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The Effect of Project-based Learning Model and Online Learning Settings on Analytical Skills of Discovery Learning, Interactive Demonstrations, and Inquiry Lessons

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ABSTRACT
This study aims to investigate the effect of the Project-based Learning (PjBL) learning model and class differences based on online learning settings (synchronous, asynchronous, and mixed) on the analytical abilities of the Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) models after adjusting for IQ of pre-service elementary teachers (PETs). The sample was randomly selected as 36 PETs who took science teaching courses in elementary schools. Data collection techniques using tests with indicators of analytical ability at the level of inquiry model stage include DL, ID, and IL. Data analysis was carried out quantitatively using two-way multivariate analysis of covariance with one covariate. The results showed that the PjBL model and the online learning setting each affected students' analytical skills in DL, ID, and IL, but after the learning model interacted with differences in online learning settings the results did not affect the analytical test results on the DL, ID, and IL models. This finding indicates that in an online learning design, the selection of project-based learning models can be effective if the right online learning setting is used, namely a combination of synchronous and asynchronous.

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Introduction

Science learning in elementary schools is still dominated by the role of the teacher. In fact, science is a vehicle for students to learn about themselves and the environment through learning by doing (Chen, 2020; Harahap & Bukit, 2020; Shin & Shin, 2020). This method is pursued based on the prospect of learning science for further student development in applying it in everyday life. The concept of science learning should be carried out by scientific inquiry to grow the ability to think, work and behave scientifically and communicate it (Artayasa et al., 2018; Effendi-Hasibuan & Sulistiyo, 2019; Schellinger et al., 2017). Therefore, science learning in elementary schools emphasizes providing direct learning experiences through the use and development of scientific process skills and attitudes.

The problem that often arises in schools is that most teachers still do not understand how to teach science to students according to their characteristics. Learning models need to be chosen to facilitate elementary school students according to their development (Hadi & Saragih, 2020; Park et al., 2017). Wenning (2011) has a suggestion on how discovery learning can be carried out following certain stages known as Levels of Inquiry (LoI). The LoI model systematically presents the stages of inquiry consisting of discovery learning, interactive demonstrations, inquiry lessons, inquiry labs, and hypothetical inquiry where the teacher will help students develop a broader scope. However, the stages of students in elementary schools are more suitable for the first three stages, namely discovery learning, interactive demonstrations, and inquiry lessons (Atmojo et al., 2017).

Discovery Learning (DL), Interactive Demonstration (ID), Inquiry Lesson (IL) as learning sequence or level of inquiry to equip students to carry out the scientific investigation process (Novia & Riandi, 2017; Sudigdo & Setiawan, 2020; Wenning, 2005). Discovery Learning (DL) is oriented to building concepts and knowledge based on students' learning experiences. The learning experience is strengthening the relevance or understanding of a concept through questions to guide students to reach certain conclusions. The teacher also directs questions for learning discussion. Interactive Demonstration (ID) contains teacher activities manipulating the equipment and then asking inquiry questions. Questions lead to an attempt to predict what might happen and explain it. Teachers also help students reach conclusions based on evidence. The teacher models appropriate scientific procedures at the most basic level, thereby helping students learn implicitly about the inquiry process. Inquiry Lesson (IL) emphasizes the transition to a more complex form of scientific experiment. Teachers model fundamental intellectual processes and explain the basic understanding of scientific inquiry while students learn by observing, listening, and responding to questions. The teacher facilitates students to plan their own experiments, identify and control variables. The teacher still plays the role of providing guidance, facilitator, and raising questions through the mentoring process using question and answer (Wenning, 2005).

Related studies to DL, ID, and IL as levels of inquiry (LoI) have been carried out in the form of theory and application. Some of them have combined LoI in various instructions, for example, conceptual models of inquiry-based social constructivism in chemistry learning (Perdana et al., 2019). The results of this study try to overcome the weaknesses of inquiry learning which emphasize the lack of social elements and collaborative learning so that elements of social constructivism need to be applied, including observation, peer reconstruction, peer manipulation, generalization, peer verification, and application. As for its application in online learning design, it has an impact on critical thinking skills in learning physics (Nafingah et al, 2020). The results of this study indicate the impact of using the model on the ability to basic clarification, basic support, inference, further clarification, as well as strategies and tactics as indicators of critical thinking skills. In another application, it has been proven that interactive demonstrations can stimulate higher-order thinking skills in science learning (Yulianti et al., 2018). Students' higher thinking ability is better when students think with interactive demonstrations than with ordinary discovery learning.

