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Development and Validation of a Problem-Based Learning (PBL)-Based Science Worksheet on Environmental Pollution for Grade VII Junior High School Students

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Abstract
This study aims to develop and validate a PBL-based science worksheet on environmental pollution for Grade VII students in Indonesian junior high schools. The worksheet was designed using the Borg and Gall development model, adapted by Sugiyono, and was validated by experts in content, language, and design. The validation process resulted in positive assessments, with content and language experts rating the worksheet at 80%, indicating its alignment with curriculum goals and appropriateness for the target grade. Media and design validation was rated at 70.58%, suggesting room for improvement in visual appeal. The worksheet was then field-tested with 10 students and one teacher, receiving high practical ratings of 88.3% from students and 96.19% from the teacher, indicating its effectiveness in fostering student engagement and learning. The findings suggest that PBL-based worksheets can enhance critical thinking, environmental awareness, and problem-solving skills, supporting the development of more interactive and student-centered learning environments. Despite some design-related limitations, the study highlights the potential of PBL as an effective teaching strategy for promoting active learning in science education. Future research should explore the broader applicability of PBL-based tools across different subjects and educational settings.

Keywords: Environmental Pollution; Problem-Based Learning; Science Education; Active Learning; Junior High School.

INTRODUCTION

Education plays a crucial role in the development of individuals, particularly in equipping them with the skills and knowledge necessary to address the challenges of the modern world (Jatmiko et al., 2024; Mizan et al., 2022; Nisa et al., 2024; Reed et al., 2021). The importance of education is clearly stated in Indonesia's national education goals, which emphasize the development of students into individuals who are not only knowledgeable but also responsible citizens, equipped with moral values, creativity, independence, and critical thinking skills (Abubakar et al., 2024; Hendarwati et al., 2021; Martin-Alguacil et al., 2024; Truskavetska, 2024). In line with these goals, it is essential that teaching strategies evolve to foster the holistic development of students, incorporating both cognitive and non-cognitive competencies.

Traditional approaches to teaching often prioritize theoretical knowledge, neglecting the development of critical thinking and problem-solving skills necessary for students to navigate real-world issues (Feriyanto & Anjariyah, 2024; Patricia Diane Mouboua et al., 2024; Supriadi et al., 2024; Yang Yang, 2024). In the current era, where students are confronted with complex environmental, social, and technological challenges, education must move beyond the simple transmission of knowledge to involve students in problem-solving and inquiry-based learning. A crucial shift in pedagogy is the adoption of active learning strategies, such as PBL, which has proven to foster critical thinking, collaboration, and the application of knowledge in authentic contexts (Adeoye & Jimoh, 2023; Dr. Lohans Kumar Kalyani, 2024; Prager, 2019; Suri et al., 2023). Problem-Based Learning is an instructional method in which students learn through the process of solving real-world problems, promoting deeper engagement with the subject matter and encouraging self-directed learning.

In science education, particularly in the study of environmental issues, traditional teaching methods have often failed to stimulate students' environmental awareness and concern (Aderoben & Darmawan, 2024; Althubyani, 2024; Kerimbayev et al., 2023). Environmental issues, such as pollution, deforestation, and climate change, require not only knowledge but also the ability to think critically and collaboratively to address these challenges. PBL is particularly suitable for teaching environmental science as it provides students with the opportunity to explore these issues in a hands-on, investigative manner. However, despite its potential, the implementation of PBL in Indonesian junior high schools remains limited, especially in the context of teaching subjects like science, where traditional lecture-based methods continue to dominate (Cao, 2024; Wenno et al., 2021; Zhang et al., 2023). This highlights a significant gap in the current literature and practice while PBL has been widely researched and applied in higher education, its use in junior high schools, especially for environmental science topics, is underexplored.

Furthermore, existing worksheets used in science classrooms often fail to align with the principles of PBL, focusing instead on rote learning and theoretical knowledge (Magaji et al., 2024; Malakul & Park, 2023; Martín-Alguacil & Avedillo, 2024). Many worksheets lack the interactive, inquiry-based features that are central to PBL, thus failing to engage students in active problem-solving. The lack of such resources further exacerbates the challenge of promoting environmental awareness and critical thinking among students. As a result, students remain passive learners, not fully developing the skills necessary to address environmental challenges or engage with scientific inquiry in meaningful ways.

