Cognitive learning outcomes with an inquiry learning model assisted by Macromedia Flash material on plant structures

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A R T I C L E I N F O	A B S T R A C T
	The inquiry learning model (IBL) has been explored in many fields of science. Therefore, this research shows the exploration of IBL assisted by Macromedia flash in improving cognitive science learning outcomes for elementary school students. This study aimed to determine the effect of Macromedia flash-assisted IBL on students' cognitive learning outcomes. This quasi-experimental research with a nonequivalent control group design used a sample of 66 students consisting of 33 students in the experimental group and 33 students in the control group. The data collection technique was carried out through tests, using test questions validated by experts and tested for feasibility. Hypothesis testing by the ANCOVA test analysis using the SPSS Statistics 23 program on the pretests obtained a sig value. (2-tailed) > which is 0.000 <0.05, then H0 is rejected, and Ha is accepted. It means that there is an influence of the learning model on cognitive learning outcomes. The results of the LSD test showed that the IBL model assisted by Macromedia flash was significantly different in cognitive learning outcomes compared to the conventional model. Thus, IBL Macromedia flash assistance can be recommended for improving students' cognitive learning outcomes.

INTRODUCTION

Learning outcomes are a person's cognitive changes in mastering concepts and being able to solve problems to achieve the expected learning goals (Ni et al., 2017). The results of previous studies stated that classrooms do not guarantee and positively impact learning outcomes. However, students themselves must strive to improve their academic achievements (Shi et al., 2020). A study in Singapore informed that developing elementary school students' skills were prioritized on aspects of the cognitive, affective, and psychomotor domains through a holistic learning experience through a pedagogic approach (Pyun et al., 2019). Learning outcomes are a description of a person's intellectual level. Learning success can be seen from learning outcomes that are neatly written in a document and presented in general in academic reports (Tuaputty et al., 2021). Learning in developed countries such as the UK has undergone a significant transformation based on technology compared to Indonesia, which still has limitations. It can be seen with virtual reality (VR) development in learning. According to research, 96% of universities and 79% of schools in the UK use VR in learning to improve students' cognitive intelligence (Mckechnie & Wilson, 2021). Cognitive aspects relate to students' intellectual abilities, which are keys to future success (Koć et al., 2020). The cognitive aspect is the most prominent and superior because it shows students' ability to master a specific subject (Zhonggen et al., 2019). The cognitive aspect refers to Bloom's taxonomy developed by Bloom, Engelhart, Furst, Hill, and Krathwohl, oriented towards thinking skills that include intellectual abilities from simple to high levels (Tsai et al., 2015). Cognitive aspects are also mental activities that connect and combine several original ideas, concepts, and procedures that are learned in solving problems (Klein et al., 2005)

Bloom's taxonomy, revised by Anderson & Krathwohl (2001), has two dimensions: dimensions of knowledge and cognitive processes. The knowledge dimension focuses on factual, conceptual, procedural, and metacognitive knowledge content. This category starts from concrete factual knowledge to abstract things in metacognitive knowledge. The cognitive process dimension refers to how that knowledge is used. The categories consist of these dimensions: remembering, understanding, applying, analyzing, evaluating, and creating. The underlying continuum in this dimension is cognitive complexity, ranging from low cognitive complexity in remembering to high cognitive complexity in creating.

Biological science is a field of science that contains facts and theories related to nature. It makes nature a scientific laboratory for improving cognitive skills (Thys et al., 2015). Conceptually, students' learning outcomes in science and mathematics are still relatively low because learning science requires mathematics as a tool for solving problems. A study in the United States showed that elementary school students were not proficient in math by 61% and science by 71% (Lee & Ginsburg, 2007). President Barack Obama innovated to advance science in the USA, aiming to increase the number and quality of students in science, technology, engineering, and mathematics (White House, 2010). It was developed so that the USA could compete and excel at the international level in research, innovation, mathematics, and science (Piasta et al., 2013). This situation is also the same with students in Indonesia, with PISA results still below the average compared to Singaporean and Malaysian students (Fenanlampir et al., 2019); Beatty et al., 2021; Agasisti et al., 2021). The 2018 PISA scores in science are; Singapore ranks 2, the average score is 551, Malaysia ranks 48 with 438 scores, Indonesia ranks 70 with a score of 396. The results of an empirical study on the average score of cognitive learning outcomes in elementary science in Ambon-Maluku for students with low and high academic abilities are 20.9 and 53.4 (Leasa & Corebima, 2017), while specifically for the creative dimension (cognitive level C6) the scores achieved by students ranged from 20-30 (Leasa et al., 2021). This data proves that science learning in Indonesia, especially Maluku, needs improvement. Therefore, it is necessary to make a promising breakthrough in improving the quality of student learning.

