Astronomy in Primary Education: A Teacher Training Project

Othman Zainon[1], Musa Aimi[2]

Department of Geoinformation, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia

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ABSTRACT

This study addresses the critical barrier to effective astronomy education in primary schools: the lack of content knowledge, confidence, and specialized pedagogical skills among educators. A two-day teacher training initiative was designed to improve comprehension of essential astronomical concepts and instructional readiness for 15 preschool educators. The project utilized a pre- and post-assessment framework to evaluate changes across domains, including awareness, comprehension, and preparedness. Pre-assessment data indicated that 53% of participants scored below the proficiency threshold. Following the intervention, post-assessment results demonstrated a profound and significant enhancement in instructional readiness. Over 90% of participants achieved high scores (levels 6–10), showing a substantial improvement in conceptual comprehension. Educators also gained increased confidence in developing practical learning resources and utilizing inquiry-based methods to rectify common misconceptions. This study validates that structured, targeted professional development is crucial for improving early childhood science education and substantially augmenting instructors' ability to provide engaging, science-oriented educational experiences, thereby fostering an early interest in STEM and curiosity about the cosmos.

Keywords - Astronomy, Teacher, Training, Outreach, Primary Student

INTRODUCTION

Significant barriers frequently hinder the effective implementation of astronomy education at the primary school level, despite the clear rationale and cognitive benefits. Many primary school teachers lack the confidence, knowledge of the subject matter, or specialized teaching skills needed to teach this subject well. A lack of familiarity with fundamental astronomical topics and uncertainty over their integration into curricula often leads to inadequate teaching or avoidance of the subject altogether. This gap points out the urgent need for targeted, specialized professional development programs that can equip teachers with the required knowledge and instructional readiness.

To address this disparity and provide more substantive astronomy education in early grades, a well-structured teacher training initiative was designed and executed. This initiative aimed to enhance educators' understanding of essential astronomical concepts and offer practical strategies for integrating them into the curriculum. This article delineates the motivation, planning, execution, and assessment of this teacher training initiative for primary educators. Furthermore, it examines the issues encountered during the project and offers solutions derived from both literature and practice, ultimately confirming that thoughtfully structured professional development can substantially augment instructors' ability to provide engaging, science-oriented educational experiences.

Astronomy is an interdisciplinary discipline that engages young minds and is crucial for enhancing scientific literacy and curiosity, particularly in elementary school environments. The study of celestial bodies and the vast universe intrinsically captivate children's imaginations, creating a natural curiosity. Successfully incorporating astronomy into basic school settings lays a foundation for critical scientific thinking, encouraging spatial reasoning, scientific inquiry, and a deeper curiosity regarding the universe's existence. This early exposure helps frame the cosmos not just as a set of facts but as a framework for observation and investigation, essential for developing lifelong learning skills.

Globally, people are increasingly recognizing the essential role of astronomy in modern education. Recent government policy and educational research, particularly within Malaysia's diverse landscape, highlight astronomy as a potent instrument for enhancing overall STEM education and scientific reasoning. Its fundamentally multidisciplinary aspect connects concepts from science, mathematics, geography, and technology, promoting comprehensive understanding across various fields. Experiential and inquiry-based learning methods often promote this integration, encouraging active participation rather than passive reception of facts. Malaysian educators are increasingly recognizing that early engagement with astronomy fosters cognitive development and cultivates interest in the earth and space beyond.

Astronomy serves as an exceptional conduit for cultivating curiosity, critical thinking, and scientific literacy among young learners. Instructing on subjects like the Earth's rotation, moon phases, and planetary motion directly enhances spatial reasoning and conceptual thinking, which are vital cognitive abilities at the elementary level. Also, an early introduction to astronomy is important for clearing up common, long-lasting misunderstandings that both students and teachers have. For instance, empirical research and proper modeling through robust astronomy education can rectify beliefs that the Sun orbits the Earth or that seasons are caused by the Earth’s fluctuating distance from the Sun.

