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The Effectiveness of the PQRST Model in Enhancing Scientific Literacy and Critical Thinking Skills of Students on the Topic of Human Excretory System in the Merdeka Curriculum Era

Efektivitas Model PQRST dalam Meningkatkan Literasi Sains dan Keterampilan Berpikir Kritis Siswa pada Materi Sistem Ekskresi Manusia di Era Kurikulum Merdeka

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Abstract

This study investigates the effectiveness of the PQRST (Preview, Question, Read, Summarize, Test) model in enhancing scientific literacy and critical thinking skills among eleventh-grade students at SMAN 3 Kota Cirebon, particularly focusing on the human excretory system in the context of the Merdeka Curriculum. The research applied a quasi-experimental design with a pretest-posttest control group approach, involving 30 students from two classes. The experimental group received instruction using the PQRST model, while the control group followed conventional teaching methods. Results indicate significant improvements in the experimental group's scientific literacy across three aspects: context, knowledge, and competence. The normalized gain (N-Gain) scores were higher in the experimental group (0.72 for context, 0.77 for knowledge, and 0.71 for competence) compared to the control group. Statistical analysis revealed significant differences ($p < 0.05$) in all aspects of scientific literacy, confirming that the PQRST model significantly enhanced students' learning outcomes. Moreover, students reported positive responses towards the PQRST model, citing improved engagement, confidence, and critical thinking abilities. This study supports the goals of the Merdeka Curriculum in fostering independent, critical thinkers with strong scientific literacy. In conclusion, the PQRST model has proven to be an effective learning strategy to improve scientific literacy, critical thinking, and student engagement, which aligns with the objectives of the Merdeka Curriculum to produce globally competitive, literate students.
Kata Kunci: PQRST model, scientific literacy, human excretory system, merdeka kurikulum

Abstrak

Penelitian ini mengkaji efektivitas model PQRST (Preview, Question, Read, Summarize, Test) dalam meningkatkan literasi sains dan keterampilan berpikir kritis siswa kelas XI di SMAN 3 Kota Cirebon, khususnya pada materi sistem ekskresi manusia dalam konteks Kurikulum Merdeka. Penelitian ini menggunakan desain kuasi eksperimen dengan pendekatan pretest-posttest kelompok kontrol, melibatkan 30 siswa dari dua kelas. Kelompok eksperimen menerima pembelajaran menggunakan model PQRST, sedangkan kelompok kontrol mengikuti metode pembelajaran konvensional. Hasil penelitian menunjukkan peningkatan signifikan literasi sains pada kelompok eksperimen dalam tiga aspek, yaitu konteks, pengetahuan, dan kompetensi. Skor normalized gain (N-Gain) pada kelompok eksperimen lebih tinggi, yakni 0,72 untuk aspek konteks, 0,77 untuk pengetahuan, dan 0,71 untuk kompetensi, dibandingkan dengan kelompok kontrol. Analisis statistik menunjukkan perbedaan yang signifikan ($p < 0,05$) pada seluruh aspek literasi sains, yang mengonfirmasi bahwa model PQRST secara signifikan meningkatkan hasil belajar siswa. Selain itu, siswa memberikan respons positif terhadap penerapan model PQRST, dengan menyebutkan peningkatan keterlibatan, kepercayaan diri, dan kemampuan berpikir kritis. Penelitian ini mendukung tujuan Kurikulum Merdeka dalam membentuk peserta didik yang mandiri, kritis, dan memiliki literasi sains yang kuat. Dengan demikian, model PQRST terbukti menjadi strategi pembelajaran yang efektif untuk meningkatkan literasi sains, keterampilan berpikir kritis, dan keterlibatan siswa, sejalan dengan tujuan Kurikulum Merdeka dalam mencetak siswa yang literat dan kompetitif secara global.
Keywords: *Model PQRST, literasi sains, sistem ekskresi manusia, merdeka kurikulum*

INTRODUCTION

The 21st-century learning demands mastery of scientific literacy as one of the core competencies in shaping students to be globally competitive. The scientific literacy includes critical thinking, collaboration, communication, and creativity integrated into the ability to understand and use scientific knowledge to solve daily problems (Limiansih et al., 2024). According to Yusmar and Fadilah (2023), scientific literacy among Indonesian students remains relatively low. Based on the 2022 PISA results, Indonesia ranked 67th out of 81 countries with an average score of 383, which is below the OECD average. This indicates the need for strengthening literacy-based learning so that students have contextual and applicable scientific competencies (Yusmar & Fadilah, 2023).

