

CULTIVATING STUDENT INDEPENDENCE IN SCIENCE LEARNING USING THE “PROBLEM BASED LEARNING” MODEL IN PRIMARY SCHOOL

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ARTICLE HISTORY

Received : 11-07-2026

Revised : 09-08-2026

Accepted : 25-09-2026

KEYWORDS

Problem-Based Learning; Crossword Puzzle; Independent Learning; Science learning; Primary School

ABSTRACT

This study aims to describe the application of the Problem Based Learning (PBL) model integrated with Crossword Puzzle media in fostering students' learning independence in science learning. This qualitative study employed a case study method. Data were collected through observation, participation, in-depth interviews, and documentation. Data were analyzed using the Miles and Huberman model, while data validity was ensured through source and technique triangulation. The findings show that the implementation of PBL integrated with Crossword Puzzle media fostered students' learning independence, reflected in increased learning initiative, problem-solving ability, responsibility, courage to participate, and self-evaluation. Students demonstrated greater willingness to identify and solve learning problems, complete tasks independently, express ideas, and reflect on their learning experiences. Crossword Puzzle media also supported students' motivation and understanding of science concepts by providing an engaging and interactive learning activity. The implementation was supported by the teacher's role as facilitator and the relevance of learning problems to students' real-life experiences. However, limited learning resources and learning time presented challenges during implementation. Overall, these findings suggest that PBL integrated with Crossword Puzzle media can foster elementary school students' learning independence while supporting meaningful and enjoyable science learning in elementary science classrooms through active and collaborative learning.

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INTRODUCTION

Education in the current era of globalization faces the challenge of preparing a young generation who not only master academic knowledge but also possess critical and creative thinking skills, communicate and collaborate effectively, and are able to manage their own learning processes. Learning independence is particularly important because students are expected to take responsibility for planning, carrying out, and evaluating their learning activities. These competencies are

closely related to the demands of 21st-century education, which emphasize creative thinking, critical thinking and problem-solving, communication, and collaboration (Jannah et al., 2020). In addition, learning approaches that encourage students to analyze problems, formulate arguments, and actively participate in the learning process are considered relevant to the characteristics of 21st-century learning (Puspita Rahayu et al., 2022).

The 21st-century curriculum places students at the center of learning activities and encourages teachers to create learning environments that are active, contextual, collaborative, and oriented toward real-world problems. Such learning environments provide opportunities for students to develop responsibility, initiative, and independence while interacting with their peers and teachers. One learning model that is relevant to these demands is Problem-Based Learning (PBL). PBL engages students in learning through problems that require investigation, information seeking, discussion, solution development, and reflection. Through these activities, students are not merely recipients of information but are encouraged to take an active role in constructing their own understanding. The application of PBL is therefore relevant to learning environments that seek to develop independent learning through continuous investigation, planning, and reflection (Chusna et al., 2025).

In PBL, students are encouraged to seek relevant information, determine possible strategies, discuss alternatives, and evaluate the solutions they develop. These activities provide opportunities for students to practice independent learning while simultaneously developing critical thinking and problem-solving abilities (Istiara et al., 2025). In science learning, this approach is particularly relevant because students can be involved in observing phenomena, planning simple investigations, collecting information or data, and drawing conclusions independently or collaboratively (E. Sari et al., 2022).

Although PBL provides opportunities for active and independent learning, the implementation of a learning model also requires appropriate learning media to support students in understanding concepts and maintaining their engagement. In elementary science learning, interactive media can provide concrete and enjoyable learning experiences that help students connect scientific concepts with meaningful activities. One form of interactive media that can be integrated into learning is the Crossword Puzzle. Crossword Puzzle media presents questions or clues that require students to recall, identify, and connect key terms with particular concepts. This activity can function as cognitive stimulation because students need to organize information and retrieve previously learned knowledge to complete the puzzle (Azizah et al., 2022). In addition, puzzle-based activities have been associated with increased student engagement and motivation in learning (Nugroho, 2017), as well as supporting students' conceptual understanding in science and social studies learning at the elementary school level (Hastuti, 2017).

