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The Effectiveness of an Inquiry-Based Worksheet in Enhancing Metacognitive Ability on Reaction Rate Factors to Support the *Profil Pelajar Pancasila*

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Abstract

Metacognitive ability is part of higher order thinking so it has an important role in strengthening the critical thinking dimensions in the *Profil Pelajar Pancasila*. This study aims to develop a learner activity sheet to improve metacognitive skills on the material of factors that affect the reaction rate through an effective inquiry learning model used to improve metacognitive skills. This research uses the ADDIE (Analysis, Design, Develop, Implement, Evaluate) research design which is limited to the develop stage. Based on the results of the pilot implementation, it was found that the student worksheet developed was effective based on the results of the metacognitive ability test which showed a p-value < 0,05 so that H_0 was rejected and H_1 was accepted which meant that there was a significant increase in value after learning using the developed student worksheet.

Keywords: student worksheet, pilot implementation, effectiveness

1. Introduction

Education has a crucial role in the progress of a nation because it is closely related to the development of human resources, especially the younger generation (Agustina & Atmazaki, 2021). Education contributes to the improvement of a productive young generation that is able to compete globally. Through education, students are expected to have good communication and collaboration abilities, be technologically skilled, be able to think creatively, and be innovative (Larson & Miller, 2011).

Education must be in line with the demands required in 21st century learning (Mustapha et al., 2020). The 21st century learning is learning that emphasises the improvement of quality human resources in terms of knowledge, abilities and attitudes. With this, the existing education system in Indonesia, especially in terms of curriculum, must focus on the competencies needed in the 21st

century (Rusman, 2021). According to the US-based Partnership for 21st Century Skills, the competencies needed in the 21st century are 'The 4Cs' which include communication, collaboration, critical thinking, and creativity. Some of the competencies needed in the 21st century are contained in the dimensions of the *Profil Pelajar Pancasila* which is part of the *kurikulum merdeka*.

According to Decree No. 9 of 2022 issued by the Head of the Education Standards, Curriculum, and Assessment Agency, the *Profil Pelajar Pancasila* is outlined through six key dimensions: faith in and devotion to God Almighty along with strong moral character, *mandiri* (independent), *gotong royong* (collaborative), *berkebhinekaan global* (appreciation of global diversity), critical thinking, and creativity. These six aspects are meant to be embedded in the learning process to help achieve the goals set by the *kurikulum merdeka*.

In line with the dimensions contained in the *Profil Pelajar Pancasila*, metacognitive abilities must be empowered because they have a positive relationship with learning outcomes (Cahyani et al., 2023). Learners who have high metacognitive abilities, their cognitive learning outcomes are also high because they are able to think critically and creatively in dealing with a problem (Setiawan et al., 2020). Metacognitive ability is part of higher-order thinking and critical thinking (Adita & Azizah, 2016). Based on this statement, metacognitive ability needs to be improved so that the dimensions contained in the *Profil Pelajar Pancasila*, especially critical and creative thinking, can be achieved by students.

However, facts in the field show that metacognitive ability and other higher-order thinking have not been deliberately empowered in the learning process at school (Suratno, 2010). The results of research Sholihah, Zubaidah, & Mahanal (2015) also reveal that many students' metacognitive abilities are still at the can not really level (still relatively low) because learning in the classroom has not been used to empower students' metacognitive abilities (Sholihah et al., 2015). In addition, research conducted by Widyawati & Nasrudin (2019) showed that students' metacognitive abilities were low with a percentage value of 37.36% planning, 44.91% monitoring, and 14.65% evaluation (Widyawati & Nasrudin, 2019).

