

Development of Teaching Materials Based on Problem-Based Learning to Improve Critical Thinking Skills: A Systematic Literature Review

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Abstract: Improving critical thinking is an essential 21st-century learning skill, and educational products that nurture it help students advance. Research identifies problem-based learning (PBL) as a highly effective instructional model for fostering critical thinking. This article reviews journal publications from 2019–2025 that explore the development of science teaching materials using the PBL model and their impact on students' critical thinking abilities. The study aims to provide a comprehensive overview of the types of PBL-based science teaching materials, their effectiveness, and their influence on critical thinking skills. Using the PRISMA literature review method, the researchers conducted identification and screening of abstracts and full texts from 1,200 journal articles, ultimately selecting 12 relevant studies. Analysis of these studies indicates that PBL-based science teaching materials significantly enhance students' critical thinking, particularly at junior high and high school levels. The findings underscore that integrating PBL into science teaching materials supports inquiry, problem-solving, and analytical reasoning. Consequently, adopting PBL-based resources in classrooms can serve as a strategic approach to strengthen students' critical thinking processes and better prepare them for complex real-world challenges. This review affirms that PBL-driven science instruction is a powerful tool for 21st-century education.

Keywords: Critical thinking; Problem-based learning; Teaching materials

Introduction

In the age of globalization, there are many changes that occur due to the development of information technology, so humans are required to have new abilities or skills to deal with these developments. 21st century skills are a set of skills needed by individuals to adapt, innovate, and contribute in an increasingly complex and connected society (Lubis et al., 2023). 21st century skills have four basic skills or often called 4C which consist of critical thinking, communication, collaboration, and creativity (Joyne et al., 2019). According to the Partnership for 21st Century Learning (P21), the

essential skills for the 21st century include creativity and innovation, critical thinking and problem-solving, communication, and collaboration. These skills can be achieved by enhancing the quality of education, personalizing the learning process, fostering communication and teamwork, implementing problem-based or project-based learning, applying appropriate instructional strategies, and designing learning activities that are relevant to real-world contexts (Hidayatullah et al., 2021).

One of the 21st century skills that plays an important role in the science learning process is critical thinking. Critical thinking skills involve accessing, analyzing, and synthesizing information that is

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considered fundamental to 21st century learning (Joynes et al., 2019). According to Raj et al., (2022), critical thinking can develop curiosity when understanding information, be able to generate bright ideas, develop creativity while looking for logical solutions, and be able to solve problems. Several indicators of critical thinking skills are basic clarification, basic decisions, inference, analysis, evaluation, reasoning, and providing further explanation (Wilujeng & Hidayatullah, 2021).

Based on research conducted by Amarila et al. (2021), the results of critical thinking skills of class VIII students are classified as low category because they have an achievement of only 32.5%. Research conducted by Nofianti et al. (2022), critical thinking skills in class VIII students are classified as a low category because the achievement of critical thinking has an average score of 43.46. One of the factors causing low critical thinking skills is that teachers do not give questions with critical thinking indicators (Sarip et al., 2022). This factor is influential because critical thinking includes a person's skill or ability to decide what to believe. In addition, students rely on memorization when learning material and forget the material that has been taught (Suriati et al., 2021). Based on this statement, the low critical thinking ability of students is caused by learning that is applied in schools is still dominated by teachers, so that it does not train critical thinking skills in students (Zaini, 2016). This is in line with research Patonah (2014), stating that science learning is dominated by teachers, learning strategies that tend to memorize rather than develop critical thinking, so that students are weak in conveying their own ideas.

Critical thinking problems can be trained or honed so that students are able to develop their potential and be able to solve problems in everyday life. One way or effort to improve critical thinking skills is to use a problem-based learning model (PBL) because this learning model is able to involve all individuals in a group to think together to solve problems, provide ideas, ideas, main thoughts on problems given by educators to solve, think creatively, and think critically in solving everyday life problems that are required to think rationally and logically (Nggeo & Saingo, 2024). Students' critical thinking skills can be developed through learning experiences so that students are directly involved in the learning process, as applied in the problem-based learning model. To realize the learning experience for students, learning resources or teaching materials are needed during the learning process in the classroom. Teaching materials as learning resources play an important role in supporting the learning process. For teachers, teaching materials function as a reference in designing learning activities, while for students teaching materials play a role in helping students master the competencies targeted in

