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Advancing of biology students' information literacy: an investigation of three different learning models

Nita Nuraini[1], Susriyati Mahanal[2], Herawati Susilo[3], Sulisetijono[4], Siti Zubaidah[5]

[1]*Faculty of Teacher Training and Education, Universitas Muhammadiyah Palembang, Indonesia, ORCID ID: 0000-0003-2475-9890*
[2]*Faculty of Mathematics and Science, Universitas Negeri Malang, Indonesia, Corresponding author, susriyati.mahanal.fmipa@um.ac.id, ORCID ID: 0000-0001-5764-2184*
[3]*Faculty of Mathematics and Science, Universitas Negeri Malang, Indonesia, ORCID ID: 0000-0002-9667-6237*
[4]*Faculty of Mathematics and Science, Universitas Negeri Malang, Indonesia, ORCID ID: 0000-0003-1066-3054*
[5]*Faculty of Mathematics and Science, Universitas Negeri Malang, Indonesia, ORCID ID: 0000-0002-0718-6392*

ABSTRACT
Information literacy (IL) is an essential skill for Biology students amidst the development of information flow. Several studies show that students' IL is still low and needs to be improved. One of the courses that students consider difficult is Animal Physiology due to the nature of the discipline. Educators tend to apply three different learning models, namely *Brain-Based Learning – Reading, Mind Mapping, and Sharing* (BBLRMS), *Brain-Based Learning* (BBL), and *Direct Instruction* (DI). This research aimed to determine the effect of these learning on the information literacy of biology students, and find out which learning model is superior in advancing their information literacy. The research was completed in a semester, and the data collection process was through a pretest and posttest using multiple choice questions distributed through Google Forms. The research results show that the choice of learning model affects the progress of biology students' IL, and that BBLRMS is a learning model that is superior to the BBL and DI models in this respect. BBLRMS has very structured stages (including adding reading activities in the first stage, making a mind map in the second step, and verification activities in the sixth stage).

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Introduction

Information literacy (IL) is one of the 21st-century skills needed by every individual to succeed amidst the increasingly rapid development of information (Nierenberg & Dahl, 2023; Wu et al., 2022). IL is a skill that allows individuals to efficiently recognise, find, evaluate and critically assess information from various sources, such as books, articles, websites and databases (Lund et al., 2023), and to form knowledge and overcome ignorance and doubt (Haider & Sundin, 2022). It is the

underlying principle for information need, evaluation, usage, dissemination and ethics (Pinto et al., 2020). Apart from being used in classroom learning, IL is also advantageous for post-graduation students facing the speed of information globally (Hays & Handler, 2020).

Students with great information literacy skills have an advantage because they can access and evaluate the best information needed (Feng & Ha, 2016). IL also enables individuals to become lifelong learners, have an ethical attitude in the use of information, and be able to identify various false information (Brisola & Doyle, 2019). It was further explained that IL is one of the competencies for digital teaching practices (Trujillo-Torres et al., 2020). So, it is important to have IL to make it easier to find, access and evaluate the credibility of the information that students need in learning.

Information literacy can be obtained through appropriate education, training and learning experiences (Banik & Kumar, 2019; Fredy et al., 2020). Proper planning and collaboration between instructors and librarians will help enhance students' IL (Ullah & Ameen, 2019). Various strategies, such as preparation of the IL programme in the first year, involvement of trained instructors, and development and integration of the IL curriculum, will help increase student information literacy (Aghauche et al., 2019). Every university and faculty from all departments need to create an information-literate campus environment (Ramasamy & Padma, 2017).

In addition, a systematically organised credit system in the university also aids students in improving their information literacy (Dolničar et al., 2017). Studies show that student literacy in various countries is still in the low and underdeveloped category, so it needs to be strengthened. Research conducted by Krubu, Idhalama, & Omigie (2017) shows that the level of student information literacy at a specialised federal university in Nigeria is still quite low, even in the third year. Assessment was carried out by qualitative analysis of individual assignments using the ACRL instrument. For example, the analysis results show that only 3 out of 50 (6%) students met ACRL standard 2 by utilising scientific sources to dig up information. Survey results at the Ardebil University of Medical Sciences from various fields and years of study show that students do not have sufficient abilities and skills in the five information literacy standards, with a total score of 45.43 out of 87 (52%) (Rezaiee & Pourbairamian, 2016).