The Merdeka Curriculum promotes independent, differentiated, and student-centered learning that emphasizes scientific literacy and critical thinking (Kemendikbudristek, 2022). According to OECD (2023), Indonesia still faces challenges in science literacy, which highlights the urgency to reform instructional strategies. Scientific literacy is crucial for preparing students to make informed decisions in real-life contexts (Bybee, 2013). According to Sari et al. (2023), the curriculum's flexibility allows teachers to select innovative methods to meet students' cognitive needs. Oktaviani et al. (2022) also emphasized that critical thinking development is central to the success of Merdeka Curriculum implementation.

To align with these goals, innovative learning models such as PQRST model (Preview, Question, Read, Summarize, Test) are considered effective in enhancing students' reasoning and comprehension skills (Cahya et al., 2020). According to Santoso and Gunawan (2022), PQRST encourages structured reading and reflective thinking, which support the development of higher-order cognitive processes. Scientific topics like the human excretory system require such strategies to deepen students' conceptual understanding (Azizah et al., 2022). According to Dewi and Handayani (2021), the PQRST model has shown positive effects on student engagement and literacy in science. Therefore, integrating PQRST within the Merdeka Curriculum context can contribute significantly to achieving the expected learning outcomes (Sari et al., 2023).

According to Suparya et al. (2022), various factors influence the low level of students scientific literacy, including poor reading habits, the use of teacher-centered conventional methods, and limited learning facilities. The lack of student engagement with scientific texts and the minimal application of teaching methods that train scientific thinking skills exacerbate this condition (Hasnawati et al., 2023). In addition, the quality of teachers' scientific literacy is also an important indicator in fostering students scientific thinking abilities (Limiansih et al., 2024). Meanwhile, low reading culture in Indonesia remains a national issue. Based on a UNESCO report, Indonesia's reading interest index ranks 60th in the world with a score of 37.2 (Suparya et al., 2022).

Scientific literacy is not merely about memorizing scientific facts but also includes competencies in understanding context, applying concepts, and demonstrating scientific attitudes in daily life. According to the OECD (Hasnawati et al., 2023), scientific literacy is defined as the ability to apply scientific knowledge in identifying questions, analyzing evidence, and making data-based decisions. Scientific literacy is closely related to reading comprehension skills. Reading comprehension is the foundation of scientific literacy because it enables students to reflect and reconstruct meaning in scientific texts (Susiati et al., 2018). Without good reading skills, students will struggle to understand scientific concepts and draw logical conclusions.

One of the learning models that can enhance scientific literacy is the PQRST model (Preview, Question, Read, Summarize, Test). According to Imama et al. (2023), PQRST is a reading learning strategy designed to improve reading comprehension through systematic stages. In the preview stage, students skim the material to get a general idea; in the question stage, they formulate questions; the read stage encourages students to read critically; the summarize stage involves students summarizing information in their own words; and the test stage is used to evaluate students understanding. According to Suparya et al. (2022), the application of PQRST is effective in promoting active engagement and building scientific thinking habits.

At SMAN 3 Kota Cirebon, initial observations showed that the scientific literacy of grade XI students, particularly on the excretory system topic, was still relatively low. The biology teacher reported that students tended to be passive and had low reading interest. This condition is in line with the findings of Suparya et al. (2022) and Limiansih et al. (2024), who stated that low scientific literacy is closely linked to low reading activity and predominantly one-way instruction. Therefore, the implementation of the PQRST model is considered

relevant to improve students' conceptual understanding and learning engagement.

This research is highly relevant to the implementation of the Merdeka Curriculum, which emphasizes differentiated learning and focuses on strengthening students' literacy competencies. According to Waseso et al. (2024), the Merdeka Curriculum is designed to improve thinking independence, problem-solving skills, and students' scientific literacy through contextual and flexible learning approaches. Thus, the implementation of the PQRST model on the human excretory system topic is expected to address the challenge of low scientific literacy while also supporting the achievement of the Pancasila Student Profile within the Merdeka Curriculum policy (Waseso et al., 2024).