learning (Kimianti & Prasetyo, 2019). Literature study research on PBL models on students' critical thinking skills has been widely conducted (Mutiarra et al., 2024). However, research on the development of teaching materials based on PBL to improve critical thinking skills has never been done by previous researchers. This research needs to be done considering that when the learning process in the classroom using a PBL model assisted by learning media will create a pleasant learning atmosphere for students (Devi & Bayu, 2020). This happens because through problem-based learning, the teacher will provide a problem that can come from students' daily problems, problems that are being discussed that are related to the material to be studied. The presentation of real problems by the teacher in a lesson will create a serious, fun and meaningful learning atmosphere (Prasetyo & Kristin, 2020).

The novelty of this research lies in its systematic literature review (SLR) of publications from the past six years (2019–2025), which specifically highlights the relationship between PBL-based science teaching materials and improving students' critical thinking skills. Unlike previous studies, which generally review PBL in general or solely assess the effectiveness of teaching methods, this study focuses on analyzing the types of teaching materials, their effectiveness, and their influence on critical thinking in the context of science learning, thus providing a comprehensive map of the latest research trends and gaps.

This research is crucial because the need for critical thinking skills is increasingly pressing amidst complex global challenges, while teachers often lack scientifically validated guidance for developing PBL teaching materials. The results of this study are expected to provide a basis for educators, researchers, and policymakers in designing science teaching materials that not only present concepts but also stimulate analysis, problem-solving, and higher-level reasoning. Thus, this research contributes to curriculum innovation and learning strategies that are relevant to the demands of 21st century education.

Based on this background, the research addresses several key issues, namely the types of teaching materials developed to support problem-based learning, the effectiveness of those materials in enhancing students' critical thinking skills, and the extent of their influence on students' critical thinking development. Accordingly, the purpose of this study is to analyze the importance of developing and applying PBL-based teaching materials in science learning as a means to improve students' critical thinking abilities.

Method

This study employed a Systematic Literature Review (SLR) to identify, evaluate, and synthesize relevant research findings as the theoretical foundation and primary data source. The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and a well-structured process.

Articles were collected from Google Scholar, CrossRef, and the Publish or Perish database using a combination of keywords such as “problem-based learning,” “science teaching materials,” and “critical thinking.” The search was limited to publications released between January 2019 and early 2025 to capture the most recent developments in the field.

The review process involved several stages. First, during the identification stage, all retrieved records were examined and duplicates were removed. Second, title screening was conducted to include only studies focused on the development of teaching materials using the Problem-Based Learning (PBL) model. Third, abstract screening applied the following inclusion criteria: (a) developmental research rather than a literature review, (b) explicit focus on improving critical thinking skills, (c) conducted at the junior or senior high school level, and (d) open-access availability. Finally, in the full-text eligibility stage, the remaining articles were read in detail to confirm that they described the development of PBL-based teaching materials and examined their impact on students’ critical thinking skills.

All eligible articles were then analyzed using a descriptive qualitative approach. Key information—including the types of PBL-based science teaching materials, their effectiveness, and their influence on critical thinking—was extracted and synthesized. The findings are presented in a narrative format to provide a comprehensive and up-to-date understanding of how PBL-based teaching materials support the enhancement of students’ critical thinking abilities. The criteria are presented in the form of Table 1 as follows.

Table 1. Article Criteria

Type of publication	Articles published in journals
Keywords	Problem-based learning, critical thinking, and teaching materials
Journal specifications	Use English and Indonesian
Year published	2019-2025
Research site	Indonesia
Field	Science, biology, physics, and chemistry
Access	Open access
Scope	Junior and senior high school

Result and Discussion

Result

This literature review aims to provide information related to research titles that examine the development of teaching materials with problem-based learning models and their results to improve critical thinking skills in students. Articles were searched from Google Scholar, Crosreff, and Publish or perish databases. The search results were 1,200 articles, 147 articles that had similarities were then reviewed based on their titles. The criteria used to select articles are articles that contain teaching materials using problem-based learning and students' critical thinking skills written in Indonesian and English, and articles that are only sourced from research results. In addition, the articles selected were only articles that discussed development.

