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Brain-Based Learning-Reading, Mind Mapping, and Sharing (BBLRMS) Model to Enhance Creative Thinking Skills of Pre-Service Biology Teachers

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Abstract

Higher education in the 21st Century must equip students with various skills, including creative thinking skills. This study was intended to investigate the effect of Brain-Based Learning-Reading, Mind Mapping, and Sharing (BBLRMS) on the creative thinking skills of pre-service Biology teachers at Universitas Islam Negeri Raden Fatah in Palembang, Indonesia. A non-equivalent pretest-posttest control group design was employed in this study. The study participants were all students enrolled in the Animal Physiology course in the odd semester of 2021/2022. The sample was chosen at random. Seventy-five students were assigned into an experimental group, a positive control group, and a negative control group. The experimental class was instructed using the BBLRMS model, the positive control class was instructed using the Brain-Based Learning (BBL) model, and the negative control class was instructed using the conventional learning model. An essay test was used to obtain research data on the participants' creative thinking skills. The test answers of participants were graded using a rubric and then analyzed using ANCOVA. The analysis revealed that (1) there were disparities in the creative thinking skills of students whose learning was facilitated by the BBLRMS, BBL, and conventional models; (2) the creative thinking skills of students taught by BBLRMS were superior to those taught by BBL and conventional models. Based on the findings of this study, it can be stated the BBLRMS model can enhance the creative thinking skills of pre-service Biology teachers at Universitas Islam Negeri Raden Fatah in Palembang, Indonesia. The BBLRMS model can also be used as an alternative learning model that helps improve the quality of learning.

Keywords: animal physiology, BBLRMS, pre-service biology teachers, creative thinking skills

Introduction

Creative thinking is viewed as one of the most important skills individuals should possess to thrive in a rapidly changing world, a knowledge society, and an innovation-based economy (Collard & Looney, 2014; Organization for Economic Co-operation and Development (OECD), 2018; Winthrop & McGivney, 2016). Creative thinking enables a person to see things from fresh angles, produce novel and helpful ideas, pose pertinent questions, and generate answers to various challenges (Sternberg, 2006). Creative thinking is essential to society because it enables individuals to overcome obstacles and adapt in their personal, educational, and professional lives (Carson, 2011). Therefore, creative thinking abilities are essential life skills for preparing individuals to face future uncertainty.

College-level training in creative thinking prepares students for several careers. Creativity should be one of the aims of higher education (Purushothaman & Zhou, 2014) and one of the most important characteristics of college graduates. Unfortunately, several studies indicate that pupils' creative thinking skills are still subpar and must be improved. The preliminary research analysis shows that prospective biology teacher students have low creative thinking skills, with an average score of 47.57. According to Oke & Olatilu (2018), Nigeria's engineering students have inadequate creativity levels. Similarly, Physical Education Training students in Jiuquan, China, must develop their creative thinking skills (Wang, 2019). According to the findings of Zhong & Liu (2014),

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students at the Institute of Ideological and Political Education of Nanjing Forestry University in China have poor creative thinking abilities. A qualitative study by Widiati et al., (2020) further indicates that mathematics education majors in Indonesia lack creative thinking skills. In Zulkipli et al., (2015), most research respondents, who are aspiring science teachers in Malaysia, have a decent knowledge of creative thinking abilities but low levels of creative thinking.

Creativity results from the interaction between the mind and the sociocultural setting in which a person is immersed (Erez & Nouri, 2010). Creativity can be acquired in one domain and transferred to another by repeated practice (Avenckuté, Mulvik, & Lucas, 2020). Creative thinking skills are essential for increasing student learning experiences; therefore, these skills must be fostered by the education system and explicitly taught in classrooms (Cropley, 2001; Fasko, 2001; Kampylis, 2010). However, schools are not always conducive to promoting creativity (Plucker, Beghetto, & Dow, 2004) since the education system emphasizes knowledge transfer more. At school, teachers must adhere to a tight curriculum, especially when imparting knowledge and provide tests that focus on the amount of material preserved in students' memories (Ozdemir, 2016). According to Saliceti (2015), memory-based learning contributes to the lack of creative thinking skills.

