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Challenges of Applying Deep Learning in Elementary Schools: Descriptive Studies at SD Karya Tunggal Surabaya

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Abstract

This study aims to comprehensively identify and analyze the dominant factors that are challenges in the implementation of Deep Learning in elementary schools, as well as the dynamics of interaction between these factors. This research uses a qualitative approach with a case study design, which was conducted at SD Karya Tunggal Surabaya. Data collection techniques include in-depth interviews, participant observations, and documentation studies. Data is analyzed by means of data reduction, data presentation, and conclusion/verification. This study reveals four interrelated dominant inhibiting factors: (1) The dense curriculum load creates a dilemma between completing the material and achieving depth of understanding; (2) Teachers' pedagogical capacity in designing and facilitating inquiry learning and process assessment which is still limited; (3) A conventional (teacher-centered) learning culture that has been institutionalized and creates resistance to change; and (4) Limited resources and support systems, such as student ratios, time, and administrative burden. These four factors form a complexity of systemic challenges.

Keywords– *Challenges, Deep Learning, Elementary School.*

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1. Introduction

The global world of education is facing the imperative to adapt to the demands of the Industrial Revolution 4.0, which transforms the foundations of modern society through the integration of digital technology, automation, and the internet on all fronts. In this era, data and technology literacy is a fundamental competency that every individual must have (Schwab, 2019). In this context, the development of Artificial Intelligence (AI), with Deep Learning as its most progressive subfield, has emerged as a major driver of innovation in various sectors, including education. Therefore, the quality of learning must undergo reform to improve the quality of education itself (Adnan et al., 2023). Deep Learning, with its network architecture that resembles neural processing, has a superior capacity to extract patterns and insights from massive and complex datasets (LeCun et al., 2015). This ability unlocks revolutionary potential to create previously difficult learning personalization, where the system can adapt to each learner's unique pace, style, and needs (Kharis & Zili, 2022). Thus, the adoption of this kind of cutting-edge technology is no longer just an option, but has become a necessity for a relevant and responsive education ecosystem in the 21st century.

In the framework of realizing the vision of 21st century education, elementary schools (SD) occupy a foundational and critical position. Education in elementary school is the foundation for the formation of students' character, therefore it is important for teachers to provide accurate knowledge (Lestari et al., 2024). In addition, this phase of basic education is not just a stage to introduce basic literacy and numeracy, but the most ideal period to instill the foundation of high-level thinking skills through the application of the Deep Learning paradigm. Deep Learning is a pedagogical paradigm that is fundamentally different from the surface learning approach. This concept was first systematically proposed by Ference Marton and Roger Säljö in 1976, distinguishing between deep and surface approaches to student learning. Essentially, Deep Learning refers to a process in which learners actively and critically engage with the material, seek to understand meaning, connect new ideas with existing knowledge, and see the

relationship between concepts and real-life contexts (Marton & Säljö in Biggs et al., 2022). This theory was later developed by experts such as John Biggs through the construct Approaches to Learning and popularized globally within the framework of New Pedagogies for Deep Learning (NPDL) by Michael Fullan and his colleagues. Its application from an early age, which is manifested through instructional design such as project-based learning, authentic problem-solving or progressive inquiry forms habits of mind or essential thinking habits in students (Fullan & Langworthy, 2014). These habits, which include curiosity, perseverance, critical thinking, and the ability to collaborate, are crucial psychological and cognitive assets. Furthermore, instilling this foundation at the elementary level is a strategic imperative, not only to prepare their cognitive readiness for higher education, but more importantly to equip them with adaptive competencies in facing the dynamics of life and future global challenges (Rahmaniah et al., 2023). A strong and well-established foundation of deep learning at the elementary level will ultimately be the main determinant for the quality and sustainability of lifelong learning in the later stages.

