



# The Development of Project-Based Learning Models That Accommodate the Reflective and Impulsive Cognitive Style

\*I Cintamulya<sup>1</sup>, Warli<sup>2</sup>, L Mawartiningsih<sup>1</sup>

<sup>1</sup>Department of Biology Education, Faculty of Teacher Training and Education, University of PGRI Ronggolawe, Indonesia

<sup>2</sup>Department of Mathematics Education, Faculty of Teacher Training and Education, University of PGRI Ronggolawe, Indonesia

## Article Info

### Article history:

Received July 6, 2023

Revised January 22, 2024

Accepted February 10, 2024

Available Online April 30, 2024

### Keywords:

Cognitive style;

Impulsive;

Model of learning;

Project-based;

Reflective;

Team project;

## ABSTRACT

Ideally, a teacher must choose a learning model, approach, method, or technique that suits the student's learning style. This research describes the design of a project-based learning (PjBL) model that accommodates reflective and impulsive cognitive styles. For this reason, development research was carried out using the Plomp model. To determine the quality of the results of PjBL development that accommodates reflective and impulsive cognitive styles, validity, practicality, and effectiveness tests were carried out. Based on the results of the validity test analysis, it was concluded that content validity was very good, while construct validity was good. The results of the practicality test concluded that the syntax and social system were declared good, while the reaction and management principles were declared very good. For the effectiveness test results, it was concluded that teacher and student activities were good, learning management abilities were stated to be very good, student responses to learning components and processes were stated to be good, and learning outcome tests were also good. Overall, it can be concluded that the PjBL model, which accommodates reflective and impulsive cognitive styles, is good and suitable for use. The research results imply that this model can be used as a choice for teachers in learning.

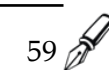


<https://doi.org/10.46627/silet>

## INTRODUCTION

One of the tasks of an educator is to design innovative learning to facilitate the learners in understanding the concept of a subject and develop high-level thinking skills like critical thinking, creative thinking, and problem-solving. Project-based learning (PjBL) is a model of learning that organizes classes in a project (Thomas, 2000; Karimah et al., 2020; Rohana et al., 2023). According to the Department of Education of New York City (Safaruddin et al., 2020), PjBL is a learning strategy, in which students must build their knowledge and demonstrate new understanding through various forms of representation. George Lucas Educational Foundation (2007) defines it as a dynamic learning approach, in which students actively explore problems in the real world, provide challenges, and gain deeper knowledge.

Learning in science emphasizes processing skills (Özer & Özkan, 2012; Damayanti et al., 2023) and gives the students experience in combining their preliminary knowledge with a new one. When students are in the learning process, the teacher facilitates learning activities so that the student's new concepts are formed following the established concepts. The 2013 curriculum presented a benchmark in the selection of learning models based on empirical methods, such as



PjBL, problem-based learning (PBL), or discovery learning. PjBL is a creative learning approach that teaches many primary strategies for success in the 20<sup>th</sup> century (Bell, 2010).

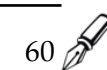
Several learning models developed such as cooperative learning models, PBL, and PjBL ignore students' cognitive styles. This cognitive style is a characteristic of thinking that is permanent in a student. Hence, to develop a learning model that is oriented towards improving critical, creative, collaborative thinking, communication and problem solving, is best to pay attention to cognitive style. For this reason, it is necessary to develop a learning model that accommodates the qualities of reflective and impulsive cognitive styles.

PjBL in science can shape the student's attitudes and actions towards the environment (Kılınç, 2010; Tseng et al., 2013), analytical thinking skills (Özer & Özkan, 2012; Arifin et al., 2020), and successful learning (Cook et al., 2012; Movahedzadeh et al., 2012; Yarno et al., 2022). When faced with real-world questions, high school students' exploration process can help them to develop in other disciplines as the student has a different way of learning. For this reason, the formation of learning communities should not only pay attention to their academic achievements but also the student's thinking and learning process.

Some educators and teachers are confused about how to distinguish the PBL and the PjBL model. Perrenet, Bouhuijs, and Smits (2000), and Afriana (2016) revealed the differences between PjBL and PBL, which are: a) the projects undertaken by students require a long time to complete compared to the implementation of PBL; b) PjBL emphasizes the application of knowledge, whereas students emphasize the knowledge acquisition in PBL; c) PjBL usually combines several disciplines, while PBL is usually confined in one subject; d) the management in obtaining information sources and time are remote in PjBLs, and e) the self-direction in PjBL is more prominent than in PBL.

