

Digital Mind Map Assisted Group Investigation Learning for College Students' Creativity

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Abstract—This study's objective was to investigate the Digital Mind Map (DMM) Assisted Group Investigation GIGI effect on students' creativity. It employed a pretest-posttest nonequivalent control group design and involved 75 students from IKIP Budi Utomo Malang, Indonesia, in the academic year of 2019/2020. Pretest and posttest were conducted to collect data on students' creativity. A rubric accompanied the tests to evaluate the keywords, material appropriateness, organization and layout, completeness of the material, creativity, image symbols, curved lines, and color used in the DMM. Assumption tests, including normality and homogeneity tests of variance, were conducted before running the ANCOVA. The analysis result showed that the DMM-GI learning model affected students' creativity ($p < 0.005$). LSD test indicated a significant difference between DMM-GI and DMM-conventional learning in improving students' creativity. Therefore, it can be said that the DMM-GI learning model can be used to enhance students' creativity.

Keywords—Students' creativity; group investigation; digital mind map

1 Introduction

Creativity is the capability to generate new products and ideas to solve problems [1] or to enrich existing knowledge [2]. Creativity makes learning more meaningful [3] since it triggers the interaction between students' abilities and experience to produce a useful product [4]. Enhancing students' creativity is one of the essential goals of education at universities and colleges [5]. It is seen as an urgent need because creativity makes students engaged more actively in learning [6]. A creative learning environment will enable students to express their ideas freely and think creatively [7].

Research shows that Indonesian students have low creativity [8, 9, 10] due to the learning process that cannot accommodate students' creativity. It is also demonstrated that the teachers have not optimized pedagogical strategies in the classroom [11]. Implementing a less innovative instructional strategy has resulted in students' low awareness of creativity development [12].

Therefore, to enhance students' creativity, changes need to be made. It is crucial to conduct active learning processes that will help students construct their knowledge [13], engage students actively in classroom discussions [14], and establish a student-student collaboration that indirectly affects students' creativity [15]. One of the active learning models that can be used to enhance students' creativity is Group Investigation.

Group Investigation GIGI is a learning model where students are organized and assigned into small groups to investigate [16]. Group Investigation emphasizes data collection by student individuals, data interpretation through group discussion, and students' contribution to the assigned group [17]. Group Investigation can promote student initiatives, creativity, and active learning [18]. Through group discussion in GI, students are encouraged to express unique ideas [19] and create a pleasing learning atmosphere [20].

Many researchers have reported the benefits and shortcomings of implementing GI Damini [21] and Hosseini [17] explain that GI is unlikely efficient since it is impossible to perform all GI learning steps in one meeting. For example, the evaluation stage is one of the learning steps that is mostly skipped during GI implementation. The evaluation stage aims to examine the achievement of the learning goals. If the teacher cannot carry out the assessment, students' learning outcomes cannot be identified, and thus learning cannot be adequately improved. Hargreaves [22] agrees that evaluation is important to monitor students' learning progress and provide a follow-up for improvement.

One way to conduct an evaluation is to ask students to conclude. William [23] explains that evaluation can be done through observation, interview, test, and conclusion drawing. Conclusion drawing is an activity that is conducted at the end of the lesson. At this moment, the learning topic is broken down into points [24]. Alternatively, evaluation can be performed by using technology assistance. Past studies have proved that digital tools such as smartphones and tablets help educational practitioners conduct an assessment and significantly influence the learning process [25-27]. Obviously, the application of technology in learning is essential, such as for evaluation.

Digital mind maps (DMM), which are also known as electronic mind maps [28], are compressed in a computer file [29]. Digital mind maps serve as a tool that can stimulate students' creativity and collaboration and improve students' confidence in contributing ideas in the classroom [30]. Providing a stimulus in the form of a visual element makes it easy to analyze, understand, and memorize a digital mind map. The relationship between information obtained from solving linear text problems can be seen clearly [31]. DMM will make students think quickly and remember a concept through predetermined keywords [32]. DMM offers efficient and dynamic mind maps because DMM is not limited to physical learning spaces. Through DMM, students are equipped to develop and organize ideas using higher-order thinking skills; this can ultimately increase their understanding of a concept [33].

