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Article

Development of object-oriented physics learning model to promote data literacy in physics instructional

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Abstract: Data literacy is an important skill for students in studying physics. With data literacy, students have the ability to collect, analyze and interpret data as well as construct data-based scientific explanations and reasoning. However, students' ability to data literacy is still not satisfactory. On the other hand, various learning strategies still provide opportunities to design learning models that are more directed at data literacy skills. For this reason, in this research a physics learning model was developed that is oriented towards physics objects represented in various modes and is called the Object-Oriented Physics Learning (OOPL) Model. The learning model was developed through several stages and based on the results of the validity analysis; it shows that the OOPL model is included in the valid category. The OOPL model fulfils the elements of content validity and construct validity. The validity of the OOPL model and its implications are discussed in detail in the discussion.

Keywords: data literacy; physics learning; object oriented; instructional model

1. Introduction

Physics is a branch of science that studies natural phenomena that exist in everyday life. Learning physics is always related to surrounding natural phenomena which are represented in the form of using data. In studying physics, students are required to have data literacy so they are able to represent natural events using data based on the inquiry process. The term data literacy is widely used to describe a person's ability to use data, as part of thinking and reasoning activities to solve various real problems in the world daily life (Wolff et al., 2016) as well as the ability to make decisions (Mandinach and Gummer, 2013; Reeves and Honig, 2015; Schildkamp et al., 2014).

Vahey et al. (2006) stated that data literacy includes the ability to formulate and answer questions using data as part of evidence-based thinking; use appropriate data and representations to support ideas and ideas; interpreting information based on existing data; develop and evaluate data-based inferences and explanations; and use data to solve real problems and communicate them to others. Data literacy includes knowledge and skills in assessing, collecting, and analyzing data to test a research hypothesis (Ebbeler et al., 2017). Data literacy is related to the ability to construct scientific explanations based on data (Wolff et al., 2016) which can be obtained through the inquiry process.

Data literacy is a life skill that needs to continue to be developed because of the various problems faced when it is often related to data. Individuals are often faced with assessing a phenomenon and making decisions related to the use of data. Gummer and Mandinach (2015) stated that data literacy is a skill and knowledge that is much needed in the field of education in schools. Data literacy is needed for students for the process of investigating various authentic problems (Cobb and Moore, 1997). Rubin (2005) states that data literacy is needed for students as evidence to support scientific reasoning and explanations. Students who are familiar with data processing activities will learn to solve problems (Erwin, 2015). Several research results show that students who are familiar with the activities of collecting, analyzing and interpreting data will have the ability to construct evidence-based scientific explanations and reasoning (Anjani et al., 2020).

Although data literacy provides many benefits for students, existing conditions show that students often have difficulty obtaining, managing and interpreting data to support their learning process. Students have difficulty writing down data acquisition procedures and have difficulty interpreting data that has been obtained from investigative activities (Supeno et al., 2019). Mandinach (2012) states that students must work hard to obtain relevant data and interpret it. Some students have minimal knowledge and skills about data (Wayman and Jimerson, 2013). The difficulties that are often experienced in relation to data are generally in the process of finding, understanding, manipulating and using data (Frank et al., 2016). The research results of Suryadi et al. (2020) show that students' abilities in collecting data are in the good category, however, students' abilities in assessing data quality, analyzing data, interpreting data, implementing data, and evaluating data are still classified as unsatisfactory. Students also often experience difficulties in interpreting data and formulating conclusions based on data.

Several efforts have been made by researchers to develop students' abilities in obtaining and processing data through investigative activities during learning, including by applying learning models. One of the learning models applied by researchers in developing investigative, data processing and data interpretation skills is the inquiry learning model. Pedaste et al. (2012) applied the inquiry learning model in learning and provided results that the activity of evaluating the process and results of investigations had a positive impact on students' inquiry skills. Reflection activities at the end of problem-solving activities are appropriate activities to improve students' evaluation skills and self-regulation skills. Research conducted by Lazonder and Harmsen (2016) shows that the implementation of the inquiry learning model helps students construct knowledge through the investigation process. Other research results show that the implementation of the inquiry learning model is able to increase students' learning motivation (Skoda et al., 2015), and is able to develop students' learning outcomes and interest in science (Areepattamannil, 2012; Teiga et al., 2018). Inquiry learning is able to teach science process skills (teaching of inquiry), teach how scientists discover science using scientific methods (teaching about inquiry), and teach scientific knowledge using science process skills (teaching through inquiry) (Cairns and Areepattamannil, 2017).

Even though it has a positive impact, the implementation of the inquiry learning model has several obstacles. Ketelhut et al. (2010) stated that implementing the inquiry learning model requires various supports in its implementation. Students often experience difficulty in ordering the stages of inquiry based on real situations (Pedaste and Sarapuu, 2014) and difficulty in formulating research problems (Pedaste et al., 2012). Research results show that students often experience difficulties when carrying out activities according to the stages of inquiry. Students often have difficulty analyzing and interpreting data to produce arguments and conclusions; does not use data to support evidence during group discussions and presentations and is unable to construct explanations even though given the time and opportunity to ask questions, analyze data, and carry out investigations. In inquiry learning, students also have difficulty identifying variables and converting data into graphs (Jeskova et al., 2016) and have difficulty providing reasoning when drawing conclusions (Ruiz-Primo et al., 2010). In its implementation, teachers often experience difficulties in determining appropriate guidance for their students (Yoon et al., 2012).

