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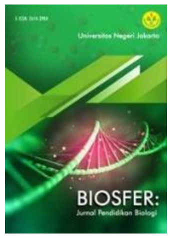

Guided discovery-blended learning (GDBL) for critical thinking skill empowerment: A learning strategy in human excretory system

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ABSTRACT

The research purpose is to learn Guided Discovery-Blended Learning (GDBL) strategy on students' critical thinking skills in the human excretory system. The research method is quasi-experiment with pretest-posttest experiment and control group design. The research population includes all Grade XI Mathematics and Science in a senior high school in East Jakarta, Indonesia, of 144 students. As regards the sample, 71 students are selected that are divided into two classes, namely: XI MIPA-2 as a control class and XI Mathematics and Science -4 as an experimental class with GDBL. Data collection uses an integration test in an essay, student response to learning strategy and observation sheet of syntax implementation—the data analysis result using ANCOVA test proofs that the GDBL affects students' critical thinking skill. The GDBL could foster thinking habits through independent rearrangement of a concept with guidance from the teacher using sourcebooks and online media. It is necessary to prepare biology teacher creativity to improve student's critical thinking skills and to modify the GDBL so as it brings a better effect.

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INTRODUCTION

Global educators must master pedagogic competences as well as enhance information technology application in learning (Montoro et al., 2015). 21st century skills are the main key to prepare human resources in the global era to be successful in the 21st century and one of the skills is critical thinking (Stupple et al., 2017). In the rapid communication and information era it is necessary to improve students' critical thinking to collect information, draw a conclusion and to evaluate (Keane et al., 2016). Critical thinking skills in biology learning play a significant role to increase the achievement of learning objectives through changes in mindset, logics, and cognitive skills (Karakoç, 2016; Noviyanti, Rusdi, & Ristanto, 2019; Harahap, Ristanto, & Komala, 2020) and information and communication technology application (Kanematsu & Barry, 2016). An observation result indicates that students' critical thinking in secondary school is not optimal. It is observable in their ability to ask, argue, and formulate problems. Biology concept in human excretory system is very complex. It discusses real life phenomena; hence, it could be a means to train students' critical thinking skills (Rusdi et al., 2016; Rindah, Dwiastuti, & Risnanto, 2019)

Critical thinking benefits students in improving their competences and as a means to overcome daily life problems. Students' critical thinking could be improved with learning strategy selection (Mahanal et al., 2019; Noviyanti et al., 2019; Harahap et al., 2020). Critical thinking is an ability to self-arrange in judging something based on evidences, concepts, methodologies, criteria, or contextual consideration (Dwyer et al., 2014). Moreover, it is an essential ability that is useful for students as a real life guidance (Zubaidah, 2015; 2018). It is also useful for rational decision making about what it believes to be true to do (Ennis, 1993; 2011).

Students' critical thinking skill is not genetics; thus, it needs to be trained and improved through repeated practice (Hokanson, 2018). Critical thinking skill improvement must be conducted intensively (Anders et al., 2019). Students' critical thinking skills can be measured by critical thinking instrument that refers to critical thinking indicators, among others, give simple explanation, establish basic skills, draw conclusion, give further explanation, and arrange strategies and techniques (Ennis, 1985; 2011). An effective critical thinking learning depends on the creation of classroom atmosphere that encourages the acceptance of different views and discussion.

Educators must apply innovations and strategies in learning to enhance critical thinking skills. Several previous researchers, among others, Banyen, Viriyavejakul, & Ratanaolarn, (2016); Nair & Bindu, (2016), apply blended learning to improve biology learning achievement; whereas Musyadad & Suyanto, (2019) compares real object learning, web, and blended learning in students' knowledge dimension. Moreover, Permana & Chamisijatin, (2019) states that project-based learning using Edmodo improve critical thinking and histology concepts and Sugiharto (2019) combines PBL and Blended learning. One effort developed in the research is combining guided discovery learning with blended learning.