Efforts to improve metacognitive abilities must use the appropriate learning model. One of the learning models that has a correlation with indicators of metacognitive ability is inquiry. The syntax of the inquiry learning model is related to indicators of metacognitive abilities so that it can be used to improve metacognitive abilities (Damayanti, 2015). The inquiry learning model emphasises students to work in their own way, both in formulating problems to find answers to these problems with its syntax, namely orientation, problem presentation, hypothesis formulation, data collection, conclusion making, and problem reflection (Putri & Pantiwati, 2015). The orientation, problem presentation, and hypothesis formulation stages are included in the planning aspect of metacognitive ability. Meanwhile, the data collection stage is included in the monitoring aspect,

and the stage of making conclusions and problem reflection is included in the evaluation aspect in metacognitive ability.

Chemistry is considered to have the potential to develop students' problem-solving skills and metacognitive abilities. Chemistry includes concepts, facts, laws, rules, theories, principles that are abstract and mathematical (Suryati, 2013). One of the chemistry materials taught in eleventh class is the reaction rate. The reaction rate material is theoretical and mathematical with one of the sub-materials is the factors that affect the reaction rate (Izzah & Azizah, 2019). However, the fact is that students only have an algorithmic understanding (Sőzbilir et al., 2010). Reaction rate also involves chemical observations (macroscopic), chemical reactions (submicroscopic), and the use of symbols or formulas (symbolic). Understanding the concept of reaction rate can be owned by students if they have the ability to think at a high level so that they are able to link the three in the reaction rate material (Sirhan, 2007). One of the efforts to overcome learners' difficulties in interpreting understanding involving macroscopic, submicroscopic, and symbolic representations is to involve metacognition in learning (Thomas & Anderson, 2013). In the context of reaction rate, the planning indicator in metacognitive ability requires learners to identify information about factors that affect the reaction rate, the monitoring indicator requires learners to conduct an experiment and interpret the results in the form of tables and important notes, while the evaluation indicator requires learners to conclude their understanding of the factors that affect the reaction rate based on the activities carried out previously.

Enhancing students' metacognitive skills through an inquiry-based learning model on the topic of factors influencing reaction rates calls for well-prepared learning tools. One effective tool is the student worksheet, which serves as a way for teachers to fulfill their role as facilitators in the learning process (Prawestri & Zulfiati, 2020). A student worksheet is a printed learning resource that includes content, summaries, and task instructions aligned with specific competencies. It guides students to gain understanding through hands-on activities based on the instructions provided, rather than relying solely on the teacher's explanations (Prastowo, 2015).

The worksheet developed in this study exhibits a distinctive structural design, wherein each stage of the inquiry process is explicitly integrated with metacognitive components. Unlike previous inquiry-based worksheets that primarily emphasize exploration and observation, this worksheet is specifically designed to guide students in planning, monitoring, and evaluating their thinking processes through systematically embedded reflective questions. This integration of metacognitive strategies elevates the worksheet from a mere exploratory tool to a medium for cultivating scientific thinking awareness. Furthermore, the selection of the topic, factors affecting reaction rates is strategically significant, as it not only requires conceptual understanding but also fosters students' abilities to analyze causal relationships, make data-driven decisions, and reflect on experimental outcomes. These aspects align closely with the critical thinking dimension of the *Profil Pelajar Pancasila*. The combination of inquiry-based learning, metacognitive activation, and contextual

relevance positions this worksheet as a unique and valuable contribution compared to previous developments in chemistry education.

Based on this description, research was conducted on the effectiveness of developing student worksheet to improve metacognitive abilities with an inquiry learning model on the material of factors that affect the reaction rate. This study addresses a critical gap in the current literature, in which most student worksheets focus on inquiry-based learning without explicitly fostering students' metacognitive skills. While several previous studies have explored inquiry or metacognition independently, few have designed worksheets that deliberately integrate metacognitive strategies such as planning, monitoring, and evaluating within each stage of the inquiry process. Moreover, there is limited research linking worksheet development to the *Profil Pelajar Pancasila*, a cornerstone of Indonesia's national curriculum that emphasizes character and competency development. The worksheet in this study not only incorporates reflective prompts that activate metacognitive processes but also aligns with the *Profil Pelajar Pancasila* dimension such as critical thinking. This integration responds directly to the demands of the *Kurikulum Merdeka*, thereby offering a contextually relevant, pedagogically innovative tool for chemistry education.