The integration of Crossword Puzzle media with PBL can provide complementary learning experiences. PBL provides a problem-oriented learning process, while Crossword Puzzle media can be used to reinforce concepts, review important terminology, and provide an engaging activity after students explore a problem. Within the PBL stages, students can be encouraged to identify problems, search for relevant information, discuss possible solutions, and use Crossword Puzzles to review and organize concepts related to the problem being studied. Such activities can create opportunities for students to manage learning tasks, seek information, communicate their ideas, and monitor their understanding. The use of puzzles as part of learning activities can therefore support students' active involvement and provide opportunities for formative evaluation (Listiani, 2022). Furthermore, an engaging learning format can help students participate in learning activities with greater confidence and reduce excessive dependence on direct assistance from the teacher (Utami et al., 2022). Previous studies have also demonstrated that problem-oriented learning can support students' cognitive and affective development. Problem-based learning has been associated with the development of students' problem-solving abilities (Novianti et al., 2020). Students' independence can also develop through their involvement in completing assignments and preparing reports based on experimental or investigative activities (M. Sari & Rosidah, 2023).

Learning independence involves more than the ability to complete assignments without assistance. It includes students' initiative in beginning learning activities, their ability to plan and manage learning tasks, responsibility for completing assignments, willingness to participate and express ideas, problem-solving ability, and capacity to evaluate their own learning. Through learning activities that require students to seek information, organize their work, solve problems, and reflect on their learning, dependence on teachers can gradually be reduced. Students can become accustomed to preparing work plans, finding relevant references, and evaluating the results of their own work (Shofiyah & Wulandari, 2018). This development is particularly important for fifth-grade elementary school students because learning independence provides a

foundation for facing increasingly complex learning demands at higher educational levels and for developing lifelong learning habits (Mustafiah et al., 2025).

However, the development of learning independence cannot be assumed simply from the implementation of a particular learning model or media. It is necessary to understand how students actually respond to learning activities and how their independence develops throughout the learning process. Previous studies have generally discussed the contribution of PBL to problem-solving, critical thinking, or learning outcomes, while studies concerning puzzle media have emphasized engagement, motivation, and conceptual understanding. These studies provide an important foundation, but there remains a need to examine how the integration of PBL and Crossword Puzzle media is implemented specifically in elementary science learning and how such integration is reflected in different dimensions of students' learning independence. Therefore, the novelty of the present study is directed toward describing the implementation of PBL integrated with Crossword Puzzle media in science learning as a learning strategy for fostering students' learning independence, rather than merely determining whether the strategy produces better learning outcomes.

This research gap is particularly relevant in the context of fifth-grade science learning at SD Negeri 1 Gumiwang, Banjarnegara Regency. Preliminary observations indicate that students' learning independence and mastery of science concepts still require attention. Most fifth-grade students tend to depend on teachers when completing exercises, experience difficulties in planning learning tasks, and are less inclined to seek their own solutions when encountering unfamiliar problems. The average daily science test score was 62.25, which was below the Minimum Completion Criteria (KKM) of 70. In addition, students' independent learning attitudes were observed to remain limited, particularly in completing assignments regularly and managing their study time.

Interviews with fifth-grade teachers at SD Negeri 1 Gumiwang further indicated that learning activities that explicitly encourage student independence have not been implemented consistently. Teachers still frequently use conventional lecture and practice methods, while the integration of PBL with interactive media such as Crossword Puzzles has not been consistently applied. This condition provides an important context for examining how a learning process that combines problem-based activities with interactive puzzle media may create opportunities for students to demonstrate initiative, responsibility, problem-solving ability, participation, and self-evaluation.

Based on the above discussion, this study aims to describe the application of the Problem-Based Learning model integrated with Crossword Puzzle media in fostering fifth-grade students' learning independence in science learning at SD Negeri 1 Gumiwang, Banjarnegara Regency. The study specifically examines the development of students' learning independence as reflected in learning initiative, problem-solving ability, responsibility, courage to participate, and self-evaluation during the learning process. The findings are expected to provide theoretical and practical contributions to the implementation of student-centered science learning at the elementary school level, particularly through the integration of PBL and interactive Crossword Puzzle media (Windy Sari, 2025).

METHOD

This qualitative study employed a case study design to explore the process of fostering students' learning independence through the implementation of Problem-Based Learning (PBL) integrated with Crossword Puzzle media. The research was conducted in Grade V science classes at SD Negeri 1 Gumiwang, Banjarnegara, from April to May 2026. The participants included 25 students, a classroom teacher, the school principal, and five parents/guardians. Five students representing varying levels of learning independence were purposively selected as key informants (coded as S1–S5) for in-depth observation and interviews.

The researcher acted as the primary instrument, supported by observation sheets, semi-structured interview guides, field notes, and multimedia recorders. The data collection focused on five observable dimensions of learning independence: learning initiative, responsibility, problem-solving ability, courage to participate, and self-evaluation. Data were gathered through three main techniques: (1) participatory observation conducted during four science learning meetings to observe the PBL syntax implementation and students' independent behaviors; (2) in-depth interviews with the teacher, key students, parents, and the principal to explore their learning experiences and perspectives; and (3) documentation study, which included lesson plans, student worksheets, Crossword Puzzle results, and self-reflection sheets.

