Studying Ecosystem in Senior High School: The Utilization of CirGi Learning Model to Enhance Mastery of Biological Concepts

LIA JUNITA HARAHAP[1], RATNA KOMALA[2], AND RIZHAL HENDI RISTANTO[3]

Abstract

Ecosystem concepts are not a science that is far from daily life. Therefore, teachers need an innovation that can support students' mastery of the ecosystem concept. This study aims to analyze the influence of the CirGi (Cooperative Integrated Reading, Composition, and Guided Inquiry) learning model on the learners' ecosystem concept mastery. This research uses a quasi-experiment method with a pre-post control group design with a sample of 104 students. Data collection is carried out using an instrument of ecosystem concept mastery in the form of multiple choices so that questions could cover all the materials. The data analysis technique used is an independent sample t-test. The conclusion of this study is that there is a significant influence of CirGi's learning model on the learners' mastery of ecosystem concept. The application of CirGi learning model on ecosystem material can revive reading activities along with environmental awareness.

Keywords
CIRC, CirGi, ecosystem, guided inquiry, mastery concepts

1. Biology Education Study Program, Faculty of Mathematics and Natural Sciences, Jakarta State University, Jakarta, Indonesia; email: liajunita52@gmail.com
2. Biology Education Study Program, Faculty of Mathematics and Natural Sciences, Jakarta State University, Jakarta, Indonesia; email: ratna_komala08@yahoo.co.id
3. Biology Education Study Program, Faculty of Mathematics and Natural Sciences, Jakarta State University, Jakarta, Indonesia; email: rizhalhendi@unj.ac.id

Introduction

Communicating ecosystem concepts is one of the scientific works of scientists, both in the form of articles and books that must be understood, mastered, and applied by students in daily life. The rise of ecosystem damage at present can affect various aspects of life. Damage that occurs in the environment could be due to natural factors and human intervention (Asaju & Arome, 2015; Komala, Suryanda, & Lismana, 2018; Torkar & Krašovec, 2019). Human activities can disturb biological communities and destroy natural ecosystems with unique functions for human survival (Li, Zhang, Cao, & Ma, 2015; Xu, Sun, & Tang, 2016). Repairing ecosystem damage requires an understanding of the complex interactions of all living things and their environment. Humans as destroyers or the main cause of extinction require education. Development of a caring attitude towards ecosystem damage in education is an important step for environmental care and understands that actions are good for nature and oneself (Morenoa, Acerob, & Rodriguez, 2011).

Minimizing cases of ecosystem damage can be done through education in schools by learning biology that discusses living things and their environment. Education is very important in developing environmental literacy (Hutcheson, Hoagland, & Jin 2018; Setiawan, Suharno, & Triyanto, 2019) and is able to direct students towards positive behavior towards the environment. Ecosystem is a useful concept as it can help students to use and reuse environmental resources to keep the system far from its equilibrium state (Shaw & Allen, 2016). Ecosystem, which is one of the materials taught in biology, contains material about ecosystem components, namely biotic components (humans, animals, plants, microorganisms), abiotic components (temperature, water, air, soil, light), interactions in ecosystems (predation, mutualism, competition, commensalism, parasitism), ecosystem types (land, freshwater, seawater), energy flow (food chain, food webs, food pyramid), and biogeochemical cycles (oxygen cycle, carbon cycle, hydrogen cycle, hydrogen cycle, water cycle) (Campbell, 2008). Overcoming the problems of ecosystem damage requires students to master the ecosystem concepts to identify the causes and be able to overcome the problems so that students' wise attitude in utilizing and conserving natural resources will grow.