An empirical study conducted over several decades by Fryer (2006) demonstrates that creative thinking skills can be enhanced regularly. Several established learning methodologies can foster creative thinking skills, such as problem-based and game-based learning that incorporates challenging problems, real-world settings, practical exercises, and group work (Barrett & Donnelly, 2008). In addition, Oliver et al., (2006) showed that the positive attitude of the teacher and the teacher-student interaction were major variables in fostering the development of student's creative thinking skills. Saliceti (2015) argues that typical teacher-centred teaching methods are insufficient to foster innovative thinking. Multiple research on creative thinking has demonstrated that a pleasant learning environment, such as humour, favours the ability to produce larger ideas and enhances the quality of creative thinking in groups (Shade & Shade, 2016). The brain-based learning – reading, mind mapping, and sharing (BBLRMS) learning model is one of the methods that can foster a pleasant learning environment for pupils.

The brain-based learning – reading, mind mapping, and sharing (BBLRMS) is a learning model that may systematically stimulate student engagement from the start to the end of the learning process. This engagement technique will foster active learning by requiring student participation to generate innovative solutions and ideas for material-related issues (Demİr, 2021; Lin & Wu, 2016). BBLRMS is a learning paradigm that combines two distinct models: brain-based learning (BBL) and reading, mind mapping, and sharing (RMS). This integration is in accordance with the strengths and weaknesses of each model, resulting in a novel approach to solving learning problems.

The BBLRMS model is one of the most effective learning breakthroughs for encouraging pupils to think creatively. The BBLRMS model can be implemented in biology classrooms, particularly in the Animal Physiology course. Due to the discipline's abstract nature and rapid flux, Animal Physiology is one of the biology courses deemed challenging by students (Zhang et al., 2017). In order to comprehend the content in the Animal Physiology course, creative thinking is essential (Slominski, Grindberg, & Momsen, 2019). Based on the context description, this study aimed to determine the disparities in creative thinking skills among pre-service biology teachers exposed to three distinct learning models: BBLRMS, Brain-Based Learning (BBL), and conventional.

Theoretical Background

Creative Thinking Skills

The concept of creative thinking has been defined differently in numerous literary works. Creative thinking is the capacity to develop new ideas and solutions, fresh ways of thinking, uncommon questions, and unexpected responses. Creative thinking refers to the ability to generate, evaluate, and productively improve ideas, resulting in creative and successful solutions, advances in knowledge, and powerful expressions of imagination (LEGO Foundation, 2020). According to Torrance, creative thinking includes characteristics such as fluency (generating a large number of ideas), flexibility (using different methods or strategies to solve tasks or problems), originality (generating non-standard solutions and ideas), development (developing ideas in detail), closure resistance (not being resistant, rejecting stereotypes, and being open to new ones), and abstractedness of the name (understanding the source of the problem) (Borodina, Sibgatullina, & Gizatullina, 2019). Creative thinking is exploring new connections by obtaining many possibilities from various, unique, and specific viewpoints (Treffinger & Isaksen, 2013).

Creative pre-service biology teachers can produce novel and beneficial ideas (Fox & Beaty, 2019)involving a relatively spontaneous generation stage sometimes (but not always. Students with creative thinking skills can think innovatively while addressing certain themes, articulating ideas, and solving issues (Kowang, Albakri, Yew, Fei, & Long, 2018). Creative thinking skills are also essential for enhancing the capacity to think, plan, analyze, operate, communicate, develop, and learn (Pecheanu & Tudorie, 2015). Students with innovative thinking are more adept at problem-solving (Batlolona, Diantoro, Wartono, & Latifah, 2019). Five indicators of creative thinking described by Treffinger et al., (2002) include a) fluency (generating many ideas in a short period); b) flexibility (generating ideas from different perspectives); c) originality (the ability to generate new and authentic ideas); d) elaboration (enriching or developing the details of the idea to make it more interesting); and e) metaphorical thinking (using comparisons or analogies to make new connections).