To ensure data credibility, this study utilized source triangulation (cross-verifying data among students, the teacher, and parents) and technique triangulation (comparing observation, interview, and documentation data). Furthermore, member checking was conducted with the teacher and the five key students to verify the researcher's interpretations. The collected data were analyzed interactively using the Miles and Huberman (2014) framework, which encompasses data reduction (selecting and categorizing data based on the five dimensions of learning independence), data display (presenting data systematically in narratives and matrices), and conclusion drawing/verification.

RESULT AND DISCUSSION

Result

This study revealed that the implementation of Problem-Based Learning (PBL) integrated with Crossword Puzzle media provided a learning environment that encouraged the development of students' learning independence. Across three science learning meetings on the theme of "Recycling and Natural Events," students demonstrated gradual changes in their willingness to initiate learning activities, solve problems, manage responsibilities, participate in discussions, and evaluate their own learning. These findings were identified through triangulation of participatory observations, interviews, and documentation of student learning activities and work. The findings are discussed according to five aspects of learning independence: learning initiative, problem-solving ability, responsibility and self-management, courage to participate, and self-evaluation.

Learning Initiative

The first finding concerns students' initiative in starting and developing their own learning activities. Learning initiative was demonstrated by students who actively sought information, opened learning resources, asked questions, and began working on learning tasks without waiting for direct instructions from the teacher. During the learning process, the teacher presented a real problem concerning heavy rainfall, flooding, and landslides in Banjarnegara. Rather than immediately explaining the causes and solutions, the teacher encouraged students to investigate the problem through group discussions and independent searches for information. This approach gradually shifted the students' position from passive recipients of information to active learners.

One of the clearest examples was demonstrated by Abdi Bara Arifki (Student A). Observation data showed that Abdi consistently initiated learning activities by opening textbooks and searching for relevant information in the classroom library before being instructed by the teacher. He also encouraged his group members to begin working on the flood-prevention poster. In an interview, Abdi stated, *"I like being told to look for it myself. It's more exciting than listening to continuous lectures."* (Interview, 11 June 2026). His learning product further supported this observation, as he submitted the project earlier than other students and produced a poster containing relatively complete information and an organized design.

These findings indicate that the PBL learning environment created opportunities for students to take greater ownership of the learning process. The teacher's role was particularly important in this process. Instead of directly providing answers, the teacher used scaffolding questions such as, *"What do you think?"* and encouraged students to obtain information from books or their surrounding environment. Such facilitation allowed students to practice initiating their own learning activities rather than depending entirely on teacher explanations.

Problem-Solving Ability

The second aspect identified was students' ability to analyze problems and formulate solutions based on information obtained from their environment. The authentic problems presented through PBL encouraged students to connect scientific concepts with situations encountered in everyday life.

This development was particularly evident in Muhammad Khoirul Anam (Student B). During the first meeting, Anam tended to wait for explanations from the teacher and showed limited confidence in expressing his ideas. However, during the subsequent meetings, he began to investigate the problem independently and relate the learning material to conditions around his home.

Anam explained, *"At first I was confused. But after Mrs. Yayuk asked me to look around the house, I realized. It turned out that the cause of the flooding near my house was because of rubbish."* (Interview, 11 June 2026). He subsequently proposed cleaning the drainage channels regularly and brought photographs of blocked gutters as supporting evidence for his

group's discussion. The photographs and his participation in the discussion provided documentary evidence that he was not merely repeating information from the teacher but was attempting to identify the cause of a real problem and propose a solution.

The finding suggests that the problem-oriented nature of PBL supported the development of students' problem-solving independence. Students were encouraged to identify problems, gather information, connect causes and effects, and formulate possible solutions. The gradual change observed in Anam also demonstrates that learning independence did not emerge immediately but developed through repeated opportunities to investigate and make decisions.

Responsibility and Self-Management

The third aspect was students' ability to take responsibility for learning tasks and manage their time and activities. Independence in this aspect was reflected in students' ability to organize group work, record agreements, divide responsibilities, and complete tasks without continuous teacher supervision.

Naila Zahra Nur Azizah (Student C) provided the clearest evidence of this aspect. During group activities, Naila carefully recorded the results of discussions and helped distribute responsibilities among group members. She also independently arranged a schedule for completing the project outside classroom hours.