Digital Mind Maps also can be used in Group Investigation as an evaluation tool. The instructional model resulted from this combination is called Digital Mind Map Assisted Group Investigation (DMM-GI). The DMM-GI model can improve students' creativity because it encourages students to be creative, especially in developing ideas through DMM development [34]. Students can insert various concepts and images in their DMM. The activity to connect the images to the concepts when drawing a digital

mind map is a creative activity that requires thinking instead of remembering [35]. A digital mind map can be saved as a file that the students can share and with the teacher to collaborate [36] efficiently. Hence, the current study aimed to investigate the Digital Mind Map (DMM) Assisted Group Investigation GIGI effect on students' creativity based on the information above.

2 Literature Review

2.1 Creativity

Creativity is a thought process that helps individuals build their knowledge and solve challenging tasks in a better way [37]. Bloom places creativity in the highest dimension of cognitive processing [38]. Creativity is often defined in three ways: creativity as the final product, creativity as a creative process, and creativity as part of the social system [39]. Creativity allows humans to access the most critical skills to innovate based on prior knowledge [40]. Past studies have confirmed the important role of creativity in students' success [41] and produce new ideas [42]. Creative people create and innovate in various fields [43]. Thus, creativity determines someone's success in the future [44].

The uppermost definition of creativity is the ability to create new products and new ideas [1]. Indicators of creativity used in this study referred to the creativity indicators developed by Trefinger, Young, Selbi, dan Shepardson [45], namely fluency, flexibility, originality, and elaboration. Fluency is being fluent in generating ideas, suggestions, and thinking relevant answers within a particular time. Flexibility refers to the capability of generating various thoughts or ideas from different points of view. Originality refers to the ability to create unique ideas, suggestions, answers that no one else has thought of. Elaboration is to generate more complex ideas, suggestions, and answers.

2.2 Group Investigation GIGI

Group Investigation GIGI is a cooperative learning model that motivates students to communicate well and cooperate [46] as well as carry out investigations in groups to raise, analyze and solve problems [47]. GI makes students responsible for their learning activity [48]. Research shows that GI provides learning experiences through creativity in group presentations using visual media that are more interesting and less tedious [49]. Therefore, this type of learning is more effective than conventional learning.

Group Investigation can facilitate students' ability to exchange materials, knowledge, ideas, and backgrounds and share what is relevant for investigating [16]. Learning in GI consists of six stages, namely; 1) choosing a topic, 2) planning a task, 3) conducting an investigation, 4) preparing a report investigation, 5) present the investigation report, and 6) evaluating [50]. GI has three main advantages, namely, inquiry, knowledge, and group dynamics [51].

2.3 Digital Mind Map (DMM)

Digital Mind Map (DMM) is a Mind Map (MM) designed with a computer program or smartphone application or via a website [52]. Some experts explain that DMM is an electronic mind map with the same results and concept of the creation process [29], [53]. DMM essentially refers to the theory proposed by Buzan [54], mentioning that DMM consists of five components, including the center, branches, keyword, image, and color. DMM can be arranged with colors, numbers, fonts, images, or videos in a non-linear format using a computer application [36]. Available applications such as Coggle, Freemind, Mindjet, MindNode, XMind, SpiderScribe.net, iMindMap, MindMeister, and Popplet are useful to assist in creating, organizing, and storing DMM [55]. Also, DMM accommodates the arrangement and visualization of thought processes.

DMM can act as a tool to stimulate activity, creativity, and collaboration between students and increase their confidence in contributing ideas in the classroom [56]. The utilization of digital technology in the learning process can improve student skills and knowledge. Similarly, Al-Haj Bedar & Al-Shboul [57] state that digital technology in the classroom helps students focus on the learning process. Al-Jarf's [58] reports that computerized mind maps can encourage creativity because they allow students to be more adept at generating and forming ideas that are complex to write about. Apart from that, DMM can also be used as an evaluation tool [59]. DMM can be used to assess students' creative thinking [60]. The relationship between indicators of creativity and mind map's essential parts can be seen in Table 1.

Table 1. The Relationship between Indicators of Creativity and Mind Map Components

Indicators of creativity	Mind Map Components
Fluency	Branch
Flexibility	Branch, keyword
Originality	Mind map center, branch, picture, color
Elaboration	Mind map center, branch, picture, color

Source: Susiana [61].

