JPII 11(2) (2022) 322-332

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

LEARNING BIOLOGY USING REAL OBJECT, ICT, AND BLENDED LEARNING TO IMPROVE FACTUAL AND CONCEPTUAL KNOWLEDGE

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DOI: 10.15294/jpii.v11i2.33706

Accepted: December 6th 2021. Approved: June 27th 2022. Published: June 30th 2022

ABSTRACT

During the pandemic of COVID-19, online learning was introduced, and the students' achievement decreased. This research aimed to find the effect of the biology learning model by using real objects (RO), ICT, and Blended Learning (BL) on students' factual and conceptual knowledge. The research design was a quasi-experiment with a pretest and posttest comparison group design. This research was done in two senior high schools. Cluster random sampling was used to choose three groups of RO, ICT, and BL, involving two biology teachers and 139 students. The instrument was mainly tests of factual and conceptual knowledge. The test items were validated by expert judgment and an empirical test. Multivariate analysis was applied to test the difference in the effect of the three learning models. The results indicate that (1) RO gives the highest students' achievement in factual knowledge, (2) ICT increases students' conceptual knowledge, and (3) BL improves both factual and conceptual knowledge. Therefore, it is concluded that learning biology should use RO and ICT through BL to improve factual and conceptual knowledge.

Keywords: blended learning; conceptual knowledge; factual knowledge; learning biology

INTRODUCTION

During the pandemic of COVID-19, online learning is the primary model of instruction in schools. Many studies claim that the results are unsatisfactory, such as dull, decreasing achievement, and indiscipline (Annisah & Masfiah, 2021; Magdalena et al., 2021). There is a tension concerning the effectiveness of learning biology, whether using real objects (RO) or online with information and communication technology (ICT). On one side, the advancement of the development of ICT has changed the education paradigm, the way to learn, and the way to teach (Odell et al., 2020). Online education is a relatively new phenomenon that started in the late 1990s because of state and federal mandates to introduce more online and blended learning in the US (Keaton & Gilbert, 2020). A systematic literature review from 1996 to July 2008 identified more than a thousand empirical online learning studies (Hauser et al., 2012). The meta-analysis found that, on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction. This finding gives empirical support to online learning using ICT. Teachers and students who are not accustomed to using ICT might have problems with learning (Johnson, 2011; Hauser et al., 2012). Moreover, students of the Z generation learn well using ICT, such as from e-books, rather than from books (Doering et al., 2012), self-paced, self-directed,

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and independently with high freedom of what and how they learn (Thomas, 2018). Thus, ICT is an essential tool required for learning biology today.

On the other side, biology learning is a study of living things, where students learn from real objects (RO) of biology (Watagodakumbura, 2013; Adedoyin & Bello, 2017). The objects of biology are plants, animals, fungi, protists, and bacteria with different shapes, sizes, colors, structures, smells, and behaviors. Students use their five senses to learn from objects by touching, smelling, tasting, or seeing. Students gain factual knowledge from the RO. Learning from the first experiences is called authentic learning, which leads to both empirically observing and manipulating the objects to gain many benefits such as fostering factual knowledge, knowledge of detail, and the characteristics of the object (Chamany et al., 2008), developing students' interest in science, skills in career preparation, and basic research skills (David & Venuste, 2021), interpersonal skills, including teamwork and communication (Alimah et al., 2016). Sudjana and Rivai (2017) say that using real objects facilitates students to make observations and do hands-on activities to get data from the objects. The data will enable the students to activate their minds on activities or to think about them. Students learn the characteristics of the objects, notify the differences and the similarities of the characteristics, and understand the objects' properties. Students may develop a conceptual understanding of the objects to make sense of the living world.

According to Chamany et al. (2008), biology is considered the front page of news that empowers students to connect what they learn in the classroom and what they see in everyday life. Historically, men have used biology in their daily life for a long time. Egyptians have been practicing mummification using Natron composed of sodium carbonate and sodium bicarbonate to preserve the dead body for thousand years BC. Ancient people started domesticating animals and farming a long time ago. They also found wheat, grained it, and used it for making food. They also used the skin and fur of the animal to make cloth. Those mean that people use real objects of biology in their daily life.

According to Fisher et al. (2001), learning biology from real objects occurs through four paths and three activities to get a conceptual understanding of biology, as it is depicted as follows (Figure 1).