Concept mastery is the capability to capture notions like being able to express a material presented in an easy-to-understand form, provide interpretation and apply it, and it can be achieved after students learning (Bloom, 2003; Nggadas & Ariswan, 2019; Gumilar, Wardani, & Lisdiana, 2020). Mastery of the ecosystem concepts needs to be taught and developed in students as a basis for action. The mastery of the ecosystem concepts is the cognitive ability of students' understanding of ecosystem material through a phenomenon, event, object, observation process, and teacher explanation to achieve learning objectives (Tursinawati, 2016; Anwar et al., 2019; Effendy, Hartono, & Yulianti, 2018; Harahap, Ristanto, & Komala, 2020a). It is needed so that students can connect the concepts learned and making it easier for them to master the material (Rustaman, 2005; Ristanto, Zubaidah, Amin, & Rohman, 2017; Putri, Rusyati, & Rochintaniawati, 2018). Students who are able to master the concept will have various benefits, among others: 1) reduce the burden of memory due to human ability to categorize a variety of limited stimulus; 2) the building blocks of thinking; 3) the basis of a higher mental process; and 4) capable of solving problems (Hamalik, 2005; Setambah, 2018).

Based on preliminary tests that had been done in class X Al Hasra High School, students' mastery of the ecosystem concept was still low. It was due to the ecosystem concept that is abstract, complex, and is interconnected with other biological concepts. Many studies on the mastery of ecosystem concepts have been carried out and the results indicate that students' achievement is still low or below the minimum criteria (Susilawati, Rahayuningsih, & Ridlo, 2016; Kurniasih & Listiawati, 2018). Interviews with biology teachers in class X Al-Hasra High School obtained information that some students had been active in learning activities in class, but some students had difficulties. Some of the difficulties related to ecosystem materials are abstract and complex concepts, and interconnected with other biological concepts. In addition, students did not have the confidence to ask teachers about material that they did not understand; therefore, more materials were not mastered by the students. The students' low achievement is also related to the use of a conventional learning model. The class usually used the CIRC (Cooperative Integrated Reading and Composition) learning model that focuses more on reading activities. A large amount of biology material prompted the teachers to use conventional learning processes more often (Ernawati, Toharudin, & Ibrahim, 2017). The teacher delivered the material quickly to meet the demands of the material that must be completed before the semester exam. As a consequence, students' mastery of the ecosystem concepts did not develop. Students' low interest in reading scientific books causes students to be passive in learning. The students' concentration, learning interest, and learning motivation is also still low.

Based on these conditions, a learning model is required that emphasizes the process of reading and writing, and the existence of teacher guidance by applying the Cooperative Integrated Reading, Composition, and Guided Inquiry (CirGi). CirGi is an integration of CIRC and Guided Inquiry learning models. Both learning models have their own strengths and weaknesses. CIRC is a cooperative learning model that accentuates reading, writing activities, and language arts at a higher level (Slavin, 2005; Ristanto, Zubaidah, Amin, & Rohman, 2018a). Reading is an interactive activity to reproduce the word mentally and to understand the content of a reading text (Rahmat, 2017; Jian, Su, & Hsiao, 2019). Robertson (2007) states that by merely reading is not the best way to learn science. On the other hand, each student's reading experience is different (Morgan, Fuchs, Compton, Cordray, & Fuchs, 2008; Schotter, Tran, & Rayner, 2014) and each student has a topic with a different interest in education (Jian et al., 2019).

Students who often read scientific books will be faster in mastering biology or ecosystem concepts than students who often read books like novels. Almost all the words in scientific texts are important and only a few of them are not. Teacher guidance is necessary in an inquiry process (Muhaimin et al., 2019; Mukminin, Kamil, Muazza, & Haryanto, 2017; Susbiyanto, Kurniawan, Perdana, & Riantoni, 2019). In the inquiry process (Almuntasheri, Gillies, & Wright, 2016), students will learn relevant contents, specific reasoning skills, and practices collaboratively (Gillies & Rafter, 2020). Guided inquiry is an effective instructional approach in science education (Lazonder & Harmsen, 2016). Students will create and evaluate their experimentation activities (Schalk, Edelsbrunnerb, Deiglmayr, Schumacherb, &