Previous studies have shown several opportunities to modify the LoI in its implementation which can effectively improve science learning outcomes. Therefore, teachers and prospective teachers are expected to have a deep understanding through critical analysis at each stage of the LoI. In contrast to previous studies, the novelty of this study lies in investigating the impact of PjBL learning models and online learning settings on critical analysis skills of primary school teacher education students at the LoI stage, including DL, ID, and IL. In accordance with previous research reports that the mastery of Pre-Elementary School Teachers (PETs) at the LoI stage at the elementary level still needs to be improved (Atmojo et al., 2017; García-Carmona et al., 2020). In this regard, a PET needs to be prepared to meet the needs of professional science educators in order to fully and effectively understand the concept of science teaching. Universities are responsible for supporting the process of improving the quality of science educators in elementary schools. One effective way is to apply appropriate and adequate learning in science learning in elementary schools to students.

The development of technology is progressing rapidly to support online-based learning to promote effective learning and maximum learning outcomes (Asniza et al., 2021; Ankhi et al., 2019; Fajardo et al., 2019; Shatri, 2020). During the covid pandemic, almost all teaching processes have been carried out online learning (Adnan & Anwar, 2020; Bahasoan et al., 2020; Dong et al., 2020). Although this method is considered effective in reducing the spread of the COVID-19 virus, online learning has reported many problems, such as limited teaching facilities and media, differences in facilities and competencies of educators, limited internet access, and students who are not serious in participating in learning (Ezra et al., 2021; Hermanto, 2020). Thus, the solution that can be done is how to organize online teaching with the right models and techniques.

The Primary School Teacher Education study program provides elementary science teaching courses to equip PETs with understanding science concepts and teaching them in elementary schools. Therefore, understanding science teaching, for example, the level of inquiry, becomes important for students to master. Problem-facing models such as project-based learning are seen as effective for improving the ability of prospective elementary school teachers in teaching science (Gezim & Xhomara, 2020; Novak & Wisdom, 2018; Suryandari et al., 2018). The PjBL gives students autonomy to learn, explore, and investigate the entire learning process and carry out projects independently, the instructor acts like a knowledge facilitator (Chiu, 2020). However, in the design of online learning, the implementation of the PjBL model has its own challenges, so it requires an appropriate method.

Various online learning settings have also been implemented, such as synchronous learning, asynchronous learning, and some of them use mixed (Neumann et al., 2020). Each method has advantages and disadvantages, whereas its success also relies on other factors. For example, synchronous virtual learning environments have developed rapidly and have the potential to overcome social isolation in distance learning, as well as make it more interactive and personal (Racheva, 2018). Synchronous is considered effective for teaching but requires internet data so it is expensive. Meanwhile, asynchronous is more cost-effective but difficult to control, or a mixture of the two is considered more effective (Subekti, 2021). Teachers need to take into account the effectiveness of this according to the level of education taken.

The problem in this study is dents in analyzing the stages of the LoI model on Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL). It is necessary to investigate the effect of implementing the project-based learning models and class differences based on settings (synchronous, asynchronous, and mixed) on the analytical skills of the DL, ID, and IL. The investigation of the influence of the model and online learning setting was carried out after adjusting for IQ in primary school teacher candidates. Previous research has reported that the level of Intelligence Quotient (IQ) is related to the level of a person's ability and performance (Murtza et al., 2020). Therefore, IQ is referred to as a concomitant variable which is thought to be a variable that cannot be controlled but greatly affects the observed response variable. The research problem is formulated through the following questions.

(1) Is there statistically meaningful effect of the learning model on the analytical skills of DL, ID, and IL after adjusting for IQ in PETs?
(2) Is there statistically meaningful effect of online learning settings on the analytical skills of DL, ID, and IL after adjusting for IQ in PETs?
(3) Is there statistically meaningful interaction between learning models and online learning settings on analytical skills on DL, ID, and IL after adjusting for IQ in PETs?