Naila stated, *"I don't like it when the assignments are haphazard. So, I note down everything that is decided. I also remind my friends what they have to do."* (Interview, 11 June 2026). This statement was supported by observation and documentation. Her discussion notes were organized, and the division of tasks among group members was clearly recorded. The evidence indicates that Naila was able to regulate her learning-related activities rather than relying entirely on the teacher to manage the completion of the group project.

The development of responsibility was also supported by the structure of PBL, which required students to complete several interconnected activities, including identifying problems, investigating information, developing solutions, and presenting the results. Because these activities could not always be completed within one 2×35 -minute learning session, students were required to organize their time and continue some activities outside the classroom. Thus, the characteristics of PBL provided a practical context in which students could exercise self-management.

Courage to Participate

The fourth aspect was students' courage to participate, particularly their willingness to express opinions, make decisions, and communicate ideas during group discussions and presentations. This aspect was important because learning independence is not limited to individual learning activities but also involves students' willingness to take intellectual responsibility for their ideas.

The development of this aspect was observed in Millian Rizky Qonita (Student D). During the first meeting, Millian tended to be shy and avoided eye contact during classroom presentations. However, her participation gradually increased during the second and third meetings. She began to express opinions that differed from those of her group members.

For example, when the group initially planned to use new cardboard for their poster, Millian proposed using used cardboard as an alternative to reduce waste. She explained, *"I was worried that my opinion was wrong. But Mrs. Yayuk said there are no wrong answers in PBL, the important thing is that we have a reason."* (Interview, 12 June 2026). Her suggestion was subsequently accepted by the group. Observation data also showed that she was able to participate more confidently during the third-meeting presentation than during the first meeting.

This finding suggests that the teacher's facilitative approach and the collaborative learning environment contributed to creating psychological space for students to express their ideas. The teacher's tendency to respond to students' answers with questions rather than immediate judgment helped reduce students' fear of making mistakes. In addition, small-group interaction provided a supportive context in which students could practice expressing and defending their ideas before presenting them to the whole class.

The Role of Crossword Puzzle Media in Supporting Learning

In addition to PBL, the use of Crossword Puzzle media at the end of each learning meeting appeared to support students' engagement in reviewing the concepts that had been discussed. Observation data showed that students were enthusiastic when completing the Crossword Puzzle because they perceived the activity as a challenging game rather than a conventional test. Students attempted to complete the puzzle independently while occasionally discussing terms with their peers.

The teacher also observed this enthusiasm, stating, *“The students were very enthusiastic when completing the crossword puzzles. They competed to complete them quickly and correctly. Interestingly, they reminded each other of the terms they had learned.”* (Interview, 12 June 2026). This finding suggests that the Crossword Puzzle provided a less formal context for students to recall and reinforce scientific concepts.

However, the Crossword Puzzle should be interpreted as a supporting learning medium rather than direct evidence of effectiveness. The quantitative scores that increased from 65.2 to 78.5 may be presented as supplementary information showing a difference in students' learning outcomes, but this change alone cannot establish that the Crossword Puzzle caused the improvement within a qualitative research design. Therefore, the primary evidence in this study remains the observed changes in students' learning behaviors, supported by interview statements and documentation.

The role of the Crossword Puzzle was therefore complementary to PBL. While PBL provided students with opportunities to investigate authentic problems, collaborate, make decisions, and develop solutions, the Crossword Puzzle provided an engaging activity for recalling and reinforcing concepts after the problem-solving process. The combination of the two created a learning process that involved both higher-order engagement with real problems and repeated reinforcement of key concepts.

Supporting and Inhibiting Factors in the Implementation of PBL

The implementation of PBL was supported by several factors. First, the teacher's facilitative role enabled students to gradually assume greater responsibility for their learning. Rather than providing direct answers, the teacher used guiding questions that encouraged students to investigate problems independently. Second, the collaborative learning environment provided opportunities for students with different levels of confidence to participate. The development observed in Millian illustrates how group interaction can encourage previously hesitant students to express their ideas.

Third, the relevance of the problems contributed to students' engagement. Flooding, waste accumulation, and landslides were closely related to the students' surrounding environment in Gumiwang and Banjarnegara. Consequently, students could connect scientific concepts with situations they had encountered in everyday life. Fourth, the Crossword Puzzle provided an engaging medium for reviewing learning concepts and maintaining students' motivation after the problem-solving activities.

Nevertheless, several factors limited the implementation. The first was the limited availability of learning resources. The school's limited collection of reference books made it difficult for some students to independently obtain supporting information. Consequently, some students relied on digital devices belonging to their parents, which were not equally accessible to all students. The second limitation was time. The complete PBL process, including problem orientation, investigation, solution development, and presentation, could not always be completed within a 2×35 -minute learning session. Some project activities therefore had to continue outside classroom hours.