The gap in the application of PBL in science classrooms, particularly concerning environmental pollution, and the absence of well-designed PBL-based worksheets present a clear need for educational innovation. This research aims to address these gaps by developing and validating a PBL-based science worksheet for Grade VII students, specifically focused on environmental pollution. The primary objective of this study is to design a worksheet that incorporates the principles of PBL, ensuring it is engaging, interactive, and effective in fostering critical thinking and environmental awareness. By doing so, this study seeks to contribute to the improvement of science education in Indonesian junior high schools, offering a practical and scalable tool that can be used to teach environmental issues in an innovative and effective manner.

The research is also intended to assess the feasibility, validity, and practicality of the developed worksheet. Specifically, this study seeks to answer the following research questions: (1) How effective is the developed PBL-based worksheet in enhancing students' environmental awareness and critical thinking? (2) What are the perceptions of teachers and students regarding the usability and effectiveness of the worksheet in the classroom? Through addressing these questions, this study not only contributes to the field of environmental science education but also provides valuable insights into the application of PBL in junior high school classrooms in Indonesia.

METHODS

This study employs a Research and Development (R&D) approach, following a procedural development model to design and validate a PBL-based science worksheet for Grade VII students, focused on environmental pollution. The research process, based on Sugiyono (2020) framework, consists of several key stages: (1) potential and problem identification, (2) data collection, (3) product design, (4) design validation, (5) product revisions, (6) product trials, and (7) final revisions. The objective of this R&D process is to develop a valid, practical, and effective PBL-based worksheet that enhances students' critical thinking and environmental awareness.

Research Design

The research design for this study follows a mixed-methods approach, combining both qualitative and quantitative data collection techniques to ensure a comprehensive evaluation of the developed PBL-based science worksheet. The primary goal is to design a worksheet that is both educationally effective and practically usable in the classroom, fostering critical thinking and environmental awareness in Grade VII students.

To begin with, the design process was based on the principles of PBL, which emphasizes student-centered learning where students are actively engaged in solving real-world problems. The worksheet was developed to encourage this active learning process by presenting environmental pollution issues in a context that is relevant to students' everyday lives. This design aims to challenge students to think critically about the causes and consequences of environmental pollution and to collaborate with their peers to explore potential solutions.

In order to ensure that the worksheet aligns with the educational needs and capabilities of Grade VII students, a thorough needs analysis was conducted. This analysis involved collecting data through interviews and classroom observations of teachers and students at SMPN 18 Kota Bengkulu, which helped to identify the existing gaps in instructional materials. Specifically, it was found that teachers often struggled to implement Problem-Based Learning effectively due to time constraints and a lack of suitable instructional materials. The analysis revealed a need for an engaging, practical worksheet that could help facilitate PBL-based lessons while being easy for both teachers and students to use.

Following the needs analysis, the development of the worksheet took into consideration not only the content and pedagogical principles of PBL but also the visual and practical aspects that would ensure its accessibility for students. The worksheet was designed to include clear instructions, visually appealing layouts, and interactive elements to guide students through problem-solving tasks. Additionally, the worksheet was crafted to integrate various media and graphic elements that would support the learning process and make the material more engaging for students.

Once the worksheet was designed, it underwent a rigorous validation process. Expert feedback was gathered from validators in the fields of content, language, and design to ensure the accuracy, clarity, and appropriateness of the material. These experts evaluated the worksheet's educational value, language use, and visual appeal, providing critical feedback for further revisions. The validation process was essential to ensure that the worksheet met the required educational standards and was aligned with the principles of PBL.

After the worksheet was revised based on expert feedback, it was tested in a real classroom setting. The field test involved students and teachers from SMPN 18 Kota Bengkulu, who used the worksheet during their science lessons. The teachers provided feedback on how the worksheet worked in practice, while students were observed for their engagement, interaction with the material, and critical thinking skills. Both teachers and students completed surveys to assess the practicality, effectiveness, and clarity of the worksheet.

The feedback collected during the field testing phase was used to make final revisions to the worksheet, ensuring that it was user-friendly and met the educational goals. This final version of the worksheet was then considered ready for broader implementation, with the potential for future use in other schools or educational contexts. The research design aimed to ensure that the developed product was not only educationally valuable but also practical and effective in real-world classroom settings.