According to Guo et al. (2020) PjBL is understood as a promising approach that improves student learning in higher education. According to Tamim and Grant (2013), PjBL is an educational model focused on a constructivist approach to learning that involves knowledge building from many perspectives, encourages self-awareness to learn, and learns in a non-free sense. Meanwhile, Kokotsaki et al. (2016) stated that PjBL is a form of student-centered active teaching characterized by student autonomy, constructive inquiry, goal setting, collaboration, communication, and reflection in real-world practice. Krajcik & Shin (2014) also stated that PjBL refers to an inquiry-based learning method that involves students in knowledge construction by asking them to complete meaningful projects and develop real-world products. Project-based learning, problem-based learning, discovery learning, and guided inquiry are learning models recommended in Curriculum 13. According to Anazifa & Djukri (2017), the application of the PjBL model, PBL is expected to be able to develop students' skills, especially students' thinking skills, creativity, and critical thinking. In addition, learning activities that are relevant to learning in the 21st century are project-based learning and problem-based learning. Krajcik and Shin (2014) showed six advantages of PjBL, including driving questions, focus on learning objectives, participation in educational activities, collaboration between students, use of scaffolding technology, and creation of real artifacts.

The five learning criteria of PjBL according to Thomas (2000) and Afriana (2016) are: a) the project is central, not peripheral to the curriculum; b) PjBL projects focus on questions or problems that encourage students to learn subjects' concepts and basic principles; (c) the projects include students in the constructivism inquiry; (d) the projects are student-driven to a degree; and (e) the projects are practical. Based on these criteria, it is clear that PjBL is developing the students to think more critically and creatively to solve problems with the teacher's guidance. The characteristics of PjBL are improving students' thinking skills, allowing them to be innovative, inspiring them to work together, guiding them to access knowledge, and eventually displaying the collection of information. According to Hakkarainen (2008) and Afriana (2016) PjBL provides a strong model to help students gain more knowledge and skills,



and the students can benefit from technology-based learning, such as computer simulations in science and mathematics.

**Table 1.** The syntax of project-based learning models

| Syntax | The George Lucas Education Foundation and Doppelt       | Laboy-Rush with STEM | Doppelt with CDP                |
|--------|---------------------------------------------------------|----------------------|---------------------------------|
| 1      | Starting with an essential question                     | Reflection           | Design Purpose                  |
| 2      | Designing a project                                     | Research             | Inquiry (Field of Inquiry)      |
| 3      | Creating a schedule                                     | Discovery            | Solution Alternatives           |
| 4      | Monitoring the students and the progress of the project | Application          | Choosing the Preferred Solution |
| 5      | Assessing the outcome                                   | Communication        | Operation Steps                 |
| 6      | Evaluation                                              |                      | Evaluation                      |

Some experts are implementing PjBL syntax based on its use. First, the PjBL phase was developed by two experts, the George Lucas Education Foundation and Doppelt, who introduced six phases of PjBL. According to Surahman et al. (2019), the Start with Essential Question stage is the stage of preparing questions that are not easy to answer and can direct students to create projects. Questions like these are generally divergent, provocative, challenging, require high-level thinking, and relate to students' lives. Secondly, the STEM (Science, Technology, Engineering, and Mathematics) learning cycle. PjBL's guide for students consists of five steps and each step is aimed to achieve a specific process. Characteristics of STEM project-based learning where students are invited to carry out meaningful learning in understanding a concept. Students are invited to explore through project activities, so that students are actively involved in the process. (Asih et al, 2020). One specialist who studied the PjBL syntax was Doppelt (2005), who created a different PjBL syntax from the George Lucas Education Foundation. According to Bertrand and Namukasa (2023) Creative Design Process (CDP) is built on a design-based learning model where students plan and design prototypes which they test and redesign. The results of put more emphasis on the CDP, which has six stages design process (Table 1).

Looking at some of the syntax expressed by experts, the author has the idea to combine various syntaxes according to the course's learning outcomes, the characteristics of the course, and the characteristics of the students. The modified syntax will accommodate various cognitive styles, especially the reflective and impulsive cognitive styles. Warli and Fadiana (2015) showed that the development of mathematical learning models that accommodate reflective and impulsive cognitive styles could improve the student's mathematical problem-solving skills. Reflective students are slow in making decisions but have accurate results. While impulsive children are fast in making decisions but inaccurate. Accommodating both styles does not mean changing the cognitive style, because it is impossible to change them. Thus, it aims to complement each other, which means reflective students can collaborate with impulsive students to accelerate their decision-making while still maintaining good accuracy.

Referring to the explanation above, the syntax can be defined as the following:

**Phase 1:** Designing a purpose. The first step in designing the method is to define the conceptual issue by paying attention to the learning achievements. The four important steps are: a) The problem and the need. The students describe their motivation in choosing the project. They also set the problems and determine the needs to find the solutions; b) The target clientele and restrictions. The students describe the target clientele and determine the restrictions they take into consideration; c) The goal design. The students determine the demand for the needs they expect. d) Learning outcomes. The project's objectives must include learning outcomes.