The inquiry process can be carried out well by students if there is cognitive assistance, one of which is in the form of web-based scaffolding (Pedaste and Sarapuu, 2014) however, students have difficulty acquiring some inquiry skills in web-based learning environments. Teachers must provide assistance in the form of questions, guidance, and modeling to assist student involvement in discussion and construction of explanations. To minimize student difficulties, assistance is needed in the form of examples of assignments, solution models, or relevant tasks (De Jong and Lazonder, 2014) in the form of real-world problems (Jerrim et al., 2019).

Another learning model applied by researchers in developing investigative, data processing and data interpretation skills is the problem-based learning model. Problem-based learning is a learning model that is able to develop 21st century skills (El Mawas and Muntean, 2018) through problem solving activities using the integration and application of knowledge in real world settings (Capraro and Slough, 2013). Through the application of the problem-based learning model, students are able to develop scientific literacy; computing skills (Tsai et al., 2013) as well as having the opportunity to carry out experiments and complete tasks using worksheets according to the experimental stages. Other research results state that the application of the problem-based learning model can develop students' inquiry and performance abilities (Chen and Chen, 2012); the ability to apply student knowledge (Wong and Day, 2009) as well as student retention and learning outcomes (Karaçalli and Korur, 2014). Even though it has advantages, the problem-based learning model in reality requires a long time to be implemented in the classroom (Yamin, 2011). Kirschner (2006) also said that the implementation of the problem-based learning model often fails if there is minimal guidance from the teacher. Based on the results of research related to the bio cell model, it has been shown that the model has content, construct and face validity which meets the eligibility requirements to be applied in the learning process. With an average syntax score <3.6 in the very good category and average student activity $<85\%$ (Wicaksono et al., 2020).

Learning models aimed at improving learning outcomes and developing investigative, data processing and data interpretation skills have been applied in the learning process. Referring to the learning models that have been used, in this research a valid, practical and effective learning model was developed to improve students' learning outcomes and data literacy in learning. Based on the weaknesses of this learning model, it was developed in this dissertation referring to the inquiry process and oriented towards real objects of physical phenomena in the field, named Object Oriented Physics Learning (OOPL). The OOPL model is designed to be able to teach students to carry out oriented investigations on real objects of physical phenomena, obtain, analyze and evaluate data to explain natural phenomena scientifically; master physics content; and provide opportunities for students to develop science process skills.

2. Literature review

2.1. Physics learning and its characteristics

Physics is a part of science which studies natural phenomena, both micro and macro, and their interactions, as well as studying relationships Among these symptoms are presented in the form of concepts, theories and laws. Learning physics should not ignore the nature of physics as a science. The essence in question is physics as a process and product. Physics is a body of knowledge that describes the collective efforts, discoveries, insights and wisdom of humanity. Meanwhile, that physics as a basic science has characteristics that include a body of science consisting of facts, concepts, principles, laws, postulates, and theories and scientific methodology. Physics is a science that is formed through standard procedures or what is usually called the scientific method.

Physics, which is a science, is not just a collection of knowledge. Collette and that science is a way from thinking (affective), a way of investigating (process), and a body of knowledge (collection of knowledge). The first aspect of the nature of physics is physics as an attitude (a way of thinking) where physics is a branch of natural science (science) which has a scientific character, including responsibility, honesty, objective, openness, curiosity, self-confidence, etc., which is firmly attached. According to Collette and some of these characters are beliefs, curiosity, imagination, reasoning and self-examination. Beliefs means genuine belief, and also means a part of religion that takes the form of a concept that is the belief of its adherents. Belief is the basis of a person's actions which he believes to be true and achievable. Belief is an important thing for a person to have, especially as a religious being. As a Pancasila country, Indonesia formulates this character in the 2013 Curriculum, especially spiritual attitude competencies. Other characters are curiosity, imagination, reasoning and self-examination which are accommodated in social attitude competence. These characters indirectly influence how a scientist or physicist thinks.

The second aspect of the nature of physics is as of a process (a way of investigating). According to Hetherington et al. (Collette and Chiappetta, 1994), understanding how the process of forming science is more important than the science itself. Process skills are divided into two, namely basic process skills and integrated process skills. Basic science process skills include: observing/observing, classifying, communicating, measuring, predicting and making inferences. If analogous to learning, basic science process skills can be reflected as psychomotor aspects which in the independent curriculum are included in the learning outcomes of science process skills elements. Meanwhile skills integrated science process, including: identifying variables, formulating operational definitions of variables, formulating hypotheses, designing investigations. Integrated science skills are reflected as higher order thinking processes.

