners' Critical Thinking	Participatory Educational Research	2022
2	Cognitive Learning Outcomes: Its Relationship with Communication Skills and Collaboration Skills through Digital Mind Maps-Integrated PBL	International Journal of Information and Education Technology	2020
3	Students' Habits of Mind Profiles of Biology Education Department at Public and Private Universities in Pekanbaru, Indonesia	International Journal of Instruction	2020
4	The Relationship between Critical Thinking and Knowledge Acquisition: The Role of Digital Mind Maps-PBL Strategies	International Journal of Information and Education Technology	2020
5	The integrated PBL-DMM: A learning model to enhance student creativity	Pedagogika	2020

Apriza Fitriani

The last five studies, place and date of publication are presented as follows

No	Studies	Place of Publication	Date of Publication
1	The quality of student critical thinking: A survey of high schools in Bengkulu, Indonesia	Jurnal Pendidikan Biologi Indonesia	2022
2	PBLPOE: A learning model to enhance students' critical thinking skills and scientific attitudes	International Journal of Instruction	2020
3	The effects of integrated problem-based	Eurasian Journal of	2020

	learning, predict, observe, explain on problem-solving skills and self-efficacy	Educational Research	
4	The integrated problem based learning and predict, observe, explain (PBL-POE) to empower students' problem-solving skills	ACM International Conference Proceeding Series	2020
5	Students' Self-Efficacy on Biology Lesson of Senior High Schools in Bengkulu City, Indonesia	1st Annual International Conference on Mathematics, Science, and Education (ICoMSE 2017). Atlantis Press.	2020

Wulandari Saputi

The last five studies, place and date of publication are presented as follows

No	Studies	Place of Publication	Date of Publication
1	The Correlation between Metacognitive Skills and Cognitive Learning Results of Biology Pre-service Teachers on Different Learnings	Journal of Turkish Science Education (TUSED)	2020
2	Students' self-regulated learning (SRL) profile dataset measured during Covid-19 mitigation in Yogyakarta, Indonesia	Data in Brief	2020
3	Question types of pre-service teachers at the implementation of a new learning model: a comparison between QASEE, RQA, and conventional learnings	Journal for the Education of Gifted Young Scientist	2020
4	QASEE: A Potential Learning Model to Improve the Critical Thinking Skills of Pre-service Teachers with Different Academic Abilities	European Journal of Educational Research	2020
5	Improving Cognitive Learning Outcomes of Student Candidate Teachers with Lower Academic Ability with the RQA Learning Model in English: Improving Cognitive Learning Outcomes of Prospective Teacher Students with Lower Academic Ability Using the RQA Learning Model	Bioilmi	2019

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