Using Electronic Learning Cycle (e-LC) to Improve Students' Higher-Order Thinking Skills (HOTS)

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Abstract-The 21st-century learning requires mastery of Higher Order Thinking Skills (HOTS) and digital competence. Field facts show that students' HOTS is low, and their utilization of technology in learning is quite limited. Thus a learning model that integrates technology to improve HOTS is needed. This research aims at comparing the influence of the application of the Electronic Learning Cycle (e-LC) learning model with the conventional learning model on the improvement of students' HOTS. This quasi-experiment research employs a nonequivalent pretest-posttest control group design. The population is the students of Biology Education Study Program, Sebelas Maret University, Indonesia of the academic year 2019/2020. The research's samples are 55 students taken using a simple random sampling technique. The research's instrument is 24 items of HOTS test. The test consists of multiple-choice with four alternative answers. The test instruments are valid and reliable, and the data are analyzed using the t-test. The research results show that the e-LC learning model application has significantly different influence on the improvement of students' HOTS from the conventional model application. Therefore, this research concludes that the use of the e-LC learning model significantly influences HOTS improvement. The e-LC learning model improves students' HOTS better than the conventional learning model.

Keywords – electronic learning, 21st-century learning, higher-order thinking skills, transfer of knowledge, learning management system, general biology course

I. Introduction

Higher education graduates in the 21st-century are expected to master some general skills such as critical, systematic, logical, and innovative thinking. Such skills are part of the 21st-century skills and have characteristics such as working independently and in the group, creative and innovative, critically choosing and sorting information, and having the necessary knowledge to be applied throughout the life (life-long learner)[1]. Therefore, education of any type and level should encourage students to master 21st-century skills. In learning, students should be engaged in the higher-order thinking process. Thus lecturers should create active learning and help the student understand scientific matters [3]. Higher-order thinking involves various thinking processes to be applied in complicated situations with many variables [4]. HOTS based assessments may improve students' HOTS [5]. Also, HOTS oriented statements may encourage students to think about lessons thoroughly [6].

Higher-order thinking skills are part of the 21st-century skills with many definitions [7], [8]. The higher-order thinking skills which may be included in the development of higher education curriculum as a transfer of knowledge include cognition, analysis, evaluation, and creation domains of Bloom's taxonomy revised by Anderson [9], [10]. Teaching skills cannot be separated from learning models, methods, and strategies. The utilization of different learning strategies may show distinct correlations between students' attitudes towards the skills learned and their cognitive learning result itself [11].

The 21st-century skills include digital competence, which is often referred to as digital literacy, as an impact of industrial revolution 4.0 [12], [13]. This digital literacy is closely related to the instrument or method in technology utilization [14]. The 21st-century skills may be developed with the assistance of varied technologies, in which some become hits such as the Internet of Things (IoT) and Artificial Intelligence (AI).

The Government of Indonesia quickly responds by arranging regulation related to the 21st-century skills through the Ministry of Education and Culture (Kemendikbud) and the Ministry of Research, Technology, and Higher Education (Kemenristekdikti). Kemendikbud has released the National Higher Education Standards (SNPT) requiring a bachelor to have higher-order thinking skills. In line with this, Kemenristekdikti also arranges regulation on the implementation of learning using technology assistance such as distance education (PJJ) or distance learning. This regulation is expected to help related parties, particularly educators, in preparing the next generation to compete globally using 21st-century skills.

II. Literature Review

2.1 HOTS learning using technology

The rapidly developing technology will lead to a change to the education process and curriculum, particularly in the utilization of technology as media and source of knowledge. Education objectives and curriculum should be adjusted to the development of science and technology and information system; thus students will readily face any challenges [14]–[16].

The 21st-century skills, particularly HOTS, may be developed with the assistance of technology (Kong et al., 2014; Lee, Lim, & Kim, 2017; Songkram, 2015), such as the Internet of Things and Artificial Intelligence. Consequently, HOTS based course is not necessarily conducted face to face in class (offline) like traditional learning but may be replaced with online learning. Therefore, lecturers, as an educator, are expectedly able to improve innovation and creativity in the learning process to achieve learning objectives and thus motivate students for better learning outcome [19], [20].

Internet technology may be utilized in daily life to teach higher-order thinking skills. Besides getting used to using technology with their gadgets, students will also be motivated to and like to use a smartphone in learning; thus the materials may be repeated and memorized for an extended period [21], [22].

