

DEVELOPING ACCESSIBLE SCHOOL ENVIRONMENTS THROUGH PROJECT-BASED LEARNING: BRAILLE ROOM SIGNS FROM RECYCLED BEVERAGE CANS

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Abstract. This study aimed to describe the implementation of Project-Based Learning (PjBL) in science education on environmental pollution, specifically the creation of Braille room signs from recycled beverage cans, and to examine the project's contribution to school accessibility. A qualitative approach with a case study design was employed involving three seventh-grade students with visual impairments at SLBN Banjar, Indonesia. Data were collected through observations, semi-structured interviews, student reflection journals, documentation, product analysis, and field notes. The findings revealed that PjBL was implemented through six stages: determining essential questions, project planning, project scheduling, project implementation, project assessment, and evaluation and reflection. Through the project, students learned about environmental pollution, waste classification and management, and the reuse of beverage cans to create Braille room signs that benefit the school community. The project resulted in the installation of 11 Braille room signs in various school facilities, which were still in use at the time of the study. The findings indicate that PjBL not only supported the achievement of science learning objectives but also improved school accessibility for students and teachers with visual impairments. This study demonstrates the potential to integrate science education, waste utilization, and school accessibility development through project-based learning activities.

Keywords: Project-Based Learning, Science Education, Environmental Pollution, Braille Room Signs, Visual Impairment, School Accessibility

INTRODUCTION

Science education plays an important role in helping students understand natural phenomena through scientific inquiry. In addition to developing conceptual and factual knowledge, science learning promotes scientific literacy, defined as the ability to use scientific knowledge and processes to explain phenomena, evaluate information, and make responsible decisions in everyday life (Budiarti & Tanta, 2021). In special junior secondary schools (SMPLB), science instruction is expected to provide learning experiences that enable students to identify problems, develop solutions, and apply knowledge in real-life contexts in accordance with learning outcomes that emphasize functional skills, problem-solving abilities, and student independence (Badan Standar, Kurikulum, dan Asesmen Pendidikan [BSKAP], 2025).

Education also plays a significant role in supporting sustainable development by fostering knowledge, skills, attitudes, and behaviors that promote environmental and social responsibility (Pratiwi et al., 2023). In line with the concept of Education for Sustainable Development (ESD), learning should equip students with the knowledge, skills, values, and actions needed to address real-world challenges and actively participate in problem-solving within their communities (UNESCO, 2020). Strengthening scientific literacy through learning experiences that connect

scientific concepts with environmental issues is considered an important strategy for achieving sustainable development goals (Pantiwati et al., 2024). Furthermore, Sustainable Development Goal (SDG) 4 emphasizes the importance of inclusive and accessible education for all learners, including students with disabilities. Therefore, learning should be designed not only to achieve academic outcomes but also to promote students' participation and independence.

Despite these expectations, science instruction is often dominated by teacher-centered information delivery, limiting students' opportunities to engage in scientific activities such as observation, investigation, analysis, and problem solving (Permana, 2019). Active student engagement, however, has been shown to contribute to the development of critical thinking, communication, collaboration, and problem-solving skills required in the twenty-first century (Fitriansyah et al., 2021; Kokotsaki et al., 2016). Consequently, learning models that connect science concepts with authentic problems encountered in students' daily lives are needed.

This situation was identified in seventh-grade science classes for students with visual impairments at SLBN Banjar during the second semester of the 2024/2025 academic year. Preliminary observations indicated that instruction remained largely focused on content delivery, offering limited opportunities for students to connect concepts of environmental pollution to real issues in their school environment. Although students had learned about types of waste, the impacts of environmental pollution, and waste management practices, they had not yet engaged in learning experiences that encouraged them to identify school-based problems and develop practical solutions.

At the same time, used beverage cans were commonly found around the school and had not been utilized effectively. In addition, although room labels in standard print were available throughout the school, Braille room signs accessible to students with visual impairments were not yet provided. As a result, students often relied on others' assistance to identify specific locations within the school. This situation created an opportunity to integrate science learning about environmental pollution with efforts to improve school accessibility by transforming used beverage cans into Braille room signs that students with visual impairments could use directly.