Although conceptually the urgency is recognized, the reality of the implementation of Deep Learning in most Indonesian elementary schools still encounters various significant obstacles, so its implementation cannot be said to be optimal. Initial observations and preliminary studies conducted by researchers at SD Karya Tunggal, for example, confirm the findings of a broader study, as expressed by Rahmawati (2025), which shows that learning practices in many elementary schools are still dominated by a teacher-centered approach, lecture methods, and emphasis on memorization aspects. The dominance of this approach is often motivated by the insistence to complete the scope of material in a dense curriculum (Sutanto, 2024), so that the space for in-depth inquiry and exploration by students is very limited. Thus, a wide gap is created between the spirit of the Independent Curriculum which has philosophically adopted the principle of Deep Learning with a focus on being aware, meaningful, and encouraging in the instructional practices that actually occur in the classroom. This gap is the focus of the in-depth study in this study.

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The systemic complexity of this challenge of applying Deep Learning can be mapped into several intersecting dimensions. In the pedagogical dimension, teachers' ability to design and facilitate inquiry learning is still the main obstacle. Many teachers are constrained in developing learning tools, such as LKPD and assessments, that are able to guide students to build conceptual understanding independently (Rahmawati, 2023). This challenge is exacerbated by the cultural dimension, namely the learning culture in the classroom that has been institutionalized for generations, where students are often positioned as passive recipients of information rather than active learning agents (Nasution, 2022). This combination of pedagogical competence limitations and hierarchical classroom culture creates a less fertile environment for the growth of critical and collaborative thinking habits that characterize Deep Learning.

In addition to pedagogical and cultural aspects, systemic challenges and resource limitations form no less significant obstacles. From the systemic side, overloaded curriculum design often forces teachers to pursue material completeness rather than depth of understanding. This is reinforced by an assessment system that is still fixated on measuring low-level cognitive aspects through written exams, as well as a high non-teaching administrative burden that takes up teachers' time to design innovative learning (Sari & Saputra, 2024). On the other hand, resource limitations are a real limiting factor. The availability of supporting facilities (such as laboratories, libraries, and technology), limited allocation of lesson hours, and an imideal student-teacher ratio in one class make it more difficult to realize a deep and personalized learning process (Nafisah, 2025). This convergence of all dimensions is what makes the implementation of Deep Learning a complex problem that requires an integrated and holistic approach to handling.

Several relevant researchers support this research, including a study by Rizkasari et al. (2022) which examines the teaching style of elementary school teachers in the context of 21st century learning demands, with a focus on efforts to implement a student-centered approach. This study provides a strong starting ground on challenges at the micro level (teachers and classroom practice). The

research to be conducted will deepen Fadillah's findings by specifically mapping these challenges into the framework of Deep Learning (as a pedagogical concept) and extending the scope of the analysis to the systemic and cultural factors that also influence the teaching style. A study by Mayangsari et al. (2024) examines the relationship between teacher workload (both teaching and administrative) and the effectiveness of curriculum implementation in public elementary schools. Sari & Hidayat's research provides an important perspective on the systemic dimensions of the challenge. This study will be integrated into current research to analyze how workload, administration, and curriculum pressure factors interact with teachers' pedagogical abilities in inhibiting the application of Deep Learning, so that the analysis becomes more holistic. A study by Nadawina et al (2025) that examines the root causes of the passive learning culture among elementary school students and offers strategies to turn it into an active learning culture. Wijayanti's study highlights a cultural dimension that is often overlooked. The current research will include these findings as one of the key variables, by analyzing how the established culture of passive learning interacts with teachers' efforts to implement Deep Learning that demands student activity and agency. Understanding this cultural dimension is crucial for designing effective interventions.

The practical significance of this research is expected to provide evidence-based input for various stakeholders. First, for the Education Personnel Education Institute (LPTK), the findings of this research can be an empirical basis in compiling and revitalizing the pre-service education curriculum and sustainable professional development programs (PKB) that are more relevant and contextual, especially in equipping prospective teachers and in-office teachers with the competence to design and facilitate inquiry learning (Darling-Hammond, 2017). Second, for policymakers at the central and regional levels, the results of this analysis can inform the formulation of more targeted supporting policies, both in terms of curriculum simplification, the development of an authentic assessment system, and the efficiency of time management and the administrative burden of teachers (Fullan & Quinn, 2015). Third, for teachers and schools, this research is

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expected to serve as a material for critical reflection and a source of inspiration to evaluate and develop more meaningful learning strategies and encourage in-depth students' intellectual engagement.