**Phase 2:** Learning begins with the basic questions that students may be asked to carry out the activity. The questions are organized by discussing the real-world problem and beginning with an in-depth inquiry. The questions are arranged to be challenging to answer and can lead students to do the projects. Such questions are generally open, divergent, provocative, challenging or require high-order thinking skills to solve, and are related to the student's life.

**Phase 3:** Team project based on cognitive style (reflective and impulsive). In the third phase, a team will be formed based on the cognitive style, academic ability, and sex of the student before working on the project. Warli (2013) developed the Matching Familiar Figures Test (MFFT) to determine the cognitive style of the student. Cognitive measurement is only done once because a student's cognitive style is consistent.

**Phase 4:** Project design. This step allows the students to make decisions about various possibilities or creative ideas that they never tried before. The students are taught and guided in the thought analysis, weighing all causes, outcomes, implications, and viewpoints of others, and work step by step.

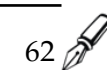
**Phase 5:** The teacher is responsible for monitoring the student activities during the project. Monitoring is done by facilitating the participation of students in each process. A section is developed that can document all essential activities in the monitoring process.

**Phase 6:** The assessment of the project's results. The evaluation is conducted to help teachers evaluate the students' abilities, determine the success of each student, provide input, and assist the teachers in planning the next learning plan. Presentation is an important step in the learning process to improve communication and teamwork as well as the ability to embrace and apply positive feedback.

**Phase 7:** The assessment of the experience. At the end of the learning process, teachers and students reflect on the projects' activities and the results of the projects. The cycle of contemplation is carried out both individually and in groups. At this stage, the students are asked to express their feelings and experiences as they complete the project. Teachers and students are developing discussions to improve performance during the learning process so that a new inquiry can be found to address the problems raised during the first stage of learning.

Cognitive style is a consistent aspect, so it is better to accommodate students' differences in thinking by designing a teaching model or method. Thus, the established model can minimize the student's learning difficulties (Warli & Fadiana, 2015). Moreover, (Riding & Rayner, 2013) revealed that a person's style defines how he or she performs learning tasks. It consists of two fundamental aspects, cognitive style, which reflects how people think individually, and learning strategies, which reflect the processes to respond to the demands of learning activities. According to Warli and Fadiana (2015), the learning strategy will change when the needs change, but not the cognitive style. Riding and Rayner (2013) said that the cognitive style of the individual is the way an individual is built and responds automatically to knowledge and circumstances. It may occur at birth and may affect the various functions of the organism. The cognitive style of a person is a defining feature of learning achievement and affects the general achievement of an individual in a learning situation.

This research concentrated on the analytical and impulsive cognitive style suggested by Jerome Kagan. Kagan & Kogan (1970), and Ubuz & Aydıner (2019) described reflective impulsivity as the degree of the subject's accuracy in the problem-solving mechanism, which includes the uncertainty of the response. Rozencajg and Corroyer (2005), and Warli (2013) described the impulsive reflective cognitive style as the nature of cognitive systems that combine their time to make decisions and work to solve problems that involve a high degree of uncertainty.



The time dimension is divided into two (fast and slow) and the uncertainty dimension of answering is divided into two, namely careful/precise (low frequency of answering) and incorrect/unprecise (high frequency of answering). In addition, the students can be divided into four groups: 1) quick and careful/precise; 2) slow and careful/precise or reflective; 3) quick and not careful/precise or impulsive; and 4) slow and not careful/precise. The students who answer questions quickly but are less careful tend to have wrong answers. That kind of student has an impulsive cognitive style. Students who are slow to answer but are attentive tend to have the right answers. What kinds of students are called cognitive and analytical types (Warli, 2009; Warli & Fadiana, 2015). Cognitive style analysis is commonly applied in the field of education, where the purpose of the study is to understand the differences in the learning process (Kozhevnikov, 2007; Rindrayani & Hairunisya, 2022).

Looking at the definition above, it is important to establish a reflective vs impulsive cognitive style-based learning model to enhance the student's critical thinking skills. The main objective of this research is to establish a project-based learning model that reacts to reflective and impulsive cognitive styles and has certain qualities (valid, practical, and effective).

### Research Question

The research question in this study is how to develop a project-based learning model that accommodates the qualities of reflective and impulsive cognitive styles (valid, practical, and effective).

### Research Purpose

- a. Produce project-based learning models that accommodate the quality of reflective and impulsive cognitive styles (valid, practical, and effective).
- b. Produce the supporting tools in the project-based learning models that accommodate the quality of reflective and impulsive cognitive styles (valid, practical, and effective).

### RESEARCH METHOD

This study used Plomp and Nieveen's (2013) method, including the initial assessment phase, the method phase, the implementation or construction phase, the testing, evaluation, and revision phase, and the implementation phase. The study was conducted at the Biology Education Study Program, Faculty of Teacher Training and Education, University of PGRI Ronggolawe, Tuban Indonesia.