Rationale For Astronomy Education

Recent government policy and research highlight astronomy as a potent instrument for enhancing STEM education and scientific reasoning within Malaysia's diverse educational landscape (Aimran, 2020). The essentially multidisciplinary aspect of astronomy, connecting science, mathematics, geography, and technology, has promoted its incorporation into primary curricula, particularly via experiential and inquiry-based learning methods. Malaysian educators are increasingly recognizing that early engagement with astronomy fosters cognitive development and cultivates interest in the earth and space beyond [6] and [1].

Astronomy functions as an exemplary gateway for fostering curiosity, critical thinking, and scientific literacy in young learners [9]. The innately intriguing aspect of the Moon, stars, and planets enhances children's sense of wonder and creativity, serving as a powerful motivation for learning science. Astronomy is inherently multidisciplinary, integrating concepts from physics, geography, mathematics, and technology; therefore, it enhances comprehensive understanding across several fields [13]. Instructing on subjects like the Earth's rotation, moon phases, and planetary motion enhances spatial reasoning and conceptual thinking, which are vital cognitive abilities at the elementary level [4]. Moreover, some students (and even educators) possess misunderstandings regarding celestial events, such as the belief that the Sun orbits the Earth or that seasons result from the Earth's fluctuating distance from the Sun. Introducing astronomy at an early stage enables educators to rectify these beliefs via empirical research.

Astronomy education cultivates an understanding of the essence of science, prompting students to inquire, observe, test hypotheses, and formulate explanations, skills that correspond with inquiry-based and experiential learning methodologies [5] and [7]. Astronomy transcends cultural and geographical boundaries, providing a universal framework for students to appreciate both scientific and human perspectives on the cosmos [3]. Consequently, including astronomy into elementary education augments scientific comprehension and fosters a connection to the expansive cosmos, encouraging curiosity, creativity, and lifelong learning. Recent government policy and research in Malaysia highlight astronomy as a powerful tool for boosting STEM education and scientific reasoning.

1) **Cognitive Benefits**: It serves as an exemplary gateway for fostering curiosity, critical thinking, and scientific literacy in young learners. Instruction on topics like the Earth's rotation, moon phases, and planetary motion enhances vital elementary-level cognitive abilities, such as spatial reasoning and conceptual thinking. Astronomy's capacity for engaging young minds translates directly into significant cognitive benefits crucial for early development and later academic success. As an exemplary gateway for

learning, astronomy fosters essential skills such as curiosity, critical thinking, and scientific literacy in young learners. The inherently fascinating nature of celestial objects like the Moon, stars, and planets stimulates a deep sense of wonder and creativity in children, which acts as a powerful intrinsic motivation for engaging with science.

Crucially, teaching concepts such as the Earth's rotation, moon phases, and planetary motion directly enhances fundamental elementary-level cognitive abilities, particularly spatial reasoning and conceptual thinking. Spatial reasoning, which involves understanding and manipulating objects in space, is a vital skill reinforced by visualizing astronomical models and movements (Chastenay, 2015). Furthermore, early engagement with astronomy supports overall cognitive development and cultivates a sustained interest in science, technology, engineering, and mathematics (STEM) fields, as well as an appreciation for the cosmos (Othman et al., 2024; Abidin, 2020). Ultimately, incorporating astronomy into primary education not only augments scientific comprehension but also encourages curiosity. Connecting students to the expansive universe fosters creativity and lifelong learning.

2) **Multidisciplinary Nature**: Astronomy is inherently multidisciplinary, integrating concepts from science, mathematics, geography, and technology, promoting comprehensive understanding across various fields. Therefore, it enhances comprehensive understanding across several fields. This quality promotes comprehensive understanding across various fields and is highly valued in modern educational research and policy, particularly in Malaysia, where it is highlighted as a potent instrument for enhancing overall STEM education and scientific reasoning. The integration of these diverse subjects is achieved through specific connections:

   a) **Science**: Astronomy is fundamentally rooted in physical science, covering topics such as planetary motion, gravity, and the lifecycle of stars. It serves as a natural extension for subjects like physics, promoting observation and investigation of natural phenomena.

   b) **Mathematics**: Calculations related to distance, scale, orbits, and time (such as calculating the duration of a planet's orbit or the size of celestial objects) require the application of mathematical concepts.

   c) **Geography**: Students connect the study of the cosmos to Earth systems by exploring topics like seasons, climate, and time zones, which are all related to the Earth's position and movement in space.

   d) **Technology**: Astronomy education often involves the use of technological tools, including simulations, planetarium software, telescopic images, mobile applications, and image processing tools, which aligns with modern digital literacy and STEM learning.