2. Methods

This research uses the type of research and development. The research design used in this study is guided by the steps or stages in the ADDIE model development research but is only limited to the develop stage because this study was only tested in a pilot implementation to obtain data on effectiveness (Branch, 2009).

At the analysis stage, researchers collect information to serve as a reference for product development. The analyses carried out were needs analysis and curriculum analysis. Then the evaluation and revision of the analysis stage was carried out according to the suggestions of the supervisor. At the design stage, researchers began to draft student worksheet and metacognitive ability test questions by considering the information obtained at the analysis stage. Then the evaluation and revision of the design stage was carried out according to the supervisor's suggestions. At the development stage, the student worksheet, metacognitive ability test questions were arranged and printed. The student worksheet includes a cover, identity, preface, table of contents, *Capaian Pembelajaran* (CP) and learning objectives, instructions for use, a sequence of learning activities based on inquiry syntax and indicators of metacognitive abilities, and a bibliography. Then the evaluation and revision of the development stage were carried out according to the validator's suggestions.

After completing the revision of the student worksheet and test instruments, a trial was carried out to assess the effectiveness of the developed worksheet. The trial used a one-group pretest-posttest

design, where students were first given a pretest before participating in lessons using the worksheet. Following the learning sessions, students were then given a posttest to measure their progress (Sugiyono, 2011). This study employed a purposive sampling technique, wherein participants were intentionally selected according to predefined criteria set by the researcher. The sample consisted of 29 eleventh-grade students who had not yet been taught the topic of factors influencing the rate of chemical reactions.

The instrument used in this study include metacognitive ability test questions. The metacognitive ability test sheet is a research instrument given to students before and after learning using the developed student worksheet. This test sheet contains four description questions which are prepared based on the analysis of metacognitive ability indicators and chemical content analysis of the material of reaction rate factors.

The analysis of metacognitive ability test questions was carried out with normality test as a prerequisite test and t-test as a hypothesis test. The normality test used is the Ryan-Joiner normality test which assumes that, H_0: significance < 0,05 then distributed not normal and H_1: significance > 0,05 then normally distributed. A data is declared normally distributed if the sig value. > 0,05.

After the data is known to be normally distributed, then a parametric test is carried out, namely the one group paired sample t-test using the Minitab application with the following assumptions, H_0: the posttest value is smaller or equal to the average pretest value and H_1: the posttest value is greater than the average pretest value

Decision making in this right one-party test uses the following criteria, If the p-value < 0,05 then H_0 is rejected and H_1 is accepted, meaning that there is a significant increase in scores between before and after the use of student worksheet. If the p-value > 0,05 then H_0 is accepted and H_1 is rejected, meaning that there is no significant increase in scores between before and after the use of student worksheet.

This study has several methodological limitations that should be acknowledged. First, the absence of a control group limits the ability to attribute observed improvements solely to the intervention. Second, the relatively small sample size of 29 participants restricts the generalizability of the findings to broader student populations. Further studies involving larger and more diverse populations, as well as experimental designs with control groups, are suggested.

3. Result and Discussion

The student worksheet developed uses an inquiry learning model to improve students' metacognitive abilities, so some of the learning theories used are information processing theory and Vygotsky's theory. Information processing theory, developed by Robert Gagne in 1985,

assumes that learning plays a major role in individual development. Learning is considered to be the result of information processing that produces human skills. Information processing involves how we take in stimuli from our surroundings, organize information, solve problems, understand concepts, and make use of both verbal and visual symbols (Gagne & Ellen, 1985). This theory underlies the research conducted because the student worksheet developed with the inquiry learning model, requires students to process information based on the interpretation of data from experiments carried out in the form of tables and so on in order to find the right concept.