Based on the complexity of the challenges outlined in the background, this study is specifically focused on identifying and comprehensively analyzing the dominant factors that hinder the implementation of Deep Learning in elementary schools, as well as examining the dynamics between these factors in shaping the reality of practice in the field.

2. Method

This study uses a qualitative approach with a case study design. Qualitative research is a scientific approach to understanding social phenomena in their natural context by prioritizing the processes and meanings constructed by participants (Creswell & Poth, 2016). This approach aims to describe, interpret, and construct a deep understanding of a reality that cannot be fully measured through statistical numbers (Sugiyono, 2016).

The selection of a qualitative approach in this study is motivated by several basic considerations, namely (1) The focus of the research is to explore and understand in depth the challenges of applying Deep Learning in elementary schools, which is a complex socio-cultural phenomenon; (2) The purpose of the research is to uncover the meaning, perception, and direct experience of education actors (teachers, principals) in facing these challenges, which require depth of narrative data (Miles et al., 2014); and (3) The characteristics of the problem being studied are multidimensional and contextual, so they require flexibility to explore the interaction between various factors that arise during the study.

This research was carried out at SD Karya Tunggal Surabaya using two types of data sources, namely primary data and secondary data. Primary data is data obtained directly from the original source by the researcher to answer the research objectives/focus (Sugiyono, 2016). In the context of this study, primary data was collected directly from participants who were directly involved in the learning process in elementary schools, namely students, teachers, and principals.

Secondary data is data that is not collected directly by researchers, but obtained from pre-existing sources (Miles et al., 2014). This data serves to complement, enrich, and contextualize primary data. Secondary data sources in this study include academic documents, reports, etc.

To obtain comprehensive and valid data, this study uses several data collection techniques with appropriate instruments, namely (1) Interview techniques are used as the main method to explore the perceptions and concrete experiences of participants regarding the challenges of implementing Deep Learning. The instrument used is an interview guide that contains a number of open-ended questions that have been designed beforehand, but allows researchers to develop further questions based on participants' responses (Bryman, 2016); (2) Observation techniques are used to directly observe learning practices in the classroom in order to match statements in interviews with realities in the field.

The instrument used is in the form of an observation sheet that contains specific aspects to be observed. These aspects include interaction (teacher-student and student), the use of learning models (such as Project-based Learning, Problem-based Learning or Inquiry), and the use of learning resources (Sugiyono, 2016); and (3) Documentation techniques are used to analyze written documents that are relevant to the research focus, such as the suitability of learning planning with Deep Learning principles, implementation in teaching materials, and school policy documents listed in the curriculum (Bowen, 2009). In this study, triangulation of sources and techniques was applied to increase the strength of research findings (Creswell & Poth, 2016).

The data analysis in this qualitative research will follow an interactive model developed by Miles et al. (2014). This model consists of three flows of activities that are carried out simultaneously and iteratively, namely: data reduction, data presentation, and conclusion/verification.

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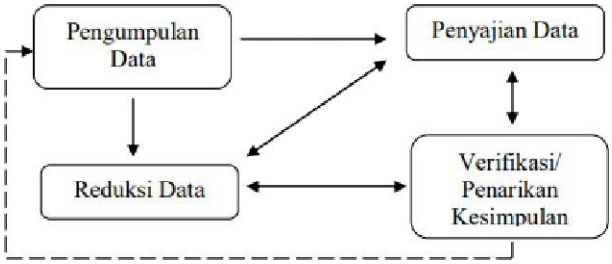

Figure 1. Stages of qualitative research data analysis (Miles et al., 2014)