Sternb, 2019). Guided inquiry can train students to find concepts with direction from the teacher through the design of procedures and to explore concepts learned (Smithenry, 2010; Rahayu et al., 2018; Siregar, Festiyed, Marsidin, & Ellizar, 2019). It begins with the teacher gives questions (problems) and students answer through a research process. Developing research procedures and getting research results is students' responsibility. Teacher duties in the guided inquiry model are guiding students in developing procedures to compile new knowledge (Adi, Suwono, & Suarsini, 2017; Nurani, Sarwanto, & Rintayati, 2018; Rahayu et al., 2018). Questions (problems) will stimulate students to think critically, actively, and make learning centered on students (student center).

This is in line with Ristanto et al.' (2018b) research that there is an effect of CirGi on the mastery of biological concepts in junior high school students and Harahap, Ristanto, and Komala (2020b) that there is an influence of CirGi on critical thinking skill in ecosystem material. Kurniawati, Wartono, and Diantoro (2014) divulged that the guided inquiry learning model integrated with the cooperative learning model could significantly influence the students' concept mastery. Bilgin (2009) added that students who are taught by the integration of guided inquiry and cooperative learning approaches have a better understanding of concept mastery and show more positive attitudes. CirGi has a character that brings more effective and creative lectures as students in groups can build and exchange knowledge to learn materials in solving a problem. It is conducted by reading books and with guidance from the teacher. Therefore, it trains students to master the ecosystem concepts and each learner gains a shared understanding. Based on the above problems, the CirGi learning model is needed to enhance the mastery of ecosystem concepts.

Methodology

Research Design, Site, and Participants

This study used quantitative research that was designed using the quasi-experiment research method and it was carried out in September 2019. The design program used was Pretest-Posttest Control Group Design. All students of class X Al-Hasra High School in Depok, Indonesia, of the academic year of 2018/2019 became the study population. Samples were selected using purposive sampling technique that resulted in 104 students from 4 classes taken as the research samples (Table 1).

Table 1. *Number of sample, each class*

Treatment Class	Class	Number of Students
Experiment	X Natural Science 1 X Social Science 1	52
Control	X Natural Science 2 X Social Science 2	52
Total		**104**

Since there were 2 classes of natural science and 2 classes of social science the natural science class would be paired with social science class to create a balanced class. The experimental class was taught using the CirGi, and the control class was taught using conventional learning.

Data collection and analysis

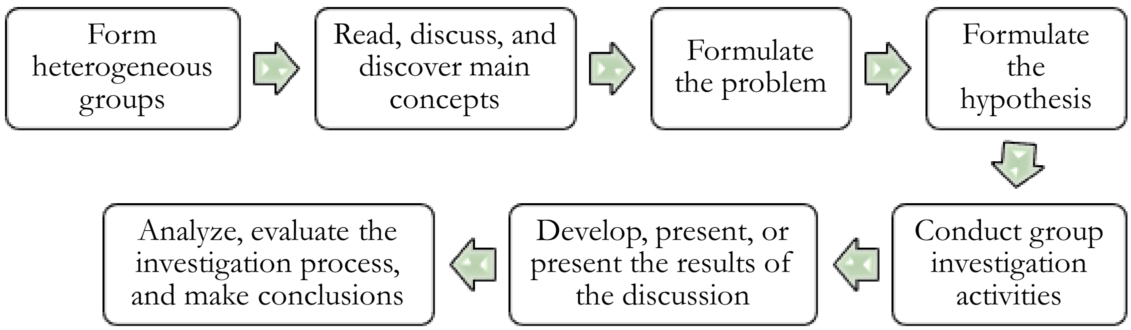
The type of test used in this research was a multiple-choice test consisting of 60 questions. A multiple-choice test could cover all ecosystem materials. The instrument testing was carried out by construct and content validity tests by the validators/experts, namely 2 Doctor of Biology Lecturers. The validity tests resulted in an average value of 85.00 indicating that the instrument was very feasible for use. Furthermore, the empirical validation test of instrument items used the Biserial Point formula. The result indicated that r_{count} was greater than r_{table} with a minimum range of 0.325; hence, there were 37 valid questions out of the 60 tested items. Kuder Richardson-20 was used to measure the reliability of concept mastery indicators by referring to Anderson and Krathwohl (2001) as presented in Table 2.