The third limitation was students' previous learning habits. Some students initially continued to wait for answers from the teacher because they were accustomed to teacher-centered instruction. This condition explains why the teacher still provided relatively strong guidance during the first meeting. However, the gradual reduction of teacher direction during the second and third meetings allowed students to assume greater responsibility for their learning activities.

Overall Interpretation of the Findings

Overall, the findings indicate that the integration of PBL and Crossword Puzzle media created conditions that supported the gradual development of students' learning independence. The evidence was not represented by a single change in academic scores but by observable changes in students' learning behaviors across five dimensions. Abdi demonstrated learning initiative, Anam demonstrated problem-solving ability, Naila demonstrated responsibility and self-management, Millian demonstrated courage to participate, and Safaras demonstrated self-evaluation. Importantly, these individual cases should be understood as evidence representing broader thematic findings, rather than as isolated student profiles.

The triangulation of observations, interviews, and documentation strengthens the interpretation because each aspect was supported by more than one source of evidence. The findings also indicate that the development of learning independence occurred progressively rather than instantaneously. The teacher's gradual shift from providing direct guidance toward facilitating student investigation was an important part of this process. Therefore, PBL can provide a meaningful learning structure for developing learning independence when teachers consistently provide opportunities for students to investigate, make decisions, manage responsibilities, communicate ideas, and reflect on their own learning.

Discussion

The findings of this study indicate that the implementation of the Problem-Based Learning (PBL) model integrated with Crossword Puzzle media provided a learning environment that supported the gradual development of learning independence among fifth-grade students at SD Negeri 1 Gumiwang, Banjarnegara. The development was reflected in five interrelated aspects: learning initiative, problem-solving ability, responsibility and self-management, courage to participate, and self-evaluation. These findings were identified through the triangulation of observation, interview, and documentation data. Rather than merely confirming previous studies, the findings demonstrate how the characteristics of PBL created opportunities for students to gradually shift from dependence on teacher explanations toward more active participation in identifying problems, seeking information, making decisions, managing tasks, and reflecting on their learning.

PBL and the Development of Learning Initiative

The development of learning initiative was particularly evident in Abdi Bara Arifki, who consistently sought learning resources without waiting for direct instructions from the teacher. Observation data showed that Abdi independently opened textbooks and searched for information in the classroom library, while documentation showed that he completed the project earlier and produced a poster containing relatively complete information. His interview statement that searching for information independently was more enjoyable than continuously listening to explanations further supports this finding.

This behavior can be interpreted as a consequence of the investigation-oriented characteristics of PBL. When students are presented with an authentic problem without being given an immediate solution, they are required to determine what information they need and where they can obtain it. In this process, the teacher's role as a facilitator becomes important because excessive teacher direction may reproduce students' dependence on the teacher. In the present study, the teacher gradually reduced direct guidance from the first to the third meeting and instead used scaffolding questions to encourage students to find information independently. This mechanism helps explain why Abdi demonstrated a stronger initiative as the learning process progressed.

The finding is consistent with Chusna et al. (2025), who reported that PBL can support independent learning through investigation, planning, and reflection. However, the present finding extends this perspective by showing that the development of initiative was not simply a consequence of using PBL but was facilitated by the teacher's gradual transfer of responsibility to students. This is also consistent with the student-centered characteristics of PBL emphasized by Puspita Rahayu et al. (2022). In the context of elementary science learning, this suggests that PBL can be particularly useful when teachers provide students with sufficient space to determine learning resources and learning strategies rather than continuously providing information directly.

PBL and Problem-Solving Ability

The second finding concerns the development of students' problem-solving ability. Muhammad Khoirul Anam initially tended to wait for teacher explanations but gradually became able to identify environmental problems, connect them with the science concepts being studied, and formulate possible solutions. His observation of blocked drainage near his home and his decision to bring photographs as supporting evidence demonstrate that he began to use information from his immediate environment to understand the problem.

The development of Anam's problem-solving ability can be explained by the authentic problem presented through PBL. The problem concerning flooding and landslides was not an abstract question separated from students' lives. Instead, students encountered similar environmental conditions in their surroundings. This relevance encouraged Anam to move beyond remembering information and to investigate the possible causes of flooding based on his own observations. Thus, the problem functioned as a stimulus that connected classroom learning with real-world experience.