As many as 25 students, who took the Plant Development course, were the participants in the study. They were assessed for their cognitive style. The Matching Familiar Figures Test (MFFT) instrument developed by Warli (2013) was used to measure the participant's cognitive styles. Based on the measurement, the participants were grouped into four: fast/accurate, impulsive, slow/inaccurate, and reflective. The students who have a reflective or impulsive cognitive style and are fast/accurate or slow/inaccurate were included in the study, while the students whose data are on the median line or undetermined cognitive style were excluded. The result was that 18 students had a reflective and impulsive cognitive style, nine students had a reflective cognitive style, and nine students were impulsive. The rest were included in the fast but accurate group and the slow but inaccurate.

The selection of 18 students was based on the grouping need in learning, namely reflective and impulsive student groups. There are four groups with four to five participants. Two groups had two reflective students and two impulsive students. Two other groups of five had fast/accurate, impulsive, reflective, and slow/inaccurate students. The grouping of different cognitive styles aims to help the students during the discussion and help each other's weaknesses. An impulsive student can help the reflective student to respond more quickly to problems but not reduce the accuracy of his thinking. Conversely, reflective students can help



impulsive students to be more careful in answering problems without reducing the speed of thought.

The syntaxes of PjBL models that accommodate reflective and impulsive cognitive styles are the following: 1) design purpose; 2) learning begins with essential questions that can assign the students to carry out an activity; 3) team project was based on cognitive style (reflective and impulsive); 4) project design; 5) the teacher is responsible for monitoring student activities while completing the project; 6) assessment of the project's results and 7) evaluation of the experience. Furthermore, a limited trial is conducted to get a good quality model. According to Nieveen (1999), validity, experience, and efficacy must be achieved to evaluate the standard of PjBL models.

To evaluate the consistency of the PjBL model with its supporting materials (teacher's books, student books, realistic books, and student's activity sheets (SAS)) and achieve the requirements of Nieveen (1999), and Rochmad (2012) some tests were needed (Table 2). Validity data analysis was obtained from the five validators. The model's practicality data was obtained from the observations of the implementation by two observers. Efficiency analysis provided the assessment of the five components of the study's effectiveness, namely the student learning outcomes, critical thinking skills, student behaviors, student reactions to learning, and the ability to navigate the learning process.

**Table 2.** Research instruments

| Indicator     | Rated Aspect         | Instrument             | Evaluator                      |
|---------------|----------------------|------------------------|--------------------------------|
| Validity      | Model Design         |                        |                                |
|               | Supporting Device    | Questionnaire          | Expert validator; five experts |
| Practicality  | Instrument           |                        |                                |
|               | Implementation Model | Observation sheet      | Observer; 2 persons            |
|               | Student Activities   | Observation sheet      | Observer; 2 persons            |
| Effectiveness | Student Response     | Questionnaire          | Researcher                     |
|               | Managing Learning    | Observation sheet      | Observer 2 people              |
|               | Learning outcomes    | Learning Outcomes Test | Researcher                     |

## Data Analysis

The data for validity, practicality, and effectiveness were analyzed descriptively and qualitatively. Validity data analysis of the PjBL model was done by 1) recapitulating validity assessment data; 2) finding the average validation results for each criterion; 3) finding the average of each aspect; 4) looking for a total average; and 5) determining the validity category of each criteria using the following categories: 1)  $1 \leq V_a \leq 2$  as invalid; 2)  $2 \leq V_a \leq 3$  is less valid; 3)  $3 \leq V_a \leq 4$  as fairly valid; 4)  $4 \leq V_a \leq 5$  as valid, and 5)  $V_a = 5$  as very valid (Hobri, 2010).

## RESULTS AND DISCUSSION

In the results and discussions, the results of the model will cover the model's validity, clarity, and effectiveness.

### Validity

Based on the assessment of five validators, it was found that the contents and constructs' validity for the PjBL model was concluded to be valid (Table 3).

The five validators found that the supporting devices for the PjBL model, including the teacher's books, student's books, practical books, and student activity sheets (SAS), were concluded to be very valid (Table 4).