Table 2. *Mastery of biological concepts indicators*

Indicator	Description	Number of Questions
Remembering (C1)	Acceptance of relevant knowledge from long-term memory that consists of recalling, finding, and choosing.	7
Understanding (C2)	Determine the meaning of instructional messages in the form of oral, written, and graphic consisting of interpreting, classifying, exemplifying, summarizing, comparing, comparing, and inferring.	9
Applying (C3)	Implement or utilize procedures in certain situations, consisting of executing, implementing, and developing.	6
Analyzing (C4)	Breakdown the material into its component parts and detect how the parts are interconnected with each other. Analyzing consists of organizing, differentiating, and attributing.	7
Evaluating (C5)	Make consideration based on criteria. Evaluating consists of checking, proving, and decide.	4
Creating (C6)	Put the elements together in a new form and create an original product. It consists of generating, planning, and producing.	4

Students of experimental and control classes were given a pretest consisted of 37 questions to measure their initial abilities. The experimental class was taught with CirGi at the first, second, and third meetings with the application steps referred to (Ristanto et al., 2018b) in Fig. 1. At the same time, the control class was taught with conventional learning. In the experimental class (Fig.1), students would be heterogeneously grouped into several groups. Students in each group would read and discuss ecosystem material from various sources. Teacher and students were discussing ecosystem materials collected by students and ecosystem articles provided by the teacher to be able to formulate problems and hypotheses then write them down on the provided student worksheets. The teacher must guide students in developing the discussion results. Instead of providing the answer, teachers directed the students to reach the discussion results. The teacher also had to guide students regarding the problems raised by each group so that each group had a different presentation topic. Each group developed and presented the results of its group discussion. The discussion results for each group would be analyzed and evaluated by the teacher and all students to obtain appropriate conclusions.

Figure 1. *CirGi syntax*



Furthermore, the posttest of the mastery of ecosystem concept was tested in the experimental and control classes. Data were analyzed using several tests, namely: (1) descriptive test, which calculates the average pretest and posttest of each indicator of the value of students' mastery of the ecosystem concept; (2) prerequisite tests for data analysis, namely the normality test (Kolmogorov-Smirnov) and homogeneity test (Levine Test) using SPSS 25 software; and (3) hypothesis testing using independent sample t-test with the help of SPSS 25 for windows.

Findings

Based on the results, the following are descriptive statistics consisting of the average value, the maximum value, the minimum value of the experimental and control classes in Table 3.

Table 3. ***Descriptive statistics on mastery of ecosystem concept***

Indicator	Average			
	CirGi		Conventional	
	Pretest	Posttest	Pretest	Posttest
Sum	310.12	506.49	304.39	472.48
Mean	51.69	84.41	50.73	78.75
Min	34.13	76.44	32.21	58.17
Max	70.60	94.78	70.60	94.51
St. Deviation	9.46	4.50	9.27	5.21
Variance	89.60	20.26	85.97	27.20