METHODS

This research was conducted at SMA Negeri 3 Kota Cirebon from June to July 2023. The research design used was a quasi-experimental method with a descriptive quantitative approach. The subjects were 30 eleventh-grade science students, consisting of two classes: XI MIPA 1 as the experimental group and XI MIPA 2 as the control group. The design implemented was the Pretest-Posttest Control Group Design, which allows comparison of improvements in students' scientific literacy between those who received the treatment and those who did not.

The instruments used in this study included a scientific literacy test, student activity observation sheets based on literacy indicators, and a student response questionnaire regarding the implementation of the PQRST learning model. The test measured students' scientific literacy improvement on the human excretory system topic. The observation sheet was used to assess students' activity during the learning process. The questionnaire was used to gather students' perceptions toward the application of the PQRST model.

Scientific literacy indicators in this study were adapted from OECD (2019, PISA Science Framework), which include (1) explaining scientific phenomena, (2) evaluating and designing scientific inquiry, and (3) interpreting data and scientific evidence. These indicators were contextualized into the human excretory system topic and embedded within the literacy test items and observation sheet.

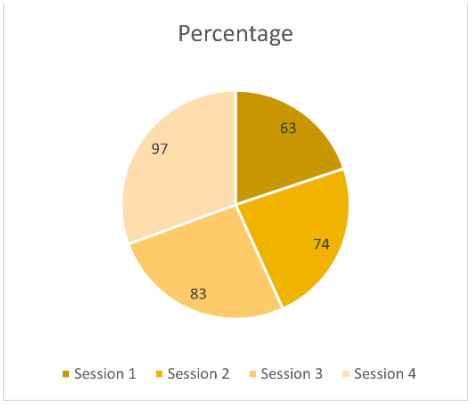
In addition to scientific literacy, this study also observed students' critical thinking skills through embedded indicators adapted from Facione (2011). The indicators included interpretation, analysis, evaluation, inference, and explanation. These aspects were integrated into literacy test items, for example interpreting diagrams of the excretory system (interpretation), connecting excretory processes with real-life phenomena such as dehydration (analysis), evaluating the validity of experimental designs (evaluation), drawing conclusions from laboratory data (inference), and presenting arguments in written form (explanation). Furthermore, the student response questionnaire also provided qualitative evidence of students' engagement and confidence, which support the development of critical thinking dispositions. While not measured as a separate standardized test, these indicators were used to infer students' critical thinking tendencies within the context of scientific literacy tasks.

Data collection was carried out in two stages. The first stage was preparation, which involved designing the instruments, conducting content validation, and obtaining research permission from the school. The second stage was implementation, which included administering the pretest, applying the PQRST learning model in the experimental class and conventional learning in the control class, followed by the posttest and the response questionnaire. The test results were analyzed using descriptive statistics (mean, percentage, and N-Gain) and inferential statistics. An independent sample t-test was applied for normally distributed data, while the Mann–Whitney U test was used for non-normal data, to compare the experimental and control groups. All analyses were carried out with the assistance of statistical software, and the results were interpreted with reference to relevant literature.

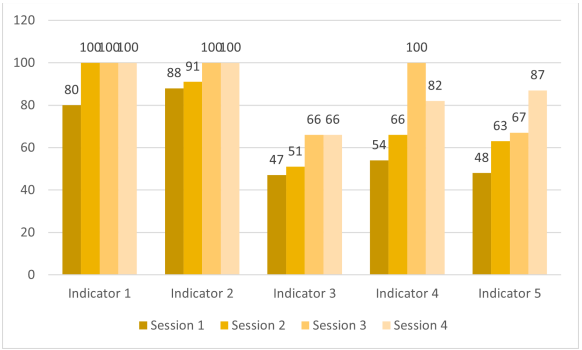
RESULT AND DISCUSSION

Scientific Literacy and Critical Thinking Activities through the PQRST Model

The application of the PQRST learning model (Preview, Question, Read, Self Recite, and Test) in teaching the human excretory system has shown a positive impact on enhancing students' scientific literacy and critical thinking skills. As shown in Figure 1(a), students overall activity increased steadily across four meetings. In the first meeting, students' activity was relatively low due to the initial adjustment phase. However, from the second to the fourth meetings, there was a significant improvement, indicating that students had begun to follow the learning process more effectively through reading, questioning, and self-reciting. This finding is consistent with Sukmawidiyanti (2013), who found that the PQRST model gradually enhances student learning activity.



(a)



(b)

Figure 1. (a) Student overall activity across four learning sessions using the PQRST model on the human excretory system. (b) Student activity based on five indicators of scientific literacy during four sessions.