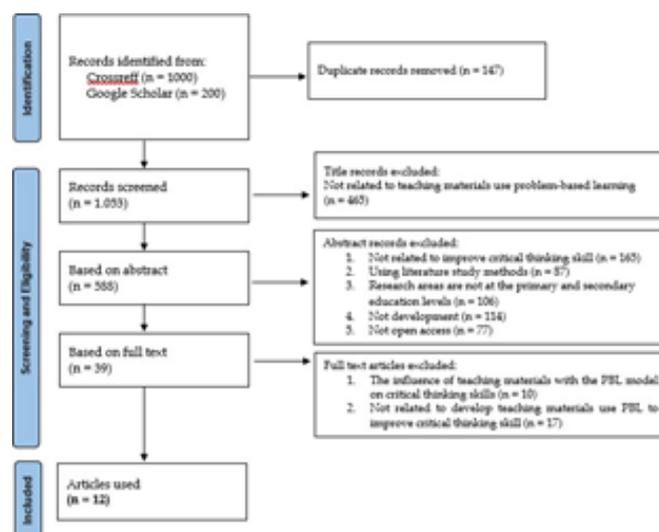


Figure 1. Diagram prisma

In Figure 1 below, displays data on the development of teaching materials with PBL models over the past six years. The use or development of teaching materials with PBL models and containing real-world examples and challenges will help students. Based on the data, the development of student worksheets (LKPD) both electronic and conventional as many as five articles, module development as many as one article, dictate development as many as two articles, multimedia development as many as three articles, and learning devices as many as one article. This shows that the development of LKPD is in great demand by teachers and researchers because problem-based science LKPD easily guides learning in forming strong associations between educators and students, so that learning becomes interesting and can adjust the situation and conditions in the classroom (Swiyadnya et al., 2021).

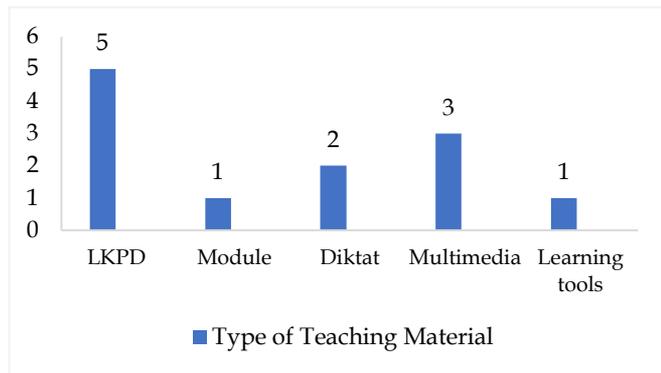


Figure 2. Teaching material development with PBL

To determine the impact or influence of the development of PBL-based teaching materials on students' critical thinking skills, it is necessary to test the effectiveness of students by giving an instrument in the form of a critical thinking skills test. In general, the effectiveness test in educational development products is obtained from learning outcomes, where learning

outcomes are effective aspects to be observed in the learning process. The purpose of this effectiveness test is to determine the extent of the effectiveness of the media developed, whether it helps students in understanding the subject matter or not. In addition, the effectiveness test aims to determine the impact or influence of the development of PBL-based teaching materials on students' critical thinking skills, it is necessary to test the effectiveness of students by giving an instrument in the form of a critical thinking skills test. In general, the effectiveness test in educational development products is obtained from learning outcomes, where learning outcomes are effective aspects to be observed in the learning process. The effectiveness test is carried out after the application of the learning media developed in the form of evaluations in the form of pretests and posttests (Faridah & Titen, 2024). Specifically in this article, the effectiveness test of teaching materials and the influence of teaching materials on students is presented in Table 2.