This finding supports Novianti et al. (2020), who found that PBL can develop students' problem-solving skills, and Ramadani et al. (2022), who emphasized the role of investigation and observation in PBL. Nevertheless, the present finding provides a more specific explanation of the process: authentic problems encouraged students to collect contextual evidence before proposing solutions. This is important in elementary science learning because problem-solving should not be limited to answering questions in textbooks but should also involve observing phenomena, identifying causes, collecting simple evidence, and proposing reasonable solutions. The finding is also relevant to the principles of deep learning discussed by Royani et al. (2024) and Istiara et al. (2025), particularly the application of knowledge to meaningful real-world situations.

PBL, Responsibility, and Self-Management

The third finding was the development of responsibility and self-management, particularly demonstrated by Naila Zahra Nur Azizah. Naila independently recorded the results of group discussions, divided tasks among group members, and prepared a schedule for completing project activities. These behaviors indicate that her independence was not limited to completing an individual assignment but also involved organizing the learning process and ensuring that group responsibilities were completed.

The development of this behavior can be understood from the structure of PBL itself. The completion of a PBL task requires students to pass through several stages, from understanding the problem and collecting information to developing a product and presenting the solution. Because these stages cannot always be completed simultaneously, students must organize their time and responsibilities. Naila's initiative in creating a schedule therefore emerged because the learning task required her to manage a sequence of activities rather than simply complete a worksheet provided by the teacher.

This finding is consistent with M. Sari and Rosidah (2023), who stated that student independence in completing assignments and organizing learning activities can develop through PBL. It also supports Shofiyah and Wulandari (2018), who emphasized the importance of planning and evaluating one's own work in reducing dependence on teachers. The present finding indicates that responsibility can develop more naturally when students are given authentic tasks with clear goals and sufficient autonomy to determine how the tasks will be completed. Therefore, PBL has implications not only for science knowledge but also for students' ability to regulate their learning activities.

PBL and Courage to Participate

The fourth finding relates to students' courage to participate and express their opinions. Millian Rizky Qonita showed a noticeable change from being hesitant during the first meeting to expressing alternative ideas and participating more confidently in the third meeting. One example occurred when Millian suggested using used cardboard for the poster instead of new cardboard. Although she initially worried that her opinion might be incorrect, she eventually expressed the idea and received agreement from her group members.

The development of Millian's participation suggests that PBL can create opportunities for students to practice expressing ideas in a relatively supportive environment. Importantly, the teacher did not immediately judge students' responses as right or wrong but encouraged them to provide reasons for their opinions. This approach appears to reduce the perceived risk of making mistakes. The small-group discussion also provided a less intimidating environment than direct whole-class participation, allowing a previously hesitant student to practice expressing an opinion before presenting it to the entire class.

This finding complements Istiara et al. (2025), who found that PBL encourages students to actively seek information and develop solution strategies. However, the present study suggests that active participation is also influenced by the social and emotional conditions created during the implementation of PBL. In other words, the problem-solving structure alone may not be sufficient for shy students; teacher facilitation and supportive peer interaction are also important mechanisms. The Crossword Puzzle media may further contribute to this atmosphere by providing an informal and game-like activity in which students can review concepts without the pressure associated with conventional testing. This interpretation is consistent with Utami et al. (2022), who found that puzzle-based learning activities can make learning feel less burdensome and encourage student engagement.

PBL and Self-Evaluation Skills

The fifth finding concerns students' ability to evaluate their own learning. Safaras Surya N demonstrated this aspect by recognizing his difficulty in understanding evaporation, seeking assistance from a peer, and creating personal notes to improve his understanding. His reflection sheet and summary notes provide additional evidence that he was able to identify a learning difficulty and determine an appropriate strategy to overcome it.

This behavior illustrates an important distinction between learning dependence and strategic help-seeking. Asking a friend for assistance does not necessarily indicate a lack of independence. In Safaras's case, he first recognized what he did not understand and then deliberately sought assistance to overcome the difficulty. He subsequently created his own notes and attempted to complete the Crossword Puzzle independently. Thus, the process involved recognizing a problem, selecting a strategy, receiving assistance, and evaluating subsequent understanding.

This finding supports Mustafiah et al. (2025), who emphasized the importance of independent learning in preparing students to deal with increasingly complex learning demands. The present finding further indicates that PBL can provide situations in which students become aware of their own knowledge gaps because they are required to work with problems rather than simply reproduce information from the teacher. Reflection therefore becomes an important component of learning independence. In elementary science education, encouraging students to identify what they do and do not understand can become an early foundation for metacognitive learning habits.