As shown in Figure 1(a), students' overall activity increased steadily across the four sessions. The lowest activity was recorded in the first session (63%) due to initial adjustment, but it improved progressively to 74% in session 2, 83% in session 3, and reached 97% in session 4. Figure 1(b) shows activity based on five scientific literacy indicators. Content mastery and understanding of conceptual and procedural knowledge reached maximum scores by the fourth session, while explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting data and scientific evidence showed continuous improvement over time.

A more detailed analysis of the five scientific literacy indicators, as illustrated in Figure 1(b), shows that the first indicator, content mastery, achieved an average score of 95% (categorized as very good). This indicates that students were able to understand key concepts in the human excretory system, such as urine formation and nephron function. The reading and self-recitation phases helped strengthen their conceptual understanding (Fang & Wei, 2010).

The second indicator, understanding conceptual and procedural knowledge, also showed very good results with an average score of 94.73%. Students could explain the processes and functions of the excretory system using diagrams and models. This supports Widiyastuti's (2018) findings that the PQRST model facilitates critical thinking and comprehension through independent and structured learning.

The third indicator, explaining scientific phenomena, reached an average of 66% (categorized as fair). Students were able to relate excretory concepts to real-life phenomena such as dehydration or proteinuria. According to Windasari (2020), PQRST improves students critical thinking by encouraging them to make observations and construct hypotheses.

The fourth indicator, evaluating and designing scientific investigations, achieved a good category with an average score of 75.5%. Students demonstrated the ability to design basic investigations, such as filtration simulations or urine protein tests, which reflects the development of their scientific inquiry skills. This aligns with Pradana and Santosa (2013), who emphasized that PQRST encourages students to evaluate and apply knowledge through reflective experiences.

The fifth indicator, interpreting data and scientific evidence, showed an average score of 66.25% (fair). Students could analyze diagrams, interpret data, and draw conclusions based on scientific information, strengthening their data literacy a key component of science assessment standards like PISA (OECD, 2023).

Comparison of Scientific Literacy between Experimental and Control Classes

The comparison between the experimental class (which received the PQRST learning intervention) and the control class (which received conventional instruction) is presented in Table 1. Both classes showed relatively similar pretest scores across all aspects of scientific literacy-context, knowledge, and competence-indicating a comparable baseline understanding of the human excretory system. Specifically, for the context aspect, the experimental class scored 64 and the control class 63; for knowledge, 61 and 65 respectively; and for competence, both scored 66. This indicates no significant difference in students' prior knowledge.

Table 1. Comparison of Pretest, Posttest, N-Gain, and Statistical Significance between Experimental and Control Classes Based on Scientific Literacy Aspects

Group	Context	Knowledge	Competence

Experimental Pretest	64	61	66
Control Pretest	63	65	66
Experimental Posttest	82	100	87
Control Posttest	74	86	67
Experimental N-Gain	0.72	0.77	0.71
Control N-Gain	0.51	0.56	0.50
p-value	**0.002**	**0.000**	**0.000**

After the intervention, however, posttest scores in the experimental class increased significantly in all aspects: context (82), knowledge (100), and competence (87). In contrast, the control class showed smaller gains: context (74), knowledge (86), and competence (67). This improvement suggests that the PQRST model had a substantial impact on students learning outcomes.

The normalized gain (N-Gain) scores reinforce this trend. The experimental group demonstrated higher gains across all indicators: 0.72 in context, 0.77 in knowledge, and 0.71 in competence, compared to the control group's 0.51, 0.56, and 0.50 respectively. These results indicate that the PQRST model not only facilitated knowledge acquisition but also supported deeper understanding and application of scientific concepts.

To verify whether these differences were statistically significant, an independent sample t-test and Mann–Whitney U test were conducted. As shown in the p-value row in Table 1, the results were statistically significant ($p < 0.05$) for all aspects: context ($p = 0.002$), knowledge ($p = 0.000$), and competence ($p = 0.000$). These findings affirm that the implementation of the PQRST model led to significantly better learning gains in scientific literacy compared to conventional teaching methods.

These results align with previous studies (Mariana et al., 2015; Windasari, 2020) which found that PQRST enhances students' conceptual understanding and ability to explain phenomena scientifically. Additionally, they support the principles of the Merdeka Curriculum, which emphasizes higher-order thinking skills and the integration of literacy and critical thinking into science education (Kemendikbudristek, 2022; OECD, 2023).