Nowadays, creative thinking must be fostered through numerous courses, including science (Akyıldız & Çelik, 2020). Students can engage in problem-solving activities, innovative assessment instruments, and appropriate learning models to foster creative thinking (Rahayuningsih, Sirajuddin, & Ikram, 2021). The participation of educators in developing an effective learning environment and activities that inspire students to produce creative and imaginative work can help foster creative thinking in the classroom (Keleş, 2022; Kimhi & Geronik, 2020; Oncu, 2016)Torrance test of creative thinking (TTCT.

The Brain-Based Learning-Reading, Mind Mapping, Sharing (BBLRMS) Model

Brain-Based Learning-Reading, Mind Mapping, and Sharing (BBLRMS) combines the brain-based learning (BBL) model with reading, mind mapping, and sharing (RMS). Brain-Based Learning (BBL) can stimulate optimal brain potential since this learning paradigm makes optimal use of the right and left brain hemispheres (Uzezi & Jonah, 2017). The BBL model can assist students in learning biology, but its application requires activities that boost skills in communicating creative ideas, such as brainstorming, reading, and writing (Danesh & Nourdad, 2017; Marcos, Ferández, González, & Phillips-Silver, 2020)and to test for a possible correlation between improvements in creative thinking and improvements in academic performance. Sixty fifth-grade students from a primary school in the south of Spain participated over two months: half received reading and writing activities in a cooperative learning classroom (experimental group, n=30. Al-Balushi & Al-Balushi (2018) highlight that connecting the concepts of the subjects being studied is one of the keys to success in applying brain-based learning. Based on this reasoning, BBL must be combined with other learning models, such as the Reading, Mind-Mapping, and Sharing (RMS) model, to promote creative thinking.

Reading, Mind-Mapping, and Sharing (RMS) is a learning model that facilitates students to be actively involved in finding and understanding concepts, connecting new concepts with previous concepts, and being appropriately applied online and offline in college (Muhlisin, 2019). Reading activities in RMS assist students in understanding concepts (Ristanto, Rahayu, & Mutmainah, 2021), while mind mapping as a brainstorming approach helps connect concepts and develop new ideas (Alqasham & Al-Ahdal, 2021). The creative ideas displayed in the form of a mind map also make it easier for pupils to share with one another.

Based on the theoretical and empirical studies, it can be concluded that the BBLRMS model is suitable for application in higher education classrooms to foster the students' creative thinking skills. The seven steps of the BBLRMS model are *reading, pre-exposure and preparation with mind mapping, initiation and acquisition, elaboration, incubation and insert the memory, sharing and verification, and celebration*. The use of the BBLRMS model in this study is anticipated to overcome university students' lack of creative thinking skills.

The first step is reading. This activity encourages students to read many sources with a critical eye (Muhlisin, Susilo, Amin, & Rohman, 2018). The knowledge gained by critical reading will make it easier for students to locate concepts and map ideas (Ammaralikit & Chattiwat, 2020). Ritchie et al., (2013) argue that reading can boost creative thinking. This reading stage is essential to present students with pertinent Animal Physiology information at the beginning of the learning process.

The second step is *pre-exposure and preparation with mind mapping*. This step encourages students' curiosity (Jensen, 2008) and aids in applying their knowledge through mind mapping. Creating mind maps by students will have a favourable effect, particularly in terms of engaging the right and left lobes of the brain, comprehending and remembering knowledge, and enhancing creative thinking abilities (Erdem, 2017; Malycha & Maier, 2017).

The third step is *initiation and acquisition*. The main focus of this step is to create understanding (Jensen, 2008) through various activities, such as: observing, identifying, and analyzing problems or facts. Problems and facts associated with the subject of Animal Physiology of vertebrate and invertebrate groups encourage thinking skills.