Research conducted by Alekseeva (2020) shows an interesting trend, namely that the level of IL among first-year Nizhnevartovsk State University students is rather low. About 84% of first-year students experience difficulties when working with information. Further analysis explains that most students tend to be reluctant to use learning resources from libraries and databases, and the rapid development of information has created frustration for students because it is increasingly difficult to find high-quality information. Our preliminary observation also suggested low information literacy among the Biology students, with an average score of 55.88 (Nuraini et al., 2023). Several factors associated with low information literacy, including the experience and usage of information and communication technology, as well as confidence in using the Internet (Šorgo et al., 2017). Effective and efficient use of information in a university environment also needs to be equipped with several means to help students access more information (Faraji-khiavi et al., 2021). Thus, information literacy is essential in using electronic information sources (Odede & Zawedde, 2018), primarily identifying and evaluating accurate information about Animal Physiology and its sources.

Animal Physiology is a mandatory course in several university programmes (Nuraini et al., 2022). The Animal Physiology course is considered challenging and complex due to the nature of its discipline (Slominski et al., 2019). One of the main problems in studying Animal Physiology is that it is difficult to access relevant sources and evaluate the information obtained. This statement is supported by the research findings of Saadeh, Henderson, Paramasivam, & Jeevaratnam (2021), which show two things, namely the importance of using online resources in learning Animal Physiology, as well as a feeling of concern about the truth and credibility of the information obtained. Based on this problem, it is important for students to have information literacy to help access information online and directly using various methods, evaluate information and its sources critically, and use information effectively according to the needs for studying Animal Physiology.

Information literacy integration into courses has been reported to improve students' participation in comprehending and utilizing information based on their assignments (Juleha et al., 2019). Another study suggested prospective teachers should improve their information literacy throughout the learning process (Kozikoglu & Onur, 2019). Learning activities that involve students' active participation, a combination of learning methods, and quality coaching significantly enhance information literacy (Banik & Kumar, 2019; Dolničar et al., 2017; Juleha et al., 2019).

Other researchers have carried out many previous studies regarding efforts to advance IL using innovative learning models, but the results have yet to be optimal. A study by Shultz & Li (2016) explains that the IL skills of most students cannot be improved through PBL. Guided discussion activities, carefully designed group activities, and the instructor's role as a facilitator are necessary to help students recognize information needs to solve problems, evaluate information sources, and explore external resources. The results of research conducted by Greenwell (2016) regarding IL also explain that using the I-LEARN model can advance the understanding and application of IL concepts. Still, the results are not significantly different from other groups due to various factors, such as requiring more time to work in groups and searching for relevant resources. IL can be taught more effectively by creating a pleasant learning atmosphere and developing good learning designs (Walsh, 2020). Several learning models that facilitate students with active learning and a pleasant learning atmosphere are the *brain-based learning* (BBL) learning model and the *brain-based learning – reading, mind mapping, and sharing* (BBLRMS) model.

BBL is a learning model that promotes optimum usage of left and right brain function (Uzezi & Jonah, 2017). Meanwhile, BBLRMS is the latest learning model innovation resulting from research by Nuraini, Mahanal, Susilo, & Sulisetijono (2023), which integrates the brain-based learning (BBL) model and the reading, mind mapping and sharing (RMS) model. Furthermore, the research results explain that the BBLRMS model is designed systematically and instructionally to make the learning process more focused. Implementing BBLRMS in this research is a form of novelty to help students overcome difficulties in studying biology, especially Animal Physiology courses while advancing information literacy. Both BBL and BBLRMS models present learning experiences with systematic phases that may advance students' information literacy. A study by Fredy, Prihandoko, & Anggawirya (2020) also described that the learning experience contributes to students' information literacy. The learning designed and organised in such a way produces systematic phases aligned with the brain (Lagoudakis et al., 2022), resulting in a particular learning experience that influences information literacy.