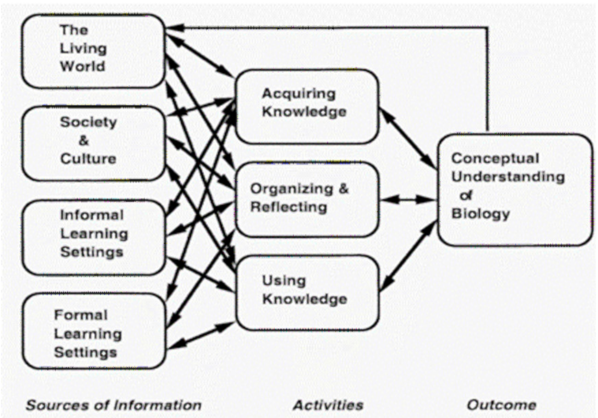

Figure 1. The Nature of Learning Biology by Fisher et al. (2001)

Figure 1 shows that learning biology has four sources: the living world, society and culture, and informal and formal settings. The living world is the first source where students can learn from real objects (RO). Learning biology using real objects has been applied for many years (Adedoyin & Bello, 2017; Gülen, 2018; Adi et al., 2021). Some biology topics, such as plant and animal diversity, provide real objects. Real objects provide students with real experience and authentic learning to observe the characteristics of the biological objects and the behaviors of the objects. Factual knowledge is knowledge about facts or properties of things, according to Bloom's Taxonomy of learning (Wilson, 2016; Widiana et al., 2020). Factual knowledge consists of essential facts, terminology, details, or elements. It is the essential element that the students must know to be acquainted with biology and to think about it deeper.

In contrast, conceptual knowledge comprises knowledge of classifications, principles, generalizations, theories, models, or structures pertinent to a particular disciplinary area (Wilson, 2016). The biological concepts do not exist in the field. Students must construct the concept in their minds. Conceptual understanding requires an introduction to subject vernacular along with common sense translations of terminology. Some biological topics require conceptual understanding. Such a topic as ecosystem requires students to observe the components of an ecosystem and construct conceptual knowledge such as the function and the relation among the components of an ecosystem, food chain, food web, energy conversion, and material cycle. Therefore, the two topics of plant diversity and ecosystem are considered appropriate to show factual and conceptual knowledge. Finally, the conceptual understanding will develop biologically literate people (American Association for the Advancement of Science, 2019, 2020).

Learning biology can occur through face-to-face learning, online learning, or both. In face-to-face learning, students and teachers are present in the classroom. This learning model has been used for decades in Indonesia. Online learning uses ICT to bridge student and teacher interaction. This model has become popular because of the pandemic of COVID-19 (Alea et al., 2020; Daniel, 2020; Putri et al., 2020; Adi et al., 2021; Chaturvedi et al., 2021). Online learning enables learners to learn from the teacher and many resources available on the websites (Means et al., 2009; Putri et al., 2020; Rana & Rana, 2020). The combination between face-to-face and online learning is called blended learning or hybrid learning (Fadde & Vu, 2014; Dangwal, 2017; Lalima & Dangwal, 2017; Cronje, 2020). Blended learning is assumed to have the best effect on students' understanding because students can acquire knowledge from the living world and then learn deeper by using ICT. This research is designed to determine the effectiveness of biology learning by using real objects, online, and blended learning.

The use of BL is increasing very fast currently (Snow & Dibner, 2017; Dangwal, 2017). There are several reasons for that. First, computers and communication technology are getting better, cheaper, and easier to use. Second, internet access is almost available everywhere. Internet users in Indonesia reached 172 million people. As many as 98.040.000 million users (50,7%) access the internet using computers and smartphones; 81.872.000 just using smartphones, and 29.240.000 just using computers. Third, the number of websites concerning biology is vulnerable. According to live statistics, the world wide web is about 1.205.874.957. Some of 1,220,000,000 using the world biology; living things is 1,510,000,000 sites, organism is 1,190,000,000 sites.

The increasing number of learning biology devices and resources make BL popular. According to a report by Legon and Garrett (2017), "The Changing Landscape of Online Education," the number of students who follow online learning was 20% for master's program and doctor (graduate), 6% for undergraduate (S-1) higher than it was in 2012-2015. Legon and Garett (2017) said, "these barriers can be overcome by strong leadership-shaping processes to promote better collaboration, as well as rewards and incentives to encourage shifts in culture."

Blended Learning (BL) sometimes is interchanged with hybrid courses or hybrid learning. It is a combination of face-to-face learning with ICT-based or online learning. BL represents an opportunity to integrate the innovative and technological advances offered by online learning with traditional learning (Lalima & Dangwal, 2017; Hussein Al Noursi, 2020). BL is a combination of different learning models. In this context, blended learning programs use many different forms of e-learning.