Discovery learning is suitable to improve critical thinking skill as it is discovery-based (Sartono et al., 2017). Discovery learning is not given in its final form in the learning process instead students must find principles and concepts through their learning experiences. Through the discovery learning students are expected to be familiar with basic principles of scientific way of thinking and capable of expressing ideas through their searching process. Biology concept in the complex and abstract excretory system is difficult to understand by students (Isnaini, Aini, & Angraini, 2016; Rindah et al., 2019). To avoid mistake by students during the formulating process it requires guidance from teachers; hence, this research uses guided discovery model. The similar type of learning is guided inquiry where teachers guide students in organizing intellectual skills and thinking skills related to reflective thinking process (Ristanto et al., 2018).

In the guided discovery learning students should be able to re-arrange concept through their search and it will be more optimal using online search. Students could learn independently through online media and teacher's explanation in the blended learning (Banyen et al., 2016). The implementation of blended learning requires information and communication technology to encourage independent learner (Heinze et al., 2007; Ark, Hudson, & Baugh, 2014; Plessis, 2015). Learning could take place periodically outside the face to face meeting hour (Diep et al., 2017). The abstract biology learning process could be actualized using e-learning media via video, flash video, and questions for discussion materials (Tudor, 2013; Ningsih et al., 2019). This research aims to combine blended learning technology and learning model of guided discovery learning with expectation of improving senior high school students' critical thinking skills.

METHODS

Research Design

The research design used was pretest-posttest experiment and control group design (Sugiyono, 2015). The experimental method aimed to learn whether there was an effect of GDBL strategy in improving students' critical thinking skills. The research independent variable was guided discovery-blended learning (GDBL) and the dependent variable was students' critical thinking skills.

Table 1. Constellation of Pretest-posttest Experiment and Control Group Design

Class	Pretest	Treatment	Posttest
E	a_1	X	a_2
C	b_1	-	b_2

Note: E=experimental class (GDBL); C=control class; a_1=pretest of experimental class; a_2=posttest of experimental class; b_1=pretest of control class; b_2=posttest of control class; X=treatment.

Population and Sample

The research population included all students of Grade XI of Mathematics and Science amounted 144 students in a senior high school in East Jakarta, Indonesia. Sampling technique used was simple random sampling and two classes were selected, namely XI Mathematics and Science -2 (36 students) and XI Mathematics and Science -4 (36 students). Number of sample was determined using Yamane's (1967) technique with precision level of 1%. The calculation resulted 71 of the 72 students were taken as the research samples that consisted of 36 students as experimental class with GDBL and 35 students as control class with discovery learning.

Instrument

The research instrument was critical thinking skill test in human excretory system with integrated essay test. The critical thinking indicators referred to Ennis (1995;2011) that consisted of providing simple explanation, establishing basic skills, concluding, providing further explanation, and arranging strategies and techniques. The instrument test carried out using construct and content validity test by lecturer of Animal Physiology expert from Universitas Negeri Jakarta. Validator I and validator II gave an average score of 88.75. It indicated that the instruments were suitable for use. The empirical validation of the instrument items used Pearson Product Moment formula. The calculation indicated that r-calculated was higher than r-table in a minimum range of 0.386 meant that 10 of the 15 questions tested were valid. The reliability test employed to find out the data consistency or the constancy of students' response. Instrument reliability identified using Cronbach's Alpha and minimum score obtained was 0.830. It suggested that the instruments were reliable to measure students' critical thinking skills in human excretory system. Analysis of students' response carried out by matching them with a rubric developed by Zubaidah, Corebima, & Mistianah (2015). The critical thinking grid is summarized in Table 2.