Student Response to the PQRST Learning Model

Students affective responses toward the PQRST learning model were assessed using a closed-ended questionnaire consisting of 20 items 10 positive and 10 negative statements measured using a four-point Likert scale. The questionnaire was designed to assess three affective dimensions as described by Krathwohl (2002): receiving, responding, and valuing.

As shown in Figure 2, students' overall responses were in the strong to very strong category. Figure 8 presents a more detailed view: the receiving dimension received a very strong response, while responding and valuing were in the strong category. Students stated that the PQRST model made the learning process more interesting, increased their confidence, and encouraged collaborative thinking. They also reported improved comprehension through reading and paraphrasing concepts in their own words.

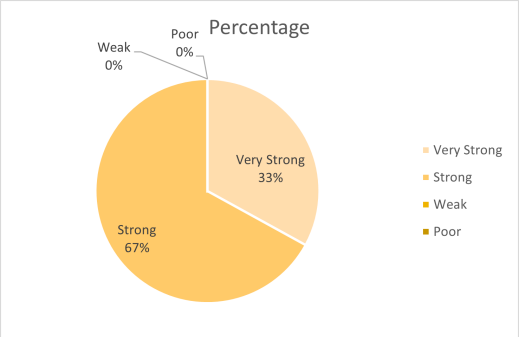


Figure 2. Percentage of students' overall responses to the PQRST learning model.

As shown in Figure 2, the majority of students (67%) responded in the "Strong" category and 33% in the "Very Strong" category, indicating a highly positive reception of the PQRST model. No students selected "Weak" or "Poor," suggesting that the learning strategy was well accepted and positively perceived by all participants.

These findings are consistent with Windasari (2020), who found that PQRST improves students' physical and psychological engagement and builds their confidence to express opinions and understand scientific content. Sukmawidiyanti (2013) also reported that students felt more enthusiastic and comfortable when learning through this model. The affective response aligns well with the goals of the Merdeka Curriculum, which emphasizes student-centered learning, differentiated instruction, and emotional well-being (Kemendikbudristek, 2022). Additionally, the results reflect the expectations of international standards like PISA, which highlight the role of engaged, motivated learners in developing scientific literacy and personal relevance (OECD, 2023).

The application of the PQRST model in teaching the human excretory system has shown significant improvements in students' scientific literacy and critical thinking skills. These improvements align with the goals of the Merdeka Curriculum, which emphasizes strengthening students' literacy competencies and critical thinking abilities. Research by Ayuningtyas and Nugraheni (2024) stated that the implementation of the Merdeka Curriculum can improve the quality of education through enhanced literacy abilities in various aspects, including science.

Moreover, the Guidelines for Learning and Assessment in the Merdeka Curriculum (Kemendikbudristek, 2022) highlight the importance of formative assessments that focus on students' competency development. The PQRST model, with its emphasis on literacy and critical thinking, aligns with these principles, providing flexibility for both educators and students to achieve the learning objectives set out.

Therefore, in addition to improving cognitive learning outcomes, the PQRST model has proven effective in enhancing students' motivation, self-confidence, and emotional engagement in science learning.

CLOSING

Conclusion

The PQRST model has proven to be effective in enhancing scientific literacy and critical thinking skills of students on the topic of the human excretory system in grade XI at SMAN 3 Kota Cirebon, in line with the objectives of the Merdeka Curriculum. Based on the data analysis, the experimental group using the PQRST model showed significant improvement in all three aspects of scientific literacy: context, knowledge, and competence, with higher N-Gain scores compared to the control group. Additionally, students gave positive feedback on the use of the PQRST model, which increased their engagement, confidence, and critical thinking abilities. Indicators of critical thinking were observed qualitatively through embedded tasks, although not measured with a separate standardized test. Therefore, the PQRST model is recommended as an effective teaching strategy to improve educational quality and support the development of critical thinkers and strong scientific literacy among students.

Suggestion

Future research is recommended to apply the PQRST model to other scientific topics beyond the human excretory system to determine its general effectiveness across different content areas. Additionally, integrating the PQRST model with digital learning platforms may further enhance student engagement and literacy development. Expanding the study to a larger and more diverse sample from various schools would also provide broader generalizability. Researchers are encouraged to explore the long-term impacts of the PQRST model on students' scientific reasoning and academic performance.

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