Referring to the preliminary study in the Biology Education Study Program, Sebelas Maret University, Indonesia, there is information that general biology course in the study program often use speech method and occasionally classical discussion; the thinking skills taught are classified into low order thinking; all students have smartphone and social media account, but not used in learning at all. To conclude, the learning is only focused on educators, and the students are passively engaged in learning. This fact, besides not in line with what the Government expects, also causes the learning process to be less significant and unable to improve students' higher-order thinking skills since the learning only uses one approach [23]. Meaningful learning oriented to higher-order thinking skills may be conducted by giving collaborated assignment, stimulation and group work [24], and motivation and attitude approach may also support significant learning implementation [25].

Some problems above prove the importance of providing significant learning to support the improvement of the 21st-century skills, particularly higher-order thinking skills, which may be taught through various learning models and methods such as laboratory practicum [26]; flipped classroom (Lee et al., 2017); e-learning [16], [18]; collaborative discussion (Lee & Martin, 2017); blended learning [29]; and mobile learning [30].

Higher-order thinking skills in this research is of the highest cognitive domain of taxonomy of Anderson & Krathwohl (2001) covering the analyzing (C4), evaluating (C5), and creating (C6) abilities. Such abilities are classified into HOTS [7], [8]. Students' HOTS abilities are arranged based on the aspects and indicators presented in Table 1 below.

Table 1. Outline of Higher-Order Thinking Skills

No	Expected final ability	Indicator
1	Students can analyze the basic concept of biology as science which studies life	Describe biology as science which studies life conceptually
		Categorize biology as science which studies life conceptually
		Assess the natural characteristics of life conceptually
		Criticize main themes in biology conceptually
		Design a concept map of hypothetical science process metacognitively
		Make a concept map of the relationship between main themes in biology conceptually
2	Students can analyze the basic concept of cell as a system and its role in the advancement of biology	Describe cell components conceptually
		Categorize cell anatomy conceptually
		Assess genetic control process conceptually
		Criticize genetic control process conceptually
		Design a concept map of protein production conceptually
		Make a concept map of the relationship of cell organelles in endomembrane system conceptually

2.2 Electronic learning cycle (e-LC) as a 21st-century learning model

Based on the problem identification, a learning model which may integrate technology into learning and teach HOTS is needed, which exists with the electronic learning cycle (e-LC) learning model. This learning model integrates Learning Management System (LMS) technologies to collaborate various learning activities, not only collaborative discussion, assignment, and group work, but also assessment and evaluation. The e-LC learning model is oriented to TLC (Technology Learning Cycle) phases analyzed with TPACK (Technology, Pedagogical, Content, Knowledge) model framework [32] and may be applied through blended learning. The e-LC learning model phases include awareness, content, learning, application, sharing, and reflection, as presented in Figure 1 below.

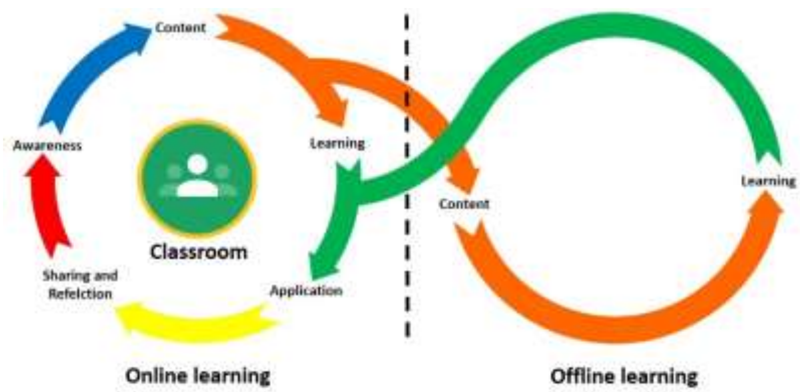

Figure 1. e-LC learning model phases

The e-LC learning model is relevant to the collaborative learning theory approach by Kenneth Bruffee [33]. The concept of collaborative learning is a learning process that integrates various knowledge characteristics into a new knowledge group character [34], [35]. The collaborative learning theory is chosen since the e-LC learning model involves students' active participation and ignores differences in students' cognitive level. Also, the e-LC learning model has to learn online through Learning Management System Classroom, collaborated with traditional classroom face-to-face learning.

Each phase in the e-LC learning model cycle has specific HOTS-oriented activity. Besides, each step in this learning model directly integrates technology into learning. For more detail, see Table 2 below.

Table 2. e-LC learning model's activities to improve students' HOTS

Phase	Learning activities
Phase 1 Awareness	- Lecturer and student's login Classroom application. Lecturer logins as teacher and students log in as a student.