Methods

Research Design

This study used an experimental post-test-only control group design. This design compares the experimental group and the control group selected at random. The experimental group of students in this study applied the Project-Based Learning (PjBL) model. The experimental group was divided into three treatment classes of online learning settings which were fully synchronous, fully asynchronous, and combined (synchronous and asynchronous). Each group of learning settings begins with the formulation of a problem to produce a science worksheet product for elementary students. Students in groups (3-4 students) make plans, integrate various supporting subjects, and provide tools and materials that can be used to complete projects. The next stage is compiling an activity schedule, monitoring the process of working on a worksheet writing project, and the lecturer assessing the worksheet products produced by students. At the end of the learning process, an evaluation is carried out on the aspects of the analysis ability of the Levels of Inquiry model which consists of Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL).

Meanwhile, in the control group, the students applied the Problem-based Learning model. This group is also divided into three groups of online learning settings, namely fully synchronous, fully asynchronous, and combined (synchronous and asynchronous). Initially, the lecturer explained the learning objectives, namely analyzing the Levels of Inquiry model consisting of DL, ID, and IL on a science worksheet for elementary school from the government. Students analyze the worksheet for analysis by reviewing the Levels of Inquiry model which consists of DL, ID, and IL. Students have searched information through the internet, written down the results of the analysis, and compiled reports. Through a virtual meeting with the zoom application, each group conveys the results of their work. At the end of the lesson, the lecturer measures the students' ability to analyze the Levels of Inquiry model consisting of DL, ID, and IL.

Participants

The sample of this study was prospective elementary school teachers who were randomly selected at one of the universities in the teaching training and education faculty in Central Java, Indonesia. The selection uses cluster random sampling where the selected sample is in the form of class groups. The experimental class consisted of 18 people and the control class consisted of 18 people. All samples selected were students with a semester level who at the time of data collection were taking Science Teaching courses in Elementary Schools. This course focuses on equipping students to understand science concepts and teaching them in elementary school classes, including selecting appropriate learning strategies and models, implementing, and evaluating science learning. However, this study focuses on students' understanding of the levels of inquiry model as a stage that is considered appropriate for teaching science in schools.

Data and Data Collection Techniques

Students are grouped where the experimental class applies the Project Based Learning (PjBL) model while the control class does not use PjBL. The project implemented in the experimental class aims to produce a report on the analysis of science worksheets that have been used by teachers and students in elementary schools in the period 2018-2021. The experimental class starts with the essential question, design a plan for the project, create a schedule, monitor the students and the progress of the project, assess the outcome, and evaluate the experience (The George Lucas Educational Foundation, 2005). As for the control class, learning takes place, as usual, presentation and discussion, then evaluation. The test was applied at the beginning and end of the treatment. The researcher measured the pretest of the analytical skills of each group to find out that both groups were at the same level. At the end of the lesson, a skill test was conducted to analyze DL, ID, and IL in both groups.

The level of Inquiry model on ID is characterized by the teacher introducing a demonstration that describes the mechanical process to be followed without explaining the final result of the experiment. Students predict what and why it will happen supported by explanations. The students engage in small group discussions, they share predictions and explanations to be able to self-correct based on predictions. The teacher performs a real demonstration with clearly visible results, then the students compare the results of the demonstration with the two sets of predictions. The teacher identifies each alternative conception that appears. The IL model encourages students to act like scientists in a more formal experimental setting where effort is now taken to define a system, and both control and manipulate a single independent variable to see its effect on a single dependent variable system (Wenning, 2010).

The research data was obtained through the level of Inquiry model analysis test technique which was developed with reference to the appropriate first three-level indicators at the elementary school level, namely Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL). The analytical skills assessment instrument on the DL, ID, and IL models in this study was developed based on primary pedagogical purpose at the level of inquiry (Wenning, 2010). To determine the analytical skills of the model, a review of the aspects of the model by Joyce et al. (2015) has been used. The description of the instrument is introduced in table 1.

Table 1

The Analytical Skills on the DL, ID, and IL

Level of Inquiry	Primary Pedagogical Purpose	Domain
Discovery Learning (DL)	Students develop concepts on the basis of first-hand experiences (a focus on active engagement to construct knowledge).	Analysis of model in action
		Analysis of social system
		Analysis of support system
		Analysis of principles of reaction
Interactive Demonstration (ID)	Students are engaged in explanation and prediction-making that allows teacher to elicit, identify, confront, and resolve alternative conceptions (addressing prior knowledge).	Analysis of model in action
		Analysis of social system
		Analysis of support system
		Analysis of principles of reaction
Inquiry Lessons (IL)	Students identify scientific principles and/or relationships (cooperative work used to construct more detailed knowledge).	Analysis of model in action
		Analysis of social system
		Analysis of support system
		Analysis of principles of reaction

The analytical instrument on each of the dependent variables has been validated through content validity by involving science learning experts and language experts. The reliability test was obtained through Cronbach's alpha test with an alpha value of $0.8 > 0.7$ meaning sufficient reliability, so that it was concluded that all items were reliable and all items consistently had strong reliability. As for the student's IQ data as a concomitant variable in this study, it was obtained through data on IQ test results obtained by students when they first entered higher education.