The mind maps generated by the participants were evaluated using a rubric of mind map creativity developed and modified from Monet & Connor [62]. The relationship between indicators of the rubric and mind map components can be seen in Table 2.

Table 2. The Relationship between Indicators of Creativity Rubric and Mind Map Components

Indicators of the Rubric	Mind Map Components
Keywords	Keywords
Material Appropriateness	Branch, keyword
Organization and Layout	Mind map center, branch, picture, keyword
Material Completeness	Mind map center, keyword, branch, picture
Creativity	Mind map center, keyword, branch, picture, color
Symbols, Images, and Curved Lines	Picture, branch
Color	Mind map center, branches, and links

2.4 Digital Mind Map Assisted Group Investigation (DMM-GI)

Digital Mind Map Assisted Group Investigation is a GI-based learning model in which implementation is assisted by digital technology in DMM. This constructivist learning model aims to improve students' ability to develop knowledge and independence to generate creativity and find steps to solve a problem, both individually and in groups. Constructivist learning directs students to organize themselves and take an active role in education by setting goals, monitoring, and evaluating their progress [63]. The constructivist-based DMM-GI model can help students develop knowledge, solve problems individually and in groups, assess learning progress, and train students' independent learning, leading to creativity.

The DMM-GI model consists of six stages, namely: 1) choosing a topic, 2) planning a task, 3) carrying out an investigation, 4) preparing a report investigation, 5) present the investigation report, and 6) evaluating using DMM. The DMM-GI model is expected to enhance students' creativity in developing ideas and making learning more fun and interesting.

3 Methods

3.1 Design of the study

The present study used a pretest-posttest nonequivalent control group design. The pretest and posttest were administered to two treatment groups (experimental and control). The experimental group was treated using the DMM-GI model, and the control group performed learning using DMM-assisted conventional learning. The research design is presented in Table 3.

Table 3. The Research Design

Group	Pretest	Treatment	Post-test
DMM-GI	O ₁	X ₁	O ₂
DMM-Conventional	O ₃	X ₂	O ₄

Note: O₁= pretest score of the experimental group
 O₂= posttest score of the experimental group
 X₁= Digital Mind Maps Assisted Group Investigation Learning
 X₂= Digital Mind Maps Assisted Conventional Learning
 O₃= pretest score of the control group
 O₄= posttest score of the control group

3.2 Participants of the study

This study was conducted in the odd semester of 2019/2020. The study participants consisted of 75 Biology students enrolled in the Vascular Plant Botany course in IKIP Budi Utomo Malang, Indonesia. The participants' Grade Point Average (GPA) was analyzed using a t-test to determine the sample's homogeneity in academic ability. The t-test result showed no significant difference between the two classes, where class A (34 students) obtained an average score of 3.39, and class B (41 students) obtained

an average score of 3.46. The experimental and control groups were selected randomly from the two classes. Digital Mind Maps assisted Group Investigation (DMM-GI) was implemented in the experimental group, while Digital Mind Maps assisted conventional (DMM-Conventional) was applied in the control group.

3.3 Research procedures

The initial stage of this study was the pretest administration. On the test, the students were asked to create digital mind maps based on the following topics: Pteridophyta, Gymnospermae, and Angiospermae. The purpose of conducting the pretest was to determine the students' initial creativity before being involved in the experiment. The DMM-GI model was applied in the experimental group, and the DMM-Conventional model was implemented in the control group for 12 meetings. The learning steps carried out in the two classes are shown in Table 4. The final stage of the study was to conduct the posttest. On the posttest, the participants were asked to create digital mind maps based on the topics that had been learned. The students had to save the maps in pdf format and send them to the teacher via e-mail for evaluation.

Table 4. Stages of Learning in DMM and DMM-Conventional Classes

DMM-GI		DMM-Conventional	
Stages of Learning	Learning Activities	Stages of Learning	Learning Activities
Organizing students into groups	The students are divided heterogeneously into 5-6 based on their academic ability.	Encouraging students to learn	Encouraging students to learn the materials being discussed.
Selecting topics and planning tasks	Each group selects a topic, then students in the group form a plan for investigation according to their roles.	Delivering the materials	The lecturer delivers the materials.
Conducting an investigation	Every group member investigates by seeking information, analyzing data, drawing conclusions, exchanging ideas, discussing, and clarifying.	Assigning students into groups	The students are divided into a group of 5-6.
Preparing a report	Group members select essential concepts that need to be reported, compile a report, prepare a presentation, share the presentation assignments.	Group discussion	The students discuss in groups and do the task assigned by the lecturer.
Presenting the report	Group members present in turn according to the tasks assigned to them and answer questions from other groups.	Presenting the discussion result	One particular group is asked to present the discussion result; those who are not given a chance to present have to provide feedback to the presenters in comments, suggestions, or questions.