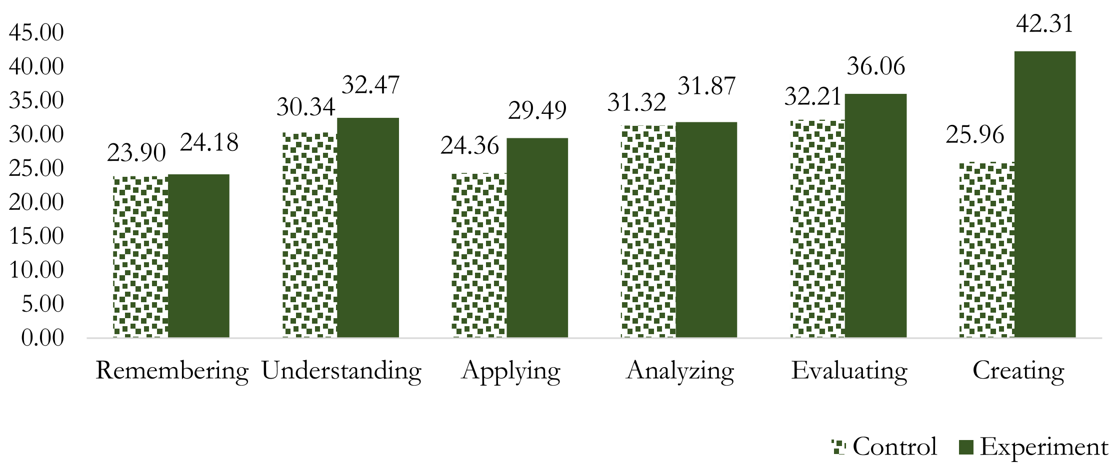
Based on the analysis, students who were taught using CirGi were higher in the mastery of ecosystem concept than students who were taught with conventional learning with an average of 84.4 (Table 4).

Table 4. *Average mastery of ecosystem concepts for each indicator by implementing cirgi learning model and conventional model*

No	Indicator	Average of Mastery Concepts			
		CirGi		Conventional	
		Pretest	Posttest	Pretest	Posttest
1	Remembering (C1)	70.60	94.78	70.60	94.51
2	Understanding (C2)	55.77	88.24	54.91	85.26
3	Applying (C3)	53.53	83.01	52.56	76.92
4	Analyzing (C4)	51.37	83.24	50.82	82.14
5	Evaluating (C5)	44.71	80.77	43.27	75.48
6	Creating (C6)	34.13	76.44	32.21	58.17

Based on the calculation of students' pretest and posttest scores on ecosystem concept mastery in the experimental class by applying the CirGi learning model, there was an increase in the score by a difference of 32.73 (Figure 2) where the average pretest score was 51.69 and the posttest score was 84.41 (Table 3). Table 2 and Figure 2 indicate that the indicators of the ecosystem concept mastery had increased. The indicator with the highest score was remembering with an increase in average score from 70.60 to 94.78 or a difference of 24.18.

Figure 2.*Differences of increase in pretest and posttest scores for each indicator of ecosystem concept mastery*



This was due to the remembering indicator that is the easiest indicator or is at the lowest cognitive level (C1) with a simple type of questions. Meanwhile, the lowest score was on creating indicators that indicated an increase from 34.13 to 76.44 with a difference of 42.31. This was because students are not familiar with the highest cognitive level (C6) questions. However, the value of 76.44 had exceeded the minimum criteria score.

The analysis prerequisite tests conducted were normality and homogeneity tests at α=0.05.

Table 5. *Normality of pretest and posttest of the mastery of ecosystem concepts*

No	Class	N	Mastery of Concepts		Conclusions
			Pretest	Posttest	
1	Experiment	52	0.961	0.100	Normal
2	Control	52	0.862	0.433	Normal

Table 6. *Homogeneity of mastery of ecosystem concepts*

Levene Statistic	df1	df2	Sig.
1.355	1	102	.247

Calculation of analysis prerequisite tests of the ecosystem concept mastery implied that the data were normal and did not have any deviation against data normality because p-values of the pretest and posttest were more significant than α = 0.05 (Table 5). In addition, the data also homogeneous because α = 0.247>0.05 (Table 6) indicating that there was no variant difference between data groups.

A statistic was used to illustrate the difference of students' ecosystem concept mastery on CirGi and conventional model with an independent sample t-test with significance value was smaller than 0.05 as presented in Table 7.