Table 2.
Critical Thinking Grid in Human Excretory System

Basic Competence of 3.9	**Learning Content**	**Question No**	**Critical Thinking**
Analyze the relationship between the tissue structure of the excretory organs and relate it to excretory process so that students could explain mechanism and disorders that likely to occur in the excretory system	Definition of excretion, secretion, and defecation	1, 5	Provide simple explanation
	Structure and functions of excretory organs (kidney, liver, skin, and lungs)	3, 8	Establish basic skills
	Homeostasis mechanism and osmoregulation in kidney and skin.	7, 9	Draw conclusion
	Disorders and abnormalities in the excretory system	10, 11	Provide further explanation
	Excretory system technology	13, 15	Arrange strategies and techniques

The critical thinking skill instruments (Table 2) had passed the content and construct validation. Based on the content validation, the instruments were in accordance with Basic Competence and indicators of competence achievement. As regards construct validation the instruments were suitable, the formulation was clear and brief, the instruction was explicit in questions, and the language was communicative, easy to understand, and not ambiguous. Therefore, the instruments were suitable for use.

Procedures

Students in the experimental class were given a pretest prior to the excretory system learning to measure their initial ability. The learning was carried out in four meetings in February-March 2020. The first meeting was discussion to prepare materials for presentation based on problems set by teachers for each group. The presentation was online before learning activity in the class. Next, presentation to synchronize perception on the materials so that concept arranged was correct and it was with guidance from the teachers. The second meeting was about kidney function and structure and kidney abnormalities. The third meeting related to excretory organs in liver, lungs, skin, homeostasis mechanism, and osmoregulation. The fourth meeting was about abnormalities and technology of excretory system. Students in the control class learned using guided discovery, whereas students in the experimental class learned using source books, teachers, and online media with facilities such as smartphone/laptop, projector, and internet connection with wifi network using Google Classroom mode that has features that can be developed and filled independently by the teachers. The result of syntax implementation is presented in Figure 2 as well as GDBL steps that arrange by adapting the Discovery Learning syntax.

Table 3
GDBL Steps

No.	**Syntax**	**Activities in Excretory System Learning**	**Implementation**
1.	Stimulation	Students pay attention on the explanation and form a group according to the content prepared by teachers online.	Online face to face meeting

		Teachers provide stimulus (flash video), questions to explore.	
2.	Problem statement	Group members collaborate to identify problems on organs, structures, functions, processes, homeostasis mechanism, osmoregulation, abnormalities, and technology of the human excretory system for presentation	Online face to face meeting
3.	Data collection	Group members work to collect data to answer questions. Solve problems by searching for literatures from source books and online media.	Online face to face meeting
4.	Data processing	Activity of processing data by matching the existing theories.	Face to face meeting
5.	Verification	Group members collaborate to determine whether or not the problem solving is correct by matching it each other and then presentation in class. Other groups give response or make questions	Online face to face meeting
6.	Generalization	Teachers review students' incorrect understanding. The discussion results will be uploaded to Google Classroom.	Online face to face meeting

The GDBL implementation steps consisted of step 1: determine a learning model that involves student actively (according to Table 3); step 2: determine a delivery mode that in accordance with blended learning principle; step 3: determine content on real life phenomena to train critical thinking skills; step 4: select media to facilitate students in understanding the content for discussion of information as an independent assignment; step 5: monitor students' independent assignment; step 6: face to face meeting in the class (group presentation); and step 7: evaluation of the learning results. These steps are summarized in Figure 1.