Data Analysis

The data was collected in the form of quantitative data consisting of analysis test data of the Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) model, and IQ. Data were analyzed using Multivariate Analysis of Covariance (MANCOVA), namely covariance analysis in which at least two dependent variables were measured simultaneously to test whether there were differences in treatment of a group of dependent variables after adjusting for the effect of concomitant variables (George & Mallery, 2018; Huberty & Petoskey, 2000). The technique used is a two-way MANCOVA with one covariate with procedures including (1) Assumption testing, including testing of multivariate normality, homogeneity of the covariance variance matrix, and (2) Hypothesis testing, to investigate the influence of the learning model, the effect of online learning settings, and the effect of interaction between learning models and online learning settings using Wilks' Lambda test statistics. The statistical test in this study used the help of the SPSS version 22 software for Windows with a significance value. If the Wilks' Lambda number is close to 0 then there tends to be a difference in the group. The decision of the hypothesis with a significance value is as follows.

First Hypothesis:

H_0 = Significance > 0.05 (There is no difference in analytical skills between the PjBL model group and the control group)

H_1 = Significance < 0.05 (There is a difference in analytical skills between the PjBL model group and the control group)

Second Hypothesis

H_0 = Sig. > 0.05 (There is no difference in analytical skills between groups of students with online learning settings in synchronous, asynchronous, and mixed)

H_1 = Sig. < 0.05 (There are differences in analytical skills between groups of students with online learning settings in synchronous, asynchronous, and mixed)

Third Hypothesis

H_0 = Sig. > 0.05 (There is no interaction between the learning model and the online learning setting)

H_1 = Sig. <0.05 (There is an interaction between the learning model and the online learning setting)

Findings

Student analysis test data on Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) were obtained after the experimental and control groups finished carrying out learning on topics or innovation materials for science learning in elementary schools. The data description of the analytical skills on DL, ID, and IL in this study is presented in Table 2. Test the assumptions on the two-way MANCOVA with one covariate performed on the findings of the test results. The normality test used was the Mahalanobis distance, the homogeneity test was carried out with the Box M test, and the balance test to determine the initial ability level of the two groups was carried out with a t-test on the results of the pretest of students' analytical skills display on Table 3.

Table 2

Data Descriptive

Dependent Variable	Group	N	Descriptive	Statistic
Analytical skills of DL	Experiment	18	Mean	84.78
			Min	77
			Max	93
			Std. Deviation	4.894
	Control	18	Mean	74.89
			Min	67
			Max	82
			Std. Deviation	5.268
Analytical skills of ID	Experiment	18	Mean	84.39
			Min	77
			Max	91
			Std. Deviation	4.692
	Control	18	Mean	74.72
			Min	67

			Max	82
			Std. Deviation	4.650
Analytical skills of IL	Experiment	18	Mean	83.06
			Min	75
			Max	91
			Std. Deviation	5.274
	Control	18	Mean	73.62
			Min	67
			Max	80
			Std. Deviation	4.327

Table 3

Assumptions Test

No	Test	Test Techniques	Results	Decision	Conclusion
1	Normality Test	Mahalanobis Distance	(r_{obs} = 0.980 > r_{tab}= 0,3246)	H_0 = accepted	Data is normally distributed multivariate
2	Homogenity Test	Box's M	p_{value} = 0.844 > α = 0.05	H_0 = accepted	Data have the same variance covariance matrix
3	Balance Test of Initial Skills	Independent Sample t-test	Analytical skills of DL (Sig. = 0.661 > α = 0.05)	H_0 = accepted	Experiment and control groups have equal initial abilities
			Analytical skills of ID (Sig. = 0.743 > α = 0.05)	H_0 = accepted	Experiment and control groups have equal initial abilities
			Analytical skills of IL (Sig. = 0.547 > α = 0.05)	H_0 = accepted	Experiment and control groups have equal initial abilities

A multivariate normality test was carried out by making a scatter plot between the distance of Mahalanobis and Chi-Square. The correlation coefficient obtained by $r_{observe}$ = 0.980 > r_{tab} = 0.3246 indicates a very high correlation coefficient. In the scatter plot, this means that the data comes from a multivariate normally distributed sample. As for the SPSS output in the Box's M test table, the p-value is 0.844 > α = 0.05, then H_0 is accepted. That is, the three dependent variables (analytical test scores in DL, ID, and IL) have the same covariance variance matrix in the existing groups (learning models and online learning settings). Based on the analysis output from SPSS on the MANCOVA test on the learning model and online learning settings for DL, ID, and IL adjusted for the IQ scores of students, it is presented in Table 4.