High schools in Indonesia mainly provide their students with ICT infrastructure so the students can use it. However, students at home may have no ICT access or a limited budget to access the internet. In addition, many biology teachers in schools are accustomed to using PowerPoint presentations, videos, and the internet to show biological objects and phenomena. As a result, fewer biology teachers use real objects to promote learning.

The research questions are: (1) What are the effects of RO, ICT, and BL learning models on students' factual and conceptual knowledge?; (2) How does the learning model determine the type of knowledge?

METHOD

This research was a non-equivalent quasi-experiment with a pretest and posttest comparison group design following Sugiyono's model (Sugiyono, 2018). The samples of the research were taken using cluster random sampling. Therefore it is considered a quasi-experiment. "Although the independent variable is manipulated, participants are not randomly assigned to conditions or orders of conditions" (Cook & Campbell, 1979). The research took place in two senior high schools of SMAN 1 and SMAN 2 Bantul. Three classes from each school were taken using a cluster random sampling as the research samples; one class learned using RO, the other was using ICT, and another was using Blended Learning (BL). The design is presented in Table 1.

Table 1. Research Design: Comparison of Pretest and Posttest Design

Group	Observation	Treatment	Observation
RO	Y_{11}	RO	Y_{21}
ICT	Y_{12}	ICT	Y_{22}
BL	Y_{13}	BL	Y_{23}

Y_1: pretest (Factual & Conceptual Knowledge)

Y_2: posttest (Factual & Conceptual Knowledge)

The subjects of this research were 139 students coming from two high schools; two classes in each school were assigned as an experimental group and a control group. The students were heterogenic on their SES and abilities. They could use computers and smartphones to access information from the internet. The two schools had a Wi-Fi wireless internet connection. The distribution of the subjects is presented in Table 2.

Table 2. Distribution of Subjects

	RO	ICT	BL	Grand total
School A	22	25	23	70
School B	22	25	22	69
Total	44	50	45	139

The RO group was taught in a face-to-face model. The teacher and the students were present in the teaching and learning process synchronously. The students learn using real objects of plant diversity and the component of the ecosystem. The ICT group learned using the online model integrated with ICT (including websites and other digital materials). The BL group learned from both the face-to-face and the ICT. Data on students' achievement in factual and conceptual knowledge were collected using objective tests. The tests were constructed in two different kinds of knowledge: factual knowledge and conceptual knowledge on Plan Diversity and Ecosystem. The factual knowledge and conceptual knowledge were included in Table 3. The research instrument was an objective test with five options. The test was constructed in two different kinds of knowledge: factual and conceptual knowledge. The topic and the number of test items are presented in Table 3.

Table 3. The Dimensions of Factual and Conceptual Knowledge and the Number of Test Items

Factual Knowledge	# of Item	Conceptual Knowledge	# of item
Plants have many parts such as roots, trunks, leaves, flowers, seeds	3	Plants belong to the Plantae kingdom.	2
		Plant can be classified in many ways	2
		Plant can be classified into dicots and monocots	1
Every part has a different detailed structure	3		
		Plants do photosynthesis, so they are called autotrophs	2
Every part has a specific function	3		
		Photosynthesis converts inorganic materials into organic materials	2
An ecosystem has abiotic and biotic components.	3		
		Energy for heterotopic organisms relies on plants	2
Abiotic components include water, air, soil, minerals, temperature, etc.	2		
		Ecosystem is a system ecology that enables organisms to perform their live activities	1
Biotic components include plants, animals, fungi, protists, and human beings.	2	Ecosystem consists of energy resources, producers, consumers, and decomposers.	2
		Ecosystem has energy flows from the sun to decomposers	2
Interaction among biotic components is called symbioses.	3		
		Ecosystem has materials cycles between inorganic and organic materials	2
		Ecosystem has food chains and food webs	2

The test items were validated by expert judgment and empirical validation using item fit on the Rasch model. The test consisted of 40 items of multiple choices test. As many as 20 items were the factual knowledge test, and the other 20 items were the conceptual knowledge test. The empirical validation shows that 39 items fit the model, so they are considered valid, but item number 19 was invalid, so it was reconstructed. The items' infit Mean Squares (MNSQ) were 0,77 – 1.30, with the Agreement index (P_o) of 0.92 for factual knowledge and 0.90 for conceptual knowledge. The pretest and posttest instruments had the same stems, but the options had a different arrangement and answer keys to avoid testing effects. The results of the Rasch model on the items analyses show that all test items, except item number 19, fit the model, as it is presented bellows (Figure 2).