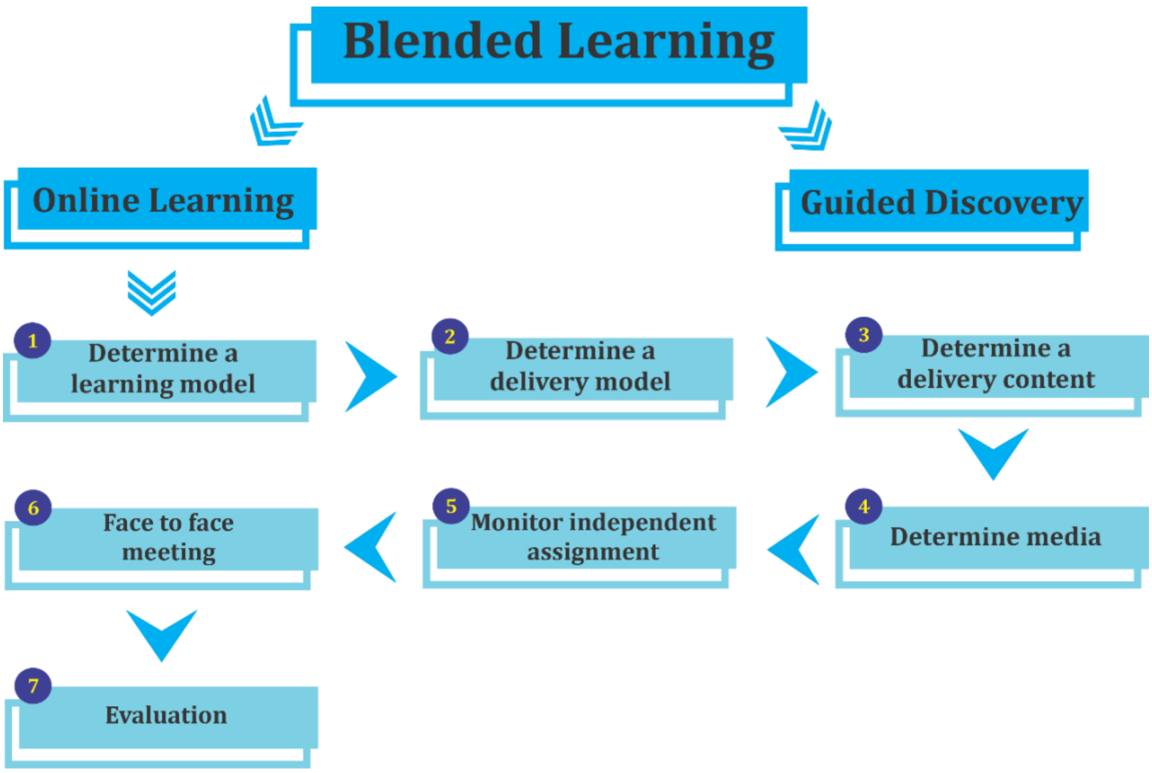

Figure 1. Design of GDBL Activities

Data Analysis

Data obtained were analyzed using descriptive test, analysis pre-requisite test, and hypothesis testing. The descriptive test carried out by calculating average pretest-posttest of each student critical thinking indicator. The normality test conducted using Kolmogorov-Smirnov and the homogeneity test used Levine's Test to find out whether the average pretest-posttest of the critical thinking in the human excretory system in GDBL class and guided discovery class are homogeneous. The correlation test employed Pearson Product-Moment. Based on the analysis pre-requisite test the data were normally distributed. Correlation of pretest scores in the experimental class and control class were significant with the posttest scores. The descriptive test carried out by calculating the average pretest and posttest of each student critical thinking score in the human excretory system. The hypothesis testing aimed to find out whether there is an effect of GDBL strategy implementation on critical thinking skills of the excretory system and it carried out using Ancova test with SPSS version 24.

Table 4

Normality of Critical Thinking Skills Pretest and Posttest.

No.	Class	Sample	Critical Thinking Skills		Significance	Description
			Pretest	Posttest		
1	Experiment	36	0.054	0.077	0.005	Normal
2	Control	35	0.064	0.121	0.005	Normal

Table 4 indicates that p-value of the pretest and posttest was greater than α=0.05; hence, the pretest and posttest data of critical thinking skills were normally distributed in both experimental class and control class. It means that H0 was accepted with interpretation that the pretest and posttest data were normally distributed.