Table 4

MANCOVA on Teaching Model and Online Learning Setting to Analytical Skills of Discovery Learning, Interactive Demonstrations, and Inquiry Lessons on the Primary School Pre-Service Teachers

Effect	Test Techniques	Sig.	Decision	Conclusion
PjBL Model	Wilks's Lambda	p_{value} = 0.000 < α = 0.05	H_0 = rejected	There is an effect of the PjBL Model on analytical skills of DL, ID, and IL after adjusting for IQ scores
Online Learning Setting	Wilks's Lambda	p_{value} = 0.000 < α = 0.05	H_0 = rejected	There is an effect of Online Learning Settings on analytical skills on DL, ID, and IL after adjusting for IQ scores
Teaching Model* Online Learning Setting	Wilks's Lambda	p_{value} = 0.188 > α = 0.05	H_0 = accepted	There is no effect of Teaching and Online Learning Settings on analytical skills on DL, ID, and IL after adjusting for IQ scores

Table 3 presents the results of the MANCOVA analysis which is known to have several test results in order to answer the proposed research hypothesis. In the learning model which is used in this study as the experimental class model is PjBL, the score $p_{value} = 0.000 < \alpha = 0.05$, then H_0 is rejected. Thus, it means that there is an effect of the project-based learning model on the analytical skills of the Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) models after adjusting for the IQ of prospective elementary school teachers. On the effect of online learning settings, p-value = 0.000 < α = 0.05, then H_0 is rejected, thus meaning that there is an effect of class differences based on settings (synchronous, asynchronous, and mixed) on the analytical skills of the Discovery Learning (DL) model, Interactive Demonstration (ID), and Inquiry Lessons (IL) after adjusting for IQ in primary school teacher candidates.

Meanwhile, the interaction effect of project-based learning models and class differences based on the setting (synchronous, asynchronous, and mixed) shows p-value = 0.188 > α = 0.05 then H_0 is accepted, meaning that there is no effect on the analytical skills of the Discovery Learning model (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) after adjusting for IQ in primary school teacher candidates.

Discussion

Paying attention to the analysis findings, the test results show that for learning models and class differences based on online learning settings (synchronous, asynchronous, and mixed), each influences the analysis ability of the Discovery Learning (DL), Interactive Demonstrations (ID), and Inquiry Lessons (IL) models after adjusting for IQ in primary school teacher candidates. The discussion in this study focuses on the variables that affect the dependent variable.

The Effect of Project-based Learning Model on Analytical Skills of Discovery Learning, Interactive Demonstrations, and Inquiry Lessons on the Pre-Service Elementary Teachers

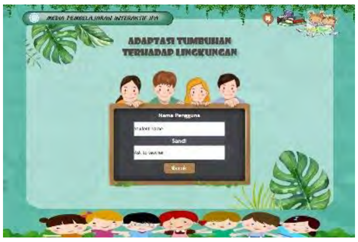
Paying attention to the analysis findings, the test results show that there is an effect of the PjBL learning model on the analytical skills of the Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) models after adjusting for the IQ of prospective elementary school teachers. The implementation of the PjBL model adapted to the online learning design emphasizes the principle that teachers can actually take on the role of facilitator, not dominate learning. The PjBL model provides opportunities for students to start in selecting and planning their projects, developing instruments, implementing plans, and evaluating the achievements of the implemented projects. In this way, similar to constructivism learning theory, the project development process allows students to construct their own knowledge through exploration and provides opportunities to learn about the subjects they are studying (Baran et al., 2021; Chiu, 2020; Tseng et al., 2013).