**Table 3.** The validity of the developed learning models

| Validity   | No | Indicators                                  |     | Criteria   |
|------------|----|---------------------------------------------|-----|------------|
| Contents   | 1  | Supporting Theory                           | 4.3 | Valid      |
|            | 2  | Syntax                                      | 4.6 | Very Valid |
|            | 3  | Social System                               | 4.8 | Very Valid |
|            | 4  | Principles of Management Reaction           | 4.6 | Very Valid |
|            | 5  | Supporting System                           | 4.5 | Valid      |
|            | 6  | Instructional Impacts and Companion Impacts | 4.7 | Very Valid |
|            | 7  | Learning Implementation                     | 4.4 | Valid      |
|            | 8  | Learning Environment and Management Tasks   | 4.5 | Valid      |
|            | 9  | Evaluation                                  | 4.5 | Valid      |
| Average    |    |                                             | 4.5 | Valid      |
| Constructs | 1  | Model Components                            | 3.8 | Valid      |
|            | 2  | Supporting Theory                           | 4.4 | Valid      |
|            | 3  | Syntax                                      | 4.5 | Valid      |
|            | 4  | Social System                               | 4.4 | Valid      |
|            | 5  | Principles of Management Reaction           | 4.7 | Very Valid |
|            | 6  | Supporting System                           | 4.4 | Valid      |
|            | 7  | Instructional Impacts and Companion Impacts | 4.5 | Valid      |
|            | 8  | Learning Implementation                     | 4.6 | Very Valid |
|            | 9  | Learning Environment and Management Tasks   | 4.2 | Valid      |
|            | 10 | Evaluation                                  | 4.4 | Valid      |
| Average    |    |                                             | 4.4 | Valid      |

**Table 4.** Supporting devices analysis results

| Indicator                         | Teacher's Book |            | Student's Book |            | Practical Book |            | SAS     |            |
|-----------------------------------|----------------|------------|----------------|------------|----------------|------------|---------|------------|
|                                   | Average        | Criteria   | Average        | Criteria   | Average        | Criteria   | Average | Criteria   |
| Title                             | 3.63           | Very Valid | 3.62           | Very Valid | 3.68           | Very Valid | 3.70    | Very Valid |
| Preface                           | 3.63           | Very Valid | 3.63           | Very Valid | 3.61           | Very Valid | 3.68    | Very Valid |
| Description in each class meeting | 3.68           | Very valid | 3.72           | Very valid | 3.70           | Very valid | 3.72    | Very valid |
| Appropriateness of                | 3.77           | Very Valid | 3.70           | Very valid | 3.80           | Very valid | 3.78    | Very valid |
| Material/Content                  | 3.62           | Very Valid | 3.72           | Very valid | 3.65           | Very valid | 3.72    | Very valid |
| Presentation                      | 3.60           | Very Valid | 3.65           | Very valid | 3.68           | Very valid | 3.63    | Very valid |
| Language & Illustration           | 3.65           | Very Valid | 3.57           | Very valid | 3.67           | Very valid | 3.58    | Very valid |
| Evaluation                        | 3.77           | Very Valid | 3.82           | Very valid | 3.77           | Very valid | 3.67    | Very valid |
| Reference                         | 3.82           | Very Valid | 3.87           | Very valid | 3.77           | Very valid | 3.78    | Very valid |
| Other completeness                |                | Valid      |                | valid      |                | valid      |         | valid      |

The validity in a development study includes content and construct validity. Akker (1999) and Rochmad (2012) claimed that validity refers to the degree that which the intervention design is based on state-of-the-art information ("validity of content") and that the different components of the intervention are consistently connected ("validity of construction"). According to (Nieveen, 1999; Warli and Fadiana, 2015), the validity can be seen by whether the curriculum or learning model is developed based on the latest knowledge and whether the different components of the learning device are consistently interrelated. The developed

learning model is said to be valid if the model is based on adequate theories (content validity) and all components of the learning model are consistently related to each other (construct validity).

The content validation analysis showed that the developed model is based on a curriculum or learning model that has been developed with strong theoretical rationales. Construct validation showed the internal consistency between the components of the model, including the syntax, the social systems, the principle of reaction, the support systems, and the direct and indirect impacts. Based on the content and construct validation analysis, the average validation content was 4.5 (very good) and the average construct validation was 4.4 (good). Likewise, the validation analysis on supporting devices showed very valid criteria. This means that the developed project-based learning models that accommodate reflective and impulsive cognitive styles and supporting devices have met good validity. This finding is in line with the study of Warli and Fadiana (2015) about the validity test of a mathematics learning model that accommodates reflective and impulsive cognitive styles, which also obtained good validity.

### Practicality

Regarding the practicality, whether the teacher can carry out the classroom learning, the researcher and observers evaluated the teacher's activities in the learning implementation. Based on the observations, the average implementation of syntax was 4.38 (good), the social system was 4.42 (good), and the principle of reaction and management was 4.65 (very good) (Table 5).