One of the breakthroughs made is to apply the latest learning model that can stimulate students' thinking skills and innovation in improving student learning outcomes. The recommended learning model for improving students' cognitive abilities to find, investigate, and express original ideas is Inquiry-Based Learning (IBL). IBL emphasizes the active role of students in learning (Schallert et al., 2020). The specifics of IBL may vary, but the principle is the same: students choose a topic that interests them, study it in-depth, and share what they have learned. Meanwhile, the teacher provides guidance and reinforcement for students in designing their questions through experience, reflection, and conversation to lead to competence, independence, and expertise (Lance & Maniotes, 2020). IBL is based

on constructivist theory, in particular, the work of Bruner (1996) and Goodlad (2004), that students construct knowledge from learning activities and that this understanding cannot be transmitted from teacher to student (Donnelly et al., 2014); (Younker & Bracken, 2015). However, IBL has its roots in the work of John Dewey from 1859–1952, an educational philosopher. He played an essential role in 20th-century educational reform. Dewey believed that instead of emphasizing memorizing facts, science education should teach students how to think and act scientifically (Lazonder & Harmsen, 2016). A learning approach characterizes IBL. The teacher acts as a facilitator who encourages students in learning activities (McKinney, 2014; Yang et al., 2020). IBL promotes active students and encourages students to investigate questions, problems, and issues independently. IBL also activates various scientific activities, namely observation, questioning, reviewing, investigating, collecting, analyzing and interpreting data, predicting, and communicating results (Arsal, 2017). The results of studies in England and America prove that IBL has spread and is promoted in various disciplines, such as a pedagogical approach to teaching public administration at the undergraduate and postgraduate levels and in medicine (Moseley & Connolly, 2020). In addition, the Ministry of Education in New Zealand (Spronken-Smith & Walker, 2010) and the Australian Government apply IBL to the social sciences and humanities (Preston et al., 2015). IBL can have a positive impact on students' cognitive learning outcomes. IBL, which has been expanded with multimedia-based learning (Hein, 2012; Joshi & Lau, 2021).

One media used in learning is Macromedia flash in collaboration with IBL. Implementation of conventional learning models in interactions between students and teachers can be revised with Flash-based learning. The study results show that people retain information seen by 10%, heard by 20%, and what is seen and done by 80%. This statistic presents a strong argument for increasing interaction through multimedia in the form of Macromedia Flash Player (Ngalamou & Myers, 2010). The novelty of the media developed was based on the needs of elementary school students in Ambon. Therefore, science learning was more concrete by using various animations that helped students understand the content of teaching materials. Flash is a commercial Macromedia application whose purpose is to produce animation. Many companies have web pages that include animations created with Macromedia Flash, mainly because of the two main characteristics of this application: graphic creation and user interaction with animation (García et al., 2007). Macromedia flash is very suitable for learning because it is solid and resilient in displaying animation in graphics, sound, and images. It is because it does not require a relatively expensive cost compared to online websites that need to be accessed using the internet network. Suppose the Macromedia flash application has been installed on the teacher's computer. It can be run or displayed in learning according to the topic to be studied (Garofalo & Bell, 2004). Computers have been an indispensable tool for scientific research since the advent of computer science because of their computing power and their ability to present multimedia information. The development of Macromedia Flash can improve students' cognitive learning outcomes and understanding of concepts because abstract things can be presented in science (Garaizar et al., 2014). Thus, the purpose of this study was to determine the effect of IBL-assisted learning media Macromedia flash on student cognitive learning outcomes.