Previous studies have suggested that BBL and BBLRMS contain learning activities that enhance students' information literacy. Reading activities (the first step of BBLRMS) help students find, identify, evaluate and integrate information from various sources (Breakstone et al., 2021; Kiili et al., 2018). Initiation and acquisition activities (the third step of BBLRMS and BBL) offer active discussion activities, enabling students to collaborate and cooperate (Huang, 2020). Further, elaboration activities (the fourth step of BBLRMS and BBL) also help students connect newly learned information and their existing knowledge (Kadioglu-Akbulut & Uzuntiryaki-Kondakci, 2021) so that the information stays longer in the brain. These learning activities are presented in the syntax of BBLRMS and BBL learning. Therefore, this study implements these two learning models to measure the different levels of information literacy obtained by students.

Animal Physiology courses generally apply the direct instruction (DI) learning model. Direct instruction has been commonly used in schools worldwide as this learning provides explicit explanation and conceptual demonstration (Ziegler & Stern, 2016). Generally, the activities in Animal Physiology courses contain lecturing, presentation, and question and answer sessions. Meanwhile, DI assumes that all students can learn when teaching is well-designed (Stockard et al., 2018). It is appropriate to be used to teach concepts (Eratay, 2020). It is relevantly implemented in Animal Physiology courses with a large amount of material and is considered difficult by students conceptually.

This research aimed to determine the influence of learning models (BBLRMS, BBL, and DI) on the information literacy of biology students, and find out which learning model, if any, is superior in advancing undergraduate biology students' information literacy. The hypothesis formulation in this research is that learning models (BBLRMS, BBL, DI) influence biology students' information literacy.

Methods

Research Design

This quasi-experimental research used a pretest-posttest control group design. Pre-test and post-test were carried out on the three treatment groups (BBLRMS, BBL, DI). The BBLRMS learning model was given to the experiment class, while the control 1 and 2 classes utilised the BBL and DI learning models, respectively.

Research Participants

This research was carried out at Universitas Islam Negeri Raden Fatah Palembang, Indonesia, involving students enrolled in the Animal Physiology course, and the number of students is 75. Research subjects were determined randomly from four biology education classes and tested for equality using the cumulative achievement index (GPA). All classes showed equivalent results, and three research classes were selected with details of one experimental class and two control classes (Cohen et al., 2018). Each experiment and control class consisted of 26 students who learned using BBLRMS and BBL models. Meanwhile, the control 2 class contained 23 students and used direct instruction (DI).

Research Instrument

This research consists of 2 variables (independent and dependent). The independent variable is the learning model, which consists of 3 types: BBLRMS, BBL, and DI, while the dependent variable is information literacy. The instruments for the independent variables used in this study were the semester learning plan, course unit, and students' worksheets. Meanwhile, for the dependent variable instrument, we used a multiple-choice test. The multiple-choice instrument contained 40 items referring to the five standards and 22 information literacy indicators proposed by ALA & ACRL (2000). Those standards and indicators for information literacy from ALA & ACRL (2000) are presented in Table 1.

Table 1

Standards and indicators for information literacy

Standards	Indicators
1. Determine the character and scope of the required information	1. Define and articulate the need for information 2. Identifies a variety of types and formats of potential sources for information. 3. Considers the costs and benefits of acquiring the needed information. 4. Reevaluate the nature and extent of the information need.
2. Effective and efficient access to the needed information	1. Selects the most appropriate investigative methods or information retrieval systems for accessing the needed information. 2. Constructs and implements effectivelydesigned search strategies. 3. Retrieves information online or in person using a variety of methods. 4. Refines the search strategy if necessary 5. Extracts, records, and manages the information and its sources.