**Table 5.** The expert's perception analysis of the model's implementation

| No  | Rated aspect                                                                                                                                                                        | X <sub>1</sub> | X <sub>2</sub> | X    |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|------|
| I   | Syntax                                                                                                                                                                              |                |                |      |
|     | 1. The level of implementation of all stages of learning                                                                                                                            | 4.00           | 4.25           | 4.13 |
|     | 2. The coverage of the important aspects of learning                                                                                                                                | 4.75           | 4.50           | 4.63 |
|     | 3. The sequence of learning activities will reflect a project-based learning model that accommodates reflective and impulsive cognitive styles to improve critical thinking skills. | 4.25           | 4.50           | 4.38 |
|     | Average                                                                                                                                                                             | 4.33           | 4.42           | 4.38 |
| II  | Social System                                                                                                                                                                       |                |                |      |
|     | 4. The level of implementation of the desired situation (group formation, discussion, asking, debating, submitting opinions, and mutual respect in work)                            | 4.25           | 4.75           | 4.55 |
|     | 5. The level of implementation of interaction in learning                                                                                                                           | 4.25           | 4.50           | 4.38 |
|     | 6. Teacher's behaviour embodies the principles and concepts of problem-solving in learning                                                                                          | 4.00           | 4.75           | 4.38 |
|     | 7. The level of social system implementation in learning                                                                                                                            | 4.00           | 4.75           | 4.38 |
|     | Average                                                                                                                                                                             | 4.12           | 4.69           | 4.42 |
| III | Principles of Reaction and Management                                                                                                                                               |                |                |      |
|     | 8. Teachers in accommodating and giving opportunities for students to ask questions, submit opinions and give responses                                                             | 5.00           | 4.50           | 4.75 |
|     | 9. Teacher's conduct gives scaffolding, support, guidance, and guiding student work                                                                                                 | 4.75           | 4.75           | 4.75 |
|     | 10. Teachers' behaviour motivates the linking of biological material with the completion of the given project                                                                       | 4.50           | 4.50           | 4.50 |
|     | 11. Teachers' behaviour involves students actively in learning                                                                                                                      | 4.75           | 4.50           | 4.63 |
|     | 12. Teachers facilitate students to learn                                                                                                                                           | 4.50           | 4.75           | 4.63 |
|     | Average                                                                                                                                                                             | 4.70           | 4.60           | 4.65 |

X<sub>1</sub> = Observer 1;

X<sub>2</sub> = Observer 2;

X = Average;



Regarding practicality, Akker (1999), and Rochmad (2012) stated that practically refers to the extent to which the user (or other experts) considers the intervention to be attractive and usable under 'normally' bad conditions. According to (Nieveen, 1999; Warli and Fadiana 2015), measuring the level of practicality is seen from whether the teacher and other experts consider that the material is easy and can be used by fellow teachers and students. The models are realistic if experts and practitioners claim that the model can be implemented in the field and that the level of implementation of the model belongs to the "nice" group.

The focus of the syntax component observation is whether it can be fully implemented by the teacher. While the social principal component and the stated reaction principle is whether the model is working well during classroom learning. Finally, the supporting system components are to see whether the supporting system ensures a smooth learning process.

The development of PjBL models that accommodate the reflective and impulsive cognitive styles and its supporting devices scored well in practicality criteria. This is in line with the results of the practical test in Warli and Fadiana's (2015) research on a mathematics learning model that accommodates reflective and impulsive cognitive styles obtained a good practicality criterion. It can be concluded that the developed PjBL model that accommodates reflective and impulsive cognitive styles can be well implemented.

### Effectiveness

The implementation of the model is said to be effective based on the following components: (1) student learning outcomes; (2) student activities; and (3) students' ability to understand teaching material. Based on the analysis, the student learning outcomes were 4.44 (good), student and teacher activities were 4.34 (good), teachers' ability to manage learning activities was 4.52 (very good), and the student's responses to the components and learning process was 4.33 (good) (Table 6).

**Table 6.** The expert's perceptions about the learning model's effectiveness

| No  | Rated aspect                                                                                                                                                    | X <sub>1</sub> | X <sub>2</sub> | X    |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|------|
| I   | Student learning outcomes                                                                                                                                       |                |                |      |
|     | 1. Mastery of content and students' performance.                                                                                                                | 4.00           | 4.25           | 4.13 |
|     | 2. Students' ability to solve problems                                                                                                                          | 4.25           | 4.50           | 4.38 |
|     | 3. Students' ability to collaborate                                                                                                                             | 4.75           | 4.50           | 4.63 |
|     | 4. Students' ability to communicate                                                                                                                             | 4.75           | 4.50           | 4.63 |
|     | Average                                                                                                                                                         | 4.44           | 4.44           | 4.44 |
| II  | Student and teacher activities                                                                                                                                  |                |                |      |
|     | 5. The quality of students' activities.                                                                                                                         | 4.25           | 4.00           | 4.13 |
|     | 6. The quality of teachers' activities.                                                                                                                         | 4.50           | 4.25           | 4.39 |
|     | 7. Student's activity in reconstructing knowledge through activation, discussion, asking questions, submitting opinions, debating, and presenting work results. | 4.50           | 4.50           | 4.50 |
|     | Average                                                                                                                                                         | 4.42           | 4.25           | 4.34 |
| III | The ability of teachers in learning management                                                                                                                  |                |                |      |
|     | 8. Teacher's ability to carry out the stages of learning.                                                                                                       | 4.25           | 4.75           | 4.50 |
|     | 9. Teachers' ability to master the teaching materials.                                                                                                          | 4.75           | 4.75           | 4.75 |
|     | 10. Teachers' ability to carry out learning with interactive educational patterns.                                                                              | 4.75           | 4.50           | 4.63 |
|     | 11. Teachers' ability to provide scaffolding in the form of assistance, guidance, and guiding student work.                                                     | 4.75           | 4.25           | 4.50 |
|     | 12. Teachers' ability to make students actively involved in learning with group work in solving problems.                                                       | 5.00           | 5.00           | 5.00 |
|     | 13. Teachers' ability to manage the time available for each stage of learning based on homework.                                                                | 4.00           | 4.25           | 4.13 |
|     | 14. Teachers' ability in providing motivation, reward, and punishment.                                                                                          | 4.50           | 4.25           | 4.38 |