One instructional model that may address these needs is Project-Based Learning (PjBL). This approach enables students to learn concepts through investigation, planning, project implementation, and product development related to real-world situations (Thomas, 2000). Through project activities, students can deepen conceptual understanding while developing critical thinking, communication, collaboration, and problem-solving skills (Tierney et al., 2022). Moreover, PjBL promotes active student engagement throughout the learning process (Baines, 2018).

In this study, PjBL was implemented in science learning about environmental pollution through a project that involved creating Braille room signs from used beverage cans. The project began by identifying environmental and accessibility issues within the school, then collected information about room names and functions through interviews, and culminated in the transformation of used beverage cans into Braille room signs installed in various school facilities.

Although numerous studies have reported the effectiveness of PjBL in improving learning outcomes, scientific literacy, creativity, and critical thinking skills, research connecting environmental pollution learning to the development of school accessibility for students with visual impairments remains limited. Furthermore, research on the contribution of project outcomes to school accessibility remains relatively scarce.

Therefore, this study aimed to describe the implementation of PjBL in science learning about environmental pollution by creating Braille room signs from used beverage cans and to examine

the contribution of the project outcomes to improving school accessibility for students with visual impairments.

METHODS

This study employed a qualitative case study design to describe the implementation of Project-Based Learning (PjBL) in science education on environmental pollution by creating Braille room signs from used beverage cans, and to examine the contribution of the project outcomes to school accessibility. A case study design was selected because the research focused on an in-depth investigation of a single instructional context, namely science instruction for seventh-grade students with visual impairments at SLBN Banjar. This approach enabled the researchers to gain a comprehensive understanding of the instructional process, student participation, learning experiences, and project outcomes. In qualitative research, the researcher serves as the primary instrument for data collection and analysis (Creswell & Creswell, 2018).

The study was conducted at SLBN Banjar, West Java, Indonesia, during the second semester of the 2024/2025 academic year as part of a science lesson on environmental pollution. The project was implemented over two instructional sessions, totaling 8×35 minutes. The first session focused on determining essential questions, planning and scheduling the project, and collecting information on room names and functions. The second session focused on project implementation, assessment, evaluation, and reflection.

Participants consisted of three seventh-grade students with visual impairments, including two students who were totally blind and one student with low vision who was unable to use residual vision effectively for reading standard print. All students in the class were included as participants because they were involved in the entire project-based learning process. In addition, the school principal served as a supporting informant, providing information on how the project outcomes contributed to school accessibility.

Data were collected through observation, semi-structured interviews, student reflection journals, documentation, product analysis, and field notes. Observations were conducted throughout the six stages of Project-Based Learning (PjBL): determining essential questions, planning the project, developing a project schedule, implementing and monitoring the project, assessing project outcomes, and conducting evaluation and reflection. Semi-structured interviews were conducted with students and the school principal to gather information on learning experiences, project benefits, and the product's contribution to school accessibility. Product analysis of the Braille room signs was conducted based on content accuracy, Braille accuracy, readability, safety, neatness, and functionality.

Trustworthiness was established through triangulation of methods and data sources. Triangulation of methods involved comparing data obtained from observations, interviews, reflection journals, documentation, product analysis, and field notes. Source triangulation was conducted by comparing information obtained from students, the school principal, activity documentation, and the project products.

Data were analyzed using the interactive model of Miles, Huberman, and Saldaña (2014), which consists of data condensation, data display, and conclusion drawing and verification. Data from multiple sources were condensed, organized, and presented in narrative form to facilitate interpretation. The final stage involved drawing and verifying conclusions based on patterns, relationships, and findings that emerged throughout the study.