3.	Critically evaluate information and its sources and combine the selected information into the knowledge basis and its system value.	1.	Summarizes the main ideas to be extracted from the information gathered.
		2.	Articulates and applies initial criteria for evaluating both the information and its sources.
		3.	Synthesizes main ideas to construct new concepts.
		4.	Compares new knowledge with prior knowledge to determine the value added, contradictions, or other unique characteristics of the information
		5.	Determines whether the new knowledge has an impact on the individual's value system and takes steps to reconcile differences.
		6.	Validates understanding and interpretation of the information through discourse with other individuals, subject-area experts, and/or practitioners.
		7.	Determines whether the initial query should be revised.
4.	Effective usage of information to reach specific purposes	1.	Applies new and prior information to the planning and creation of a particular product or performance.
		2.	Revises the development process for the product or performance.
		3.	Communicates the product or performance effectively to others.
5.	Comprehend abundant issues in the field of economy, law, and society related to the use of information in ethical and legal approach	1.	Understands many of the ethical, legal and socio-economic issues surrounding information and information technology.
		2.	Follows laws, regulations, institutional policies, and etiquette related to the access and use of information resources.
		3.	Acknowledges the use of information sources in communicating the product or performance.

Note. Standards and indicators for information literacy from ALA & ACRL, 2000: 8-14

Prior to the data collection, the test was validated by four validators. Then, we conducted a validity and reliability test on the information literacy instrument by involving 100 students who had completed the Animal Physiology course. From the total of 50 multiple choice items, we found ten invalid items, while the remaining 40 items were valid, with *r* count > *r* table (r table = 0.195) and significance of (Sig.) < 0.05. The 40 valid items were used in the research process. The reliability test suggested that the test attained Crobanch's Alpha of 0.878, signifying that the instrument is highly reliable.

Research Procedures

Our research was completed in 14 meetings, with additional two sessions, at the beginning and the end of the course. During those meetings, we collected the data, as the variables were measured through the pretest and posttest. The detailed learning activities using BBLRMS, BBL, and DI learning models are summarized in Table 2.

Table 2

Learning stages of BBLRMS, BBL, and DI models

Model	Student Activities
BBLRMS	1. *Reading*: critically reading a specific topic on several relevant learning sources
	2. *Pre-exposure and preparation with mind mapping*: implement the existing knowledge and new information attained from critical reading through constructing a mind map. Further, it is followed by comprehending the purposes and a figure relevant to the topic (images related to physiological disorders of the body, for example, digestive system disorders and respiratory system disorders) to induce curiosity.
	3. *Initiation and acquisition*: develop comprehension by observing pictures related to the topic, followed by identification and analysis of images presenting issues or facts
	4. *Elaboration*: conduct active discussion based on the analysis and identification results using numerous sources of information. The obtained knowledge is used to complete the mind map.

	5. *Incubation and insert the memory*: This stage emphasizes the importance of taking a break and reviewing what has been learned (Jensen, 2008, 2011). It was further explained that several activities that can be carried out at this stage include stretching and relaxing, listening to music, holding discussions, and keeping a learning journal (Jensen, 2008, 2011). The activities chosen to help students relax more were listening to music and stretching. The music chosen is classical.
	6. *Sharing and verification*: present the discussion results in the form of a mind map, then conduct a question-and-answer session, as well as material verification 7. *Celebration*: This step emphasizes the importance of involving emotions. This step needs to be designed to be fun, and cheerful, and instil a love of learning (Jensen, 2008, 2011). Activities that can be carried out are giving awards to students as a form of self-motivation to achieve better learning performance. Forms of appreciation given include applause, praise and motivation.
BBL	1. *Pre-Exposure*: construct initial knowledge related to the topic through a question-and-answer session. 2. *Preparation*: preparation is carried out by taking a glance at attractive pictures relevant to the topic (images related to physiological disorders of the body, for example, digestive system disorders and respiratory system disorders) to induce curiosity and enjoyable learning. 3. *Initiation and acquisition*: establish understanding by observing pictures relevant to the topic in the students' worksheet. Then, identify and analyse related images of an issue or fact. 4. *Elaboration*: conduct active group discussion based on the results of identification and analysis using numerous sources of information 5. *Incubation and Insert the Memori*: this stage emphasizes the importance of taking a break and reviewing what has been learned (Jensen, 2008, 2011). The activities chosen to help students relax more were listening to music and stretching(Jensen, 2008, 2011). The music chosen is classical. 6. *Verification and Confidence Check*: present the discussion results, followed by a question-and-answer session as well as material verification 7. *Celebration and integration*: This step emphasizes the importance of involving emotions. This step needs to be designed to be fun, and cheerful, and instil a love of learning (Jensen, 2008, 2011). Activities that can be carried out are giving awards to students as a form of self-motivation to achieve better learning performance. Forms of appreciation given include applause, praise and motivation.
DI	1. Introduction: prepare the learning and conduct apperception 2. Primary activity: do presentation, question and answer session, take note of the discussion results, present feedback toward the materials, and conclude the discussion results 3. Closing: give the opportunity to ask a question related to the complex material and assignments