The Role of Crossword Puzzle Media in Concept Reinforcement and Motivation

The Crossword Puzzle media played a complementary role in the implementation of PBL. The activity was conducted at the end of each meeting and was designed to encourage students to recall important terms and concepts from the learning process. Observation data showed that students participated enthusiastically because they perceived the activity as a challenge or game rather than as a conventional test. Students also occasionally helped one another recall scientific terms while attempting to complete the puzzle.

The function of the Crossword Puzzle in this study can therefore be interpreted primarily as concept reinforcement and engagement, rather than as the main mechanism for developing learning independence. PBL provided the main context in which students investigated problems, discussed solutions, and managed learning activities, while the Crossword Puzzle provided an opportunity to retrieve and reorganize concepts after the investigation. This complementary relationship is important because understanding scientific concepts requires not only contextual application but also opportunities to recall and reinforce terminology.

The increase in the average score from 65.2 to 78.5 should nevertheless be interpreted cautiously. Because this study primarily used qualitative data from observations, interviews, and documentation, the score difference should be treated as supporting data rather than evidence that the Crossword Puzzle caused an improvement in learning outcomes. Establishing the effectiveness or causal contribution of the Crossword Puzzle would require a quantitative design with clearly defined procedures for measurement and comparison. Therefore, the stronger evidence in this study lies in the observed student engagement, conceptual recall during the puzzle activity, and students' willingness to participate in reviewing learning materials.

The finding is broadly consistent with Azizah et al. (2022), Nugroho (2017), and Hastuti (2017), who reported that puzzle-based learning activities can support engagement, motivation, and conceptual understanding. Windy Sari (2025) also emphasized the potential of Crossword Puzzles to encourage responsibility for learning. The present study adds that Crossword Puzzle media can function effectively as a reinforcement activity following problem investigation, rather than replacing the investigation process itself.

Relationship Between PBL and Crossword Puzzle Media

The findings suggest that PBL and Crossword Puzzle media contributed to different but complementary components of the learning process. PBL provided the structure for students to encounter authentic problems, investigate information, collaborate, make decisions, and develop solutions. Meanwhile, Crossword Puzzle media provided a relatively enjoyable mechanism for recalling and reinforcing scientific concepts after the problem-solving activities.

This combination may explain why students remained engaged throughout the learning process. The authentic problem gave students a reason to investigate, while the Crossword Puzzle provided a different form of cognitive activity after the investigation. Consequently, learning did not rely exclusively on discussion or teacher explanation. For elementary students, variation between investigation, collaboration, production, reflection, and game-based reinforcement can help maintain attention while providing repeated opportunities to interact with the learning material.

Implications for Science Learning and the Initial Learning Problem

The findings directly address the initial problem identified in this study, namely the tendency toward low learning independence and relatively weak science learning outcomes among students at SD Negeri 1 Gumiwang. The initial average daily science score of 62.25, which was below the school's minimum mastery criterion of 70, indicated that students required learning experiences that could encourage more active engagement with science concepts.

However, the findings suggest that the most important change was not simply an increase in scores but a change in learning behavior. Abdi demonstrated greater initiative in seeking information, Anam connected scientific concepts with environmental problems, Naila organized group responsibilities, Millian became more willing to express ideas, and Safaras

developed strategies for addressing his learning difficulties. These changes indicate that PBL provided students with opportunities to practice independence through actual learning activities.

The implication for elementary science education is that teachers should not interpret learning independence merely as students being able to work without assistance. Instead, independent learning involves students being able to initiate activities, identify problems, seek information, make decisions, manage responsibilities, communicate ideas, and evaluate their own understanding. PBL can facilitate these behaviors when teachers gradually transfer responsibility to students rather than maintaining continuous control over the learning process.

Supporting and Inhibiting Factors

The implementation of PBL was supported by the teacher's facilitative role, the collaborative learning environment, the relevance of problems to students' daily lives, and the use of engaging Crossword Puzzle media. These factors worked together to create opportunities for students to participate more actively. In particular, the teacher's transition from more directive guidance during the first meeting toward greater student responsibility during the second and third meetings appears to have been important in supporting the gradual development of independence.

Nevertheless, the implementation was constrained by limited learning resources, restricted instructional time, and students' previous passive learning habits. The limited availability of reference books made independent information searching more difficult for some students, while the 2×35 -minute lesson duration was not always sufficient to complete the entire PBL process. In addition, students who were accustomed to teacher-centered instruction initially tended to wait for answers rather than investigate problems independently.

These constraints indicate that successful PBL implementation requires more than simply changing the learning model. Teachers need to prepare adequate learning resources, allocate sufficient time for investigation and presentation, and gradually train students to assume responsibility for their learning. The findings therefore suggest that the transition from passive to independent learning should be viewed as a gradual process, particularly among elementary school students who have previously experienced predominantly teacher-centered learning.