The fourth step is *elaboration*, sometimes known as the stage of processing. The elaboration stage also helps students make connections between knowledge to obtain a deeper grasp of the given issue (Priawasana, Degeng, Utaya, & Kuswandi, 2020)but lectures often use many methods of learning. This fact does not match the demands of 21st-century learning that requires creative, critical, and communicative learning. This research aims to analyze the effect of the elaboration learning strategy on students' learning outcomes and critical-thinking skills. A two-factor mixed design (learning strategy and learning achievement. Elaboration is filled with active discussion activities to find and deepen material. Oderinu, Adegbulugbe, Orenuga, & Butali (2020)PBL, in comparison with the traditional lecture (TL added that the discussion process would result in students' understanding. So, the discussion activities carried out in the elaboration step will create an active learning atmosphere so that students can build knowledge related to Animal Physiology.

The fifth step is *incubation and insert the memory*. The activity carried out in this step is listening to music to produce a more relaxed, easy, and fun learning (Demir, 2017). This process will make students more relaxed and remember what they have learned. The incubation process also impacts students' emergence of creative ideas (Gilhooly, 2016)in which novel solutions are required, has often been seen as involving a special role for unconscious processes (Unconscious Work.

The sixth step is *sharing and verification*. This step facilitates students to convey the results of discussions and mind maps made (Muhlisin, 2019). This activity also encourages students to be more active in interacting. Active interactions between students will provide an effective pedagogical experience (Holper et al., 2013). In this step, verification activities are also carried out on the material that has been obtained.

The seventh step is a *celebration*. Celebration is done as a form of appreciation to students and by giving a smile, clapping, or praise (Edgerly, Mourão, Thorson, & Tham, 2020). Giving praise can also encourage someone to persevere in carrying out tasks and have goals in learning (Droe, 2012)

Method

Research Design

This quasi-experimental research used a pretest-posttest control group design. Pretest and post-test were carried out on the three treatment groups (BBLRMS, BBL, conventional). The research design is shown in Table 1.

Participants

The current study was conducted at Universitas Islam Negeri Raden Fatah in Palembang, Indonesia. Seventy-five students (aged 20 to 22 years) enrolled in the Department of Biology Education during the odd semester of the academic year 2021/2022 served as the research subjects. Research subjects were determined using a random sampling technique from four biology education classes tested for equality using a cumulative achievement index (GPA). All classes showed equal results (significant level of GPA value of 0.054 > 0.05). Three research classes were chosen with details of one experimental class, one positive control class, and one negative control class. The experimental class was taught with the BBLRMS learning model, the positive control class with the BBL model, and the negative control class with conventional learning.

Data Collection Tools

The instruments used to measure the independent variables in this study consisted of semester learning plans, lecture program units, and student worksheets. The instrument used to measure the dependent variable was 15 essay test questions on Animal Physiology. These were developed based on the indicators of creative thinking skills: fluency, originality, elaboration, flexibility, and metaphorical thinking. The essay test was equipped with a scoring rubric adapted from Treffinger et al., (2002). The rubric for assessing creative thinking skills is shown in Table 2.

Four experts assessed the validity of the research instruments before data collection. One hundred students who had taken the Animal Physiology course evaluated the validity and reliability of the essay test measuring creative thinking. Table 3 provides an overview of the outcomes of the instrument validity test.

Table 3 shows that 15 essay questions used in this study were valid with r-calculated > r table (r table = 0.195) and

Table 1: Research Design

Pretest	*Treatment Groups*	*Hottest*
O1	BBLRMS	O2
O3	BBL	O4
O5	Conventional	O6

Remarks:
A1 : The BBLRMS (experimental) group
A2 : The BBL (control) group
A3 : The conventional (control) group
O1, O3, O5, and O7 : Pretest score
O2, O4, O6, and O8 : Postest score