Data Analysis

The data were analysed using covariant analysis (ANCOVA) at a 0.05 significance level. If the result of the ANCOVA analysis was significant, then the analysis was continued with the *Least Significance Different* (LSD) analysis to identify significant differences on the statistical average. Prerequisite tests were also carried out before ANCOVA analysis on information literacy data using the normality test (Kolmogorov-Smirnov) and homogeneity test (Levene test) at ($p>0.05$). The summary of normality and homogeneity test are shown in Table 3.

Table 3

Summary of normality and homogeneity tests results

No.	Data	Normality		Homogeneity	
		N	Sig.	*Levene's test*	Sig.
1.	Pretest	75	0.697	0.151	0.860
2.	Posttest	75	0.692	0.284	0.754

Table 3 shows that the pretest and posttest information literacy data have a normal distribution and are homogeneous. Following these results, we conducted an ANCOVA test.

Findings

The results of ANCOVA for the BBLRMS, BBL, and DI learning models on students' information literacy are shown in Table 4.

Table 4

Results of the ANCOVA test

Source	df	Mean Square	F	Sig.
Pre_Literasi Informasi	1	58.099	1.253	.267
Learning Model	2	478.822	10.327	.000
Error	71	46.366		
Total	75			
Corrected Total	74			

According to the ANCOVA analysis results in Table 4, we obtained a F_{count} of 10.327 at a significance of 0.000, lower than α = 0.05, and then the research hypothesis is accepted. So, learning models (BBLRMS, BBL, DI) influence biology students' information literacy. Then, we also carried out LSD analysis at a 0.05 significant score. The results of the LSD test are shown in Table 5.

Table 5

Summary of LSD test results

No.	Class	Average		Corrected	Notation	Increase
		Pretest	Posttest	Average	BNT	
1.	BBLRMS	61.15	80.67	80.72	a	32%
2.	BBL	62.50	76.15	76.08	b	22%
3.	DI	61.30	71.85	71.88	c	17%

The LSD test results in Table 5 show that there are differences in the average corrected scores of students who received learning using three different models, namely BBLRMS with the highest information literacy score of 80.72, BBL with an average score of 76.08 and DI with an average score of 71.88. The LSD results also show that the BBLRMS learning model is significantly different and superior to the BBL and DI learning models in advancing biology students' information literacy with an increase of 32%.

Discussion

The results showed an influence of learning models (BBLRMS, BBL, DI) on biology students' information literacy. The analysis results also show that the BBLRMS model has the highest average value (80.72), with an increase of 32%. This high average and increase in score suggest that the BBLRMS is significantly different and superior to the BBL and DI learning models in advancing biology students' information literacy. BBLRMS is one of the appropriate learning innovations for encouraging student information literacy (Nuraini et al., 2023). Therefore, the BBLRMS model was implemented in Animal Physiology courses for Biology students. The implementation of the BBLRMS model is focused on the Animal Physiology course through 7 systematic steps. Each step will be filled with activities that direct and help advance student IL. Bakermans & Ziino Plotke (2018) also explained that one effort to support the development of information literacy (accessing information and evaluating relevant sources) is to include activities and tasks that are appropriate and support the development of abilities.

The first stage is reading. In this activity, students are directed to critically read specific topics from various relevant learning sources, such as the topic of the digestive system. *Reading* is a learning activity attached to students and subjects (Djudin, 2021). The reading process will help students interpret and decipher words (Akkuş & Doymuş, 2022), deepen understanding, and complete assignments (Wright et al., 2016) so that knowledge can be stored longer in the brain. The rapid progression of information has necessitated students to identify and evaluate their reading content and sources (Kiili et al., 2018). Besides, reading also enables students to evaluate the content's facts and credibility (Breakstone et al., 2021). This explanation clearly shows that the reading step can advance information literacy, especially in the second indicator (identifies a variety of types and formats of potential sources for information) standard 1 (Table 2).