The third aspect of the nature of physics is as of a product (a body of knowledge). Science (including physics) as a product can be interpreted as a collection of information/facts resulting from scientific processes that are based on scientific attitudes. A physics as a product is composed of facts, concepts, principles, laws, hypotheses, theories and models. Physics as a product can also be interpreted as mature information that exists in physics. Studying physics can provide several benefits for students. Giambattista et al. (2010) stated that by studying physics students can develop various skills, including logical and analytical thinking, solving problems, building mathematical models, and making precise definitions. Based on the description above, it is clear that the characteristics of physics cannot be separated from the characteristics of science in general. The characteristic of science itself is a problem-based investigation to understand a natural phenomenon so that a new law, theory, concept or problem is obtained for further research.

2.2. Data literacy in physics education

Data literacy is defined as the ability to understand and use data to support decision making (Mandinach and Gummer, 2013). Data literacy covers several interconnected areas, including scientific data, quantitative reasoning, contextual phenomena. Data literacy is characterized by several habits of thinking, namely curiosity, flexibility, and decision making. Thus, data literacy is part of the educational target in the era of industrial revolution 4.0. Using personal data in the context of decision making is an essential skill because there is a lot of data related to various problems in everyday life. With data literacy, students can interpret and use data to formulate arguments based on evidence so that they are accustomed to conveying scientific reasoning.

Data literacy as part of learning outcomes can be assessed using a written assessment in the form of a multiple-choice test. Assessments are carried out on aspects of data literacy. Several experts state that there are aspects of data literacy. Physics learning activities carried out in the classroom or laboratory that produce data and are related to inquiry projects include formulating scientific problems, identifying variables, defining operational designs for experiments, analyzing data. Data literacy has several aspects, namely using data, analyzing data, communicating the results of data analysis, and formulating conclusions based on the data. Meanwhile, aspects of data literacy include identifying data, analyzing data, communicating data, evaluating data, processing data, using data, differentiating data, implementing data, and interpreting data. A more detailed review of literacy aspects was stated, where data literacy has several aspects, namely collecting data, connecting data, analyzing data, interpreting data, and formulating conclusions. Each aspect can still be broken down into sub-aspects and indicators as shown in **Table 1**.

Table 1. Data literacy indicators.

Aspect	Sub Aspect r	Indicator
Collecting data	Select variables based on data	Students can choose interrelated variables based on the data presented
	Using data based on variables	Students can use variables obtained based on the data presented
Linking data	Differentiating data	Students are able to differentiate data that has been linked based on the objects presented.
	Combining data	Students are able to combine several related data

Table 1. (*Continued*).

Aspect	Sub Aspect r	Indicator
Analyze data	Select data	Students can analyze data according to concepts
Interpreting data	Configure data	Students are able to interpret data represented in graphic objects or diagrams
	Interpreting data	Students are able to interpret the variables contained in the graph into data.
Formulate conclusions	Formulate results	Students can formulate conclusions based on the data obtained
	Reviewing results	Students can formulate interpretations of the objects obtained based on conclusions from the data presented

2.3. Learning model

The learning model is a comprehensive approach to planning learning with attributes including a theoretical framework, orientation to what students are learning, as well as teaching procedures and structure. The concept of learning models can be classified according to learning objectives, model syntax, and learning environment. Learning objectives are learning outcomes that are designed to be achieved, model syntax is the flow of learning activity steps, and the learning environment is the context in which learning must be carried out, including ways to motivate and manage students.

The general characteristics of a learning model include syntax, social system, reaction principle, support system, instructional impact, accompanying impact. Model syntax is a pattern that describes the flow sequence of learning activity stages; the social system is a description of the roles of teachers and students and the pattern of relationships between the two, the reaction principle is a pattern of activities that describes how teachers see and treat students, including how they should respond to students; the support system is all the facilities, materials and tools needed to implement the learning model; instructional impact is a learning result that is achieved directly by directing students to achieve the expected goals; and accompanying impacts are other learning outcomes produced by a learning process.

3. Materials and methods

This type of research is educational development research or educational design research. This development research aims to develop the OOPL learning model as a valid, practical and effective intervention for teaching students' physics and data literacy. The research subjects in the limited trials and extensive tests on the implementation of the OOPL model were high school students who were studying physics. Limited trials were carried out on students at certain high schools involving students from one class. Extensive testing was carried out at several high schools involving several classes. Considerations for selecting schools are: 1) student data literacy is still low; 2) teachers have not integrated data literacy in physics learning; 3) willingness of schools to be used for research; 4) availability of facilities and infrastructure. Research design for developing the OOPL learning model. This development design was chosen because it aims to produce a product in the form of an OOPL learning model. The product developed was then tested for feasibility with validity and product trials to determine the extent to which physics learning outcomes and student data literacy improved after learning physics using the OOPL model. The learning model development flow is carried out through the needs and context analysis, Design, Development, and Formative Evaluation stages, Semi-Summative Evaluation. The limited trial design used was the Pre-Experimental Design. Research with Pre-Experimental Design results is a dependent variable, because there are no control variables, and the sample was not chosen randomly. The sample used in this research was class X E Pakusari 1st Senior High School which consisted of 30 students.