This interdisciplinary aspect, often promoted via experiential and inquiry-based learning methods, encourages active participation and cultivates a sustained interest in the earth and space beyond. It also provides a universal framework for students to appreciate both scientific and human perspectives on the cosmos, as astronomy transcends cultural and geographical boundaries.

3) **Correcting Misconceptions**: Early introduction to astronomy is vital for clearing up common, long-lasting misunderstandings that are frequently held by both students and teachers regarding celestial events. Some educators themselves possess misunderstandings about the cosmos. These common misconceptions can include the belief that the Sun orbits the Earth, a geocentric view often derived from direct observation, or the belief that seasons are caused by the Earth’s fluctuating distance from the Sun. Teaching astronomy to kids at a young age gives teachers a chance to change these long-held beliefs. This correction is achieved through robust astronomy education that utilizes empirical research and proper modeling, providing a scientific and conceptual framework to replace intuitive but incorrect notions. This proactive approach ensures that young learners establish an accurate foundation for understanding Earth's place in the solar system and how celestial mechanics govern daily phenomena.

4) **Inquiry-Based Learning**: It cultivates an understanding of the essence of science by prompting students to

inquire, observe, test hypotheses, and formulate explanations, aligning with inquiry-based and experiential learning methodologies. Astronomy education is uniquely This approach is designed to foster an understanding of the fundamental essence of science by aligning with inquiry-based and experiential learning methodologies. This approach cultivates scientific habits of mind by actively prompting students to engage in the core processes of scientific discovery:

a) **Inquiry and Observation**: Astronomy starts with prompting students to inquire about and watch the natural world around them, such as the daily and seasonal movements of the Sun, Moon, and stars.

b) **Hypothesis Testing**: Students are encouraged to formulate tentative explanations (hypotheses) for celestial phenomena and devise ways to test these ideas, moving beyond passive information reception to active investigation.

c) **Formulating Explanations**: The learning process culminates in the formulation of evidence-based explanations for what they have observed, reflecting authentic scientific practice.

This emphasis on inquiry, modeling, and experiential activities ensures that students are not merely memorizing facts but are developing the critical thinking skills and scientific literacy essential for future STEM engagement. Furthermore, the experiential nature of observing the sky and using practical tools helps to ground abstract concepts in tangible experience, making the learning more meaningful and durable.

Teacher Training Project: Structure And Phases

The two-day teacher training course was designed specifically to enhance educators' understanding of essential astronomical concepts and to offer strategies for integrating these concepts into the curriculum. The curriculum was created using theoretical seminars addressing core astronomical topics, such as the moon, solar system, and diurnal cycle, complemented by practical sessions in which instructors engaged students in hands-on activities using models, visual aids, and various instructional tools. The project employed a pre- and post-assessment framework to evaluate changes in educators' awareness, understanding, and readiness to incorporate astronomy into early childhood education. A total of 15 preschool educators participated, consisting of 87% female and 13% male, the majority possessing 1–5 years of teaching experience. The training consisted of five primary phases, as shown in Table 1.