The PjBL model has been widely applied in science learning. In this study, students were given the opportunity to carry out projects by making observations at partner universities' schools. Dealing with school principals and classroom teachers, the students then analyzed the problems that existed in science learning in relation to the availability of teaching materials and online learning strategies during the pandemic at the elementary school level. The findings of the analysis of the preliminary study on the project of each group of students play a role in determining project planning designed to address the problem of learning science in elementary schools. With this, science learning in elementary schools cannot be separated from the inquiry stage as the variables observed in this study include the Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) models as the stages of inquiry (Yanto et al., 2019; Yulianti et al., 2018).

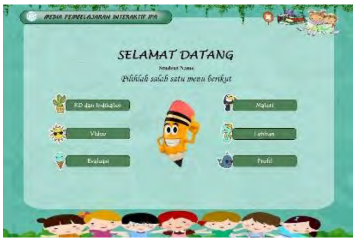
Some of the student projects include the development of digital teaching materials, digital media, and digital worksheets that really support science learning in elementary schools with a level of inquiry perspective. For example, Figure 1 presents the display of digital teaching materials as a product of PjBL results from one of the students on material about the adaptation of plants to the environment. Teaching materials are made with the help of the Lectora Inspire application.

Figure 1

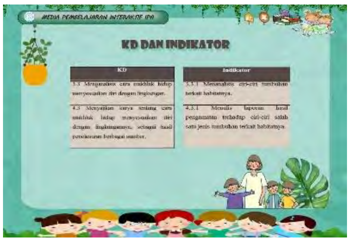
Digital Learning Media with Lectora Inspire App (PjBL Products)



Request student name and password



Frontpage



Competency and indicator

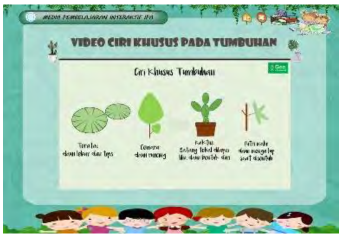
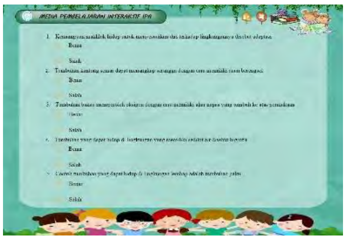


Illustration using video and animation


Evaluative thinking exercise

The product of the plant adaptation learning digital teaching materials initially asked students to write down their names and passwords which could be obtained by asking the teacher as a creator. The front page displays a variety of menu options such as competencies to be achieved, illustrated materials through videos and animations, practice thinking evaluation questions, and tests. The characteristics of elementary school students who require instructional facilities and complete media make students develop their projects by taking into account the principles of the LoI stage. The student who makes the product then explains the results of the analysis of his own product by referring to the LoI stage, such as the product above according to the DL Model. Students explain the theory that supports, the stages of learning, the social system built using the product. This refers to what students do and which learning objectives are targeted with the products that students have made.

The research findings show students explaining how students in elementary school use inductive reasoning to build relationships or simple principles based on teacher-guided observations. In the ability to analyze the ID stage, students demonstrate, develop and ask probing questions, generate responses, ask for further explanations, and other students act as students to reach conclusions based on evidence. Presenters in the presentation of their project results then model appropriate scientific procedures at the most basic level, so it is hoped that students can learn implicitly about the investigation process and communicate it (Anazifa & Djukri, 2018; Saldo & Walag, 2020).

The role of the PjBL model in developing the ability of prospective elementary school teachers in analyzing the IL phase of the LoI model is demonstrated through the identification of IL principles in the products developed in their projects. The development of digital teaching materials that they have developed through PjBL is equipped with sufficient explanations of how in terms of features and usage, the developed media products facilitate simple experimental practices with complete detailed instructions according to the stage of development of students in elementary schools. This method is in accordance with the LoI stage in IL which emphasizes subtly shifting to more complex forms of scientific experiments (Mulyeni et al., 2019; Vorholzer, A., & von Aufschnaiter, 2019). The product facility developed in the student project is equipped with a guide and a column for uploading questions from users so that it is facilitated to plan experiments, identify, and begin to control variables. Thus, the implementation of PjBL in online learning design can be made possible in online learning design at the elementary school teacher education level.

The Effect of Online Learning Settings on Analytical Skills of Discovery Learning, Interactive Demonstrations, and Inquiry Lessons on Pre-Service Elementary Teachers

Science learning which is carried out online in the elementary school teacher education program is carried out with various methods which are then in this study called online learning settings. In general, there are three choices in online learning settings, consisting of synchronous, asynchronous, and mixed with various advantages and disadvantages (Lin & Gao, 2020). The findings that have been presented previously show that there is a significant effect of online learning settings (synchronous, asynchronous, and mixed) on the ability to analyze models of Discovery Learning (DL), Interactive Demonstration (ID), and Inquiry Lessons (IL) after adjusting for IQ in candidates. primary school teachers.