The research design used was a one group pretest-posttest design using one sample group that was chosen deliberately and then given treatment in the form of pre-test O1 followed by treatment (treatment) X, and at the end of the study the sample was given post-test O2. This design is used to determine the effectiveness of the learning model. The instruments used at the model implementation stage are learning implementation observation sheets, student activity observation sheets, obstacle note sheets during learning implementation, assessment sheets, and student response questionnaires. The data collection techniques used in the research were adapted to the research stages, namely the model development stage and the learning model implementation stage. The data analysis technique used is adapted to the data obtained during the research stage, namely data obtained in the model development stage and data obtained in the model implementation stage.

4. Results and discussion

The characteristics of the learning model for teaching physics and data literacy that was developed and named the OOPL model were formulated based on the results of theoretical studies and analysis carried out at the model development stage. The learning model developed refers to cognitive psychology theory, constructivist learning theory, and connectivism theory. There are several characteristics of learning models that refer to these learning theories.

a. Learning is associated with students' prior knowledge. For this reason, teachers need to check students' prior knowledge. If students do not have sufficient initial knowledge, teachers need to provide learning experiences according to their needs.

b. Integrate learning with situations often experienced by students in everyday life. This can be done by providing assignments or problems related to the application of physics in everyday life.

c. Learning begins with problem identification activities proposed by the teacher. The problems posed are real problems about real physical phenomena in life using data.

d. Solutions to problems must be prepared by students based on evidence in the form of data obtained through the inquiry process and accompanied by scientific reasoning.

e. Data to support problem solutions is obtained through an inquiry process, including through experimental activities, investigations and literature searches.

f. Students are facilitated and encouraged to interact with other students when constructing solutions, obtaining data, and reasoning to answer problems. experimental conclusions that can be drawn.

g. Solutions to problems that have been prepared by students must be evaluated and validated through discussion activities and connected with various information obtained from internet networks.

h. Discussion activities involve social activities through dialogue activities, collaborative group discussions, students are involved in activities of asking questions, positioning data, building solutions and explanations, as well as proposing, criticizing and evaluating ideas between students.

The main features of the OOPL model can be reviewed based on syntax. Syntax logically describes a series of teacher and student activities which are often referred to as phases. Syntax explains in detail how to start learning, how to present information including managing learning, the parts of information that must be presented, and how to end learning. The OOPL model was developed referring to the inquiry process proposed and is supported by several learning theory views, especially cognitive, constructivist and connectivism learning theories. The OOPL model consists of six phases. Each phase of the learning model is equally important in achieving learning goals. Therefore, the six phases are designed to be related to each other. The first phase is identification of contextual problems, the second phase is collecting information and data, the third phase is representing data, the fourth phase is data-based connection and reasoning, the fifth phase is presenting contextual problem solutions, and the sixth phase is analysis and evaluation of the contextual problem solution process. An illustration of the five-phase flow in the OOPL model syntax is shown in **Figure 1**.

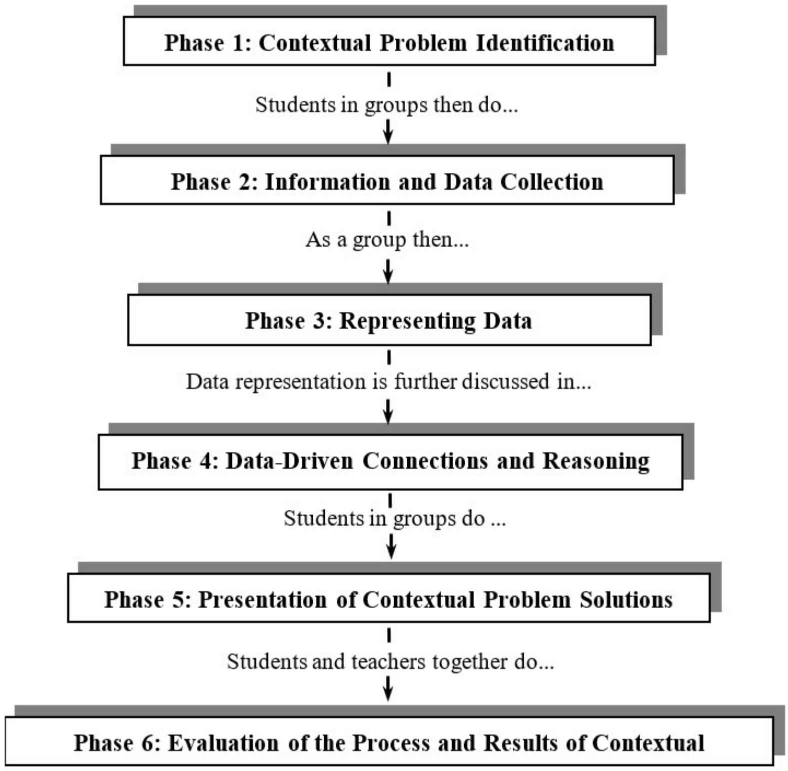

Figure 1. Stages of the OOPL model.