Table 5

Homogeneity of Critical Thinking Skills

No	Indicator	Levene Statistics	df1	df2	Sig
1	Critical Thinking Skills	0.008	1	69	0.573

Based on Table 5, the homogeneity test carried out using Levene's test with α=0.05. The result indicated that db = 1.69 and α= 0. 573 > 0.05 or accepting H0. It can be interpreted that the average pretest and posttest in group that was taught using GDBL model and group with guided discovery learning was homogeneous.

Table 6

Correlation of Pretest and Posttest Scores of Critical Thinking Skills in the Human Excretory System

Class	N	r	Sig.	Description
Experiment	36	0.801	0.000	Significant
Control	35	0.443	0.008	Significant

Significance at α=0.05

Based on experimental class and control class data in Table 6, the pretest score had a significant correlation with the posttest score after treatment. It could be seen from the calculation result that the correlation significance was 0.000 smaller than 0.05 in the experimental class and 0.008 smaller than 0.05 in the control class. The relationship level of the experimental class was in a very strong category since the r value was within the interval of

0.80-1.000, whereas the control class was in a moderate category as the r value was within an interval 0.4-0.59.

RESULTS AND DISCUSSION

Descriptive statistics of the research results that consist of average score, maximum and minimum value of the GDBL class and guided discovery class obtained by the students are presented in Table 7.

Table 7
Descriptive Statistics of Critical Thinking

Data	Average			
	Control		GDBL	
	Pretest	Posttest	Pretest	Posttest
Total	1182.00	2870.00	1294.00	3096.00
Mean	33.77	82.00	35.94	86.00
Min	26.00	74.00	26.00	80.00
Max	40.00	90.00	44.00	92.00
Standard deviation	3.69	4.40	3.69	2.75
Varian	13.59	19,29	13.60	7.54

The calculation implied that the posttest score of critical thinking skills in all indicators increased in both classes, with GDBL strategy implementation and with guided discovery. The difference in the increase from pretest to posttest in each indicator was higher in the GDBL class. It was due to the students in the class who were more capable of exploring their learning experience. Moreover, they prepared materials from source books, searched for literatures from online media, and consulted with the teachers. The finding is in line with (Banyen et al., 2016) that learning with blended learning is more fun thus it increases learning outcome

Table 8
Average Critical Thinking Skills of Human Excretory System per Indicators with the Implementation of Guided Discovery learning and GDBL

Indicator	Control			GDBL		
	N	Pretest (Mean ±SD)	Posttest (Mean ±SD)	N	Pretest (Mean ±SD)	Posttest (Mean ±SD)
Simple Explanation	35	38,00(±7,97)	84,85(±8,53)	36	43,05(±6,68)	90,56(±6,29)
Basic Skills	35	34,00(±7,35)	84,28(±7,39)	36	38,05(±6,24)	90,00(±7,55)
Concluding	35	33,71(±7,70)	83.14(±8,32)	36	36,11(±6,44)	86,94(±7,23)
Further Explanation	35	32,57(±7,00)	80,28(±7,46)	36	33,88(±9,03)	82,77(±9,13)
Strategies & Techniques	35	30,57(±7,64)	77,42(±7,00)	36	28,61(±6,39)	80,00(±4,14)
Average	35	33,77(±2,72)	81,99(±3,10)	35	35,94(±5,31)	86,05(±4,58)

Based on the calculation, the critical thinking skills posttest score in all indicators experienced an increase in both GDBL class and guided discovery class. The posttest score of both groups had a difference of 1.89. In the GDBL class the average difference was 50.11, whereas in the guided discovery class the average difference was 48.22 (Table 8). The difference in the increase from pretest to posttest in each indicator was higher in the experimental class (Figure 2). It was related to the learning in the guided discovery class that only employed source books and teachers instead of utilizing online media as the learning source. During discussion and presentation, students' questions and answers did not indicate their critical thinking skills. In the GDBL class, on the contrary, students were more motivated to deliver the content and had self-confidence in asking and answering questions; therefore, the GDBL is applicable in senior high school to motivate students' critical thinking. It supports a research by Permana & Chamisijatin (2019) that project-based learning using Edmodo improve critical thinking and histology concept. The difference in the average achievement of the critical thinking indicators in the GDBL class and guided discovery class was converted as indicated in Figure 2.