	- Students watch video/movie/animation. - Students discuss the video with the group. - Students formulate problems and hypotheses based on the video. - Students design a technology concept map to be used to answer the problems they have formulated.
Phase 2 Content	- Lecturer and students access e-module uploaded to the Classroom through smartphone/laptop/PC. - Students review the e-module under the topic of discussion. - Students observe the outcome of the practicum.
Phase 3 Learning	- Students discuss problem-solving under the e-module and practicum outcome (if any). Discussion may be performed online and offline using the Classroom. - Students analyze the results of module review in correlation with the problem solving and practicum outcome (if any).
Phase 4 Application	- Students collect information from the internet related to the results of the evaluation of the discussion. - Students process information under the discussion results. - Students discuss and correlate information from the internet with the discussion results. - Students arrange report of discussion results (draft). - Students collect reports on the discussion results. Reports on discussion results and practicum reports are received through the Classroom.
Phase 5 Sharing and Reflection	- Students hold presentations and question and answer sessions on the discussion results. - Students assess and communicate with other group's presentations. - Students evaluate answers on discussion results. - Students formulate important notes or matters. - Students conclude the discussion results. - Students arrange a summary to be collected in the Classroom. - Students perform self-evaluation in learning.

The research conducted by Schlager (2016) proves that using LMS may facilitate any learning characters desired by students, teachers, parents, and technology experts. Song (2014), in his research using the *Edmodo* type of LMS, can implement a cooperative learning model. LMS facilitates the collaboration of both small groups and big groups [37], [38]. The results of research conducted by Zydney & Warner (2016) show that learning online generally only measures low-level cognitive ability and conceptual understanding. However, some also measure higher-order thinking skills, such as problem-solving, critical thinking, and creative thinking [6], [40], [41].

The e-LC learning model application may expectedly enhance students' higher-order thinking skills. Also, integration using the latest technology in the e-LC learning model application may expectedly provide new knowledge to the education world, particularly educators (lecturers), so that they will not only be oriented to conventional learning strategies, models and methods in empowering higher-order thinking skills, but also to using technology in learning. Educators' habits should be changed and directed to a higher level of the cognitive process with the assistance of technology to encourage and improve students' thinking skills.

Based on the background and description above, the research's problems are:

(1) Is there a significant difference between before and after treatment with the e-LC learning model in HOTS improvement?

(2) Is there a significant difference between the e-LC learning model and the conventional model in HOTS improvement?

III. METHOD

3.1 Research Design

This quasi-experimental research employs a nonequivalent pretest-posttest control group design. The research's population is the students of Biology Education Study Program, FKIP, Sebelas Maret University of the academic year 2019/2020. The samples consist of 55 students, which are taken with a simple random sampling technique and divided into two classes. One class is the experimental class (EC), which applies the e-LC learning model, and the other type is the conventional class (CC), which is the control group with design, as presented in Table 3 below.

Table 3. Nonequivalent Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
EC	T_1	X_1	T_2
CC	T_1	X_0	T_2

Information:
T_1 : Pretest
T_2 : Posttest
X_1 : The e-LC learning model
X_0 : Conventional model (Direct Instruction).

This research is conducted in two months with the subject of general biology in biology education from September to October 2019. The e-LC learning model is implemented based on learning phases and activities. The class is held once a week for 100 minutes each.

3.2 Data Collection and Analysis

The data are collected from the (pretest and posttest) cognitive test score of higher-order thinking skills. The multiple-choice test uses 24 test items with four alternative answers. The test instrument is valid and reliable. The validity is analyzed using construct validity, and each item's score will be declared valid if the t value is higher than 1.96 [42]. The construct validity result shows that the t value of each item is higher than 1.96, indicating that each test item has significant validity. Cronbach's alpha analysis method is employed to analyze the reliability value, in which the generally acceptable standard minimum reliability value is .65 [43]. The coefficient resulted from Cronbach's alpha test is .78, indicating that the reliability value is high.

The data are analyzed using a t-test analysis to determine the significant difference in the mean score of e-LC learning implemented. A prerequisite test is conducted to determine the normality and homogeneity of data variance. The data analysis is performed using SPSS.

IV. Result And Discussion

4.1 Result

The result of the test on students' higher-order thinking ability shows that the pretest scores of CC and EC are almost equal. The CC class's pretest means the score is 51.24, and the posttest means the score is 55.66, while the EC class's pretest means the score is 51.23, and the posttest mean score is 69.54, as presented in Table 4.