This comprehensive research design allowed for the development of a PBL-based worksheet that was validated through expert input and tested in a classroom environment, ensuring its suitability for enhancing students' learning experiences and fostering environmental awareness through active problem-solving.

Data Collection Instruments

To gather comprehensive data throughout the development, validation, and testing phases, several instruments were employed in this study. A structured questionnaire was developed and distributed to various stakeholders, including content experts, language experts, media/design experts, teachers, and students. The questionnaire used a Likert-scale format to assess the validity, practicality, and clarity of the developed PBL science worksheet. For the validation process, experts in the fields of content, language, and design evaluated the worksheet's alignment with educational standards, its clarity in language use, and its visual appeal. The Likert-scale responses provided quantifiable feedback, enabling an assessment of how well the worksheet met the necessary educational requirements.

In addition to the expert evaluations, the teachers and students who participated in the field testing phase completed similar questionnaires to evaluate the worksheet's practical application in a classroom setting. These surveys aimed to gather feedback on the worksheet's usability, student engagement, and its ability to foster critical thinking and problem-solving. The teacher's questionnaire focused on the effectiveness of the worksheet in supporting the PBL model and how it impacted the teaching process. Meanwhile, the students' questionnaire provided insights into their experiences with the worksheet, specifically their levels of engagement and the extent to which they felt the worksheet helped them understand the environmental pollution topics.

To complement the questionnaires, direct observations were conducted during the field testing phase. The researcher observed how students interacted with the worksheet, noting their participation in group discussions and problem-solving activities. These observations provided qualitative data on how the worksheet facilitated active learning, critical thinking, and collaboration among students. The researcher also monitored the teacher's role in guiding students through the PBL activities, observing the overall classroom dynamics and the effectiveness of the worksheet in stimulating student inquiry.

Finally, informal interviews with the teacher and select students were conducted to gain deeper insights into their experiences with the worksheet. These interviews allowed for more nuanced feedback, uncovering aspects of the worksheet's design and content that might not have been captured through the structured questionnaires alone. This combination of quantitative and qualitative data collection instruments ensured that the feedback gathered was both comprehensive and detailed, allowing for a thorough evaluation of the worksheet's effectiveness and practicality in a real-world classroom setting.

Data Analysis

The data collected from various sources, including questionnaires, observations, and interviews, were analyzed to assess the validity, practicality, and effectiveness of the developed PBL-based science worksheet. The primary method of analysis involved using descriptive statistics to quantify responses from the Likert-scale questionnaires completed by the validators, teachers, and students. This allowed for an objective assessment of how well the worksheet met the required educational standards, its ease of use, and its ability to engage students in meaningful learning activities.

For the Likert-scale responses, the percentage of agreement or disagreement was calculated to evaluate the validity and practicality of the worksheet. High percentages indicated that the worksheet was perceived as effective, relevant, and suitable for classroom use. In addition to the numerical data from the questionnaires, qualitative data were gathered through observations during the field testing phase. These observations provided insight into how students interacted with the worksheet, how actively they engaged in problem-solving tasks, and their ability to apply critical thinking to environmental issues. The observations also highlighted the role of the teacher in facilitating the learning process and supporting student collaboration.

Interviews with the teacher and students were conducted to gather more in-depth feedback on the user experience. These interviews were analyzed thematically to identify patterns in the feedback, such as areas where the worksheet facilitated or hindered learning, and how the PBL model impacted students' engagement with the material. The themes that emerged from the interviews were used to refine the worksheet further and ensure it aligned with the educational goals of fostering critical thinking, environmental awareness, and problem-solving skills.

Overall, the analysis aimed to assess the effectiveness of the PBL-based worksheet in achieving the desired educational outcomes, while also considering its practical usability in the classroom context. The combination of quantitative and qualitative data provided a holistic view of the worksheet's performance, helping to ensure that it was both an educationally valuable and user-friendly tool for students and teachers. The results of this analysis were used to make final revisions to the worksheet before concluding the development process.

RESULTS AND DISCUSSION

The results of this study were gathered from multiple stages: the validation process, field testing, and feedback from teachers and students regarding the developed PBL-based science worksheet on environmental pollution. These results were analyzed through both quantitative data, obtained from questionnaires, and qualitative data, from observations and interviews. The findings are discussed below, with a focus on the validation, practical application, and effectiveness of the developed worksheet.