Based on Figure 1 above, the following is the explanation (1) Data reduction is the process of selection, concentration, simplification, and transformation of rough data obtained from the field. In the context of this study, data reduction is carried out in several ways, namely (a) Summarizing and encoding interview transcript data, observation notes, and documents to identify statements or phenomena relevant to the focus of the research; (b) Classify data based on potential themes that arise; (c) Removing data that is deemed inconsistent or less relevant; and (d) This process allows researchers to manage data to be more organized and ready for presentation; (2) The presentation of data is carried out in a format that allows the researcher to understand what is happening and to take further action based on that understanding. The presentation of data in this study was carried out through: (a) A matrix that compares the perception of students, teachers, and principals on a certain challenge; (b) Flowcharts that describe causal relationships or interactions between various inhibiting factors; and (c) Thematic networks to map the main themes, sub-themes, and supporting evidence; (3) Drawing conclusions and verifying the meaning of the data that has been presented. Tentative conclusions are formulated, then verified continuously throughout the study. Verification activities in this study include:

(a) Triangulation, by comparing findings from interviews, observations, and document analysis to obtain data consistency; (b) Member check, by confirming provisional interpretations and conclusions to participants to ensure the accuracy of meaning; and (c) Negative case analysis, i.e. looking for data or cases that are not in accordance with the general pattern or conclusion that is being built. Through this systematic process, the conclusions reached are expected to be reliable, credible, and supported by strong empirical evidence.

3. Result and Discussion

Based on the results of the observations made by the researcher, the following results are presented which include interaction (teacher-student and student-student), the use of learning models (such as Project-based Learning, Problem-based Learning or Inquiry), and the use of learning resources.

Figure 2. Observation of learning practices by MAMR and SW teachers

Interaction Aspect

Observations on the interaction aspect show quite lively learning dynamics. Teacher-student interaction is characterized by teachers' efforts to ask open-ended questions, such as "What do you think happens if the number of locusts in the rice fields decreases drastically?". The teacher acts as a facilitator by guiding the discussion using guiding questions, although it is still limited in providing adequate waiting time for students to think. The teacher's response to the student's answer is good, as can be seen from the way he appreciates the student's thought process even though the answer is not right, by saying "Interesting idea, even though it is not right. Let's explore the flow of food again". Interaction between students develops very positively in a group learning setting. All group members are actively involved in the creation of food chain diagrams, with the division of tasks occurring naturally. Observe the process of building constructive ideas with each other, where students complement each other's understanding of relationships in the food chain. Some students give feedback to their peers on the results, although the frequency can still be increased.

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Learning Model

Learning using the PJBL Model began with a challenging starter: "What if we made a model of a rice field ecosystem complete with its food chain?". Students engage in active investigation with a variety of strategies, some searching for information in the library, while other groups conduct interviews with library staff. The process of creating a real product in the form of a 3D diorama of the rice field ecosystem using recycled materials is running with enthusiasm. The Inquiry Learning aspect is seen when some students start formulating independent questions, such as "Are farmers part of the rice field ecosystem?". They plan the completion steps systematically through the stages of research, sketching, making dioramas, and presentations. The data analysis process was seen when students analyzed information from farmer interview videos, and drew the conclusion that humans are an integral part of the rice field ecosystem.

Utilization of Learning Resources

The use of learning resources shows adequate variation although there is still room for development. Teachers not only rely on textbooks, but also use videos of farmer interviews, examples of native rice crops, and the school environment as learning resources. The relevance of learning resources to students' real lives is very visible, especially by associating the material with the rice fields around the school that are experiencing a harvest period. Some students show initiative in self-exploration by bringing plant pest samples from home. The use of technology to support investigations has begun with the use of smartphones to search for additional information, although its use is not optimal and is only used by some groups. Technology primarily functions as a tool for information research, not yet developed into a medium for creation and collaboration.

Based on the results of interviews conducted by the researcher on SW (grade II teachers), MAMR (grade V teachers), N (grade II students), PNK (grade IV students), and ISH (school principals).

Figure 3. Interviews with ISH principals, MAMR and SW teachers

Perception of the Challenges of Implementing Deep Learning at SD Karya Tunggal Surabaya

The principal of Mrs. ISH emphasized that "Deep Learning is at the heart of the development of the quality of education in our school" a statement that is in line with the deep understanding shown by the teachers. Mrs. SW, a grade II teacher, explained in detail: "Deep Learning is not just memorizing, but how students really understand concepts so that they can apply them in their daily lives". This conceptual understanding was agreed by the students, as PNK expressed: "If we study with a project, we remember it longer. When I made an ecosystem mockup, until now I still remember the food chain". This shows an alignment of vision from the school policy level to admission at the student level. However, this vision faces real implementation challenges. Mr. MAMR, a grade IV teacher, confirmed the gap between theory and practice: "This approach is very important... However, we are often faced with the demands of completing dense curriculum materials". The systemic challenges mentioned by the teacher are confirmed by the strategy of the principal of the school Mrs. ISH in responding to it: "Our strategy is to do gradual integration" which indicates that full transformation cannot be done instantly.