METHODS
Research Design
The approach in this research was quantitative. The method used was quasi-experimental with a nonequivalent control group design. This design was carried out to investigate the effect of Macromedia flash-assisted IBL on students' cognitive learning outcomes, according to Table 1.

Table 1.
The Research Design of Noneequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experiment	Y_1	X_1	Y_2
Control	Y_3	X_2	Y_4

Where
(X_1) : The group that was given IBL treatment assisted by macromedia flash
(X_2) : Group with conventional model

(Y_1) : Measurement of the initial ability of the experimental group
(Y_2) : Measurement of the final ability of the experimental group
(Y_3) : Measurement of the initial ability of the control group
(Y_4) : Measurement of the final ability of the control group

Population and Samples

The population in this study were all fourth-grade students of Public Elementary School 5 Ambon. The sample in this study was 33 students of class IVA as the experimental group and 33 students of class IVB as the control group. A simple random sampling technique was carried out the sampling technique. The schools referred to in this study were included in the medium level category.

Instrument

The research instrument used was a cognitive learning outcome test instrument consisting of levels C2-C5 to measure students' cognitive learning outcomes. The pretest was carried out before being given treatment, as well as the posttest was carried out after being given the treatment. The test instrument was in the form of 8 description questions that are declared feasible because they have met the instrument's requirements: validity and reliability.

Procedure

Before taking the data, a trial was conducted on the question instrument at 5 elementary schools in the city with a total test sample of 150 people. The values of validity and reliability were 0.72 and 0.78. After that, a lottery was conducted for the determination of the sample, in which there were two sample classes that would be treated as the experimental group and the control group. The selected sample was class IVA Public Elementary School 5 Ambon as the experimental group (treatment of the IBL model assisted by macromedia flash) and class IVB as the control group (treatment of the conventional learning model).

The following procedure in quasi-experimental research is described as follows. The first step was a placement test. The results were tested with ANOVA to ensure that the two treatment groups were equal before implementing the treatment. Second, a pretest was conducted on both treatment groups simultaneously to determine the students' initial abilities before implementing the treatment. Third, treatment was carried out in the form of a learning process within a period of 5 meetings with the material being taught including 1) plant structure & function, 2) root structure and function, 3) stem structure and function, 4) leaf structure and function, and 5) structure and function of flowers. The learning process with Macromedia flash assisted IBL can be seen in Figure 1.
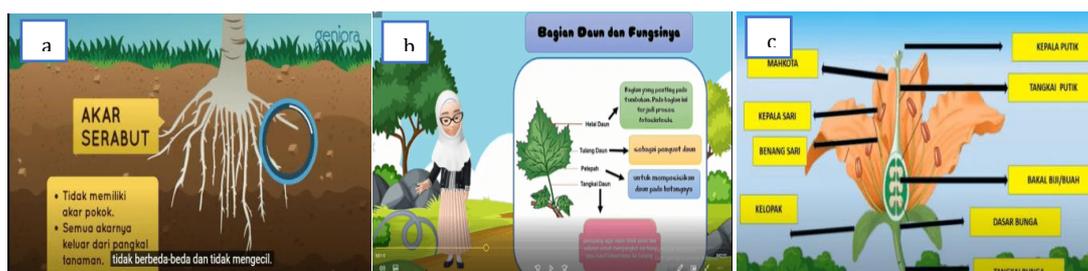
Figure 1. Macromedia Flash display, (a) fibros roots, (b) parts of leaves, (c) parts of flowers

The fourth step was to hold a posttest in both treatment groups to determine the achievement of cognitive learning outcomes after the implementation of the treatment.

Data Analysis Techniques

The data obtained were analyzed based on data analysis techniques, including descriptive analysis, testing assumptions or prerequisites, and testing hypotheses. After being tested for normality and homogeneity, the average difference was made for the achievement of the two classes. The analysis used was the analysis of the ANCOVA test with a significant level of 0.05 on the SPSS 23 software.