Table 2: Creative Thinking Rubric

Aspect	*Description*	*Score*
Fluency	Mention/write down four or more different ideas, suggestions or alternative answers	4
	Mention/write down three different ideas, suggestions or alternative answers	3
	Mention/write down two ideas, suggestions or alternative answers that are not too different	2
	Mention/write down an idea, suggestion or alternative answer	1
	No answer or wrong answer	0
Originality	Mention/write some interesting, unique ideas logically, relatively new and relevant to the given problem	4
	Mention/write some interesting, unique ideas logically, relatively new but less relevant to the given problem	3
	Mention/write ideas that are unique, interesting and logical and relevant to the given problem	2
	Mention/write down ideas that are commonplace, logical and relevant to the given problem	1
	No answer or wrong answer	0

Aspect	*Description*	*Score*
Elaboration	Explain some logical details on existing ideas so that the formulation of ideas becomes easier to apply and clear	4
	Explain one logical detail of an existing idea so that the formulation of the idea becomes easier to apply and clear	3
	Provide some logical details on an existing idea, but it is not in accordance with the main idea, so it cannot be used to clarify the idea	2
	Does not add details to existing ideas so that the formulation of ideas is less applicable	1
	No answer or wrong answer	0
Flexibility	Write down several alternative answers that are highly logical and relevant to the problem given from different perspectives	4
	Write down several alternative answers that are quite logical and relevant to the problem given from different points of view	3
	Write down several alternative answers that are quite logical but less relevant to the problem given from different points of view	2
	Write one alternative answer that is quite logical and relevant to the problem given only from one point of view	1
	No answer or wrong answer	0
Metaphorical thinking	Combine several ideas, modify, and explain the formulation of ideas with logical and coherent analogies	4
	Combine several ideas, modify, but unable to explain the formulation of ideas with logical and coherent analogies	3
	Combine several relevant ideas but unable to explain the formulation of ideas with logical analogies	2
	Unable to combine relevant ideas to become a coherent whole.	1
	No answer or wrong answer	0

(Modified from Treffinger et al., 2002)

Table 3: *The Pearson Validity Test Result*

No Soal	r_{hitung}	r_{tabel} *5% (100)*	*Sig.*	*Kriteria*
1	0.412	0.195	0.000	Valid
2	0.493	0.195	0.000	Valid
3	0.524	0.195	0.000	Valid
4	0.421	0.195	0.000	Valid
5	0.477	0.195	0.000	Valid
6	0.409	0.195	0.000	Valid
7	0.466	0.195	0.000	Valid
8	0.397	0.195	0.000	Valid
9	0.328	0.195	0.001	Valid
10	0.299	0.195	0.003	Valid
11	0.547	0.195	0.000	Valid
12	0.512	0.195	0.000	Valid
13	0.492	0.195	0.000	Valid
14	0.446	0.195	0.000	Valid
15	0.494	0.195	0.000	Valid

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

a significance value (Sig.) < 0.05. In addition, a Cronbach's Alpha of 0.710 indicated that the instrument had "**High**" reliability.

Data Collection

Creative thinking data was collected through pretest and posttest in the three treatment groups. Questions are in the form of essays, distributed via a google form. Students' answers were scored by referring to the creative thinking skills assessment rubric developed by Treffinger et al., (2002).

Research Procedures

This study has received ethical approval from both participating universities and students and was conducted with permission from the Dean of the Faculty of Tarbiyah and Teacher Training (FITK), UIN Raden Fatah Palembang based on a copy of the research permit Number: 3.8.21/UN32.3.1/TU/2021. At the beginning of the semester, ethical approval was obtained from students by describing the semester learning plan, the lecture program unites facilitated by learning models (BBLRMS, BBL, and Conventional), and the learning outcomes measured creative thinking skills. The learning process of the experimental class followed the steps of the BBLRMS learning syntax, the learning process of the positive control class followed the steps of the BBL learning syntax, and the learning process of the negative control group was non-systematic and conventional. Table 4 depicts the details of the learning steps using the BBLRMS model, and Table 5 shows the learning steps using the BBL model.