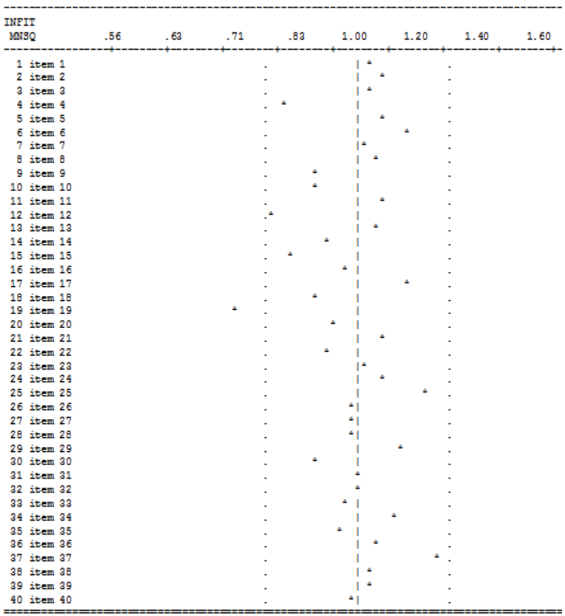

Figure 2. The Rasch Model MNSQ of the Test Items

RESULTS AND DISCUSSION

Pretest was given to the students to know their prior factual and conceptual knowledge before being treated with the independent variables of RO, ICT, and BL. The results indicate that the three groups had almost the same mean scores of 38-39 on factual and conceptual knowledge. The score range was from the lowest of 25.00 to the highest of 55.00. The scores were tested with Box's M covariance matrices with sig.=0.21>0.05, so it can be concluded that the variances among the groups were equal. The pretest scores are presented in Table 4.

Table 4. The Pretest Score of Learning Biology Using the Real Object, ICT, and Blended Learning

	Model	Mean	Std. Deviation	N
Factual	RO	46.25	9.77211	44
	ICT	38.60	7.35680	50
	BL	43.55	9.20858	45
	Total	42.62	9.29257	139
Conceptual	RO	41.36	8.51562	44
	ICT	35.00	5.24891	50
	BL	38.00	6.51920	45
	Total	37.98	7.26615	139

FK: Factual Knowledge CK: Conceptual Knowledge

After the treatment, the groups were given a posttest on factual and conceptual knowledge. The data show that all treatments gave a maximum score of 100. It means that students were able to learn biology by using RO, ICT, and BL on factual and conceptual knowledge. The mean scores were different among the groups, ranging from 78.61 to 85.79 on factual knowledge and from 76.08 to 82.22 on conceptual knowledge. It means that learning conceptual knowledge was more difficult than learning factual knowledge. The posttest score was presented in Table 5.

Table 5. The Descriptive Statistics of the Posttest Score of RO, ICT, and BL

Model	Knowledge	N	Mean	Std. Deviation	Minimum	Maximum
RO	Factual	44	85.79	9.74319	65.91	100.00
	Conceptual	44	78.61	7.84769	61.36	95.45
ICT	Factual	50	79.36	9.79329	60.00	100.00
	Conceptual	50	76.08	6.48968	64.00	86.00
BL	Factual	45	85.58	8.74488	68.89	100.00
	Conceptual	45	82.22	6.42652	71.11	97.78

Table 5 also indicates that RO gave more knowledge to the student on factual knowledge. However, ICT gave more knowledge on conceptual knowledge, and BL gave more both factual and conceptual knowledge. Regarding research question # 2, it seems that the learning model determines the type of knowledge the students learn. Overall data on the effects of RO, ICT, and BL on factual and conceptual knowledge can be seen in the following figure (Figure 3). From the figure, we e could infer that RO was still the best way to learn biology, specifically for gaining factual knowledge.