Based on the characteristics of the model and model components, an OOPL model book was prepared which contains a description of the characteristics of the model and model components, including aspects of model development needs, aspects of model novelty, OOPL model rationale, theoretical and empirical support, model syntax, social systems, reaction principles, system supporting, as well as instructional impact and accompanying impact. The model book has been validated by three learning experts and the validation results are shown in **Table 2**.

Table 2. Expert validation results.

Aspect	Score Validation	Validity Criteria	Reliability Score	Reliability Criteria
Content Validity:				
Needs Aspect	3.84	Very Valid	93.0%	Reliable
Novelty Aspect	3.67	Very Valid	86.0%	Reliable
Construct Validity:				
Rational Learning Model	3.50	Very Valid	86.0%	Reliable
Theoretical and Empirical Support	3.92	Very Valid	96.5%	Reliable
Learning Syntax	3.79	Very Valid	97.0%	Reliable
Social Systems	3.96	Very Valid	98.0%	Reliable
Reaction Principles	3.40	Very Valid	93.0%	Reliable
Support System	3.62	Very Valid	95.0%	Reliable
Instructional Impact and Accompanying Impact	3.55	Very Valid	95%	Reliable

The practicality of the OOPL learning model developed to improve learning outcomes and data literacy of high school students in physics learning is shown in **Table 3**.

Table 3. Data practicality results.

Learning Activities	Score	Stdv
Learning 1	3.17	0.41
Learning 2	3.33	0.52
Learning 3	3.50	0.55
Learning 4	3.33	0.52
Learning 5	3.83	0.41
Learning 6	3.83	0.41
Learning 7	3.83	0.41

Practicality tests were carried out on models developed involving students. Practicality tests are obtained through student learning outcomes and data literacy through pre-tests and post-tests on student learning outcomes and data literacy.

5. Discussion

5.1. Review of the basic theory of learning in the OOPL model

The characteristics of the learning model for teaching physics and data literacy that was developed and named the OOPL model were formulated based on the results of theoretical studies and analysis carried out at the model development stage. The learning model developed refers to cognitive psychology theory and constructivist learning theory. The cognitive theory view of learning is characterized by changes in thinking involved in learning. Cognitive theory emphasizes the importance of mental processes that underlie the processing of new information or connecting new concepts with previous knowledge. Cognitive theory defines learning as a change in mental structure that occurs as a result of an individual's interaction with their environment. The learning process occurs in individual thinking, where different individuals will construct different knowledge even though they interact with the same environmental conditions. Teachers who hold cognitive theory views will tend to adapt their learning activities to the needs of each individual. Teachers monitor students' thinking processes by using open-ended questions that require students to learn and provide explanations and reasoning.

Cognitive learning theory looks to information processing models to describe how cognitive systems receive input from the environment, process new information, and build knowledge by integrating new information and previous knowledge. According to this theory, the learning process is no different from the process of receiving, storing and expressing previously received information. Information processing refers to how we collect or receive stimuli from the environment, organize data, solve problems, discover concepts, and use verbal and visual symbols. Symptoms related to learning can be explained by viewing the learning process as a process of transforming input into output. In learning, there is a process of receiving information, which is then processed to produce an output in the form of learning outcomes. Information processing occurs when there is an interaction between an individual's internal conditions and external conditions and ultimately results in changes in behavior. Internal conditions are conditions within the individual that are needed to achieve learning outcomes and cognitive processes within the individual, while external conditions are stimuli from the environment that influence the individual in the learning process.

The constructivist theoretical view of learning is that learning science includes thinking and explaining nature; conveying knowledge to others for a specific purpose, and reasoning to support knowledge claims. For this reason, studying physics involves investigative activities, analyzing physics data, reasoning about data, and conveying the results of physics data analysis through social and personal processes. The social process in learning physics includes the use of concepts, language, representation, and scientific inquiry. This process requires guidance from other people who have better abilities. The personal process of learning involves the process of building knowledge and understanding by thinking. Teachers believe that knowledge must be built by students and not transferred by teacher to students (Slavin, 2018).

According to the view of social constructivist theory, students build their knowledge through social interactions with teachers or other students thus providing opportunities for students to evaluate each other and improve their understanding by expressing ideas and sharing understanding with other students. In their learning, students use everyday language through discussion activities and use various representations of physics data as the main component in making connections and testing the validity of their knowledge. Based on the social constructivist view, there are several important components for the learning process to occur, namely the Zone of Proximal Development (ZPD), scaffolding, cognitive apprenticeship, and cooperative learning.

5.2. Overview of OOPL model syntax

The first phase is contextual problem identification. This phase is designed to arouse students' curiosity and interest in what will be learned and students are challenged to solve problems posed by the teacher. In order to arouse curiosity and interest in learning, students must pay attention (ARCS theory) One way to stimulate students' attention is through stimulating inquiry, namely stimulating curiosity by posing contextual problems. Piaget stated that a person is challenged to face new experiences compared to the knowledge schema they already have. The problems posed to students can be real problems that often occur in everyday life so that they can arouse curiosity and motivate them to find answers. Research results show that students who are cognitively involved in defining a problem will be actively involved in the subsequent learning process.