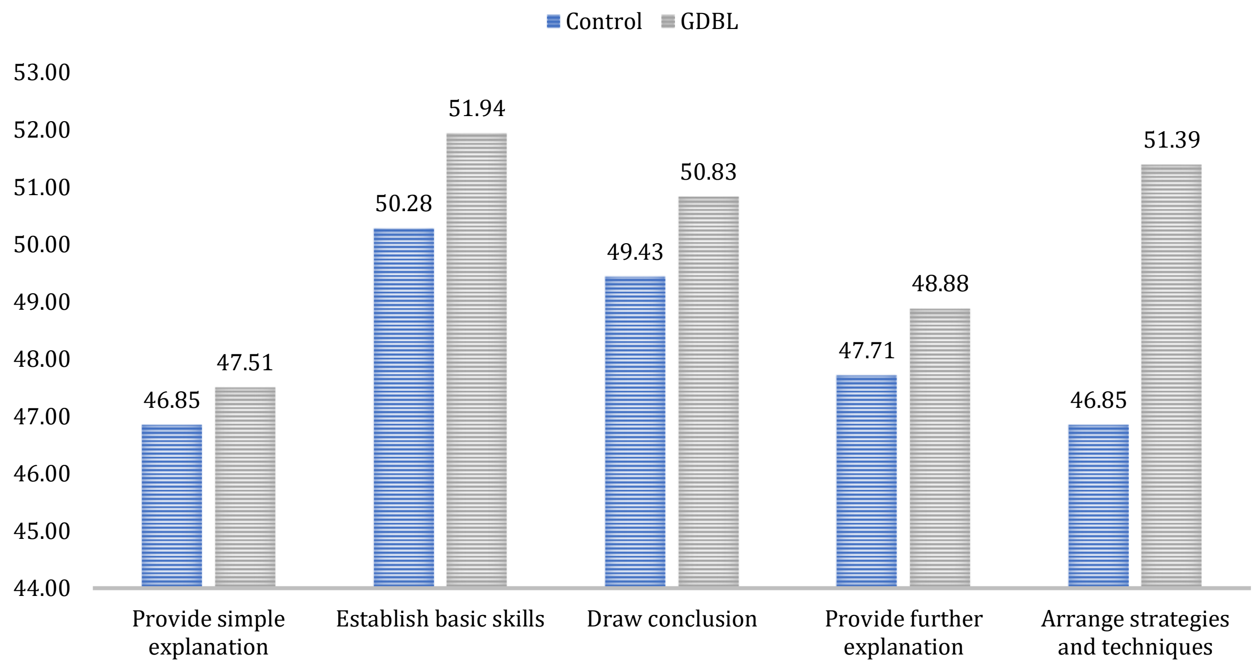

Figure 2. Differences in the increase in critical thinking skill pretest and posttest for each indicator.

Table 8 and Figure 2 suggested that the achievement of indicator of establish students' basic skill with GDBL implementation was excellent and it requires habituation in elaborating a content or problem in detail so that all critical thinking indicators experience a more optimal increase and critical thinking become a life skill. Developing critical thinking potential should be conducted intensively in learning activities. Intensive activities will familiarize students with critical thinking skills and it is similar to (Anders et al., 2019).