Evaluating	Each group evaluates the materials studied, creates digital mind maps based on the evaluation results, saves them in pdf format, and then sends them to the lecturer via e-mail.	Conducting an evaluation	The lecturer asks the students to conclude the discussion, transfer it into DMM, save the DMM in pdf format, and then send them to the lecturer via e-mail.
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3.4 The instrument of the study

The rubric used to assess the students' creativity was adopted from Monet & Connor [62]. The rubric was used to assess the keywords, material appropriateness, organization and layout, completeness of the material, creativity, image symbols, curved lines, and color used in the students' DMM (Table 5). The rubric used a score range of 0-4 for each of the indicators evaluated, where 4 = very good, 3 = good, 2 = fair, 1 = bad, 0 = very bad. Before use, the rubric underwent expert validation, where experts were invited to evaluate the rubric. The evaluation criteria for rubric validity ranged from $0 \leq X \leq 0.50$ for highly invalid, $0.50 \leq X \leq 1.50$ = invalid; $1.50 < X \leq 2.50$ = fairly valid; $2.50 < X \leq 3.50$ = valid; and $3.50 < X \leq 4.00$ = highly valid. Based on the expert validation, the rubric obtained an average score of 3.81, which suggested that the rubric in use was highly valid and can be used in data collection.

Table 5. Creativity Rubric to Evaluate Digital Mind Map

No	Indicator	Descriptor	Score
1	Keywords	The keywords are written in words	4
		The keywords are written in a sentence	3
		The keywords are written in several sentences	2
		The keywords are written in a paragraph	1
		No keywords used	0
2	Material's comprehensiveness	The mind map contains the correct sections and understanding.	4
		The mind map contains a few inaccuracies, but most of the links are correct.	3
		The mind map contains some inaccuracies that are not fundamental.	2
		The mind map contains many inaccuracies of the topic.	1
		The mind map contains the wrong topic's interpretations.	0
3	Organization and Layout	The mind map is organized with a complete branch structure with interrelated topics.	4
		The mind map is organized with a complete branch structure but less related topics.	3
		The mind map is organized with an incomplete branch structure with less related topics.	2
		The mind map is organized with an incomplete branch structure with unrelated topics.	1
		The mind map has no branch structure organization.	0
4	Material's completeness (topics and sub-topics)	The mind map is complete because all topics and sub-topics are represented.	4
		The mind map is complete, but one or two essential topic sections and sub-sections are missing.	3
		The mind map is not complete enough to represent each topic and sub-topic.	2
		The mind map is incomplete because some of the topic sections and sub-topics are missing.	1

No	Indicator	Descriptor	Score
		The mind map contains no material completeness (topics and sub-topics).	0
5	Creativity	Different ideas are developed from one idea into more than 15 branches, with logical layouts and a good presentation.	4
		Different ideas are developed from one idea into more than 10-15 branches, with logical layouts and a good presentation.	3
		Different ideas are developed from one idea into five branches, with logical layouts but a confusing presentation.	2
		Different ideas are developed from one idea into less than five branches, with confusing layouts and presentations.	1
		There is no development of the idea.	0
6	Symbolization: pictures and curves	The mind map contains images/symbols in the central idea, the main branch, and other branches connected by curved lines.	4
		The mind map contains images/symbols only on the main branch, other branches connected by curved lines.	3
		The mind map contains images/symbols only on other branches connected by curved lines.	2
		The mind map does not contain any images/symbols but uses curved lines.	1
		The mind map does not contain any images/symbols nor curved lines.	0
7	Color use	Various colors are used in the mind map (the center, branches, and links).	4
		Various colors are used in the mind map (branches and links).	3
		Only one color is used in the mind map (the center, branches, and links).	2
		Only one color is used in the center of the mind map.	1
		No color is used in the mind map.	0

Source: Modified from Monet & Connor [62].