RESULTS AND DISCUSSION

Data on students' cognitive learning outcomes in learning with Macromedia flash assisted IBL in the experimental and control in the form of pretest and posttest are shown in Figure 2.
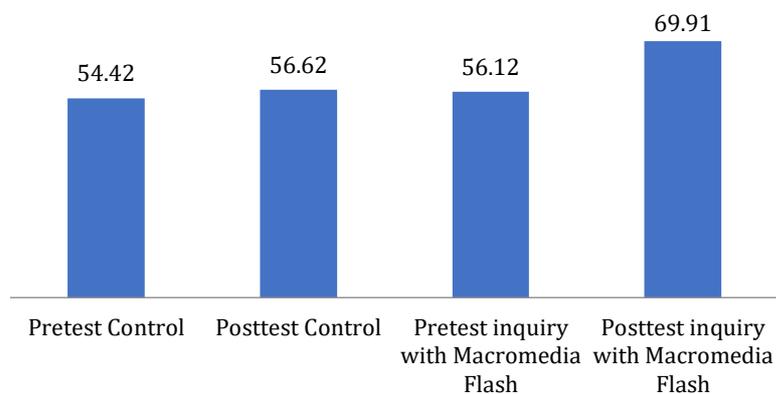
Figure 2. The results of the pretest and posttest in the experimental and control groups

Figure 2 shows that the pretest score in the experimental group was 1.7 points higher than the control group. Similarly, the posttest score in the experimental group was 13.29 points higher than the control group. These data illustrate that cognitive learning outcomes in the experimental group are higher than those in the control group.

The normality test results of the pretest and posttest of the experimental group obtained a sig value. (2-tailed) > (0.091 > 0.05) and (0.200 > 0.05) respectively. It means the data is normally distributed. The normality test results of the pretest and posttest of the control group stated the value of sig. (2-tailed) > (0.134 > 0.05) and (0.136 > 0.05) respectively. It means that the distribution of pretest and posttest data in the control group is normally distributed. The results of the data homogeneity test obtained sig. (2-tailed) for the pretest and posttest data in the experimental and control groups were 0.934 and 0.936 (> 0.05). It shows that the data meet the homogeneity criteria.

The ANCOVA learning model test results show that the value of sig = 0.000. It is smaller than the alpha value (0.05). Thus, H0 is rejected, which states that the learning model does not influence cognitive learning outcomes. It means that the learning model affects students' cognitive learning outcomes. The results of the ANCOVA test are shown in Table 2.

Table 2

ANACOVA Test on the Effect of Learning Model on Cognitive Learning Outcomes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9944.966[a]	2	4972.483	424.584	.000
Intercept	26.308	1	26.308	2.246	.139
Pre-Test	8051.909	1	8051.909	687.527	.000
LearningModel	2413.469	1	2413.469	206.078	.000
Error	702.685	60	11.711		
Total	274229.000	63			
Corrected Total	10647.651	62			

Table 3 below presents the average corrected cognitive learning outcomes in each treatment group of the learning model.

Table 3

Average Corrected Score on Cognitive Learning Outcomes in Learning Model

Learning model	HBKX	HBKY	Difference	Average corrected	LSD Notation
Conventional	54.42	56.52	2.10	59.42	a
IBL assisted by macromedia flash	56.12	69.91	13.79	71.78	b

The average corrected score for experimental group learning outcomes (IBL learning model assisted by Macromedia flash) was 71.78. In contrast, the average corrected score for the control group (conventional model) was 59.42. These data indicate that the average corrected score for cognitive learning outcomes in the Macromedia flash-assisted IBL model is higher and significantly different from the average corrected score for cognitive learning outcomes in the conventional model. IBL empowers students' ability to search and investigate critically, systematically, and analytically to formulate their findings well (Coleman & Nichols, 2011; Zorn & Seelmeyer, 2017). The role of the teacher is to facilitate the inquiry process, for example giving group assignments. The teacher's parameters set followed the material to be studied, neatly arranged in a teaching material in a Macromedia flash display or student worksheets for students to solve problems. It indicates that students should also use learning media such as Macromedia flash to concretize the material being studied to be more readily accepted in the structure of their knowledge. In IBL, students are given tasks that require them to solve problems, hypothesize, experiment, explore, present, and communicate (van Uum et al., 2016). First, students must be as responsible as possible for what is given and collaborate with group friends in solving problems. Second, they should be responsible for re-examining the ideas presented in the form of an investigation. It means that students should not depend on the teacher as the only source of learning. However, they can examine various sources to develop their thinking. Furthermore, they present their ideas or findings. They can criticize ideas from other groups when presenting solutions from the discussion results. The teacher straightens and provides input and reinforcement for what has been accounted for.