Table 2. Research Findings Related to Teaching Materials Based Problem-Based Learning to Improve Students' Critical Thinking Abilities

Author and year of publication	Title of Journal	Research Finding
Nisa et al. (2019)	Developing a Problem-Based Learning Physics Textbook to Improve Students' Critical Thinking Skills	The development of the handouts adapted the ADDIE model, which encompasses the stages of analysis, design, development, implementation, and evaluation. During the implementation phase, pre-test and post-test results demonstrated an increase in students' critical thinking skills, with an average pre-test score of 26.4 and a post-test score of 88.6. As a class, 100% of students were deemed to have achieved a gain of 0.845, a high category, as the gain value falls within the normalized gain $g \geq 0.7$ criterion. This indicates that problem-based learning materials (PBL) foster critical and creative thinking.
Putranta et al. (2019)	Physics Learning by PhET Simulation-Assisted Using the Problem-Based Learning (PBL) Model to Improve Students' Critical Thinking Skills in Work and Energy Chapters at MAN 3 Sleman	The development of student worksheets (LKPD) using PBL assisted by PhET on the topic of work and energy adopted the 4-D model, encompassing the stages of define, design, develop, and disseminate. Improved critical thinking skills in the control class were demonstrated by a standard gain value of 0.35, which is in the moderate category. Meanwhile, the critical thinking skills in the treatment class were 0.61, which is in the moderate category.
Wati & Yuliani (2020)	Developing Student Worksheets (LKPD) Based on Problem-Based Learning (PBL) for the Membrane Transport Subtopic to Train Critical Thinking Skills	The 4-D model was developed with the stages of defining, designing, and developing. However, the dissemination stage was not conducted. The effectiveness of the PBL-based student worksheet (LKPD) was assessed by the results of the critical thinking test. Students' pretest scores were 50.6 and posttest scores were 83.83, with an average n-gain of 0.65, categorized as moderate. This indicates that the use of PBL-based LKPD can help students directly observe the material being studied, facilitating their development of knowledge and answering questions.
Hasanah et al. (2021)	Developing Problem-Based Learning Physics Learning Tools to Improve Critical Thinking Skills	The development of learning tools, including syllabi, lesson plans, LKPD, test instruments, and learning videos, adapted the 4-D model, consisting of defining, designing, developing, and disseminating. The effectiveness of the problem-based learning tools on harmonic vibrations achieved an n-gain

Author and year of publication	Title of Journal	Research Finding
Noris et al. (2022)	The Virtual Laboratory Based on Problem-Based Learning to Improve Students' Critical Thinking Skills	value of 0.66, categorized as moderate. This indicates that the use of problem-based learning tools on harmonic vibrations is effective in learning. The development of a multimedia virtual laboratory based on HTML5 and Construct 2 allows it to be used on smartphones and PCs, supporting effective performance-based learning. Furthermore, this development process includes the following stages: potential and problem identification, data collection, data development, and product design. The effectiveness of the virtual laboratory was tested in two locations: SMPN 1 Woha and SMPN 2 Belo. The results of the virtual laboratory's effectiveness on critical thinking skills showed an N-gain score of 0.76 at SMPN 1 Woha and 0.75 at SMPN 2 Belo. This indicates that the virtual laboratory can improve students' critical thinking skills in the learning process by supporting problem-solving skills.
Yusuf et al. (2022)	Developing Problem-Based Learning Tools to Improve Students' Understanding of Physics Concepts and Critical Thinking Skills	The development of learning tools, including teaching materials, lesson plans (RPP), student worksheets (LKPD), and test instruments, adapted the 4-D model, consisting of defining, designing, and developing. However, the dissemination stage was not included. The effectiveness of the problem-based learning tools in improving critical thinking skills was analyzed using the N-Gain test, based on students' pretest and posttest scores. The average pretest score was 39.6, while the average posttest score was 65.9. These scores were analyzed using the N-gain test, yielding a result of 0.43, which is classified as moderate. This indicates that the developed learning tools are capable of improving students' understanding of physics concepts and critical thinking skills.
Purba et al (2023).	Developing Problem-Based Learning Student Worksheets (LKPD) Based on Problem-Based Learning (PBL) for the Sensory System Topic to Train Students' Critical Thinking Skills	The development of the student worksheets adapted the 4-D development model with four stages: define, design, develop, and disseminate. To determine the effectiveness of the student worksheets, the results of the pretest and posttest on 30 respondents were used. The average pretest score was 46.17, while the posttest score increased to 74.67. Therefore, when tested using the N-Gain test, the N-Gain score was 0.80, categorized as high and effective. This indicates that the problem-based learning worksheet (LKPD) contains a collection of information, images, and questions used to determine students' knowledge and understanding of the learning material.
Hasibuan et al. (2023)	Developing Problem-Based Learning Student Worksheets (LKPD) for the Human Excretory System Topic to Improve High School Students' Critical Thinking Skills	The LKPD development adapted the 4-D development model (define, design, develop, and disseminate). The effectiveness of the LKPD product was determined by administering pretests and posttests to students during field trials. In terms of effectiveness, the PBL-based LKPD had a high and effective N-gain score of 0.76. This indicates that using PBL-based LKPD on the human excretory system provides opportunities for students to learn independently and increase their knowledge.
Yulanda et al. (2023)	Developing Electronic Student Worksheets (E-LKPD) Based on Problem-Based Learning as an Effort to Improve Critical Thinking Skills of Eighth Grade Students on the Respiratory System	The development of the PBL-based E-LKPD adapted the Lee and Owens development model, which includes the following stages: analyze, design, development, implementation, and evaluation. The effectiveness test using the N-gain test was conducted to determine improvements in students' critical thinking skills. The average pretest score was 35.71, while the average posttest score was 71.38. Therefore, the N-gain score achieved was 0.56, categorized as moderate. This indicates that the PBL-based e-LKPD on the respiratory system was systematically structured and included critical thinking