Table 7. *Independent sample t-test of mastery of ecosystem concepts*

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	4.731	102	.000	4.52058	.95544	2.62547	6.41568
Equal variances not assumed	4.731	99.864	.000	4.52058	.95544	2.62498	6.41617

Based on Table 7, the calculation of the learning model variable indicated a p-value of 0.000<0.05 or rejected the H_0. It could be inferred that the CirGi learning model was better in improving the students' ecosystem concept mastery than the conventional one.

Discussion

The increase in the value of all indicators (pass the minimum criteria) was inseparable from the successful implementation of the CirGi syntax that indicated an improvement from the first to the third meetings (Table 4). It is relevant to Ristanto et al. (2018b) that CirGi can increase the mastery of biology concepts in Junior High School. This suggests that it is also important for senior high school students to improve their reading activities. Moreover, senior high school students also still require guidance and direction in achieving mastery of biological concepts just in the case of junior high school students. The first stage of the CirGi syntax is forming heterogeneous discussion groups. In the heterogeneous groups, students whose learning ability is low will co-exist or work together with students who have more abilities. In this regard, students who have more abilities will act as peer tutors for students or group members who have less ability in learning (Arends, 2008; Dewanti, 2020; Schullery & Schullery, 2006). Therefore, it is expected that the heterogeneous groups will facilitate the learning process. In the stage of reading, discussing, and discovering the concept of the article, the application of the CirGi learning model emphasizes reading activities as well as guidance from the teacher in achieving results. Students are required to read articles provided by the teacher as well as articles brought by students.

One factor that causes students to get bored of reading scientific books is the font type used. Moreover, pictures in the biology books are still abstract; thus, students are lazy to read them. Therefore, the existence of articles compiled by the teacher with more interesting font types, such as the Comic San MS type face, triggers students interest and excitement to read the ecosystem materials through articles. Teachers who prioritize reading activities to encourage students' cognitive abilities in learning will produce students who have high reading comprehension ability (Hernida, 2009; Prasetiyo, 2019). Reading activities are closely related to memory. Some students find it very difficult to remember material. Hence, it is necessary to write or to conclude material that has been read in written form. This is in accordance with Higbee (1991) that material that exists or available in memory but difficult to recall is due to the material that cannot be obtained immediately when needed; however, it does not mean that the material does not exist; it is just that the students are unable to find it (recall it). Therefore, it depends on how the information is read, recorded, and stored in memory. Furthermore, Mueller & Oppenheimer (2014) stated that storing ideas in a long time requires a writing strategy or activity, namely by concluding the material that has been read into writing. It is similar to Hernowo (2009) arguing that reading and writing activities will organize the mind, construct ideas, sharpen understanding, and be able to sharpen memory. The next activity in implementing CirGi is discussion. Learners in the group will discuss to answer the questions given by teacher that contained in the students' worksheet.

Discussion activities in groups will motivate students to learn because each student is given an opportunity to express their opinions thus it enriches the students' knowledge. From these ideas, the most appropriate answer will be selected or considered by all group members, so that the best answer is obtained. This is supported by Hubble & Lipton (2005) that students will be motivated to think hard and clarify ideas when talking with group friends. It corresponds to Gaddis and Schoffstall (2007) on guided inquiry learning that students will be provided with steps to be examined, but the results have not been determined so that students will be curious. Curiosity and inquisitiveness will motivate students to work together in finding answers with group members and with the teacher's assistance. The implicit interactions between students can enhance motivation, get into the habit of reading and writing, and build other skills linked to conceptualization (Gillies, 2014). If students discuss with other group friends, it will be easier to find and understand intricate concepts (Yudasmini, Marhaeni, & Jampel, 2015). Students can express opinions, offer hypotheses, and provide information to complete tasks (Marcos, Fernández, González, & Phillips-Silver, 2020). In addition, Silvana (2017) and Sánchez-Escobedo and Lavadores (2018) opine that the opportunity for students to explore more knowledge and work together in groups can bring success to each group member. Other findings from this study are that students have equal and broad opportunities in gaining mastery of the ecosystem concepts due to discussions between group members and guidance from teachers. Intensive interactions that are in line with CirGi syntax bring students towards success in mastering the concept of ecosystems because they find it through discussion activities. The next activities are formulating problems and hypotheses and conducting investigations with work instructions provided on the student worksheets from the first to the third meetings.