3.5 Data analysis

Data analysis was performed in three stages:

1. The students' creativity score was calculated using the following formula: $DMM \text{ creativity} = \frac{\text{score obtained}}{\text{maximum score}} \times 100$ (1)
2. SPSS 23 was used to analyze the results of the pretest and the posttest. The normality and homogeneity of variance were examined using Kolmogorov-Smirnov and Levene tests, respectively. The test results showed that the data had a normal distribution with a score of 0.131 for pre-creativity and 0.120 for post-creativity and distributed homogeneously with p-value 0.447 ($p > 0.05$).
3. After the data were proven normal and homogeneous, ANCOVA was run to investigate the instructional models' effect on student's creativity. An LSD test followed this process.

4 Results and Discussion

The ANCOVA analysis results on the students' DMM creativity can be seen in Table 6.

Table 6. The Results of the ANCOVA Analysis

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1346.682 ^a	2	673.341	22.979	.000
Intercept	1872.650	1	1872.650	63.908	.000
Pre-Creativity	446.730	1	446.730	15.245	.000
Model	272.436	1	272.436	9.297	.003
Error	2109.780	72	29.303		
Total	451989.796	75			
Corrected Total	3456.463	74			

a. R Squared = .390 (Adjusted R Squared = .373)

Table 6 shows an F-calculated of 9.297 with a significance level of 0.003 (α 0.05). Therefore, it was concluded that the DMM-GI and DMM-conventional models affected student's creativity. The covariance analysis was followed by an LSD test with a significance level of 0.05 to investigate the mean scores between the two treatment groups. The results of the LSD test can be seen in Table 5.

Table 7. The Results of the LSD test on Student's creativity

No.	Model	Pretest	Post-Test	Difference	Average	LSD Notation
1.	DMM-Conventional	51.58	73.53	21.95	74.96	a
2.	DMM-GI	57.23	80.49	23.26	79.30	b

Based on Table 7, it can be concluded that there was a difference in the mean scores between the DMM-GI and DMM-conventional groups. The mean score achieved by the DMM-GI group (79.30) was higher than that obtained by the DMM-conventional group (74.96). The highest pretest and posttest scores were found in the DMM-GI group (Figure 1).

The statistical analysis results showed that the DMM-GI model affected students' creativity on Vascular Plant Botany. The students' creativity was developed through the learning activities conducted in DMM-GI, which included carrying out an investigation, writing a report, and conducting an evaluation.

At the investigation stage, the students were trained to independently collect information from relevant learning resources such as textbooks or journal articles. The information collected by each group member was formulated into an idea. The idea was then discussed, clarified, and analyzed with other group members to generate more creative ideas. The investigation stage encouraged the students to explore many ideas, enrich knowledge, and share a lot of information with their peers [64]. The investigation stage also allowed students to solve problems and inquiries based on what had been learned in the classroom [65]. These activities can stimulate students' thinking skills, knowledge construction, and creativity [66].