From a cultural perspective, the shift from conventional learning to deep learning has created its own dynamics. Mrs. SW observed that "Many (teachers) are still comfortable with the lecture method because it is considered more practical" a statement that is actually confirmed inversely by the students'

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experience. Student N firmly stated his preference: "It's very different from just being preached... it feels like an inventor and understands better". The enthusiasm of these students is tangible evidence that drives transformation efforts. Principal Mrs. ISH sees this as an opportunity: "We don't see it as an additional burden, but rather as an approach to achieving the core competencies of the curriculum in a more meaningful way". This statement is a direct response to teachers' concerns about the curriculum load, as well as a confirmation of the effectiveness of the methods that students prefer.

Concrete Experience of the Challenges of Implementing Deep Learning at SD Karya Tunggal Surabaya

Ms. SW shared her specific experience in implementing PjBL: "When creating a waste recycling project, I faced very real time management constraints. The activity that was planned for 2 hours turned out to require 3 meetings because the students were so enthusiastic about exploring". This experience was agreed by Mr. MAMR who said: "In inquiry learning about alternative energy, the biggest obstacle is precisely in assessment. Assessing the thought process of each student individually takes a lot of time". From the perspective of students, N confirmed this challenge by saying: "When we started the hydroponic plant project, we were confused because the data did not match the hypothesis. But that's exactly what we learned more – that in real research the results can be different from the theory." PNK added: "The biggest challenge in group work is the uneven division of tasks. But we learned to solve it by making the job desk clear and reminding each other".

Regarding the pressure of the curriculum, Mr. MAMR revealed his strategy: "I integrate project-based learning with the core curriculum topics. For example, the field area measurement project while covering mathematics material about flat buildings". Ms SW added: "The key is careful and flexible planning. Despite the dense curriculum, I chose depth over coverage - it's better to have some topics mastered in depth than many topics just on the surface". Principal Mrs. ISH acknowledges this challenge from a policy perspective: "The concrete support we provide includes allocating 20% of lesson hours to project-based learning and

providing guidance modules. However, the operational obstacle is the gap in teachers' ability to implement the module".

Mrs. ISH emphasized that "The most decisive factor is collaboration and learning leadership. We have established a community of practice where teachers can share their experiences of successes and challenges in implementing Deep Learning". This statement is in line with the experience of Ms. SW who acknowledged: "The support of colleagues in the practice community is very helpful. From there I learned efficient learning process documentation techniques for assessment". From the student side, N gave valuable input: "The school could have given more time to the presentation of the project results, because that's where we learned a lot from the work of our friends". Meanwhile, PNK hopes: "If there is a more complete lab or experimental room, surely our projects can develop even more".

Challenges of Implementing Deep Learning at SD Karya Tunggal Surabaya

The first dominant factor is the dense curriculum load versus the depth of learning. The findings of the study revealed that the pressure to complete the curriculum coverage is the main obstacle. The teachers stated that they experienced tension between the administrative demands of completing the material and the desire to explore the concept with the students. As one of the teachers said, "We are torn between the desire to explore students' interests and the obligation to complete all KD before the semester ends". This phenomenon is in line with the findings of Sari et al. (2025) who stated that the overload of the curriculum causes teachers to tend to choose time-efficient learning strategies, even though they do not encourage deep understanding. This conflict between breadth and depth of curriculum is a classic dilemma in pedagogical innovation (Fullan & Quinn, 2015). This is exacerbated by the assessment system that is still focused on content mastery rather than thinking competence.