IBL encourages students to work in pairs, collaborate in developing knowledge, and provide opportunities for students to be independent in asking questions that are useful in improving cognition. The previous findings stated that in IBL activities, 60% was spent on student-centered activities while 87% was spent on conventional learning more by the teacher. (Love et al., 2015).

IBL enables and encourages students to work independently in developing their materials, practice skills at work, emphasize active learning, think critically and creatively through activities such as group work (Capaldi, 2015). In addition, IBL facilitates the development of thinking processes, problem-solving skills, communication skills, and scientific reasoning (Zafra-Gómez et al., 2015). In Canada, McMaster University has implemented IBL as a core program in pedagogic learning since 1979 (Justice et al., 2009). At the University of Prince Edward Island, several Faculties have implemented IBL for the last 6 years. The University of Calgary has included IBL in its learning plans for 5 years (University of Calgary, 2018). Other universities include the University of Sheffield and the University of Gloucestershire in America; Marymount University, Miami University, and Virginia Wesleyan College in the United States; and several in New Zealand (Lee, 2012). They accommodate IBL in the university curriculum because it is considered effective in improving the learning outcomes of undergraduate and postgraduate students (Archer-Kuhn et al., 2020). In addition, IBL has received various accolades from primary to secondary levels for improving student learning outcomes (Furtak et al., 2012). The four-phase model of the inquiry process (Lynott & Bittner, 2019) can be shown in Figure 3.
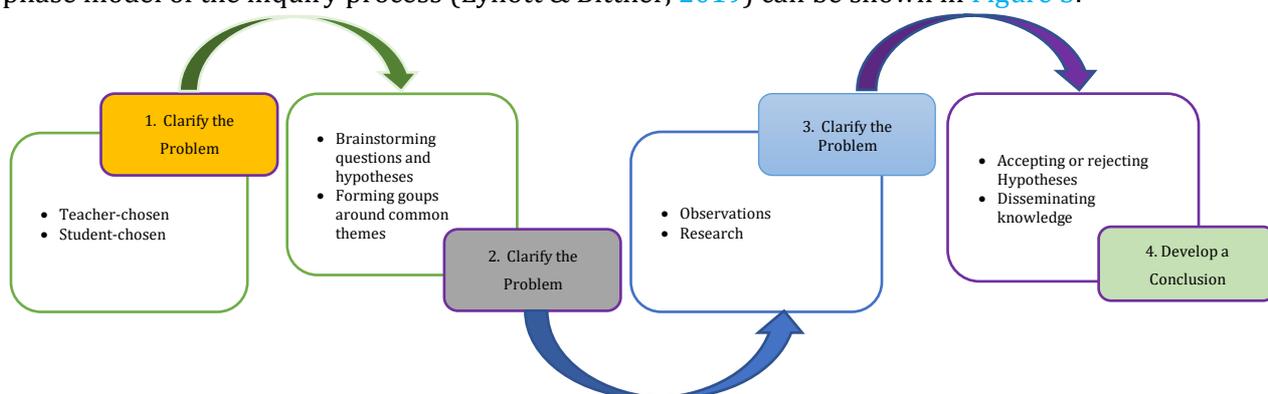
Figure 3. The four-phase model of the inquiry process