The second learning stage is pre-exposure and preparation with mind mapping, in which students implement the obtained knowledge from the critical reading activity and their existing knowledge through mind map creation. The mind map is a visual tool to regulate information, record information, and summarise concepts (Jiang, 2020). The creation of a mind map aids students in thinking and learning (Hidayati et al., 2023), understanding the material, enhancing their memory (Badriyah et al., 2021), and learning information by managing the addition of colour and pictures (Fatmawati, 2016). A mind map also facilitates students to identify the primary concepts obtained from reading, sort the relevant information, and conclude the material (Astriani et al., 2020). This pre-exposure and preparation with mind mapping step help students advance information literacy, especially in indicator 1 (summarizes the main ideas to be extracted from the information gathered), and indicator 3 (synthesizes main ideas to construct new concepts) standard 3, and indicator 5 (extracts, records, and manages the information and its sources), standard 2.

The third learning stage is initiation and acquisition, which focuses on enhancing students' comprehension (Jensen, 2011) by carefully observing pictures relevant to the learning topic. In this activity, students identify and analyse images that illustrate issues of facts relevant to the topic. The initiation stage also contributes to students' comprehension and conceptual skills (Kim, 2016). The activities carried out at this stage are images identification and analysis including structure and function, physiological mechanisms, disorders or diseases, and preventive measures. Molina, Sundar, Le, & Lee (2021) described that content analysis should focus on the content characteristics, its system, source, and structure. Thus, the analysis during the Animal Physiology course was conducted focusing on the content and material sources. The initiation and acquisition stages help students advance information literacy, especially in indicator 2 (identifies a variety of types and formats of potential sources for information) standard 1.

The fourth stage is elaboration. Elaboration encourages students to have active discussions following previous identification and analysis results. Also, this phase aids students in correlating the obtained information and comprehending the correlation (Priawasana et al., 2020). The discussion is completed with guidance and direction from the lecturers to enable more comfortable and less

complex learning (Ertmer & Koehler, 2015). Students can also express their opinions or thoughts through discussion activities (Karakaş, 2022). The active discussion and use of the information obtained to support and complete the mind map is one effort to advance information literacy. Specifically in indicator 2 (identifies a variety of types and formats of potential sources for information) standard 1 and indicator 1 (applies new and prior information to the planning and creation of a particular product or performance) standard 4 (ALA & ACRL, 2000). Maybee, Doan, & Flierl (2016) reported that information could be used to realise an active learning process. Thus, the discussion process using different types of information from numerous sources aids students in empowering their information literacy.

The fifth stage is incubation and inserting the memory. This step emphasizes the importance of taking a break and reviewing what has been learned (Jensen, 2008, 2011). It was further explained that several activities that can be carried out at this stage include stretching and relaxing, listening to music, holding discussions, and keeping a learning journal (Jensen, 2008, 2011). The activities chosen by researchers to help students relax more were listening to music and stretching. Classical music was chosen because it is identical to calm and not noisy and can encourage the creation of a positive mood, increase enthusiasm for learning, help to learn to be more effective and efficient, and reduce anxiety in studying and exams (Fritz et al., 2020; Lilley et al., 2014).

Incubation substantially impacts problem-solving skills (Yoo et al., 2015). Gilhooly (2016) explained three components of incubation. First, pre-incubation is where students face issues during the problem-solving process. Second, incubation is where students rest from solving the problem and work on other tasks. The last stage is where students determine to solve the unsolved problem. In this study, when facing issues in analyzing Animal Physiology pictures, students use numerous sources of information to resolve their problems with their group members. This collective problem-solving process also advances students' information literacy, specifically in standard 4, effectively using the information to reach specific purposes (ALA & ACRL, 2000). Thus, the incubation and insert the memory stage indirectly influence students' information literacy.