The second phase of the model developed is collecting information and data. In this phase, students work in collaborative groups to carry out data acquisition activities that are used to develop reasoning and answer the problems posed in the first phase. The number of students in the group is 4 to 6 heterogeneous students. Collaborative groups are defined as groups of students who work together to achieve a common goal. In order to teach science from a social constructivist perspective, learning through laboratory activities can be designed to help students learn. Data acquisition does not have to be done through hands-on activities but can also be done through mind-on activities through library searches. Teachers design data acquisition activities through various strategies such as experiments, demonstrations, or library searches, depending on the availability of learning resources at school.

The purpose of the information and data collection phase is to provide students with the opportunity to learn how to obtain information and data through investigative activities so that they understand how the science process works. The most appropriate nature of investigation is guided inquiry because each group must choose the right way to obtain the desired data to answer the problem. Teachers can change the level of assistance gradually or scaffolding in the form of structured worksheets and guiding questions so that all students in the group can carry out investigative activities. Students who are more skilled at conducting investigations can provide cognitive apprenticeship for other students who do not yet have the skills. The data collection phase also allows students to have scientific experience by applying scientific methods so that an attitude of thoroughness, honesty, politeness, respect for other people's opinions, communication skills, and applying the ability to collect information through various means will be instilled. The research results show that student involvement in activities to obtain data and interpret data can provide opportunities for discussions, reviews and clarifying problems and inquiry processes.

The third phase is representing the data. In this phase students must present the information and data obtained in the second phase in the form of various representations. Data can be converted into tables, graphs, mathematical formulas, symbols and verbal representations. Data representation is an important part in explaining natural phenomena because data obtained through the investigation process is an important element in learning science. Apart from that, the physics learning objectives stated in the phase E learning outcomes in the independent curriculum also support this activity. It is stated that students must have the ability to be responsive to global issues and play an active role in providing problem solutions. These abilities include processing and analyzing data and information. The third phase was designed with the aim of emphasizing the importance of representing data resulting from scientific investigations in science. Students must understand that previous scientists conducted investigations and were able to provide explanations and conclusions about science accompanied by empirical evidence support. This third phase is also to help students write down the results of investigations and analyze the data obtained. Research results show that the use of multiple representations in physics learning can help students document natural phenomena increase interest, curiosity and learning outcomes as well as developing students' critical thinking.

The fourth phase is data-based connection and reasoning. In this phase, students connect various data representations obtained in the third phase with various contextual physics events that occur in everyday life. Students can obtain contextual physics events by exploring them using connections on the internet, encyclopedias, videos, popular articles, scientific articles, and books that discuss contextual physics events. The various events obtained are linked to data and data representation by providing scientific reasoning on how the data and data representation relate to the contextual physics events obtained by students. Students will be more interested in learning when given the opportunity to explore their ideas when related to real events they have experienced or seen. Research results show that learning associated with contextual application can not only open students' imagination and increase their cognitive development but can also increase learning motivation, increase students' interest in carrying out more applications in authentic contexts.

The fifth phase is presenting solutions to contextual problems. In this phase, each group is given the opportunity to present the results of scientific investigations and solutions to contextual problems to other groups. Other groups were given the opportunity to provide criticism of the results of the investigation and solutions to contextual problems as well as the inquiry process that had been carried out. Students are more interested in learning when given the opportunity to convey their ideas to other students, respond to other students' questions, provide evidence for their ideas, and evaluate the benefits of exchanging ideas. In this way, students have the opportunity to evaluate and improve the investigation process, analyze research data, contextual problem solutions, and conclusions obtained through discussion activities. Ability to evaluate the process and results of scientific investigations as well as solutions to contextual problems. The research results show that the lack of opportunities for students in exploratory talk activities contributes to the lack of success in reasoning activities about science.

The contextual problem solution presentation phase is designed so that students have the opportunity to provide feedback on the entire process of scientific investigation and the results of agreed problem solving, thereby helping students develop their metacognitive abilities. This phase is also designed to create an attitude of respect for work results and critical thinking in the classroom and to create a learning environment that requires students to be responsible for the quality of the agreed conclusions. Students also have the opportunity to develop the ability to analyze, evaluate and conclude knowledge so that they have the ability in self-regulated learning, namely knowledge about effective strategies and how and when to use them. At the end of this phase, the teacher must provide feedback by providing corrections and strengthening the process and results of problem solving that have been agreed upon so that students can reach the upper limit of the ZPD. Feedback must be given specifically and as soon as possible because without feedback students will gain little knowledge.

The sixth phase is evaluating the process and results of problem solutions. This phase is designed so that students have the opportunity to provide feedback on the entire process of investigation, data representation, reasoning about data, and the results of agreed problem solving so that it can help students develop their metacognitive abilities. This phase is also designed to create an attitude of respect for evidence and critical thinking in the classroom and to create a learning environment that requires students to be responsible for the quality of agreed conclusions and reasoning. Students also have the opportunity to develop the ability to analyze, evaluate and conclude knowledge so that they have the ability in self-regulated learning, namely knowledge about effective strategies and how and when to use them. At the end of this phase, the teacher can provide feedback by providing corrections and strengthening the agreed problem-solving results so that students can reach the upper limit of the ZPD. Feedback must be given specifically and as soon as possible because without feedback students will only gain little knowledge.