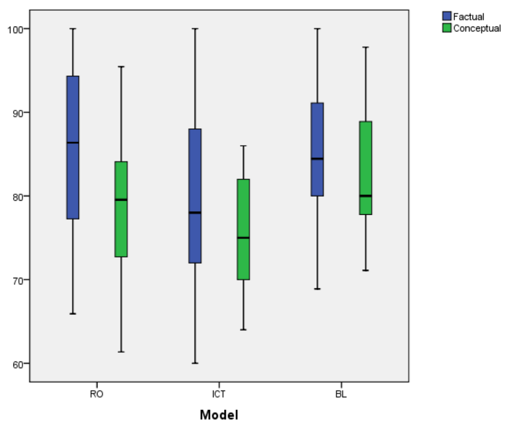

Figure 3. Students' Achievement of Factual and Conceptual Knowledge based on the Learning Model

The pretest scores were tested using Multivariate Analysis of Variance (MANOVA) to determine the groups' variance. The pretest scores were analyzed on the equality of the variances using the Box M test. The results indicate that p=.195> 0.05. It can be concluded that the students of the three groups had the same variances or equal.

Table 6. Box's M Test of Equality of Covariance Matrices

Box's M	F	df1	df2	Sig.
8.818	1.438	6	426741.662	.195

The homogeneity of variance in the population from which the samples are taken was tested using Levene's test based on the data of students' achievement on pretest and posttest. There was no difference in variance among the groups of models (RO, ICT, BL), F=0.802 >.05 on factual knowledge and conceptual knowledge F=0.932>0.05. It meant that the condition of the students among the treatment groups had the same variance.

The Multivariate Analysis of variance (MANOVA) was applied to measure the students' factual and conceptual knowledge differences among three learning models (RO, ICT, BL). The MANOVA of posttest scores show that there were very significant effects of the learning model (RO, ICT, and BL) on the factual knowledge and conceptual knowledge with Wilks' Lambda of 0.005 ($p<0.05$). Therefore, it can be concluded that there were different effects among the teaching model on the students' achievement. There were significant differences among the groups (RO, ICT, and BL) in students' achievement of factual and conceptual knowledge ($p=0.000$). There was also a significant interaction effect between teaching models of RO, ICT, and BL on factual and conceptual knowledge ($p=0.000<0.05$).

Using real objects increased students' factual knowledge, and it positively motivated students to learn biology. Interesting objects raised students' attention and enthusiasm to learn biology, specifically when the object was unique, rare, and engaging. This finding was reliable with the Fisher model, where learning biology originated from the living world. The finding was also in line with experiential learning theory and constructivist learning theory of biology learning (Mostyn et al., 2013; Fauzi et al., 2021; Yapici & Karakoyun, 2021). When the students learned about Plant Diversity, they observed many plants growing in the schoolyard. Students interacted with the plants. They observed the plant parts such as the leaf, the trunk, the fruit, and the flower. They noticed the differences in the plants' characteristics of the organs. These activities enabled students to learn the characteristics of the objects. When they encountered Sapodilla, the students used their hands to touch the upper and lower parts of the leaf, pierced it, and smelled the fragrance. They also observed the fruit. Learning from the objects promotes students' factual knowledge, characteristics, and parts. This finding was relevant to the theory of authentic learning (Fisher et al., 2001; Li, 2011; Irez, 2016).

It seemed that the students faced difficulties finding the names of the plants and the parts. They asked the teacher the plant's name, specifically in Latin words. The teacher asked students to search the internet, and they found the name *Manicara*. They also noticed many similar names, such as *Manikara sapota* and *Manikara dissecta*. This evidence revealed that learning from ICT gave more information on the name of the organism and parts of the organism.

Learning factual knowledge sometimes is not enough to construct a concept. Özarslan and Çetin (2018) studied the understanding of students on essential components of a living organism. They found that students' knowledge of a total number of words about essential components of living organisms was more than the total variety of words. Students use a keyword to determine the concepts; several concepts may use the same words. Real objects give basic knowledge. The mastery of knowledge and the production of knowledge need more than real objects and ICT (Agboghoroma & Oyovwi, 2015; Tan et al., 2017; Özarslan & Çetin, 2018; Gümüş et al., 2021; Samoylenko et al., 2022).