Table 9
Percentage of students' response to GDBL learning

No.	Response	%			
		SA	A	DS	SD
1.	Prepare students to learn.	44.45	48.50	6.50	0.00
2.	Develop learning in a new learning situation.	44.70	50.00	3.60	2.80
3.	Encourage students to think and work on their initiative.	46.35	52,75	2.80	0.00
4.	Develop critical thinking skills.	52.75	46,75	0.00	0.00
5.	Facilitate the understanding of the human excretory system.	58.30	34.70	4.70	2.80
6.	Conduct classroom and online learning.	51.40	45.80	2.80	0.00
	Total	297.98	278.50	20.40	5.60
	Average	49.66	46.41	3.40	0.93

Note: SA (Strongly Agree); A (Agree); DS (Disagree); SD (Strongly Disagree).

Table 9 indicates that students' response to the human excretory system content with the GDBL implementation was, in overall, signified an agreement on the increase of learning with GDBL strategy. The students developed capabilities to solve problems by exploring the content through discussion and make a conclusion in their own language through reading and looking for literature on the internet independently and with guidance from the teacher. It, in turn, has impact on the increase in critical thinking. It is supported by students' response of 99.5%. Agreement by students of the learning implementation in the conventional class combined with online learning was 97.2%. It indicated that the students were pleased with the implementation of the combined learning with guidance and direction from the teacher.

Observation of Syntax Implementation

Based on the observation result of syntax implementation, Table 10 describes the average percentage of syntax implementation achieved in the learning activity.

Table 10.

GDBL Syntax Implementation

No.	Syntax	Percentage of Meeting (%)			
		Group Discussion	Structure and Abnormalities of kidney	Liver, Lungs Skin and Homeostasis	Abnormalities & Technology of Excretion
1.	Stimulation	90.74	95.86	97.22	100.00
2.	Problem Statement	87.50	91.67	92.67	100.00
3.	Data Collection	84.72	87.50	91.67	97.22
4.	Data Processing	83.33	84.72	91.67	100.00
5.	Verification	87.50	90.28	91.67	95.83
6.	Generalization	84.72	90.28	95.83	100.00

Based on the data obtained, the GDBL syntax implementation indicated an increase in each meeting. In the first meeting, the average was 86.46% and it increased to 98.84% in the fourth meeting. It was related to the students who already familiar with the GDBL syntax.

Table 11

Result of Critical Thinking Skills Test with ANCOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	581.136[a]	2	290.568	31.725	.000
Intercept	3165.396	1	3165.396	345.607	.000
Method	125.623	1	125.623	13.716	.000
PreTest_BK	297.192	1	297.192	32.448	.000
Error	622.808	68	9.159		
Total	502516.000	71			
Corrected Total	1203.944	70			

The hypothesis testing employed ANCOVA with $\alpha=0.05$. Table 11 implies that the calculation of learning model variable generated p value=0.000 < $\alpha=0.05$ thus rejecting HO. Hence, without pretest score in the confidence level of 95% there was an effect of the GDBL model and guided discovery learning model on the posttest score of students' critical thinking skills.

The descriptive analysis and hypothesis testing results proved that GDBL had a significant effect on students' critical thinking skills in the human excretory system. Students who were taught using GDBL strategy had higher critical thinking skills than students who were taught using guided discovery learning. The students had achieved critical thinking indicators that consisted of providing simple explanation, establishing basic skills, concluding, providing further explanation, and arranging strategies and techniques on differences, structures & function, homeostasis mechanism and osmoregulation, and abnormalities and technologies related to the human excretory system.

The students were also more critical in responding problems of abnormalities and technologies in the excretory system in the steps of providing further explanation and arranging strategies and techniques. They could give argumentation and state a decision on skin and kidney transplantation, draw conclusion on the cause of excretory system disease-related pandemic (hepatitis) occurred in the communities. It is similar to previous research (Nuroifah, 2014; Rindah, 2019) that students were expected to solve daily life problems and cases, especially in diseases and disorders in kidney, liver, lungs, and skin.