Author and year of publication	Title of Journal	Research Finding
Aniq & Peniati (2024)	Development of a Coordination System Design Based on Problem-Based Learning to Improve the Critical Thinking Ability of XI Graders	indicators, effectively improving students' critical thinking skills. The development of PBL-based instructional materials adapted the ADDIE model with the stages of analysis, design, development, implementation, and evaluation. The improvement in critical thinking skills after using the instructional materials resulted in an N-gain score of 0.61, categorized as moderate. This improvement in critical thinking skills occurred due to the contribution of the instructional materials to the coordination system material.
Indarwati & Harun (2024)	Development of Problem-Based Learning (PBL) Oriented Student Worksheets to Improve Students' Critical Thinking Skills on Redox Reaction Material	The development of the LKPD adapted the 4-D development model (define, design, and develop), but did not include a dissemination stage. The effectiveness of the PBL-based student worksheet (LKPD) on critical thinking skills was tested using a pretest and posttest. The results obtained were n-gain scores of 0.85 (interpretation indicator), 0.30 (inference indicator), 0.75 (analysis indicator), and 0.39 (evaluation indicator). These results are categorized as moderate to high. This demonstrates that each critical thinking skill indicator experienced an increase between the pretest and posttest. This demonstrates that the PBL-oriented student worksheet is effective in improving students' critical thinking skills.
Yanti et al. (2024)	Development of an E-Module on Basic Chemical Laws Using a Problem-Based Learning Model Assisted by FlipHTML5 to Improve Critical Thinking Skills and Scientific Literacy	The e-module development using the PBL model adapted the ADDIE (analyze, design, development, implementation, and evaluation) development model. The effectiveness of the e-module was tested using a control class and an experimental class. The n-gain score of the experimental class was 0.80, indicating higher critical thinking skills than the control class. This indicates that the e-module using the PBL model, supported by FLIPHTML5, is highly effective and capable of improving students' critical thinking skills.

Based on the results of the analysis of 12 journals or articles, as many as seven articles use or adapt the 4-D development model to develop products, as many as three articles use or adapt the ADDIE development model, and as many as two articles use or adapt other development models. This shows that the development of teaching materials begins with the process of analyzing the problem and the discovery of the problem is overcome by the development of a product (Waruwu, 2024). Therefore, the development of teaching materials is developed according to the problems and needs of students.

Discussion

This study aims to provide a comprehensive overview of the trends in the development of science teaching materials based on Problem-Based Learning (PBL) in the last six years, namely from 2019 to 2025. teaching materials contribute to improving students' critical thinking skills. Based on the results of a literature review of 1200 articles obtained from the Google Scholar, Crossref, and Publish or Perish databases, a screening process was carried out to obtain 13 articles that met the criteria that focus on developing teaching materials, applying PBL learning models, examining aspects of

critical thinking skills, and published in Indonesian and English.