The second dominant factor is the pedagogical capacity of teachers in designing differentiated learning. The results of interviews and observations show that teachers' ability to design and facilitate inquiry learning is still a significant obstacle. Teachers have difficulty in formulating effective triggering questions,

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managing a guided inquiry process, and assessing students' thought processes. These findings are consistent with Malahayati's (2020) research which identified that the majority of elementary school teachers still need intensive assistance in designing learning that triggers Higher-Order Thinking Skills (HOTS). The Technological Pedagogical Content Knowledge (TPACK) theory underlines that the integration between knowledge content, pedagogy, and learning context requires continuous professional development (Mishra & Koehler, 2009). In this study, it was observed that teachers who had participated in special training showed better ability to facilitate in-depth discussions compared to their peers who had not received adequate training.

The third dominant factor is the institutionalized conventional learning culture. The cultural aspect has proven to be an obstacle that is no less significant. The learning culture that places teachers as the primary source of knowledge and students as passive recipients is still deeply rooted. Observations in the classroom show that even though teachers have designed inquiry activities, in practice there is still a tendency to provide "shortcuts" when students have difficulties. This confirms the findings of Nisa et al (2024) about the strength of teacher-centered culture in learning practices in elementary schools. Fullan & Quinn's (2015) theory of educational change emphasizes that pedagogical transformation is not only concerned with technical aspects, but also requires cultural change at the school level. Resistance to this change mainly comes from senior teachers who have been using conventional methods for years and are comfortable with the pattern.

The fourth dominant factor is the limitation of resources and support systems. Systemic factors in the form of time constraints, non-ideal student ratios, and non-teaching administrative burdens also affect the optimization of implementation. Teachers complain about the lack of time to design complex learning because they are burdened by administrative tasks. In addition, the 1:32 student ratio in a single class makes it difficult for teachers to monitor each student's thought process individually. These findings are in line with the research of Fitria & Limgiani (2024) which highlights the impact of teachers' workloads on

the quality of learning. The theory of resource dependence in education management explains that the success of pedagogical innovation is highly dependent on the availability of adequate resources (Baker et al., 2016). In this context, the support of the principal in allocating resources and creating a conducive environment is a determining factor, as expressed by the principal in an interview.

These four factors do not stand alone, but interact with each other in creating the complexity of implementation challenges. The heavy workload of the curriculum is exacerbated by the limited pedagogical capacity of teachers, while the conventional learning culture is reinforced by inadequate support systems. These findings confirm Bronfenbrenner's theory of educational ecology which emphasizes the importance of viewing the problem of education as an interconnected system (Tudge & Rosa, 2019). Therefore, a partial and fragmented solution approach will not be effective in overcoming the barriers to Deep Learning implementation.

4. Conclusion

Based on the overall data analysis and discussion, this study concludes that the implementation of Deep Learning in elementary schools is faced with four main interrelated challenges. First, structural pressure due to the heavy curriculum load triggers a dilemma between completing the coverage and achieving depth. Second, teachers' pedagogical capacity in designing inquiry learning, differentiating, and conducting process assessments is still limited. Third, the conventional learning culture that is teacher-centered and has been institutionalized creates resistance to changes in practice in the classroom. Fourth, limited resources and support systems, such as large student ratios, limited time, and administrative burden, are significant operational bottlenecks. These four factors form an ecosystem of complex and mutually reinforcing challenges.

The findings of this study have several important implications for various stakeholders: (1) For LPTK (Education Personnel Education Institutions): There

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is a need to revitalize the teacher education curriculum that emphasizes more on the development of Technological Pedagogical Content Knowledge (TPACK) for Deep Learning, including the skills of designing triggering questions, facilitating philosophical discussions, and conducting authentic assessments; (2) For School Policies and Education Offices: Policies need to shift from a rigid top-down approach to giving greater autonomy to schools and teachers in managing time and curriculum content, for example through a block schedule system and reducing the content of memorized materials;

(3) For Teacher Professional Development: Teacher training programs should focus on establishing a sustainable community of practice, where teachers can collaborate, reflect on practice, and jointly develop learning tools that encourage high-level thinking skills; and (4) For Principals: Instructional leadership of school principals is key in creating a conducive school climate, by providing resources, protecting teachers' learning time, and being a model in the implementation of innovative learning.

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