Table 4. The Pretest and Posttest Scores of Students' HOTS

Class	N	Pretest		Posttest	
		Mean	Std. Error	Mean	Std. Error
EC	26	51.23	1.640	69.54	1.563
CC	29	51.24	1.926	55.66	2.097

Based on the Kolmogorov-Smirnov normality test, both classes' pretest and posttest scores are significant, with $p > .05$; thus, the scores of all tests are normally distributed as presented in Table 5 below.

Table 5. Normality Test Result

Tests of Normality				
	Model	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Test	EC Pretest	.099	26	.200*
	EC Posttest	.158	26	.094
	CC Pretest	.113	29	.200*
	CC Posttest	.136	29	.183*

Besides the normality test, a homogeneity test is also conducted to the two classes for both pretest and posttest scores. The homogeneity test scores in Table 6 show that the significance of the pretest is .371 and of the posttest is .120.

Table 6. Homogeneity Test Result

Test of Homogeneity of Variance				
	Levene Statistic	df1	df2	Sig.
Pretest	.813	1	53	.371
Posttest	2.503	1	53	.120

Both pretest and posttest have significance value > .05, indicating that both classes' pretest and posttest scores have the same or homogenous variance. Since the normality test and homogeneity test are met, a t-test may be employed to test both groups' mean scores. The t-test result in Table 7 shows that there is a difference in the mean between before and after the application of the e-LC learning model.

Table 7. Result of pretest and posttest mean score

Paired Sample Test							
		Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	EC Pretest - EC Posttest	-18.308	12.425	-7.513	-7.513	25	.000

The t-test result shows that the significance value is .000 (p< .05), indicating that there is a very significant mean difference between before and after the application of the e-LC learning model. In conclusion, the e-LC learning model influences the improvement of students' HOTS.

This research's main objective is to compare the effectiveness of the e-LC learning model and the conventional learning model in improving students' HOTS. To examine this, both learning models are tested for mean value. Table 8 below shows the result of the mean test for the EC posttest and CC posttest.

Table 8 Result of a mean test of EC posttest and CC posttest

Independent Sample Test			
	t	df	Sig. (2-tailed)
HOTS	5.210	53	.000

Based on Table 8, the significance value is .000 (p < .05), indicating a very significant difference in EC posttest mean, and CC posttest mean. We may conclude that the e-LC learning model is better than the conventional model in improving students' HOTS. For more detail, observe the bar chart of the percentage of achievability of each indicator of ability to analyze (C4), evaluate (C5), and create (C6) in Figure 2 below.

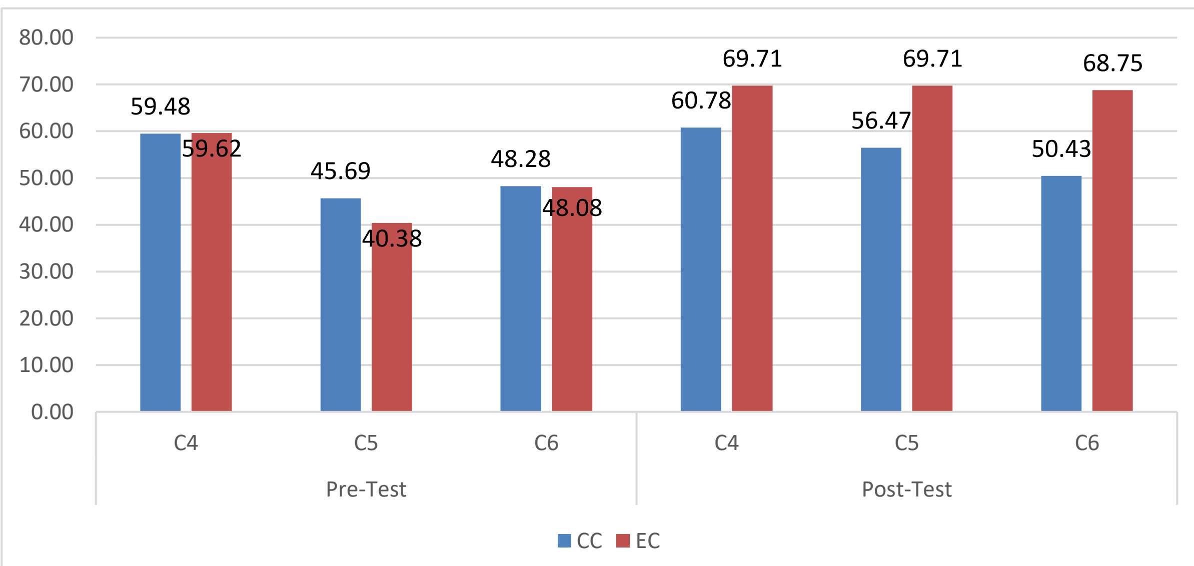

Figure 2. Bar chart of the percentage of achievability of students' HOTS indicators