|    | Average                                                                                                                 | 4.57 | 4.47 | 4.52 |
|----|-------------------------------------------------------------------------------------------------------------------------|------|------|------|
| IV | Student and teacher response to learning components and processes                                                       |      |      |      |
|    | 15.The opportunity for students to experience the benefits of a plant development course in life and everyday problems. | 4.25 | 4.00 | 4.13 |
|    | 16.Students' pleasure in learning about plant development.                                                              | 4.25 | 4.50 | 4.38 |
|    | 17.The emergence of confidence in carrying out the tasks of the courses.                                                | 4.25 | 4.50 | 4.38 |
|    | 18.Students' reaction to the new approaches, methods, and components of learning.                                       | 4.25 | 4.50 | 4.38 |
|    | 19.Students' desire to take lessons on other topics with this model                                                     | 4.50 | 4.25 | 4.38 |
|    | Average                                                                                                                 | 4.30 | 4.35 | 4.33 |

X<sub>1</sub> = Observer 1;

X<sub>2</sub> = Observer 2;

X = Average;

The students' positive responses to the application of the PjBL model are said to be achieved if the positive response to the four aspects (learning process, student books, experimental guidebook, and student worksheets) are met. The student's response to those 4 aspects was observed to be positive (Table 7).

**Table 7.** Student's response to the learning activities

| No  | Rated aspect                                                                                                                               | Likes (%)  | Dislikes (%)   |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|
| I   | How do you feel about ...                                                                                                                  |            |                |
|     | 1. Lesson Material                                                                                                                         | 100        | 0              |
|     | 2. Student Books                                                                                                                           | 95         | 5              |
|     | 3. Practical Guidebook                                                                                                                     | 100        | 0              |
|     | 4. Student Worksheets (SW)                                                                                                                 | 95         | 5              |
|     | 5. Learning atmosphere in class                                                                                                            | 95         | 5              |
|     | 6. Teacher teaching method                                                                                                                 | 100        | 0              |
|     |                                                                                                                                            | New        | Old            |
| II  | What do you think of ...                                                                                                                   |            |                |
|     | 1. Lesson Material                                                                                                                         | 95         | 5              |
|     | 2. Student Books                                                                                                                           | 84         | 16             |
|     | 3. Practical Guide Book                                                                                                                    | 100        | 0              |
|     | 4. Student Worksheets (SW)                                                                                                                 | 95         | 5              |
|     | 5. Learning atmosphere in class                                                                                                            | 79         | 21             |
|     | 6. Teacher teaching method                                                                                                                 | 90         | 10             |
|     |                                                                                                                                            | Interested | Not interested |
| III | Are you interested in taking part in the following learning activities?                                                                    | 100        | 0              |
| IV  | What do you think about Student Books and Student Worksheets (SW)?                                                                         |            |                |
|     | 1. Can you understand the language used in student books?                                                                                  | 95         | 5              |
|     | 2. Can you understand the language used in student worksheets?                                                                             | 95         | 5              |
|     | 3. Are you interested in the appearance (writing, illustrations, pictures, and the location of the picture) in the student book?           | 100        | 0              |
|     | 4. Are you interested in the appearance (writing, illustrations, pictures, and the location of the picture) in the Student Worksheet (SW)? | 100        | 0              |

Based on Table 7, it can be explained that the opinions and feelings of students about the subject materials, student books, practical manuals, student worksheets, learning atmosphere in the classroom, and teacher teaching methods showed more than 80% to be positive. All (100%) of the reflective and impulsive students were interested in participating in learning activities



using student books, and practicum manuals developed student worksheets and applied teaching methods. This showed that the reflective and impulsive students' responses to the development of student books, practical manuals, and student worksheets in the Plant Development course are very positive. According to Matsun & Saputri (2020), declared effective if student graduation is greater than 80% of the number of participants. The students' and teachers' activities, the student's abilities, and understanding of the lecture material were tested using quizzes 4 (four) times and the results are in Table 8.