Vygotsky's theory highlights the crucial role of the environment in the learning process. This environment includes people, cultural influences, and personal experiences. Social interactions with others play a key role, as they serve as the starting point for students to acquire knowledge, which then becomes internalized and develops into individual understanding (Vygotsky, 2003) in (Tamrin et al., 2011). Vygotsky emphasised that the connection between a person and their social environment is crucial in shaping knowledge. He believed that social interaction how individuals engage with others is the key factor driving cognitive development. This theory underlies the research conducted because students are required to carry out activities according to the student worksheet with an inquiry learning model in groups.

The effectiveness of the student worksheet developed is based on the pretest and posttest scores of students. Student worksheet is considered more effective than other media or teaching materials. This is because it contains learning steps that help students to be directly involved in the problem solving process, so that learning becomes more directed and meaningful (Malahayati, 2017). The pretest was done by students before learning using the developed student worksheet, while the posttest were done by students after learning using the developed student worksheet. The use of an inquiry-based learning model in this study was grounded in its documented effectiveness in fostering metacognitive skills. Pambudi et al. (2022) reported that inquiry-based instruction positively influences students' metacognitive improvement (Pambudi et al., 2022). Similarly, international research by Antonio and Prudente (2021) emphasized that the integration of inquiry learning with metacognitive strategies significantly contributes to the enhancement of students' conceptual understanding (Antonio & Prudente, 2021)

The effectiveness of student worksheet is based on metacognitive ability test questions. The metacognitive ability test questions consist of a pretest and posttest. The pretest was done by students before the student worksheet trial, while the posttest was done by students after the student worksheet trial. A recapitulation of the results of the pretest and posttest of students is presented in Table 1.

Table 1.
The Results of Pretest and Posttest

Students	Pretest Score	Posttest Score
Student 1	14,5	91,6
Student 2	47,9	93,7
Student 3	20,8	85,4
Student 4	37,5	87,5
Student 5	37,5	87,5
Student 6	39,5	91,6
Student 7	25	83,3
Student 8	22,9	89,5
Student 9	20,8	93,7
Student 10	20,8	91,6
Student 11	75	89,5
Student 12	45,8	87,5
Student 13	72,9	91,6
Student 14	25	85,4
Student 15	14,5	89,5
Student 16	18,7	85,4
Student 17	43,7	79,1
Student 18	62,5	91,6
Student 19	33,3	85,4
Student 20	14,5	87,5
Student 21	41,6	93,7
Student 22	41,6	95,8
Student 23	39,5	89,5
Student 24	14,5	87,5
Student 25	31,2	95,8
Student 26	58,3	93,7
Student 27	54,1	93,7
Student 28	14,5	77
Student 29	37,5	89,5
Average	35,38	89,11

Metacognitive ability has three indicators, including planning, monitoring, and evaluating (Pulmones, 2007). Based on Table 3. it is known that the average overall score of students has increased after learning using the developed student worksheet. The results in accordance with the findings reported by Winarseh and Azizah (2023), who demonstrated that the pilot implementation of an inquiry-based worksheet led to a statistically significant improvement in students' academic performance from the pretest to the posttest (Winarseh & Azizah, 2023). The percentage of pretest

and posttest results of students based on indicators of metacognitive ability is presented in Table 2.

Table 2.
Percentage of Pretest and Posttest Result

Indicators of Metacognitive Ability	Pretest (%)	Posttest (%)
Planning	36,78	92,67
Monitoring	39,08	85,06
Evaluating	29,31	85,92

The planning indicator demonstrated a substantial improvement, with pretest and posttest scores increasing from 36.78% to 92.67%, respectively. This indicator was measured through test items 1a, 1b, 2a, 2b, 3a, 3b, 4a, and 4b. Items 1a, 2a, 3a, and 4a assessed students' ability to identify the objective of an experiment based on the given narrative. In the pretest, several students struggled to interpret the purpose of the experiments. However, after the pilot implementation of the inquiry-based student worksheet, most students were able to articulate the experimental objectives accurately in the posttest. Meanwhile, items 1b, 2b, 3b, and 4b focused on identifying variables within the experimental scenarios. Although many students initially had difficulty distinguishing between independent and control variables, posttest results indicated notable improvement, with most students answering these items correctly.