In online classes held asynchronously, it was found to be no more effective than synchronous or mixed. Implementation in the synchronous setting of educators uses online learning media such as the Spada page. In this system, educators have arranged from the beginning the number of meeting sessions and what activities and materials are studied by students independently. This method can be carried out by taking into account the abilities of students and allowing students to be more satisfied with the independent learning environment. The instructions given by the teacher in asynchronous meeting sessions did not motivate students to study seriously. The PjBL and PBL models do not differ significantly in providing motivation and learning outcomes as well as students' critical thinking skills (Koszalka et al., 2021). There was minimal asynchrony in the supervision process and some students were found to be inactive, both in discussion sessions and in collaboration on projects. Asynchronous shows no better results than synchronous and mixed.

The setting in the synchronous class is done where the teacher can interact in real-time with students. Synchronous learning is the closest way we can get to feeling alive in an electronic environment to keep students engaged (Khan et al., 2021). The application of problem-solving learning in a synchronous environment is considered effective, supports cooperation, and better results (Erickson et al., 2020; Shukri et al., 2020). However, this method found problems where the condition of students who were in a geographical area that did not support the availability of internet access experienced obstacles in project coordination and implementation. The way to anticipate this weakness is done by the cohesiveness of the project group in managing member collaboration. Another finding on synchronous learning is that it is less efficient in cost. The high internet data quota has made some students found to be inactive in participating in virtual face-to-face meetings.

In mixed settings, teachers continue to use online learning systems such as smart pages to carry out learning. The teacher has planned the number of sessions and virtual face-to-face rules for certain sessions. Several sessions were used in five virtual face-to-face sessions which were divided into the early stages of project planning, development of the required project instruments, monitoring and evaluation of project progress, and final project presentations. This method is considered the most effective in controlling student learning progress compared to asynchronous or synchronous only. In addition, the application of mixed online learning settings also shows other advantages such as saving internet access costs for students. Mixed synchronous environments offer learners benefits in terms of flexibility, but there are technological and pedagogical challenges in implementing this approach (Zydney et al., 2020). This challenge is in the form of educators' readiness in managing to teach and learning media readiness, both devices and internet access from educators and students.

This research provides a new perspective on how project-based learning models during a pandemic can be implemented by choosing the right online learning setting. The research findings are different from previous studies which only compared models that did not use the online learning setting factor variable (Putra et al., 2021; Samsudin et al., 2020; Setyarini et al., 2020; Wu & Wu, 2020). In addition, the observed variables considering that previous studies have focused on the application of LoI in learning (Heleri et al., 2019; Hidayati et al., 2021; Nafingah et al., 2020), however, in this article, we specifically investigate students' ability to understand and analyze the stages of LoI (DL, ID, IL). The findings of this study can be considered by instructors in primary school teacher education programs to organize online learning in their science classes.

Conclusion and Implications

This study provides a view of how the implementation of innovative learning cannot necessarily be implemented in different conditions, such as between face-to-face and online learning. The case of project-based learning in online learning design requires strategies through online learning setting methods such as choosing when to be synchronous, asynchronous, or mixing the two as deemed appropriate. Based on the findings of this study, it can be concluded that for learning models and class differences based on online learning settings (synchronous, asynchronous, and mixed), each has an influence on the analysis ability of the Discovery Learning (DL), Interactive Demonstration (ID) and Inquiry Lessons models. (IL) after adjusting for IQ in primary school teacher candidates. But after the learning method has interacted with class differences, the results do not affect the test scores or can be said to have the same average for each group.

This study uses a relatively small sample so that future research is expected to involve more samples in similar studies in order to obtain a more representative picture of conclusions to be generalized. This study also recommends teachers and lecturers in universities to pay attention to mastery at the level of inquiry, especially at the levels of Discovery Learning (DI), Interactive Demonstration (ID), and Inquiry Lessons (IL) which are in accordance with the characteristics and development of students at the level of primary school. The development of instruction in elementary school science learning is expected to be more precise and impactful. Project-based learning provides access for students to be able to deepen their knowledge of the LoI stages so as to assist them in analyzing these stages.

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