**Table 8.** The student's ability after model implementation

|               | Quiz 1 | Quiz 2 | Quiz 3 | Quiz 4 |
|---------------|--------|--------|--------|--------|
| Lowest score  | 25     | 30     | 28     | 30     |
| Highest score | 85     | 100    | 88     | 100    |
| Average       | 67.63  | 76.32  | 70.37  | 76.84  |

Reigeluth (1999) argued that the most important aspect of effectiveness is the application level of the model in a particular situation. Akker (1999) and Rochmad (2012) explained that effectiveness refers to the degree that which the perceptions and results of the intervention are compatible with the intended objectives. Nieveen (1999), and Warli & Fadiana (2015) measured the level of effectiveness from the level of students' appreciation of learning and their desire to continue using the program.

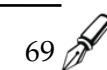
The developed PjBL model is considered to be effective. The student's responses to the model implementation were concluded to be very well. Warli and Fadiana's research (2015) reported that their mathematics learning model that accommodates reflective and impulsive cognitive styles obtained an effective criterion on the effectiveness test.

The third quiz results showed a decrease compared to the second quiz. This is due to the material on the third quiz being more conceptual, so the students tend to experience difficulties. In the next quiz, they were well-adapted and the results improved. According to Chia (2016), project-based learning could increase not only students' learning motivation in vocational schools but also facilitate their problem-solving abilities. The results of Warli and Fadiana (2015) showed that students, who are impulsive when discussing, can improve their accuracy in thinking before making decisions. But for reflective ones, the accuracy is slightly decreased, although it still exists within good limits.

The developed PjBL model is effective. Looking at the definition above, it is important to establish a reflective vs impulsive cognitive style-based learning model to enhance student's critical thinking skills. The main objective of this research is to establish a project-based learning model that accommodates reflective and impulsive cognitive styles that have certain qualities. There is a connection between PBL and research-based learning (IBL) in PjBL. PBL focuses on real-world approaches, and IBL focuses on problem-solving skills, while PjBL focuses on the development of projects or goods to create ideas for the subject.

## CONCLUSION

Based on validity, practicality, and effectiveness tests in trials, it can be concluded that the PjBL model, which accommodates reflective and impulsive cognitive styles to improve critical thinking skills, meets good quality criteria. In detail, it can be described that in the validity test, construct validation shows internal consistency between model components, including syntax, social systems, reaction principles, and support systems, as well as direct and indirect impacts. Based on the analysis of content and construct validation, the average content validation was very good, and the average construct validation was good. Likewise, the model supporting tools, which include teacher books, student books, practice guidebooks, and student activity sheets, meet the criteria for very good validity. The practicality test shows that the application of model syntax and social systems has good criteria, while the reaction principles and learning

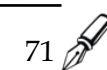


management have very good criteria. Apart from that, it also has very good effectiveness criteria according to the perception of experts. Student responses to the PjBL model, which accommodates reflective and impulsive cognitive styles, also meet the ideal criteria. Likewise, student and teacher activities during the learning process and learning outcomes are also effective. The PjBL model, which accommodates reflective and impulsive cognitive styles, can be an alternative teaching model for teachers who will develop critical thinking skills. The model syntax that has been successfully developed can be used as a learning step because it meets the requirements for good syntax. However, before learning is carried out, the teacher must know the student's cognitive styles. Students' cognitive styles are the basis for grouping students, but this is only done once, and henceforth, there is no need to measure it again because cognitive styles are consistent. Another limitation of this research is that the new trial is limited to the Plant Development course; it needs to be expanded to other courses or even to other fields (apart from Biology). Further, research can be carried out in other subjects or other fields of study. Likewise, the group system that is formed needs to be tried with more variations, for example, reflective and impulsive groups or those with similar cognitive styles.

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**Author (s):**

\*Imas Cintamulya (Corresponding Author)

Department of Biology Education, Faculty of Teacher Training and Education,  
University of PGRI Ronggolawe, Tuban 62391, Indonesia.

Email: [cintamulya66@gmail.com](mailto:cintamulya66@gmail.com)

Warli

Department of Mathematics Education, Faculty of Teacher Training and Education,  
University of PGRI Ronggolawe, Tuban, 62391, Indonesia.

Email: [warli66@gmail.com](mailto:warli66@gmail.com)

Lilik Mawartiningsih

Department of Biology Education, Faculty of Teacher Training and Education,  
University of PGRI Ronggolawe, Tuban 62391, Indonesia.

Email: [cintamulya66@gmail.com](mailto:cintamulya66@gmail.com)

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