These improvements reflect the development of key competencies aligned with the *Profil Pelajar Pancasila*, particularly in the dimensions of critical thinking and *mandiri* (independent). The ability to identify experimental objectives and variables demonstrates students' growing capacity to analyze information, construct meaning from scientific texts, and reflect on the structure of inquiry a manifestation of critical and logical reasoning. Furthermore, the observed progress indicates that students are becoming more autonomous in regulating their own learning processes, which is in line with the cultivation of independent learners as envisioned in the national education goals.

The monitoring indicator also showed marked progress, increasing from 39.08% in the pretest to 85.06% in the posttest. This indicator was evaluated through items 1c, 2c, 3c, and 4c, which required students to construct a table of experimental results based on the narrative provided. During the pretest, students generally lacked the ability to determine relevant variables, leading to inaccuracies in data presentation. Following the use of the developed worksheet, students demonstrated improved comprehension, enabling them to organize and present data more appropriately.

This progress illustrates the development of students' metacognitive monitoring skills, which are closely aligned with the critical thinking and *mandiri* (independent) dimensions of the *Profil Pelajar Pancasila*. By learning to identify relevant information and translate it into structured data

representations, students exhibited enhanced analytical thinking and problem-solving abilities. Moreover, their capacity to self-correct and refine their approach to presenting experimental data reflects a growing sense of responsibility in managing their own learning an essential attribute of autonomous and reflective learners envisioned by the national curriculum framework.

The evaluation indicator rose from 29.31% in the pretest to 85.92% in the posttest. This indicator was assessed through items 1d, 2d, 3d, and 4d, which required students to draw conclusions from experimental data. Pretest responses revealed that students were unable to construct proper data tables, which affected their ability to formulate valid conclusions. However, post-intervention results showed that students were more capable of organizing experimental results and deriving logical, evidence-based conclusions.

This improvement aligns with the *Profil Pelajar Pancasila*, particularly the critical thinking dimension, where students are expected to analyze information objectively and make decisions based on data. Additionally, the ability to independently interpret data and draw conclusions also reflects growth in the *mandiri* (independent) dimension, as students demonstrated greater responsibility and initiative in processing information through scientific reasoning.

Based on the data presented in Table 2, it is evident that the monitoring indicator in the metacognitive ability test yielded a relatively lower percentage compared to the other indicators on posttest. This suggests that the monitoring process which requires students to actively identify, comprehend, and systematically organize experimental information remains a significant challenge for some learners. One of the primary contributing factors to this outcome is students' difficulty in accurately distinguishing between independent, dependent, and control variables, despite having been exposed to instruction through the developed inquiry-based worksheet. This condition may have occurred during the pilot implementation phase of the developed worksheet, as several students experienced difficulties in identifying and articulating the variables involved in the experimental activities. In response, the teacher facilitated guided discussions to support students in addressing these challenges. Through collaborative discussions, students who initially struggled to identify relevant information were able to benefit from the explanations provided by their peers, gaining alternative perspectives that contributed to a clearer understanding of the concepts. This process also allowed students to express confusion, clarify misunderstandings, and refine their comprehension in real time. Such peer-assisted learning reflects the core principles of Vygotsky's sociocultural theory, which emphasizes the importance of social interaction in cognitive development. In accordance with this theory, students are encouraged to work collaboratively, enabling scaffolding through group dialogue and shared problem-solving (Vygotsky, 2003) in (Tamrin et al., 2011).