Sharing and verification is the sixth stage, where students are directed to present the discussion results in the form of a mind map. Sharing has been acknowledged as an interactive means of accurately disseminating knowledge to others (Lawrence, 2019). The support and participation of the lecturer in establishing an intellectual environment also promote information-sharing activity (Eletter et al., 2022). The sharing activity is followed by a question-and-answer session, along with material verification. During material verification, students are guided by their lecturer in finding misinformation (Edgerly et al., 2020). Based on the explanation, sharing and verification steps can advance information literacy. The students can communicate their product and performance using the sharing process (3rd indicator on the 4th standard of information literacy), while the verification process can be used to validate the information interpretation and understanding with the help of lecturers or practitioners (6th indicator on the 3rd standard of information literacy).

The seventh stage is a celebration, where students are appreciated to increase their self-motivation for their future learning. The appreciation is given through hand clapping (non-verbal), compliments (verbal), and learning motivation. Edgerly et al. (2020) explained that appreciation positively affects students' learning performance and motivation. Further, appreciation can also be given through smiles, applauses, or praises. Meanwhile, Gundersen & McKay (2019) stated that compliments correlate with higher test scores. Thus, celebration increases students' enthusiasm and motivation for better learning achievement, including information literacy skills. Students' excellent information literacy also impacts their other literacy skills essential for 21st-century learning (Sari et al., 2021).

In addition, the analysis results on data from control 1 and 2 classes showed that the BBL model (76.08) carries greater effects than the DI model (71.88). This finding shows that the BBL model has more potential to advance students' information literacy skills than the DI learning model. Brain-based learning (BBL) has activities that provoke optimum brain potential (Rahmatin & Suyanto, 2019). BBL helps students process the knowledge and information obtained and is actively involved in

learning (Seaba, 2023). The BBL model can also create an active learning atmosphere through discussion and observation activities so that students can build and maintain knowledge (Koşar & Bedir, 2018; Rahmatin & Suyanto, 2019). The BBL model is appropriate to be applied in biology courses. The discussion process also develops active learning, encouraging students to accelerate their conceptual understanding. Further, this activity advances students' information literacy, specifically on indicators 3 and 4 on standard 2.

At the end of the study, we observed that students attending DI learning obtained the lowest score (71.88). These results show that DI learning with lectures, presentations, and question-and-answer activities still influences students' information literacy, but the results are less optimal. DI has been reported to lead students to focus on the essential aspects of the material (Ziegler & Stern, 2016). Results of a study conducted by van der Graaf, van de Sande, Gijsel, & Segers (2019) show that DI help students build conceptual understanding. Lecturing activity also expedites students' material comprehension (Sewasew et al., 2015). This explanation is relevant to the research results, which show that learning with DI has the lowest average, meaning that DI affects students' IL. However, the results and improvements are less optimal. DI focuses on helping students to understand Animal Physiology materials.

The research showed that implementing learning using the BBLRMS model in Animal Physiology courses was superior to advancing IL compared to the BBL and DI models. The mean score and percentage increase in student IL also showed significant differences. BBLRMS can provide a learning experience that is systematic, fun and in harmony with the work of the brain. These learning conditions will help students find, access and evaluate the information needed for learning. IL also helps students be more ethical, wise, and successful in facing the increasingly rapid development of the flow of information.

Conclusion and Implications

Based on the analysis and discussion results, learning models (BBLRMS, BBL, DI) influence biology students' information literacy. The analysis results also show that BBLRMS is the best learning model and is superior to the BBL and DI models in advancing biology students' information literacy. The BBLRMS model is superior in advancing information literacy because it has very structured steps (including adding reading activities in the first step, making a mind map in the second step, and sharing activities in the sixth step). Implementing BBL and DI in research also has the potential to advance IL, even if the results are insignificant. All information obtained from this research has the potential to contribute to science education, especially in efforts to advance student IL using different learning models.

This research has several limitations. *First*, the study involved three 5th-semester classes. *Second*, the findings were limited to the Animal Physiology course and information literacy variables. Therefore, researchers suggest that future research uses a larger sample by considering student demographic variables so that the research results obtained can be used globally and widely. Students at different semester levels may demonstrate different IL skills. Further research can be done by applying learning models to different subjects and skills. We can get an idea of the other advantages of the BBLRMS model to improve 21st-century skills. Maximum preparation in each implementation of the learning model is also something that researchers need to pay attention to so that each activity is carried out well.

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