Practicality in learning physics at school refers to students' learning conditions and data literacy. The learning model used can be easily developed by teachers and easily understood by students. In this practical aspect, the learning model is seen from the time available, the model used, and the suitability of the model to the student's development and experience. Apart from that, this model is also very practical and suits educators and is able to facilitate students to understand the material through the model developed.

6. Conclusion

A physics learning model that is oriented to physics objects which are represented in various modes and is called the Object-Oriented Physics Learning Model (OOPL). The learning model was developed through several stages. The first stage is identification of contextual problems. The second stage of the model developed is collecting information and data. The third phase is representing the data. The fourth phase is data-based connection and reasoning. The fifth phase is to present solutions to contextual problems. Presentation phase. Contextual problem solving is designed so that students have the opportunity to provide feedback on the entire process of scientific investigation and the agreed results of problem solving, thereby helping students develop their metacognitive abilities. The sixth stage is an evaluation of the process and results of problem solving and based on the results of the validity analysis, it shows that the OOPL model is included in the valid category. The OOPL model fulfills the elements of content validity and construct validity. The validity of the OOPL model and its implications are discussed in detail in the discussion. Practicality tests are obtained through student learning outcomes and data literacy through pre-tests and post-tests on student learning outcomes and data literacy. In the practicality test, the average score obtained from the first and last learning was 3.35 with a standard deviation of 0.46. Based on expert validation data from several aspects, the validation value ranged from 3.50 to 3.96 with a reliability score range of 86.0%—97.0% with very valid validation criteria.

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References

Anjani, F., Supeno, S., Subiki, S. (2020). Scientific reasoning ability of senior high school students in physics learning using guided inquiry model accompanied by multidimensional thinking diagram (Indonesian). Lantanida Journal, 8(1), 13. https://doi.org/10.22373/lj.v8i1.6306

Areepattamannil, S. (2012). Effects of Inquiry-Based Science Instruction on Science Achievement and Interest in Science: Evidence from Qatar. The Journal of Educational Research, 105(2), 134–146. https://doi.org/10.1080/00220671.2010.533717

Cairns, D., Areepattamannil, S. (2017). Exploring the Relations of Inquiry-Based Teaching to Science Achievement and Dispositions in 54 Countries. Research in Science Education, 49(1), 1–23. https://doi.org/10.1007/s11165-017-9639-x

Capraro, R. M., Capraro, M. M., Morgan, J. R. (2013). STEM Project-Based Learning. Sense Publishers. https://doi.org/10.1007/978-94-6209-143-6

Chen, C. H., Chen, C. Y. (2012). Instructional approaches on science performance, attitude and inquiry ability in a computer-supported collaborative learning environment. Turkish Online Journal of Educational Technology, 11(1), 113–122.

Cobb, G. W., Moore, D. S. (1997). Mathematics, Statistics, and Teaching. The American Mathematical Monthly, 104(9), 801–823. https://doi.org/10.1080/00029890.1997.11990723

de Jong, T., Lazonder, A. W. (2014). The Guided Discovery Learning Principle in Multimedia Learning. The Cambridge Handbook of Multimedia Learning, 371–390. https://doi.org/10.1017/cbo9781139547369.019

Ebbeler, J., Poortman, C. L., Schildkamp, K., et al. (2016). The effects of a data use intervention on educators' satisfaction and data literacy. Educational Assessment, Evaluation and Accountability, 29(1), 83–105. https://doi.org/10.1007/s11092-016-9251-z

Erwin, R. (2015). Data literacy: real-world learning through problem-solving with data sets. American Secondary Education, 43(2), 18–26.

Frank, M., Walker, J., Attard, J., et al. (2016). Data Literacy—What is it and how can we make it happen? The Journal of Community Informatics, 12(3). https://doi.org/10.15353/joci.v12i3.3274

Giambattista, A., Richzrdson, B. M. Richardson, R. C. (2010). Physics, 2nd ed. New York: McGraw-Hill.