Validation Results

The validation process involved expert assessments in three areas: content (material), language, and media/design. These evaluations were conducted by experts to assess the validity of the worksheet before it was used in field trials. The validation scores from each expert category are presented in Table 1.

Table 1. Validation Results of the PBL-Based Science Worksheet

Validator	Score (%)	Category	Interpretation
Material Expert	80	Content	Valid: Content aligns with learning objectives and is suitable for the target grade.
Language Expert	80	Language	Valid: Language is clear and appropriate for Grade VII students.
Media/Design Expert	70.58	Design	Valid: Design is functional but could be improved for better visual appeal.
Teacher Response	96.16	Teacher Perception	Very Practical: The worksheet was deemed highly useful by teachers in facilitating learning.
Student Response	88.83	Student Perception	Very Practical: Students found the worksheet highly engaging and helpful.

This table presents the validation scores from experts in content, language, and media/design. The high ratings from the material and language experts confirm that the content and language of the worksheet are suitable for Grade VII students. The slightly lower score for media/design indicates areas for improvement in the visual presentation.

Field Testing Results

After the worksheet underwent validation by experts, it was tested in an actual classroom setting with 10 Grade VII students and one science teacher at SMPN 18 Kota Bengkulu. The field testing phase was crucial to assess the practical usability of the PBL-based science worksheet and how well it facilitated active learning in the classroom. The purpose was to observe whether the worksheet engaged students effectively, whether it enhanced their understanding of environmental pollution, and whether it supported the teacher in facilitating student-centered learning.

During the field test, students worked through the problem-solving tasks presented in the worksheet. These tasks required them to analyze environmental issues, collaborate in groups, and formulate solutions based on their findings. The teacher's role was to guide the students and facilitate discussions, helping them navigate the problems and encouraging critical thinking. The field test aimed to assess the overall practicality of the worksheet, including its usability, clarity, and effectiveness in promoting engagement and learning.

Feedback from both students and the teacher was gathered using a structured Likert-scale questionnaire, which allowed the participants to rate their experiences based on their perceptions of the worksheet's effectiveness. The results of this feedback are presented in Table 2.

Table 2. Field Testing Results from Students and Teacher

Response Group	Mean Score (%)	Category	Interpretation
Students	88.3	Student Engagement	Very Practical: Students actively participated in the learning process, displaying a high level of engagement.
Teacher	96.19	Teacher Feedback	Very Practical: The teacher found the worksheet highly effective in encouraging student participation and enhancing learning.

This table presents the feedback from students and the teacher during the field testing phase, highlighting the high practicality and engagement of the PBL-based worksheet.

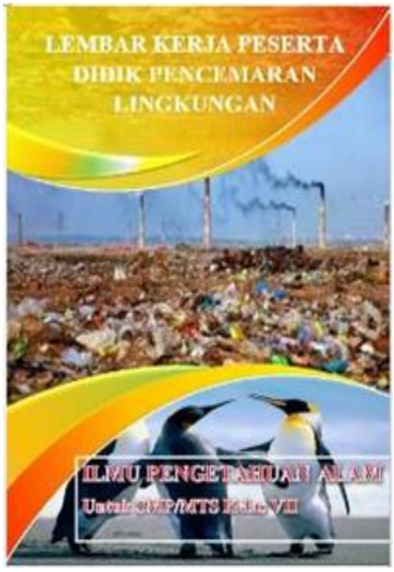

Figure 1. Cover Page of the PBL Worksheet

This figure shows the cover page design of the PBL-based science worksheet, which introduces the environmental pollution topic. The design incorporates a clear and engaging title along with a visual that represents the theme of pollution, aligning with the problem-based learning approach.