This IBL phase activity makes students more active in learning. In the phase of planning activities, the teacher provides student worksheets that students will experiment with. Students were asked to be independent with the teacher's guidance through group discussions in working on worksheets. Students feel enthusiastic to try the experiments carried out to encourage students to think and arouse

enthusiasm for learning. This IBL focuses on developing the concept of thinking through observation to make it easier for students to abstract into their minds (van Schijndel et al., 2018). The results of studies from pedagogical experts, namely Hudspith & Jenkins (2001) and Justice et al. (2007), reveal that the conceptualization of IBL to develop student-centered learning visuals (Archer-Kuhn et al., 2020) is shown in Figure 4.
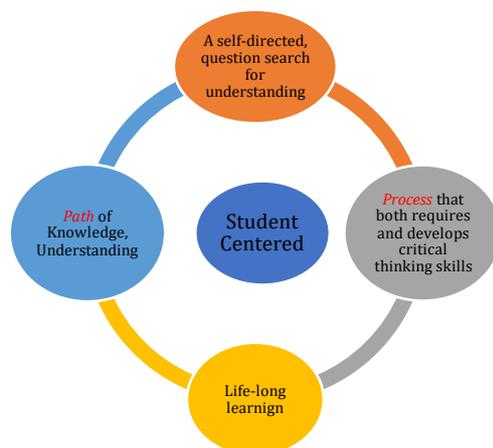
Figure 4. Student-centered IBL

This figure starting with 1) self-directed, a question-driven search of stimulating student understanding; 2) develop critical thinking skills; 3) lifelong learning; and, 4) as a path to knowledge and understanding. This framework guides the process and implementation of IBL in the classroom.

The use of media with the IBL learning model in the experimental group showed that students' cognitive learning outcomes could be higher than the control group. Macromedia flash in IBL significantly affects cognitive learning outcomes compared to the control group. It is in line with Elfarssi's (2007) findings, who concluded that learning using Macromedia flash could increase students' interest and understanding of science learning. The use of multimedia in the form of Macromedia flash helps support inquiry learning. This media helps students process information verbally and visually actively. The display of words and pictures accompanied by animation strengthens students' cognition because they can build mental representations of the objects or phenomena presented (Bruckermann et al., 2017). It is usually put at the beginning of learning when the teacher starts learning and presents factual content according to students' cognitive development. It is followed by the core part of learning when the teacher tries to encourage students to solve problems through investigations that have been designed. Macromedia flash improves content visualization and interaction with fellow students and teachers, making it more varied to conduct joint discussions and solve problems (Rahmawati, 2018; Leasa et al., 2019). This process can contribute to the cognitive and affective development of students. In science learning with IBL, Macromedia flash offers an opportunity for students to manipulate scientific experiments that are difficult or have never been done and are time-consuming to be implemented easily by elementary students. Therefore, Macromedia flashes in IBL can offer students a fun independent learning experience (Heller, 2006).

The cognitive learning outcomes of students who take IBL lessons assisted by Macromedia flash show an increase in student competence, according to Spronken-Smith & Walker (2010). IBL follows a pattern, 1) asking questions as a basis, 2) building knowledge, 3) student-centered learning orientation, 4) being given responsibility by teachers in improving their learning, and 5) focusing on discovery rather than focusing on final results. This stage makes students feel comfortable, love learning, and students understand better teaching the material presented by the teacher.

CONCLUSION

Based on the description of the findings, it can be concluded that the learning model affects cognitive learning outcomes. Between the two learning models, the IBL model assisted by Macromedia flash has more influence on cognitive learning outcomes than the conventional model. It can be seen that the average corrected score for the experimental group is higher than the control group. Therefore,

IBL, with the assistance of Macromedia flash, can be recommended as a learning model that has the potential to increase students' cognitive learning outcomes. IBL can also be recommended as one of the relevant, innovative learning models used in learning in the 21st century to improve students' competence in science. Some suggestions for the future are 1) learning using IBL assisted by Macromedia flash can be used as an alternative in science learning in elementary schools in a more extended learning period, for example, half or one semester, 2) IBL stages can be mastered by the teacher and the objectives can be explored in student learning activities in class in improving student academic achievement, 3) other researchers can explore IBL with other dependent variables by using a larger sample.

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