The achievement could be identified from the indicator value of providing further explanation and arranging strategies and techniques that exceeded the minimum completeness criteria. It was supported by data from students' response to learning and agreement score in indicator of establishing critical thinking skill that reached 52.75% for strongly agree category and 46.75% for agree category. Therefore, 99.50% students stated that the GDBL was able to increase critical thinking skill. It is in accordance with a research by Permana & Chamisijati (2019) that the project-based learning and blended learning developed students' critical thinking skills and histology concept. Another research by Nair, Bindu, (2016) suggested that blended learning strategy was effective to improve achievement in biology, social and environmental attitudes of senior high school students.

The achievement of GDBL effect was higher than the guided discovery learning as GDBL syntax reinforces the human excretory system content more. The first step in the GDBL syntax was stimulation. In this step, the teacher provided stimulus of flash video on the human excretory system. It is consistent with Tudor (2013) and Ningsih, Miarsyah, & Rusdi (2019) that the utilization of media, images, concept map, and videos could actualize content, assist stimulation, and facilitate students' understanding in learning. Students' positive response to be ready to learn was 92.95% that consisted of 44.45% students were strongly agreed and 48.50% were agreed.

The second and third step required students to identify problems through group discussion, whereas teacher compiled materials by means of questions and images so that students were active in solving problems based on the student worksheet. In the data collection step, students collaborate in group to solve the problems. Teachers play a role as a mentor in the learning process and verify students' wrong concept. Students in the GDBL class searched in source books as well as online media and consulted with the teachers. Moreover, they had more flexible time. According to Musyaddad, et al (2019), knowledge will last longer with internet exploration.

Processing discussion result data was the next step. Students exchanged opinion in group, analyzed problems, expressed ideas and solution, and synchronized perception to make a decision, and solved problems based on evidences and their learning experiences. Critical thinking development occurred in this step. It is similar to Dwyer et al. (2014); Ristanto et al. (2018); Harahap et al. (2020) opined that ideas emerge in the discussion to look for a correct answer. Students' response to GDBL that the GDBL encourage students to think and work hard on their initiative of 99.10% led to an expectation of the increase in students' critical thinking skills as indicated by the above minimum completeness criteria average score of 86.00. Students, in this step, were trained to develop their critical thinking skills by exchanging opinion and expressing arguments and solution to arrive at the correct answer, which is in line with Ennis (1993; 2011). Students must be trained intensively in learning activities to be accustomed to critical thinking that is similar to (Anders et al., 2019)

The last stage in the GDBL was drawing conclusion. Teachers discussed incorrect content related to daily life on the human excretory system by involving the students. It is also in line with a study by Rindah, Dwiastuti, Rinanto (2019) that human excretory system can be utilized to train students' problem solving skill level as it is related to daily life. The GDBL is suitable for critical thinking development since it provides more time both inside and outside the classroom. Students will be required to think critically during discussion and they were obliged to express opinion to synchronize perception on the discussed subject. In accordance with (Ark, Hudson, & Baugh, 2014; Banyen, 2016), blended learning can be an incentive for independent and authentic learning since students could learn and complete the material on schedule outside the face-to-face meeting.

The current research is an update of the previous research in terms of combination of GDBL in the excretory system. In the guided discovery, students are stimulated with daily life problems as a discussion subject. In the blended learning, students prepare the materials first by online searching, consulting with the teachers, and exchanging idea with friends. Moreover, they are not only learning in the classroom and they have flexible time. They are encouraged to understand the content before classroom learning. The students are satisfied with the blended learning as it trains them to explore their abilities and motivate them to draw conclusion of the content and further explain the content that has impact on their critical thinking skill improvement. The GDBL implementation must consider sufficient time allocation, wifi network, and student readiness to be active in preparing materials by reading from source books and online media.

CONCLUSION

Build upon the research and data analysis results, it can be inferred that there was an effect of GDBL strategy on students' critical thinking skills. The integration of online and conventional learning based on inventory-based learning and collaborative activities can be used as a prospective effort for implementation in Biology learning in the classroom. It could motivate students in exploring their potential because students have prepared the materials prior to the classroom learning.

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