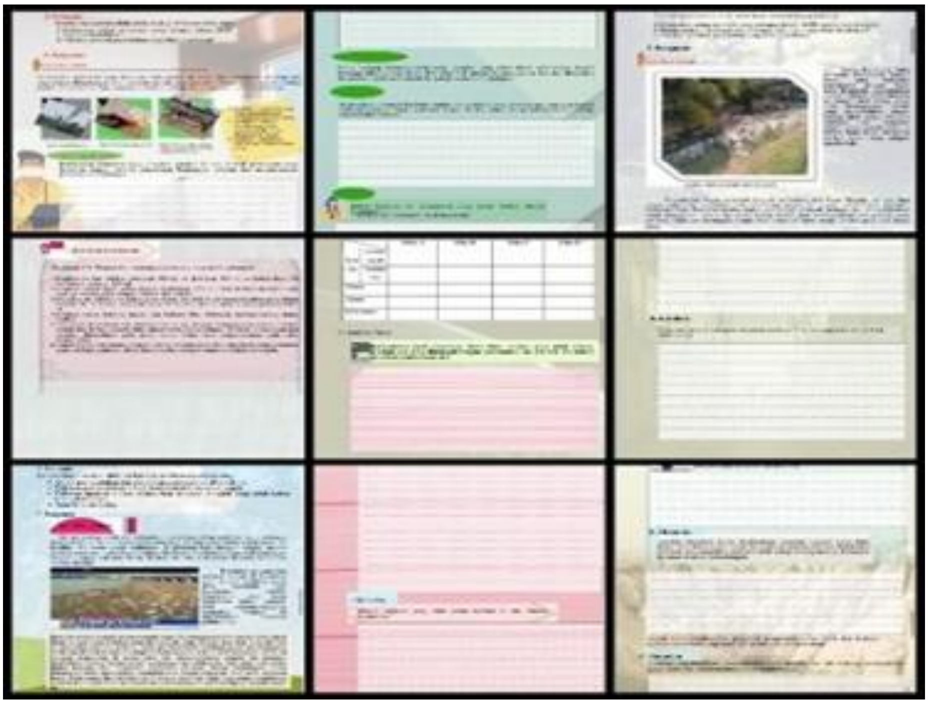

Figure 2. Design Layout of the Worksheet

This figure presents the layout of the PBL worksheet, highlighting its structured format with sections for introductory content, problem-solving tasks, and reflection. The layout is designed to be user-friendly, guiding students through each stage of the learning process while encouraging collaboration and critical thinking.

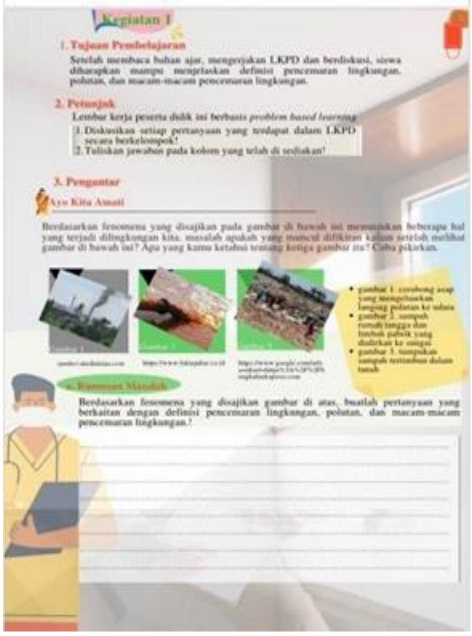

Figure 3. Problem-Based Learning Task Example

This figure illustrates a sample task from the worksheet where students are presented with a real-world environmental pollution problem. The task is designed to encourage students to analyze the issue, gather relevant data, and collaborate in groups to propose solutions, demonstrating the core principles of PBL.

Discussion

The findings of this study underscore the efficacy of PBL-based science worksheets in enhancing student engagement, critical thinking, and environmental awareness in Indonesian junior high schools. The PBL approach, known for fostering active learning, collaboration, and problem-solving, was successfully integrated into the development of a science worksheet focused on environmental pollution. The positive validation results, along with the strong feedback from both teachers and students, indicate that the worksheet is not only practical but also an effective tool for achieving the educational objectives of the curriculum.

One of the key innovations of this research lies in its application of PBL at the junior high school level in Indonesia, particularly in the context of environmental science. While PBL has been widely studied and applied in higher education, its implementation in secondary education, especially in developing countries like Indonesia, remains limited. The development of a PBL-based worksheet specifically for environmental pollution is a novel contribution to the literature on science education. This research highlights the potential of PBL to bridge the gap between theoretical knowledge and real-world applications, helping students engage meaningfully with global challenges such as environmental degradation.