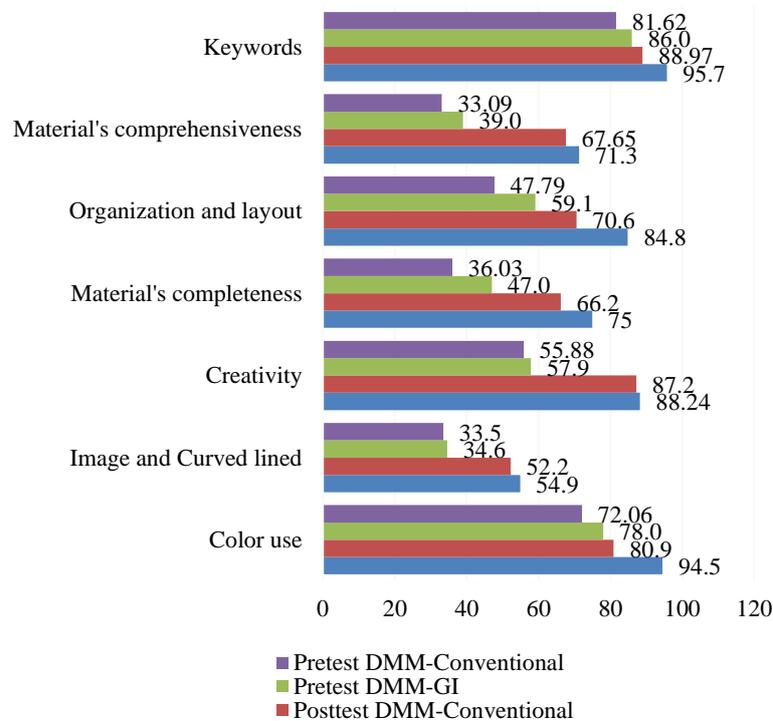
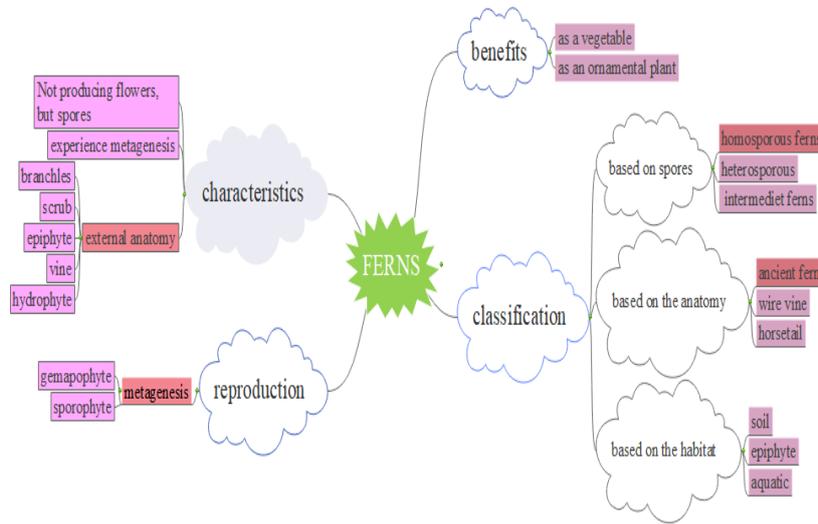


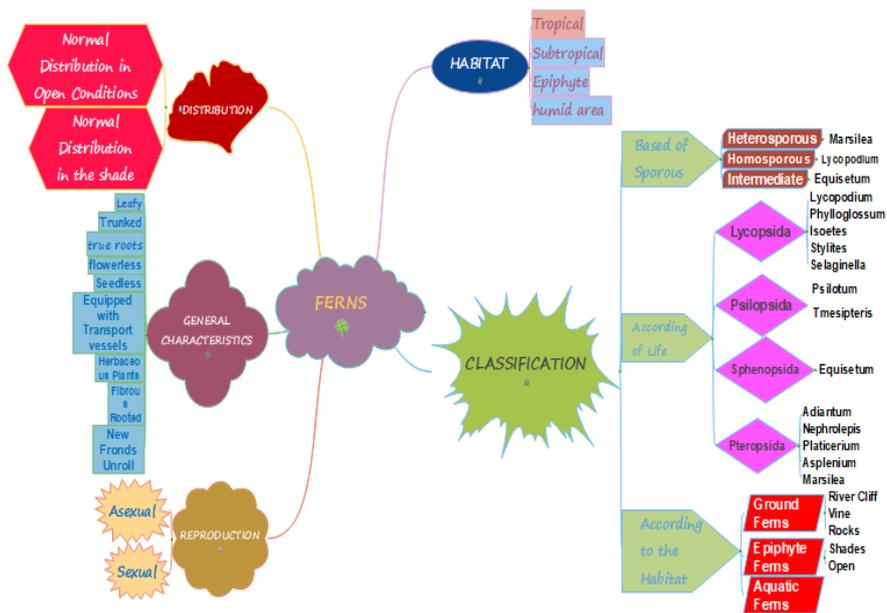
Fig. 1. Students' Creativity Scores through DMM

Each group had to write an attractive report containing sufficient and comprehensive materials and generate ideas and explore their creativity in the next stage. Creativity is associated with recognizing ideas, finding new solutions, and maximizing efforts to produce something different [67]. The students were instructed to generate the correct concept based on each group member's investigation and thoughts and then put them into a report. Writing reports can be an alternative task to increase students' creativity [68].