Data Analysis

Using analysis of covariance (ANCOVA) with a significance value of 0.05, the research data were evaluated. Since the findings were significant, the Least Significance Different (LSD) test was conducted to evaluate if there was a statistically significant difference between the means. Before the ANCOVA

Table 4: Steps (Syntax) of the BBLRMS Learning Model

BBLRMS Learning Steps	*Student Activities*
Reading	Students critically read a variety of relevant learning resources on a specific topic (e.g., nervous system topics).
Pre-exposure and preparation with mind mapping	Students apply prior knowledge and new knowledge gained from critical reading by creating mind maps. Students continue to prepare for learning by comprehending the learning objectives and paying close attention to topic-related images to stimulate their curiosity.
Initiation and acquisition	Students develop comprehension by observing topic-related images. Students identify and analyze visual representations of problems or facts related to the topic (analysis generally includes structure and function, physiological mechanisms, disorders or diseases, and disease prevention efforts).
Elaboration	Students use various sources to actively discuss the results of prior identification and analysis. The acquired knowledge or information is subsequently utilized to complete the mind map.
Incubation and insert the memory.	Students listen to the currently playing music and stretch to become more relaxed.
Sharing and verification	Students convey the discussion results to the rest of the group through a mind map. The activity is followed by question-and-answer sessions and a review of the previously learned subject. The teacher directs the verification process.
Celebration	Students participate in the celebration activities enthusiastically as a form of self-motivation to achieve better learning performance (for example: by giving applause, praise, and learning motivation).

Table 5: Steps (Syntax) of the BBL Learning Model

BBL Learning Steps	*Student Activities*
Pre-Exposure	Students develop prior knowledge of the topic through question-and-answer sessions (e.g., nervous system topics).
Preparation	Students prepare for study by perusing topic-related images that pique their attention and inspire learning enjoyment.
Initiation and Acquisition	Students develop comprehension by meticulously studying topic-related images on the student worksheets (LKM). Students discover and analyze visual representations of problems or facts relating to the topic (analysis generally includes structure and function, physiological mechanisms, disorders or diseases, and disease prevention efforts).
Elaboration	Utilizing a variety of information sources, students engage in active group discussions based on the outcomes of identification and analysis conducted before.
Incubation and Insert the Memory	Students stretch their muscles and listen to classical music to become calmer.
Verification and Confidence Check	Students relay the discussion outcomes to other groups, followed by question-and-answer sessions and a review of the studied content.
Celebration and Integration	Students participate in the *celebration* activities enthusiastically as a form of self-motivation to achieve better learning performance.

teachers' creative thinking skills after implementing different learning models. The BBLRMS model is superior to the BBL and conventional models in improving creative thinking skills. The BBL group experienced a greater increase in creative thinking (5.65%) than the conventional learning group (3.66%). This indicates that the BBL model is better than conventional learning in fostering students' creative thinking skills.

The Brain-Based Learning (BBL) procedures encourage students to engage in active discussion to generate interactions that stimulate brain synchronization (Dikker et al., 2017). During the elaboration phase, vigorous debate and interaction play a role. Elaboration is a processing stage that aids students in acquiring a deeper understanding of information and solving associated challenges by creating creative and scientific ideas (Mierdel & Bogner, 2018). This active discussion and interaction enabled the BBL students to experience a greater change in their creative thinking than students in the conventional group.

In contrast, students in the conventional group reported the smallest gain in creative thinking, 3.66%. This number implies that conventional learning, which includes lectures, discussions, presentations, and question-and-answer sessions, is unable to maximize the creative thinking skills of pre-service teachers. Lecturing is widely utilized with teacher-centred learning patterns and is the most archaic learning technique. In traditional classes, pupils tend to receive knowledge passively (Oderinu et al., 2020). Conventional learning focuses more on enhancing material comprehension (Nakiboğlu & Nakiboğlu, 2021). This argument is consistent with prior research findings indicating that groups of students who learned using conventional study methods performed poorly in terms of creative thinking.