The positive reception of the PBL-based worksheet from both students and teachers suggests that this method significantly enhances students' understanding of complex topics like pollution. By presenting environmental issues through real-world scenarios, the worksheet allowed students to apply their learning in a collaborative, hands-on way, rather than merely absorbing information passively. This aligns with previous research, which has shown that active learning strategies such as PBL lead to deeper understanding and greater retention of knowledge (Abdullah et al., 2019; Feldman, 2019; Márquez et al., 2023; Metsäpelto et al., 2022; Ogbonnaya, 2024). Furthermore, the high levels of engagement reported by students support the notion that PBL encourages students to take responsibility for their learning, enhancing their autonomy and problem-solving skills.

An important implication of this study is the potential for widespread implementation of PBL-based materials in other subjects and educational contexts in Indonesia. The success of this PBL-based worksheet suggests that similar approaches can be applied to other science topics or even non-science subjects. In Indonesia, where traditional lecture-based methods are still dominant, adopting PBL can serve as a significant step towards creating more student-centered learning environments. PBL encourages critical thinking and collaboration, which are essential skills for the 21st century. Integrating PBL in classrooms can help foster students' abilities to think independently, communicate effectively, and work collaboratively, all of which are necessary for addressing the challenges of a rapidly changing world.

However, despite the promising results, this study has several limitations. The small sample size for the field testing comprising only 10 students and one teacher limits the generalizability of the findings. Future studies should involve a larger and more diverse sample, incorporating students from different regions, backgrounds, and school types to assess the broader applicability of the findings. Additionally, the study focused exclusively on environmental pollution as a topic, and while this is a highly relevant and important issue, the findings may not be directly transferable to other subjects without further adaptation. Future research should explore the effectiveness of PBL-based worksheets across various subjects and grade levels to assess their scalability and impact on a wider range of learning outcomes.

Another limitation of the study was the feedback on the worksheet's design, which received a slightly lower rating compared to its content and language. The media/design expert rated the worksheet at 70.58%, indicating that while the design was functional, there was room for improvement in its visual appeal and user experience. Visual elements such as layout, color schemes, and image quality play a crucial role in engaging students, especially in younger age groups. Future iterations of the worksheet should focus on refining its design to ensure that it not only communicates the content effectively but also attracts and retains the attention of students. Research on the relationship between design aesthetics and learning outcomes could help improve the overall usability of the worksheet.

In terms of future directions, the long-term effects of using PBL-based worksheets should be explored. While the field test demonstrated immediate engagement and positive feedback, it is important to investigate whether these improvements in critical thinking and environmental awareness are sustained over time. Additionally, exploring how PBL impacts students' academic performance across different subjects and its influence on their attitudes toward learning would be valuable. Future studies could also examine the professional development needs of teachers to implement PBL effectively, as successful PBL implementation requires proper teacher training and support.

Lastly, while this study focused on the development and validation of a specific educational tool, further research could explore how other interactive and collaborative learning strategies might complement PBL in fostering deeper student engagement. Integrating technologies such as digital platforms or simulations with PBL could enhance the learning experience, providing more dynamic and immersive opportunities for students to engage with complex issues.

In conclusion, this study has made significant contributions to the field of science education by demonstrating the potential of PBL-based worksheets to enhance student engagement, critical thinking, and environmental awareness in junior high school classrooms. The findings have important implications for future educational practices in Indonesia, where there is a growing emphasis on innovative teaching methods that promote active learning and 21st-century skills. While the study has limitations, it paves the way for future research that can further refine PBL-based tools and explore their impact on a larger scale.

CONCLUSION

This study demonstrates the effectiveness of a PBL-based science worksheet in enhancing student engagement, critical thinking, and environmental awareness among Grade VII students. The positive feedback from both teachers and students validates the practical applicability of the worksheet, confirming its potential to improve active learning in Indonesian junior high schools. By integrating real-world environmental issues into the learning process, the worksheet encourages students to actively collaborate, problem-solve, and engage with the content in a meaningful way. Despite some limitations, including a small sample size and areas for improvement in design, the findings suggest that PBL-based worksheets are a promising approach for fostering critical thinking and environmental responsibility, with potential for broader application across subjects and educational contexts. Further research is needed to explore the long-term impacts and scalability of such tools in diverse learning environments.

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