Gummer, E. S., Mandinach, E. B. (2015). Building a Conceptual Framework for Data Literacy. Teachers College Record: The Voice of Scholarship in Education, 117(4), 1–22. https://doi.org/10.1177/016146811511700401

Jerrim, J., Oliver, M., Sims, S. (2019). The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England. Learning and Instruction, 61, 35–44. https://doi.org/10.1016/j.learninstruc.2018.12.004

Karaçalli, S., Korur, F. (2014). The Effects of Project-Based Learning on Students' Academic Achievement, Attitude, and Retention of Knowledge: The Subject of "Electricity in Our Lives." School Science and Mathematics, 114(5), 224–235. Portico. https://doi.org/10.1111/ssm.12071

Ketelhut, D. J., Nelson, B. C., Clarke, J., et al. (2009). A multi-user virtual environment for building and assessing higher order inquiry skills in science. British Journal of Educational Technology, 41(1), 56–68. https://doi.org/10.1111/j.1467-8535.2009.01036.x

Kirschner, P. A., Sweller, J., Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educational Psychologist, 41, 75–86. https://doi.org/10.1207/s15326985ep4102_1

Lazonder, A. W., Harmsen, R. (2016). Meta-Analysis of Inquiry-Based Learning. Review of Educational Research, 86(3), 681–718. https://doi.org/10.3102/0034654315627366

Mandinach, E. B. (2012). A Perfect Time for Data Use: Using Data-Driven Decision Making to Inform Practice. Educational Psychologist, 47(2), 71–85. https://doi.org/10.1080/00461520.2012.667064

Mandinach, E. B., Gummer, E. S. (2013). A Systemic View of Implementing Data Literacy in Educator Preparation. Educational Researcher, 42(1), 30–37. https://doi.org/10.3102/0013189x12459803

Pedaste, M., Mäeots, M., Leijen, A., Sarapuu, T. (2012). Improving students’ inquiry skills through reflection and self-regulation scaffolds. Technology, Instruction, Cognition and Learning, 9, 81–95.

Pedaste, M., Sarapuu, T. (2012). Design principles for support in developing students’ transformative inquiry skills in Web-based learning environments. Interactive Learning Environments, 22(3), 309–325. https://doi.org/10.1080/10494820.2011.654346

Reeves, T. D., Honig, S. L. (2015). A classroom data literacy intervention for pre-service teachers. Teaching and Teacher Education, 50, 90–101. https://doi.org/10.1016/j.tate.2015.05.007

Rubin, A. (2005). Math that matters. Hands On: A Journal for Mathematics and Science Educators, 28(1), 3–7.

Ruiz-Primo, M. A., Li, M., Tsai, S., et al. (2010). Testing one premise of scientific inquiry in science classrooms: Examining students’ scientific explanations and student learning. Journal of Research in Science Teaching, 47(5), 583–608. Portico. https://doi.org/10.1002/tea.20356

Schildkamp, K., Karbautzki, L., and Vanhoof, J. (2014). Exploring data use practices around Europe: Identifying enablers and barriers. Studies in Educational Evaluation, 42, 15–24. https://doi.org/10.1016/j.stueduc.2013.10.007

Škoda, J., Doulík, P., Bílek, M., et al. (2015). The effectiveness of inquiry-based science education in relation to the learners´ motivation types. Journal of Baltic Science Education, 14(6), 791–803. Internet Archive. https://doi.org/10.33225/jbse/15.14.791

Supeno, Astutik, S., Bektiarso, S., et al. (2019). What can students show about higher order thinking skills in physics learning? IOP Conference Series: Earth and Environmental Science, 243, 012127. https://doi.org/10.1088/1755-1315/243/1/012127

Suryadi, Mahardika, I. K., Sudarti, S., Sudarti, S. (2020). Data literacy of high school students on physics learning. Journal of Physics Conference Series.

Tsai, C.W., Lee, T.H., Shen, P.D. (2013). Developing long-term computing skills among low-achieving students via web-enabled problem-based learning and self-regulated learning. Innovations in Education and Teaching International, 50(2), 121–132. https://doi.org/10.1080/14703297.2012.760873

Vahey, P., Yarnall, L., Patton, C., et al. (2006). Mathematizing middle school: Results from a cross-disciplinary study of data literacy. In Annual Meeting of the American Educational Research Association.

Wayman, J. C., Jimerson, J. B. (2014). Teacher needs for data-related professional learning. Studies in Educational Evaluation, 42, 25–34. https://doi.org/10.1016/j.stueduc.2013.11.001

Wicaksono, I., Supeno, S., Budiarso, A. S. (2020). Validity and Practicality of the Biotechnology Series Learning Model to Concept Mastery and Scientific Creativity. International Journal of Instruction, 13(3), 157–170. https://doi.org/10.29333/iji.2020.13311a

Wolff, A., Gooch, D., Cavero Montaner, J. J., et al. (2016). Creating an Understanding of Data Literacy for a Data-driven Society. The Journal of Community Informatics, 12(3). https://doi.org/10.15353/joci.v12i3.3275

Wong, K. K. H., Day, J. R. (2008). A Comparative Study of Problem-Based and Lecture-Based Learning in Junior Secondary School Science. Research in Science Education, 39(5), 625–642. https://doi.org/10.1007/s11165-008-9096-7

Yamin, S., Masek, A. (2011). The effect of problem-based learning on critical thinking ability: A theoretical and empirical review. International Review of Social Sciences and Humanities, 2(1), 215–221.

Yoon, H.-G., Joung, Y. J., Kim, M. (2011). The Challenges of Science Inquiry Teaching for Pre-Service Teachers in Elementary Classrooms: Difficulties on and under the Scene. Research in Science Education, 42(3), 589–608. https://doi.org/10.1007/s11165-011-9212-y