The final stage, which was conducting an evaluation, focused on the students' knowledge during the learning process and the Digital Mind Maps (DMM) final product. Digital Mind Maps as an assessment tool guided and supported the students to achieve the learning goals [69], better understand and memorize the whole concept [28]. Besides, it encouraged the students to improve their concept knowledge [70]. In making mind maps, the students were required to compile, organize, and reconstruct relevant knowledge and understand the contents of knowledge independently [71]. Figure 2 and Figure 3 contain the examples of the participants' DMM creativity, both in GI-DMM and Conventional-DMM groups.



a) Pretest



b) Posttest

Fig. 2. The DMM-GI students' Digital Mind Maps

Figure 2 contains two digital mind maps about fern that the DMM-GI students worked on in the pretest and posttest. In the pretest, the word “fern” was written in the center of the mind map as a keyword, connected by a curved line to the four main branches explaining the characteristics, reproduction, classification, and fern benefits. Each branch was assigned the same color. Meanwhile, the Digital Mind Map produced in the posttest increased the number of main branches from four to five. The creativity shown on these digital mind maps can be explained through the branches generated on the maps. For example, the digital mind map done in the posttest had several main branches describing the characteristics and classification of fern that were further divided into sub-levels of branches. Also, each branch was colored differently so that the mind map is easier to remember and is more appealing to students. Color makes DMM more effective and provides tremendous benefits for memory [72].

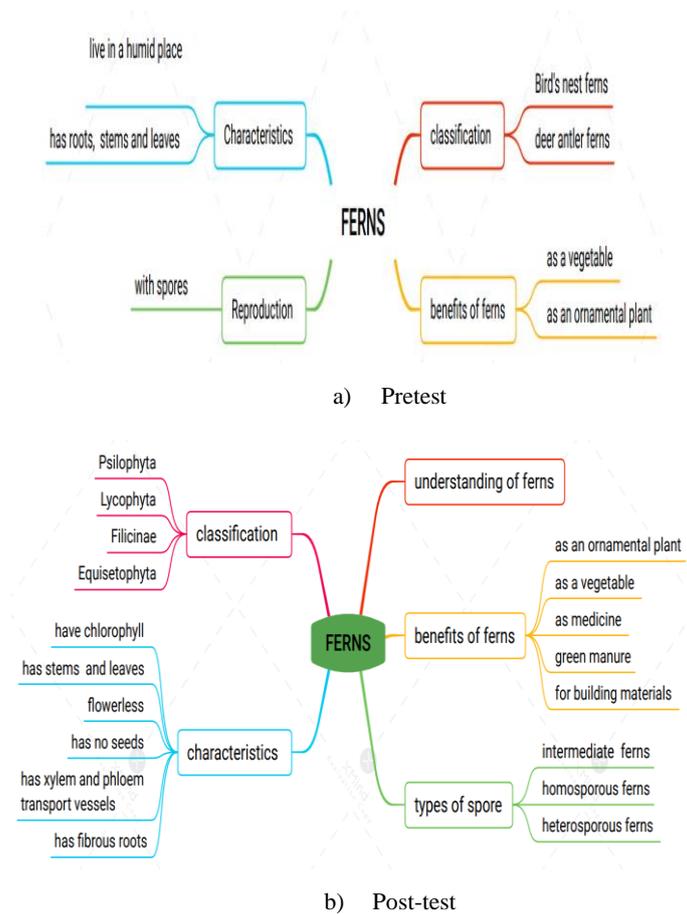


Fig. 3. The DMM-Conventional students' Digital Mind Maps

Figure 3 presents two digital mind maps about “fern” created by the DMM-Conventional students in the pretest and posttest. A difference was found between the mind maps produced by the DMM-GI students and DMM-Conventional students in the way they described their ideas into the map’s branches. For example, the word “fern” was written in the mind map center as the keyword. Curved lines were put to connect this keyword to the four main branches containing the characteristics, reproduction, classification, and fern benefits. The main branch and the tiers of the main branch are of the same color. In the posttest, the word “fern” was written in the center of the map; then, curved lines were drawn to connect the keyword to the five main branches and sub-levels of the same branches color. Several branches were developed from one branch level to represent the ideas that emerged. This suggests that DMM-Conventional students have not developed ideas due to insufficient knowledge of the topic. Creative tasks can help individuals improve their learning performance because there is a relationship between task structure and initial knowledge [73].

The differences between the DMM-GI and DMM-Conventional students’ creativity (Figure 2 and Figure 3) are described in Table 8 through each creativity indicator.