RESULTS AND DISCUSSION

A. Implementation of Project-Based Learning in Science Education

1. Determining the Essential Question

The project began with a video presentation illustrating environmental pollution caused by waste in Indonesia. Students then explored concepts of environmental pollution through a web-based learning resource. Following the exploration activity, students completed a five-item Quizizz quiz to assess their initial understanding of the topic. The teacher subsequently facilitated a discussion on waste-related issues, the reuse of discarded beverage cans, and the need for Braille room signs within the school environment. Observational data indicated that students actively participated in the discussion, although several questions needed to be simplified to accommodate their learning needs.

2. Project Planning

During this stage, students and the teacher collaboratively determined the project objectives, required materials and tools, and task allocation based on each student's abilities. Task distribution was intended to ensure meaningful participation by all students throughout the project activities.

Table 1
Student Roles and Responsibilities During the Project

Student	Role	Responsibility
KRM	Group Leader	Coordinated project activities and embossed Braille room signs
STR	Information Gatherer	Collected information about room names through interviews with school administrative staff
SLS	Presenter and Installer	Assisted in presenting project outcomes and installing Braille room signs

Note. Observational data indicated that students were able to participate in project planning with teacher guidance tailored to their individual abilities.

3. Project Scheduling

Students developed a project schedule that included information gathering, material preparation, product construction, installation, presentation, and evaluation activities. Observations showed that students experienced difficulty estimating the time required for each activity. Consequently, the teacher provided guidance in organizing the sequence of activities and establishing realistic completion targets.

4. Project Implementation

The implementation stage began with the collection of six used beverage cans obtained from students' homes and the school environment. The cans were cleaned, cut into aluminum sheets, and used as media for Braille embossing with a slate and stylus. After gathering information about room names through interviews with school administrative staff, students embossed the room names in Braille and installed the completed signs in the designated locations.

Observational data indicated that students were actively engaged throughout the production process. However, several activities, including cutting aluminum sheets and installing the signs, required teacher support to ensure safety and accuracy.



Figure 1.

Students embossing Braille room signs on recycled aluminum sheets.

Note: The figure shows students embossing Braille room signs on recycled aluminum sheets using a slate and stylus as part of the Project-Based Learning activity.

5. Project Assessment

At this stage, students reviewed the accuracy of room names, the correctness of Braille inscriptions, and the functionality of the completed signs. Observations revealed that several aluminum sheets could not be used because Braille writing errors could not be corrected. Nevertheless, all targeted products were completed and installed in the appropriate locations.

6. Evaluation and Reflection

Interview and reflection journal data indicated that students enjoyed participating in the project and expressed pride that their work was used within the school environment. Students were also able to identify the benefits of Braille room signs for individuals with visual impairments as well as the value of reusing discarded beverage cans in everyday life.

B. Students' Learning Experiences in Environmental Pollution Education

Interview and reflection data indicated that students developed an understanding of environmental pollution, waste classification, waste management, and the reuse of discarded beverage cans. KRM reported that the project helped develop an understanding of the impacts of waste, waste management practices, and the process of transforming used cans into Braille room signs. SLS stated that the project enhanced understanding of the types of waste and the procedures involved in producing Braille signs. At the same time, STR emphasized learning about the importance of waste management and material reuse.

Students also reported positive learning experiences throughout the project. KRM identified the Quizizz activity and Braille writing process as the most enjoyable aspects of the project. SLS particularly enjoyed installing the Braille signs, whereas STR described the entire project as an enjoyable learning experience.

Several challenges emerged during implementation, particularly when cutting aluminum sheets, embossing Braille on aluminum surfaces, and installing the completed signs. However, observational and field-note data indicated that these difficulties were successfully addressed through teacher guidance and support.

Reflection data further showed that students recognized the practical value of the Braille room signs. Students reported that the signs would help individuals with visual impairments identify rooms more independently. In addition, all students expressed satisfaction and pride that members of the school community used their products.

C. Outcomes of the Braille Room Sign Project

1. Product Description

The project resulted in 11 Braille room signs installed in various school facilities, including the administrative office, library, vocational classroom, information technology room, teachers' room, principal's office, restroom, hall, prayer room, school health unit, and security post.