Compared to the BBL and conventional groups, BBLRMS demonstrated a higher increase (13.24%) and mean score (54.21) in creative thinking skills. The results of this investigation reveal that the BBLRMS model is notably distinct and superior in enhancing pre-service biology teachers' creative thinking skills. The steps of BBLRMS are developed systematically and instructively so that the learning process is more concentrated. Systematic learning steps can generate an active and enjoyable learning environment, foster a culture of mutual respect for ideas and perspectives among students, and promote collaboration in generating new ideas (Chan & Yuen, 2014). Following is an explanation of the seven steps of the BBLRMS model for developing students' creative thinking skills.

The first step of the BBLRMS model is reading. Critical reading activities will affect academic achievement and the growth of creative thinking since reading helps pupils acquire relevant information and original ideas over time (Baki, 2020; Wang, 2012). Reading in BBLRMS is highly significant for assisting students in comprehending the information and making connections between ideas from various reading sources, particularly those linked to Animal Physiology.

The second step of the BBLRMS model is *pre-exposure and preparation* with mind mapping. This task is performed as a type of preparation to aid students in constructing beginning knowledge regarding previously understood topics and those acquired through the reading process. This method is essential for producing more effective learning, minimizing learning obstacles, and enhancing students' readiness to learn (Hackl & Ermolina, 2019; Weiss, Pellegrino, & Brigham, 2017) laboratory practical teaching is not always inclusive beyond general university requirements. Lab classes can present many barriers to disabled learners. Proactive adjustments embedded into the design and preparation of laboratory classes can make lab-based teaching as inclusive and accessible as possible. Perspective: The main challenges, difficulties, and barriers experienced by students with disabilities during laboratory classes were identified and analysed. A review of a large number of sources was conducted, and the best available evidence of inclusive practice in science and medicine laboratories (including those already implemented in the Reading School of Pharmacy and Leicester School of Pharmacy. In this study, the pre-exposure and preparation activities were carried out to build students' initial knowledge through mind mapping. Creating mind maps can enhance active, collaborative, critical, and creative learning and assist students in comprehending, summarizing, recalling, and implementing ideas associated with the Animal Physiology concept being studied or previously owned (Tavares, Meira, & Amaral, 2021).

Activating the right and left lobes of the brain is an additional advantage of applying pre-exposure and preparation with mind mapping to learning. Research by Ganiev & Abdunazarova (2021) demonstrates that mind mapping can stimulate both brain hemispheres by developing "imagination" in the left hemisphere and creative thinking skills in the right hemisphere. Thus, it is evident that the second step of the BBLRMS model facilitates the development of creative thinking skills in pupils through mind mapping.

The third step of the BBLRMS model is *initiation and acquisition*. This step instructs pupils to develop comprehension by observing, identifying, and analyzing situations or facts. Initiation and acquisition also guide active discussion activities, allowing students to assist one another and collaborate throughout this phase (Huang, 2020). The acquisition also emphasizes the search, selection, categorization, collection, storage, and distribution of knowledge (Obeidat, Al-Suradi, Masa'deh, & Tarhini, 2016). Therefore, it can be stated that these processes are extremely beneficial for developing students' creative thinking, particularly in generating ideas to produce useful information.

The fourth step of the BBLRMS model is *elaboration*. This step is important for active learning because it allows students to engage in conversations and partnerships, allowing them to express thoughts and arguments logically and scientifically (Widiana & Jampel, 2016). Elaboration stimulates the creative process through a variety of actions, such as collecting information relevant to ideas, conducting experiments, and compiling ideas (Calic, Mosakowski, Bontis, & Helie, 2020). This description demonstrates that the BBLRMS model's elaboration process will aid students in processing animal physiology-related information and ideas, fostering their creative thinking skills.