When the teacher assigned groups to learn about Plant Diversity and asked students to seek information on the diversity within species and among species, the students searched for the information from the ICT. They related the diversity of canistel/sapodilla trees they learned from the school yard to the names of the genus and species. They found many kinds of sapodilla (*Manikara sp*) trees, which were very common in their home, and some that they had never seen before, such as *Manikara sapota*, *Manikara dissecta*, and *Manikara fischeri*. They searched for explanations and detailed characteristics. They were excited to discuss the similarities and differences among the characteristics of Sapodilla, the colors, and the shape of the leaves and fruits. They discussed in their group why the trees had the same genus name but different species names. They finally get an explanation of why some plants have the same genus name and different species names. They gained not only factual knowledge but also conceptual knowledge, precisely the concept of the genus and species name of a plant. ICT enabled students to get more information and explanation on the "why", so they could learn more about conceptual knowledge. This finding was relevant to the theory of using ICT in education (Meenakshi, 2013; Odell et al., 2020; Ramadhan & Suyanto, 2020; Rana & Rana, 2020; David & Venuste, 2021; Gutiérrez-Martín et al., 2022)

Students learned about the ecosystem from the real world, the bush surrounding the school. They found some plants, animals, and other nonliving things. When the teacher asked them to relate among the components of the ecosystem, the students faced difficulties because the relationships were not observable in the existing conditions. The teacher then asked them to search on the internet for the relationships among the components of an ecosystem. The students found some terms such as living and non-living components, symbiont and symbiosis, producers, consumers, food chains, food webs, and energy transfer. Blended Learning (BL) seemed to provide both the benefits of face-to-face and online learning using ICT. From face-to-face learning, students use real objects to learn, observe, manipulate, and experiment with the real world. Then, students used the internet to get more information about what they learned. Therefore, BL gave both factual and conceptual knowledge. This finding was similar to the previous studies by Husamah (2015) and Delgado et al. (2015). In BL, students try to think more profound about the information from real objects by seeking more information on the internet (Hussein Al Noursi, 2020). The combination of face-to-face learning and ICT-based learning enabled students to get factual and conceptual knowledge equally (Sayed, 2013; Eryilmaz, 2015; Lalima & Dangwal, 2017; Harahap et al., 2019; Pitaloka & Suyanto, 2019; Seraji et al., 2019; Al-Bazar et al., 2021; Nurhayati et al., 2021; Sitthiworachart et al., 2021).

In BL, teachers still contributed to guiding and motivating students to learn. The teacher suggested a URL or website the students could access, as mentioned by Suárez and Colmenero (2021). The teacher also functioned as the more capable person to scaffold students to develop a zone of proximal development as stated in the social learning theory (Marginson & Dang, 2016; Lasmawan & Budiarta, 2020). Thinking or rational development is directed in a social context. It is increasingly subordinated to the laws of experience and pure logic.

Learning biology using RO, ICT, and BL enabled students to get a maximum score of 100 on factual or conceptual knowledge. Table 2 shows that those three learning models enabled students to achieve a score of 100 on the posttests. Learning using RO gave a maximum score on factual knowledge, while ICT gave a maximum score on conceptual knowledge. BL gave a maximum score on both factual and conceptual knowledge. Therefore, the three models of learning were suitable for learning biology. However, on average, BL gave the best results in learning biology. A Post hoc test was used to measure the highest difference among the methods. It was found that the RO was 11.064 points higher than ICT on factual knowledge. It meant that RO was the best learning model for learning factual knowledge. This finding was in line with several previous studies (Purwianingsih et al., 2017; Adegboye et al., 2018; Rifai et al., 2018; Ramadhan & Suyanto, 2020; Ebrahim & Naji, 2021).

CONCLUSION

From the results of the research and the discussions, referring to research question #1, it can be concluded that (1) RO has the most substantial power to increase factual knowledge, (2) ICT improves conceptual knowledge, and (3) BL gives the best results on students' achievement both on factual and conceptual knowledge. Referring to question #2, learning models determine the types of knowledge the students achieve. Learning using five senses from real objects allows students to know the objects, the characteristics of the objects, and the detail of the objects. Factual knowledge is essential to constructing the conceptual knowledge. Since the concepts do not exist in nature, students must relate the facts, sort and prompt, and finally make sense of the concepts. Therefore, it is crucial to learn biology, starting from real objects and moving to the construction of the concepts. Several conditions can explain the decrease in students' achievement during the pandemic of COVID-19. First, online learning requires a specific environment, such as the internet, gadgets, and infrastructure. When the environment is not established then the online learning will be failed. Second, online learning requires such learning behaviors and disciplines. Students must be persistent in learning online, seek information from books or other resources, and be able to be a self-independent learner. Third, online learning needs specific software. The research suggests that biology teachers include real objects and ICT in an integrated way to foster students' achievement. It is suggested that biological processes be animated using multimedia, virtual reality, or augmented reality to understand the process more easily. Schools should provide the teachers and the students with real objects and an online learning infrastructure to make BL work well. Parents should provide students with internet access and gadgets to learn. The ICT must be used wisely and carefully to optimize learning.

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