Student worksheet is one of the important things that increase the concept mastery, especially in Creating (C6) indicator. It facilitates teacher to regulate the questions in terms of how many C1 level or C2-C6 levels in the questions. Biology books still contain numerous instruments in the level of C1-C4 that hamper students to solve problems in C5 and C6. Therefore, teachers can improve students' knowledge level by providing some highest-level instruments in student worksheets. Each group member is required to be active in solving problems and finding answers from both the articles provided by the teacher and the students' articles or books. Group members must investigate their own answers to get the best results or answers to be presented. The next activity is the presentation of students' group work. In this activity, groups take turns presenting or communicating their group discussion results. Groups that have presented or have not read the discussion results must listen and respond by asking questions or providing inputs to the presenting group. Next, the teacher, along with all students, concludes the learning material on the ecosystem. This presentation activity will encourage students to be more confident because each student must convey or communicate the results of the group discussion. Education not only expects students to learn contents, but also communication to interact with each other efficiently (Verdejo & Guinda, 2015). Communication is very important in student development (Johnson & Johnson, 2004; Erikson & Erikson, 2018; Nwabueze & Mileski, 2018) and it takes many opportunities to train and develop these skills. Reading and writing are important for communication, understanding, mastery, and learning (Teng, 2020).

In the control class that applied conventional learning, students' mastery concepts was lower (Table 2) than the experimental class with the application of CirGi. Student scores had increased, but the creating aspects were still very low. The low achievement of the value on the indicator of creating was due to the learning model applied that had not been able to support or optimize the highest cognitive level (C6) in the ecosystem material. The discussion process was also undirected, so each group solved the problem and developed a rough solution. The absence of the students' worksheet created or provided by the teacher made students less enthusiastic in solving problems. Group members were more focused on the book being read, so that the students' answers were the same as the one stated in the book. It has an impact on the presentation of the group discussion result where some group members were unable to convey the results of the discussion verbally. The students delivered it by reading the discussion results that had been written and discussed earlier. In the control class, the teacher's role as a facilitator was also less optimal. As a consequence, group members developed materials merely based on books and articles. This resulted in a misconception of some group members in completing the discussion task.

The significant results of the CirGi learning model application (Table 7) signify that the CirGi is very suitable for teaching ecosystem material at senior high school level. Students taught with CirGi learning are able to remember, understand, and create ecosystem materials in the aspects of ecosystem components, interactions in ecosystems, ecosystem types, energy flow, and biogeochemical cycles. Ecosystem materials that contain scientific concepts and languages can be overcome by using the CirGi learning model that emphasizes reading, writing, and is accompanied by guidance from the teacher. If students often read scientific or biology books, it will be easier for them to master the material or biological concepts extensively.

Conclusions

The mastery of ecosystem concepts in high school students can be improved with the utilization of CirGi learning model as it has a significant influence on the concept mastery. The application of CirGi can also develop students' interest in reading science books. The CirGi model implementation, however, is time-consuming. Therefore, it must be carried out in accordance with the syntax and the time allocation of each syntax that has been set, so students gain maximum mastery of the ecosystem concepts.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Biographical notes

LIA JUNITA HARAHAP is a student at Biology education study program in the Faculty of Mathematics and Natural Sciences, Jakarta State University, Jakarta, Indonesia.

RATNA KOMALA is a lecturer at Biology study program in the Faculty of Mathematics and Natural Sciences, Jakarta State University, Jakarta, Indonesia

RIZHAL HENDI RISTANTO is a lecturer at Biology education study program in the Faculty of Mathematics and Natural Sciences, Jakarta State University, Jakarta, Indonesia.