From the results of the review, it can be concluded that the development of PBL-based teaching materials shows a positive influence on improving students' critical thinking skills at various levels of education, especially in the context of science learning. The teaching materials developed in the articles reviewed include student worksheets (LKPD), dictates, modules, interactive multimedia, e-modules, and other learning tools such as lesson plans and syllabi. The variety of forms of teaching materials shows the flexibility of the PBL approach in being applied to various learning media, both conventional and digital. This is very relevant to technological developments and learning needs that increasingly demand higher-level thinking skills.

The most dominant type of teaching material developed is LKPD, both in printed and electronic form. PBL-based LKPD is proven to be able to guide students in the learning process that requires active participation, starting from problem identification, information search, analysis, to solution preparation. Through LKPD, students are trained to formulate questions, solve problems, and make the right decisions. LKPD also

allows teachers to more easily direct the learning process systematically and focus on learner involvement. In this context, LKPD not only functions as a learning tool, but also as a means of developing scientific character and critical thinking skills.

Some articles also develop teaching materials in the form of diktate and modules. PBL-based diktates are designed so that students can understand the material with a systematic problem-solving approach. Modules and e-modules allow independent and flexible learning that remains oriented to contextual problems. Some articles also developed PBL-based interactive multimedia and virtual laboratories, which allow students to interact with content visually and simulatively, strengthening understanding and critical thinking skills through digital practice.

In terms of development methodology, the articles reviewed generally adopted the 4-D (define, design, develop, disseminate) and ADDIE (analysis design, development, implementation, evaluation). Total of seven articles used the 4-D model, three articles used the ADDIE model, and two other articles used alternative models such as Lee & Owens. This development model emphasizes the importance of systematic stages in creating learning products that suit the needs of learners and the learning context. The use of this development model also shows that the development of teaching materials is not an instant process, but requires in-depth needs analysis, structured instructional design, data-based development, and rigorous evaluation of product effectiveness.

The effectiveness of the teaching materials developed was tested through giving pretests and posttests to students, which were then analyzed using the N-Gain formula. The results of the effectiveness test show that all PBL-based teaching materials developed have a significant contribution to improving students' critical thinking skills. The N-Gain values obtained ranged from 0.35 to 0.85, most of which were in the moderate to high category. These results indicate a real improvement in students' critical thinking skills after using PBL-based teaching materials. This improvement includes aspects of critical thinking such as the ability to analyze, evaluate, make inferences, interpret information, and make logical decisions.

In the context of learning materials, the developed PBL teaching materials cover various important topics in science such as the respiratory system, excretory system, sensory system, basic laws of chemistry, harmonic vibrations, and redox reactions. These materials were chosen because they are related to everyday life and require students to understand concepts in depth. Through the PBL approach, science materials are not only delivered as factual information, but processed as contextual problems that must be analyzed and solved

by students. This is in line with the principle of meaningful learning, which prioritizes real and relevant learning experiences.

The application of PBL-based teaching materials in science learning also encourages active participation of students in the learning process. Students are no longer passive recipients of information, but rather active subjects involved in discussion, exploration and reflection. Problem-based learning encourages students to work in groups, share ideas, compare opinions, and agree on solutions together. This process strengthens communication skills, collaboration, and scientific attitudes such as curiosity, openness to new ideas, and responsibility for the learning process.

Conclusion

This systematic literature review confirms that science teaching materials designed with a Problem-Based Learning (PBL) approach effectively enhance students' critical thinking skills—a core competency for 21st-century education. By synthesizing recent studies from 2019–2025, the review highlights that PBL-based resources foster inquiry, problem-solving, and analytical reasoning across junior and senior high school contexts. The findings imply that teachers should prioritize creating well-structured PBL-based materials, such as student worksheets and guided inquiry projects, to strengthen critical thinking. Curriculum developers are encouraged to integrate these materials into science curricula, while governments and educational institutions can support implementation through professional development and accessible resource platforms. Emphasizing real-world problems and higher-order thinking in material design will better prepare students to meet future global challenges.

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A.A.I.B.P.D; I.W.S; N.T; I.W.R: searched for articles, analyzed the data, and wrote the manuscript. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The author declares no conflict of interest in writing the article.

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