The signs were produced from recycled beverage cans that were transformed into aluminum sheets and embossed with Braille room labels. Each sign was installed above the door handle to enable tactile reading by students with visual impairments.



Figure 2.

A braille room sign was installed in one of the facilities at SLBN Banjar.

Note: The sign was installed to improve accessibility for students with visual impairments.

2. Product Analysis

Product analysis indicated that the Braille room signs were of satisfactory quality and suitable for use as room identifiers in the school environment.

Table 2
Product Analysis Results

Criteria	Score	Category
Content Accuracy	4	Excellent
Braille Accuracy	4	Excellent
Readability	4	Excellent
Safety	3	Good
Neatness	3	Good
Functionality	4	Excellent

Note: Product analysis was conducted based on content accuracy, Braille accuracy, readability, safety, neatness, and functionality.

The analysis showed that all signs were installed in the correct locations, were readable through tactile exploration, and remained in use at the study's completion. Nevertheless, the aesthetic appearance and neatness of the products could be further improved by adding a supporting base material behind the aluminum sheets to enhance durability and visual presentation.

D. Contribution of the Project to School Accessibility

Interview data from the principal indicated that the project made a positive contribution to school accessibility. The Braille room signs enabled students and teachers with visual impairments to identify rooms more independently, thereby supporting orientation and mobility within the school environment. Through this project, the school obtained 11 Braille room signs, which were installed across various facilities and are available to individuals with visual impairments.

In addition to improving accessibility, the project promoted the productive reuse of discarded beverage cans that had previously been underutilized. The transformation of waste materials into functional products provided a practical example of waste utilization within science learning activities.

Interview, reflection, and documentation data further indicated that the Braille room signs provided direct benefits to students with visual impairments. Students reported that the signs enabled them to locate rooms without consistently relying on others' assistance. They also expressed pride in knowing that their work could benefit other students with visual impairments and members of the wider school community. These findings suggest that the project functioned not only as a learning activity but also as a meaningful contribution to improving school accessibility.

Discussion

A. Project-Based Learning as a Contextual Approach to Science Learning

The findings indicate that Project-Based Learning (PjBL) effectively connected environmental pollution content with authentic issues encountered within the school environment. Through identifying problems, planning and implementing a project, and reflecting on the outcomes, students not only learned environmental pollution concepts but also applied their knowledge to address real-world challenges. This finding is consistent with Thomas (2000), who emphasized that PjBL promotes meaningful learning by engaging students in authentic tasks and contexts.

Student engagement observed throughout the project further suggests that PjBL can foster active participation in the learning process. This finding supports Kokotsaki et al. (2016), who reported that PjBL provides opportunities for students to engage in investigation, collaboration, and problem solving. In the present study, students actively identified waste-related problems within the school environment, gathered information through interviews, and developed a product that served a practical function within the school.

In addition, the use of videos on environmental pollution and digital learning resources appeared to facilitate connections between scientific concepts and students' everyday experiences. These findings suggest that science learning becomes more meaningful when concepts are linked to contexts that are relevant to students' lives and immediate surroundings.

B. Science Learning Through Waste Reuse and Authentic Experiences

The interview and reflection data demonstrated that students developed an understanding of environmental pollution, waste classification, waste management, and the reuse of discarded beverage cans. These findings suggest that science learning can extend beyond conceptual understanding by providing opportunities for students to apply scientific knowledge in authentic contexts. This interpretation is consistent with Fitriansyah et al. (2021), who highlighted the importance of direct scientific experiences in promoting meaningful learning.

In this study, discarded beverage cans were transformed into Braille room signs, enabling students to engage in practical waste management through material reuse. Rather than learning about environmental issues solely through classroom instruction, students directly participated in an activity that demonstrated how waste materials can be repurposed into useful products.