4.2 Discussion

Based on the research results, the application of the e-LC model significantly influences the improvement of students' HOTS. The explanation of the difference in the results between EC (the e-LC learning model application) and CC (Direct Instruction learning model) is that the e-LC learning model application may be easily accessed everywhere and any time by educators and students, thus it may be applied through blended learning. The reason is that the e-LC learning model's philosophy is electronic learning [21], [39], [44]–[49]. Information provided in the e-LC learning model application may be accessed accurately, since it is directly given by the primary source, which may be accessed or cross-checked online [21], [44], [50], [51].

The e-LC learning model is able to improve independent learning and problem-solving abilities since the stimulus developed in the awareness phase forces students to find their problem-solving method [21], [50], [52], [53]. In addition, the e-LC learning model is able to improve students' learning motivation since the learning process uses smartphone from the beginning to the end of learning [54]–[59]. Through the e-LC learning model, students' confidence in using e-learning supporting program or application improves since the application is used continuously throughout learning, thus they will use the app without any difficulty (Abdelaziz et al., 2011; Chapman-Waterhouse, Silva-Fletcher, & Whittlestone, 2017; Chiang, Yang, & Hwang, 2014; Magen-Nagar & Shonfeld, 2017).

Students may memorize materials in the e-LC learning model for a long time since they may be accessed through smartphones [21], [22]. The e-LC learning model may be implemented on a big scale and monitor all assessment processes authentically (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; García-Marco, 2017; O'Flaherty & Phillips, 2015). The e-LC learning model allows improvement of academic interaction between students and between students and educator that it starts with offline classroom discussion and is followed with online discussion [21], [44], [49], [52], [64]–[66].

The e-LC learning model may improve a good collaboration between students and between educators and thus allow research [44], [66]–[69]. The e-LC learning model facilitates the renewal of learning material contents that they may be directly renewed through smartphone [44], [50], [51], [61], [70]. According to Squillante, Wise, & Hartey (2014), LMS's communication feature is an essential point as the advantage of using Classroom as LMS. Discussion may be performed in small and big groups in the Classroom communication forum. Classroom communication forum also allows communication between educators and students, students and educators, and educators and educators. Students may discuss learning materials, assignments, and exam materials.

The e-LC learning model is designed and developed to be applied to blended learning. Increasing smartphone usages by educators and students may be utilized in learning activities. Educators and students may negotiate the timing of learning online and learning offline. Educators should have had a syllabus and lesson plan as a guide to learning implementation, but for flexibility of technology usage and laboratory results that need discussion, it is possible to change learning activities as necessary.

The e-LC learning model may provide assistance activity for reflection of learning implemented in the sharing and reflection phase as the final phase of the e-LC learning model. This reflection becomes a critical point for correction in the next meeting. Some of the essential points are, among others, related to learning activity implemented, learning materials discussed in teaching and learning activity, method or process of assessing students in various learning activities, and the Classroom application program itself, whether it has effectively achieved the expected objective. Self-reflection implementation is divided into three in time, which are after learning, after mid-term semester exam, and final semester exam. Therefore, lecturers' competence improvement should be implemented in the form of an organized e-LC learning model in teaching practice. Lecturers play a strategic and determining role in the success of education derived from their academic competence.

V. Conclusion

Based on the research results, this research concludes that the application of the electronic Learning Cycle (e-LC) learning model significantly influences the improvement of higher-order thinking skills. The e-LC learning model is effective in improving higher-order thinking skills. Thus, e-LC learning model implementation is a good strategy as an effort to enhance students' HOTS. It is essential to teach the e-LC learning model to students to prepare and provide them to apply to learn well. Based on the research, we suggest that systematic efforts to improve students' HOTS, design learning activities, evaluate and promote learning through the e-LC learning model's phases are needed. Also, the e-LC learning model may become a reference for other educational institutions to improve students' HOTS.

The results of this research imply that it is necessary to apply the e-LC learning model integrated with biology courses as collaborative learning. Such effort influences how students represent, receive, negotiate, and interpret information virtually, which will later affect the students' assessment and evaluation processes. Collaborative learning allows the creation of a new scenario in learning where students collaborate at a distance in planning and completing a joint assignment with other students. Educator, in this case, serves only as a guide and partner in learning, instead of giving a speech in the classroom. Students learn that technology-supported collaborative learning class prioritizes the generation of learning products, such as learning how to analyze information from different sources.

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