Learning is a condition that facilitates reciprocal interaction between teachers and students in aligning their understanding of the subject matter being studied. In this process, students who encounter difficulties in articulating their prior knowledge tend to seek clarification by asking the

teacher or engaging in group discussions (Payung et al., 2016). Through such exchanges of ideas, conceptual understanding is more likely to develop in depth, making the learning experience more meaningful and contextually grounded.

This indicates that the critical thinking skills for effective monitoring have not yet been fully internalized, particularly in the context of analyzing experimental structures. In light of these findings, it is recommended that future researchers design instructional interventions that explicitly emphasize conceptual understanding of experimental variables. This can be achieved through the integration of visual diagrams, interactive simulations, or hands on laboratory activities accompanied by structured metacognitive reflection. Moreover, incorporating guided group discussions led by the teacher can further enhance students' engagement in collaborative learning, thereby strengthening the *gotong royong* (collaborative) dimension of the *Profil Pelajar Pancasila*. Through structured peer interaction, students learn to communicate ideas, evaluate perspectives, and construct shared understanding abilities that are essential for both scientific inquiry and character development in a diverse learning community.

The students' pretest and posttest scores were analyzed for normality using the Ryan-Joiner test in the Minitab 18 software. This test was conducted to determine whether the data followed a normal distribution.The pretest and posttest normality tests are respectively shown in Figure 1. and Figure 2.

Figure 1

Normality Test of Pretest

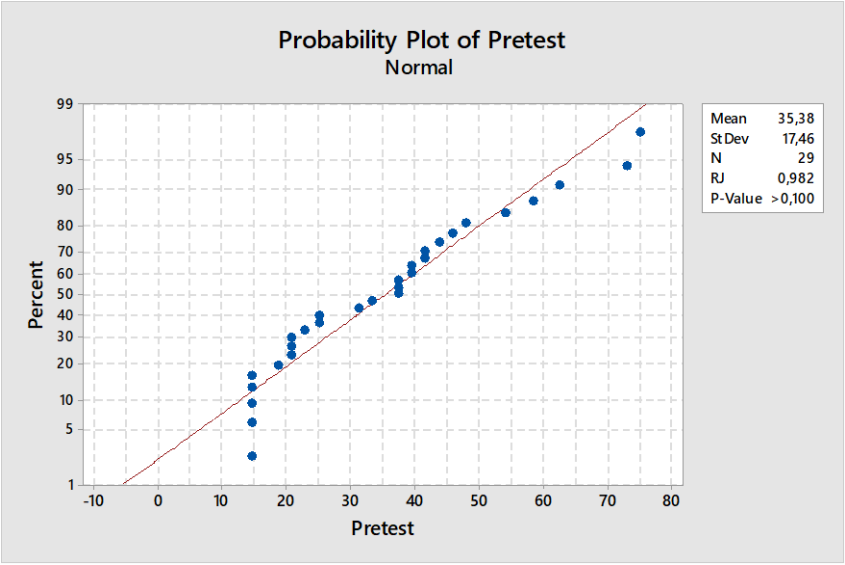
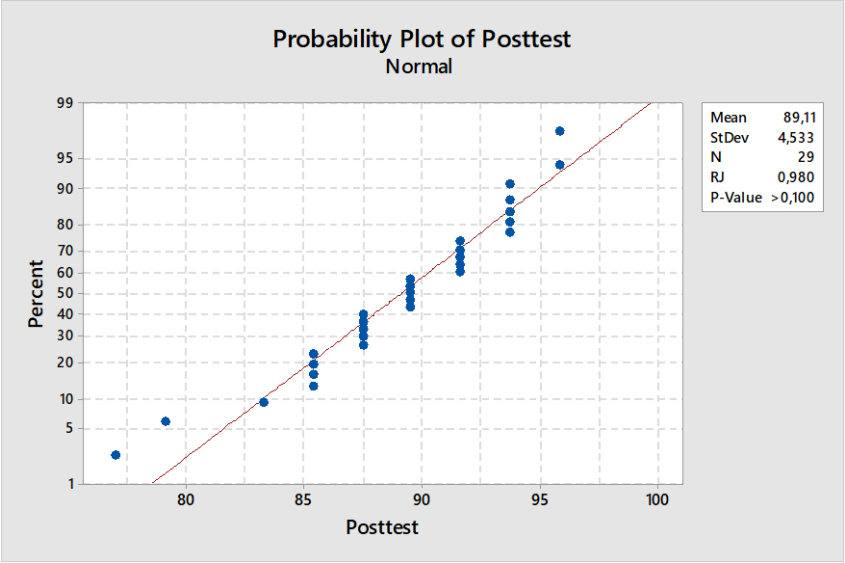