Table 8. The differences between the DMM-GI and DMM-Conventional Students’ Creativity

No	Indicator	Pretest		Post-test	
		<i>DMM-Conventional</i>	<i>DMM-GI</i>	<i>DMM-Conventional</i>	<i>DMM-GI</i>
1.	Keywords	The ideas are unclear or lack connection to the keywords.	Some of the ideas are unclear or lack connection to the keywords.	Some of the ideas are unclear or lack connection to the keywords.	The ideas are clear and connected to the keywords.
2.	Material Appropriateness	Main ideas are associated with a lot of material appropriateness.	Main ideas are associated with some material appropriateness, but the topic is still understandable.	Main ideas are associated with a little material appropriateness, but most of the links are correct, relevant to the topic.	Main ideas are associated with the right parts and correct understanding without misunderstanding the topic.
3.	Organization and Layout	One part contains at least one branch	One part contains a limited number of branches.	One part already contains some parts, although there are missing links between branches.	The map contains a complete structure of branches.
4.	Material Completeness	The material is incomplete because some important topics and subtopics are missing from the DMM.	The material is incomplete because the topics and subtopics are not represented entirely by the DMM.	The material is complete, but some parts are less connected to the topics and subtopics.	The material completely defines the main idea, topic, subtopics, and all-important information.

5.	Creativity	The DMM lacks creativity by containing less than five branches.	The DMM lacks creativity by containing less than five branches.	The DMM shows creativity by containing 10-15 branches	The DMM shows creativity by containing more than 15 branches.
6.	Image Symbols and Curved Lines	The DMM does not contain image symbols but uses curved lines.	The DMM does not contain image symbols but uses curved lines.	The DMM does not contain image symbols on the main idea or branches, but uses curved lines to connect branches.	The DMM contains image symbols on the main idea or main branches that are connected with curved lines.
7.	Color Use	There are a few similar colors applied. The colors do not show any connection between topics.	There are a few similar colors applied. The colors do not show any connection between topics.	The different colors applied show some connections between topics.	The different colors applied show connections between topics.

Based on Table 8, it was known that there were differences in the students' DMM creativity, indicated by the difference in the pretest and posttest scores for each indicator measured. The experimental (DMM-GI) students performed better than the control (DMM-Conventional) students in creativity. This may be caused by the fact that ideas elaborated through the keywords into branches are connected with different colors, hence producing creativity. A digital mind map comprises meaningful keywords and symbols relating to the topics discussed, curved lines, and various color distribution [74]. The process of making a mind map using software or an application becomes an interactive game for students because this fun-filled activity allows students to exchange ideas and feel the satisfaction of creating a beautiful and informative product [75].

Every student can use a unique way to build a digital mind map based on their ideas. The findings show that each student had a different way of exploring colors, lines, branches, and images to convey ideas [76]. The use of DMM allows students to move freely in an unlimited learning space by easily drawing branches, deleting ideas, or replacing them with new ones [77]. Digital Mind Maps allow the creators to draw, fix, save, and convert maps into PDF files or images [78], so DMM can facilitate learning.

The study results showed that the DMM-GI instructional model had a positive effect on students' creativity. One of the advantages of the GI-DMM model is that it enables students to work collaboratively in small groups to carry out investigations, make reports and presentations, and evaluate students' ability to develop ideas, apply existing knowledge and add new knowledge. In line with Sojayapan & Khaisang's [48] research, Group Investigation can bring out creativity through investigation and presentation. Also, learning using DMM will help students generate many ideas and develop creativity.

5 Conclusion

The current study showed that the Digital Mind Map Assisted Group Investigation (DMM-GI) effectively improved student's creativity. It was proven that the mean score obtained by the DMM-GI group was higher than that achieved by the DMM-conventional group. Therefore, the implementation of DMM-GI in the classroom is highly recommended.

Furthermore, this study suggests that DMM-GI could compensate for the Group Investigation weaknesses and play a vital role as an evaluation tool in the process. This study's findings suggest that Digital Mind Map (DMM) can be used as a tool to evaluate student's creativity products. This study only involved Biology students as the participants; therefore, other researchers should study the potential of DMM-GI in improving the students' creativity from other departments or different levels of education. Future studies can also examine the effect of DMM-GI on other capability or skills.

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