Table 1. Summary of Findings and Implications

Aspect of Independence	Student Name	Main Findings	Theoretical Links
Learning Initiative	Abdi Bara Arifki	Actively search for learning resources without waiting for teacher orders	Chusna et al; 2022 Puspita et al; 2022
Problem solving	M. Khoirul Anam	Identify real problems and propose concrete solutions	Novianti et al., 2020; Ramadani et al., 2022
Responsibility	Naila Zahra N.A.	Dividing tasks, being disciplined, and managing your own schedule	Sari & Rosidah, 2023; Shofiyah & Wulandari, 2018
Courage to Participate	Millian Rizky Qanita	Dare to convey alternative ideas even though initially shy	Istiara et al., 2025; Utami et al., 2022
Self-Evaluation	Safaras Surya N	Acknowledge weaknesses and actively seek help to improve them.	Mustafiah et al., 2025

Overall, this study demonstrates that the integration of PBL with Crossword Puzzle media can create learning conditions that support the gradual development of learning independence. The contribution of PBL was most apparent in students' investigation, problem-solving, responsibility, participation, and reflection, whereas the Crossword Puzzle functioned primarily as a medium for reinforcing concepts and maintaining engagement. The development of independence was not instantaneous and was influenced by teacher facilitation, peer interaction, problem relevance, and the availability of learning resources.

The findings also indicate that the value of PBL in elementary science learning lies not only in improving academic achievement but also in creating opportunities for students to practice behaviors associated with independent learning. Therefore, the effectiveness of the learning process should be understood through changes in students' learning behaviors and the quality of their engagement, while numerical score changes should be interpreted as supplementary evidence unless supported by an appropriate quantitative research design.

CONCLUSION

Based on the findings and discussion, the implementation of the Problem-Based Learning (PBL) model integrated with Crossword Puzzle media supported the development of learning independence among fifth-grade students in science learning at SD Negeri 1 Gumiwang, Banjarnegara. The findings indicate that learning independence developed gradually through students' involvement in problem orientation, investigation, discussion, solution development, presentation, and reflection. The teacher's role as a facilitator was important in this process, particularly through the use of scaffolding questions that encouraged students to investigate problems and formulate solutions rather than relying solely on direct explanations. The development of learning independence was observed across five aspects: learning initiative, problem-solving ability, responsibility and self-management, courage to participate, and self-evaluation. These aspects were demonstrated by different students through observable behaviors, including independently seeking learning resources, relating science concepts to real-life problems, organizing group tasks, expressing opinions, recognizing learning difficulties, and seeking appropriate strategies to overcome them. The triangulation of observation, interview, and documentation data strengthened the interpretation of these findings.

The integration of Crossword Puzzle media provided additional opportunities for students to review and reinforce science concepts in an engaging learning environment. Students showed enthusiasm in completing the puzzles and used the activity to recall key scientific terms discussed during the learning process. The increase in the average Crossword Puzzle score from 65.2 in the first meeting to 78.5 in the third meeting may be considered supporting evidence of students' improved performance during the activity; however, this change should not be interpreted as direct evidence of the effectiveness or causal impact of the Crossword Puzzle because the study primarily employed a qualitative approach.

Practically, the findings suggest that elementary school teachers can use PBL combined with engaging learning media to provide students with greater opportunities to investigate real-life problems, manage learning responsibilities, express ideas, and reflect on their understanding. However, the implementation requires adequate preparation, sufficient learning resources, and realistic time allocation. The study also found that students' transition from passive learning habits to more independent learning did not occur immediately and required consistent teacher facilitation and gradual transfer of responsibility.

This study has limitations related to the limited number of research subjects, the relatively short implementation period of three learning meetings, limited learning resources, and restricted instructional time. Therefore, the findings should be interpreted within the context of the participating students and learning setting. Future studies may involve a longer implementation period, a broader range of participants, and a mixed-method or quantitative design to further examine changes in learning independence and the contribution of Crossword Puzzle media to science learning outcomes.

ACKNOWLEDGMENT

The highest gratitude should be conveyed to the honorable Rector of Universitas Muhammadiyah Purwokerto Prof. Dr. Jebul Suroso, S.Kep; M.Kep.; Director of the UMP Postgraduate Program Prof. Drs. Ahmad, Ph.D.; Head of the Master of Elementary Education Study Program Assoc. Prof. Dr. Subuh Anggoro, M.Pd. for their permission and guidance in writing this research.

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