Figure 2
Normality Test of Posttest



The following normality test results were obtained based on Figure 1 and Figure 2.

Table 3.
Normality Test Result

Test of Normality					
Score	Ryan-Joiner (similar to Shapiro-Wilk)				
	Mean	StDev	N	RJ	p-Value
Pretest	35,38	17,46	29	0,982	>0,100
Posttest	89,11	4,533	29	0,980	>0,100

Based on the results of the normality test, the p-values for both the pretest and posttest scores were greater than 0.100, which exceeds the threshold of 0.05. This indicates that the data are normally distributed. Since the data met the assumption of normality, a parametric test specifically, a right-tailed paired sample t-test was conducted, yielding the following results.

Table 4.
Result Test Analysis

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Posttest	29	89,11	4,53	0,84
Pretest	29	35,38	17,46	3,24

Estimation for Paired Difference

Mean	StDev	SE Mean	95% Lower Bound for μ_difference
53,73	16,49	3,06	48,52

μ_difference: mean of (Posttest - Pretest)

Test

Null hypothesis	H_o: μ_difference = 0
Alternative hypothesis	H_1: μ_difference > 0

t-Value	p-Value
17,54	0,000

The results of the right-tailed paired sample t-test show a p-value of less than 0.05, indicating that the alternative hypothesis (H_1) which states that the posttest scores are significantly higher than the pretest scores is accepted. This means there was a meaningful improvement in students' performance after using the student worksheet. These findings are consistent with the study conducted by Laili and Azizah (2024), which demonstrated that the use of inquiry-based worksheets can significantly enhance students' metacognitive abilities. The inquiry approach encourages students to take an active role in their learning process by engaging in strategic planning, monitoring their understanding, and evaluating learning outcomes (Laili & Azizah, 2024). In addition Malahayati et al. (2017) argued that student worksheets are more effective than other instructional media or materials. Their effectiveness lies in the fact that they incorporate the steps of the learning model, guiding students through problem-solving activities (Malahayati, 2017). In addition, Nieveen and Plomp (2007) argue that an instructional device can be considered effective if it demonstrates a significant impact on formative evaluation outcomes in line with the intended learning objectives (Nieveen & Plomp, 2007).

Through the pilot implementation of inquiry-based worksheet, students' metacognitive abilities showed a marked improvement, which was accompanied by an increase in the critical thinking dimension of the *Profil Pelajar Pancasila*. Notably, an unexpected finding of this study was that the enhancement of metacognitive skills also aligned with the development of the *gotong royong* (collaborative) and *mandiri* (independent) dimensions of the Profil Pelajar Pancasila. During the

LAPD-based learning process, students engaged in collaborative discussions, reflecting the implementation of the gotong royong dimension. Meanwhile, in both the pretest and posttest phases, students independently assessed and reflected on their metacognitive abilities, thereby strengthening the *mandiri* (independent) dimension.

4. Conclusion

The one-sided paired t-test resulted in a p-value of 0,000 which is below 0,05. This means that there is an increase in the metacognitive ability score obtained by students after using the student worksheet developed. Therefore, the student worksheet developed has met the criteria for effectiveness.

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