The findings also reflect the principles of Education for Sustainable Development (ESD), which emphasize integrating knowledge, values, and action to address sustainability issues (UNESCO, 2020). Beyond supporting scientific literacy, the project encouraged students to engage in environmentally responsible practices by reusing materials available in their surroundings.

C. Adapting Project-Based Learning for Students with Visual Impairments

The findings indicate that PjBL can be successfully implemented with students with visual impairments when appropriate instructional adaptations are provided. Observational and field-note data showed that simplifying guiding questions, providing concrete learning experiences, and offering targeted support during technically demanding tasks were important for facilitating participation.

Task allocation based on students' abilities and characteristics also contributed to the project's successful implementation. Each student assumed a specific role that aligned with their strengths, enabling all participants to contribute meaningfully throughout the project. These findings suggest that flexibility in activity design and task distribution is particularly important when implementing project-based learning in special education settings.

Several project activities, including cutting aluminum sheets, embossing Braille on aluminum surfaces, and installing the signs, required teacher assistance to ensure safety and accuracy. Importantly, such support did not diminish student participation. Instead, it enabled students to engage more fully in the learning process and complete project tasks. These findings demonstrate that, with appropriate accommodations and support, students with visual impairments can actively participate in project-based learning and produce outcomes that benefit their school community.

D. Contribution of the Project to School Accessibility

One of the most significant findings of this study is the project's contribution to improving school accessibility. Unlike many classroom projects that conclude once learning activities are completed, this project resulted in 11 Braille room signs that were installed and actively used throughout the school.

Interview data indicated that the signs supported greater independence among students and teachers with visual impairments by facilitating room identification and supporting orientation and mobility within the school environment. Students also reported that the signs reduced their reliance on others' assistance when locating rooms. In addition, participants expressed a sense of pride knowing that their work benefited other members of the school community.

These findings suggest that the project functioned not only as a learning activity but also as a practical intervention that improved accessibility within the school environment. From the perspective of SDG 4, which advocates inclusive and equitable quality education, learning environments should support participation and accessibility for all learners, including those with disabilities (UNESCO, 2020). The present study demonstrates how project-based learning can contribute to these goals by producing tangible outcomes that enhance accessibility and support student independence.

E. Implications for Practice and Study Limitations

The findings suggest that PjBL can serve as an effective instructional approach for connecting science learning with authentic needs within the school environment. For teachers, particularly those working in special education settings, projects using locally available materials may offer opportunities to develop scientific understanding while producing practical products.

The study also highlights the importance of adapting instruction to learners' characteristics. Appropriate task allocation, accessible learning resources, and structured teacher support enabled students with visual impairments to participate actively throughout the project. These considerations may be useful for educators seeking to implement inclusive project-based learning experiences.

From a practical perspective, projects derived from genuine school needs may provide a meaningful way to integrate science education, waste reuse, and accessibility development. Such an approach has the potential to create learning experiences that are contextual, participatory, and beneficial to the wider school community.

This study has several limitations. The project involved only three students from a single class and was conducted over two instructional sessions. Consequently, the findings are not intended to be generalized to all educational contexts. Rather, they provide an in-depth understanding of how PjBL can be implemented within a special education setting for students with visual impairments.

CONCLUSION

This study demonstrates that Project-Based Learning (PjBL) can be effectively implemented in environmental pollution science instruction for students with visual impairments. Through the project, students developed an understanding of environmental pollution, waste management, and the reuse of discarded beverage cans while actively engaging in problem-solving activities connected to authentic needs within their school environment.

The project resulted in 11 Braille room signs that were installed and used in various school facilities. Beyond supporting science learning objectives, the project helped improve school accessibility by assisting students and teachers with visual impairments in identifying rooms more independently. These findings highlight the potential of PjBL to integrate science education, waste reuse, and accessibility development by creating products with practical value for the school community.

Future studies may explore the implementation of PjBL in other science topics, involve a broader range of participants, or examine the long-term impact of accessibility-oriented projects on student independence and the development of more inclusive school environments.

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