The fifth step of the BBLRMS model is incubation and insert the memory. Subconscious thoughts that occur during incubation will impact creative thinking (Ritter & Dijksterhuis, 2014). According to the period, each individual's incubation process generates unique creative concepts. This can be caused by various factors, such as the difficulty of the problem being solved and each individual's condition in stimulating creative ideas, habits, and habits, among others (Sitorus & Masrayati, 2016). Important to note in this step is that the difficulty of generating creative ideas varies from person to person based on the complexity of the problem.

During the *incubation and insert the memory* processes, students are invited to listen to classical music, which is proven to help develop creative thinking (Guan, 2021; Ritter & Ferguson, 2017)aged 19–22 years, from 7 faculties, 1–4 years of study took part in the study. Group 1 consisted of 98 students who occasionally listened to music (no more than 2 times a week for half an hour. Listening to classical music can also promote a positive mood, increase motivation for learning, and decrease learning anxiety (Fritz, Montgomery, Busch, Schneider, & Villringer, 2020). The importance of implementing the *incubation and inserting the memory* step is based on students' benefits from listening to classical music, particularly in terms of boosting their creative thinking and enthusiasm for studying Animal Physiology.

The sixth step of the BBLRMS model is sharing and verification. In this step, students present the knowledge and comprehension gained during the discussion and mind mapping sessions, which occurs at the beginning of the learning process. A process of active sharing will produce a cooperative learning environment and inspire each individual to generate novel ideas (Akram, Lei, Haider, & Hussain, 2020). This sharing activity is also used to validate the correctness of the concepts acquired with the aid of group mates. The study's findings indicate that sharing is an interactive process used to disseminate knowledge to others effectively and appropriately to positively enhance knowledge and achieve learning objectives (Rafique & Mahmood, 2018). The numerous benefits obtained from sharing and verification activities are one of the reasons why this step should be incorporated into the learning process, particularly to assist students in sharing their knowledge and creative and innovative ideas.

At the final stage of the BBLRMS, *celebration,* students are rewarded for their performance in the classroom. Stewart & Wubbena (2014) explained that celebrations could be held to recognize and honour the activities and works created by students. Praise is one form of celebration performed in this study. Hodgman (2014) adds that praising students has proven to create a more positive classroom environment and motivate students to improve their academic performance. Therefore, it is essential to hold a celebration in which students are praised or applauded for their achievements in learning.

The BBLRMS steps described in this study have enhanced pre-service biology teachers' creative thinking skills. The BBLRMS model facilitates the activation of the right and left hemispheres of the brain, thereby fostering the generation of original ideas. Beaty et al., (2014) argue that optimal brain function will assist students in generating creative ideas due to increased functional connectivity between the inferior prefrontal cortex and the default network. The application of the BBLRMS model is relevant to be applied to overcome the difficulties of learning biology, especially in the Animal Physiology course. The BBLRMS model can also be implemented to improve creative thinking skills which can have an impact on the quality of learning.

Conclusion

The study findings showed differences in creative thinking skills of pre-service biology teachers after implementing BBLRMS, BBL, and conventional learning models. Based on the statistics, the BBLRMS model improved pre-service biology teachers' creative thinking more effectively than the BBL and conventional models. The highest increase occurred through the BBLRMS learning model with a score of 13.24%, followed by the BBL model with an increase of 5.65%, and the lowest increase in conventional learning with a score of 3.66%.

The BBLRMS model can also be used as an alternative learning model that helps improve the quality of learning and the quality of education in Indonesia. The syntax of the BBLRMS model has learning steps that can facilitate students to think creatively. This is evidenced by all activities carried out by students in learning that can provide interaction and cooperation to process information and ideas that encourage creative thinking skills.

Limitation and Suggestion

This research is limited to Animal Physiology courses and certain semester levels. The skills measured in the study were limited to creative thinking. Therefore, it is recommended that further researchers be able to explore the effect of the BBLRMS model on different courses and semester levels.

Future research on the BBLRMS model could also focus on measuring different skills. The population and research samples can be further expanded at the primary and secondary school levels to obtain a more in-depth study related to the BBLRMS model.

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