TABLE 1. The Project Phases and Activities

Phase	Activities
Pre-training assessment and diagnostics	Pre-test of astronomy conceptual knowledge, interviews of teachers' beliefs, surveys of confidence and attitudes
Content & pedagogy workshops	Sessions on astronomy fundamentals, common misconceptions, inquiry pedagogy, modeling, use of visuals/simulations
Hands-on and digital tools introduction	This study uses simulations, planetarium software, telescopic images, mobile apps, and image processing tools.
Design of classroom lessons	Teachers draft one or more astronomy lesson plans suitable for their grade levels, peer review, feedback from trainers
Classroom implementation	Teachers teach astronomy lessons over several weeks and collect data (student responses, observations)
Reflection, sharing, and follow-up	Teachers present experiences, share student work, discuss challenges, receive mentoring and revision of lessons

RESULT AND DISCUSSION

This section provides a detailed breakdown of the study's outcomes, presenting the data collected through the pre- and post-assessment framework. This analytical approach was designed to precisely measure the effect of the teacher training initiative on educators' instructional readiness, encompassing their awareness, conceptual understanding, and confidence regarding astronomy education, as shown in Table 2. The results compare the initial diagnostics, which established a critical need for intervention by showing inadequate knowledge and confidence among participants, with the subsequent data collected after the training. Ultimately, the analysis demonstrates the significant and positive changes achieved in all measured areas.

The pre-assessment findings were crucial in establishing a clear and concerning baseline regarding the instructional readiness of the participating educators. The overall results unequivocally indicated that the majority of the preschool teachers possessed inadequate knowledge and confidence when it came to instructing astronomy. The training project relied heavily on this initial diagnostic step to gauge the extent of the problem it aimed to tackle.

By utilizing a comprehensive framework that included a pre-test of thorough conceptual knowledge, interviews on teachers' beliefs, and surveys of confidence and attitudes, the project effectively documented a significant gap in preparedness before any intervention took place.

TABLE 2. Summary of Pre-Assessment Findings on Educators' Instructional Readiness for Astronomy Education.

Assessment Area	**Finding**	**Details**
Overall Knowledge & Confidence	Inadequate knowledge and confidence when instructing astronomy	The majority of preschool teachers
Quantitative Performance	Below-average scores recorded across all assessed domains	More than fifty percent of participants
Domains Assessed	Deficiencies noted in awareness, comprehension, and preparedness	All three domains were affected
Instructional Readiness	Indicated that over half of the teachers were ill-equipped to provide effective instruction	Confirmed a critical need for specialized training

The quantitative analysis of the initial assessment demonstrated the widespread deficiency among the participants. Specifically, the data revealed that more than fifty percent of the educators recorded below-average scores across all three assessed domains: awareness, comprehension, and preparedness. This high percentage of below-average performance served as a compelling empirical indicator of the urgent need for specialized professional development. The findings confirmed that without targeted training, over half of the teachers were ill-equipped to provide effective instruction in astronomy.

This poor performance suggested a widespread lack of foundational knowledge concerning astronomical topics. The scores in the conceptual knowledge pre-test pointed to specific gaps in understanding, reflecting a general unfamiliarity with the core concepts required to teach celestial subjects accurately. This knowledge deficit is a major barrier, as teachers can only effectively instruct concepts they fully comprehend. Therefore, the training needed to focus heavily on content mastery before addressing pedagogical techniques.

Beyond the purely conceptual knowledge, the pre-assessment diagnostics highlighted a significant issue of instructional uncertainty among the participants. The results highlighted an inherent uncertainty among the educators regarding how to integrate astronomical concepts effectively into the existing preschool curricula. This challenge is compounded by the fact that numerous educators also exhibited insufficient familiarity with appropriate astronomy-related pedagogical practices and resources, such as models, simulations, or hands-on

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activities that are essential for teaching abstract concepts to young learners. The lack of pedagogical confidence was, therefore, just as critical as the lack of content knowledge.

In summary, the detailed analysis of the pre-assessment findings provided the necessity and justification for the specialized training initiative. The clear baseline—showing inadequate knowledge, low confidence, widespread below-average scores, and a lack of both content familiarity and instructional resources indicates that a structured intervention is vital to enhance educators' ability to provide engaging, science-oriented educational experiences. These initial results framed the subsequent training as a direct response to documented deficiencies in teacher preparedness.

The initial inadequacy and the subsequent success are visually represented in Fig. 1, which compares the mean overall scores of the pre- and post-assessments. The bar chart starkly illustrates the effectiveness of the training intervention: a mean score that was initially established below the proficiency level.

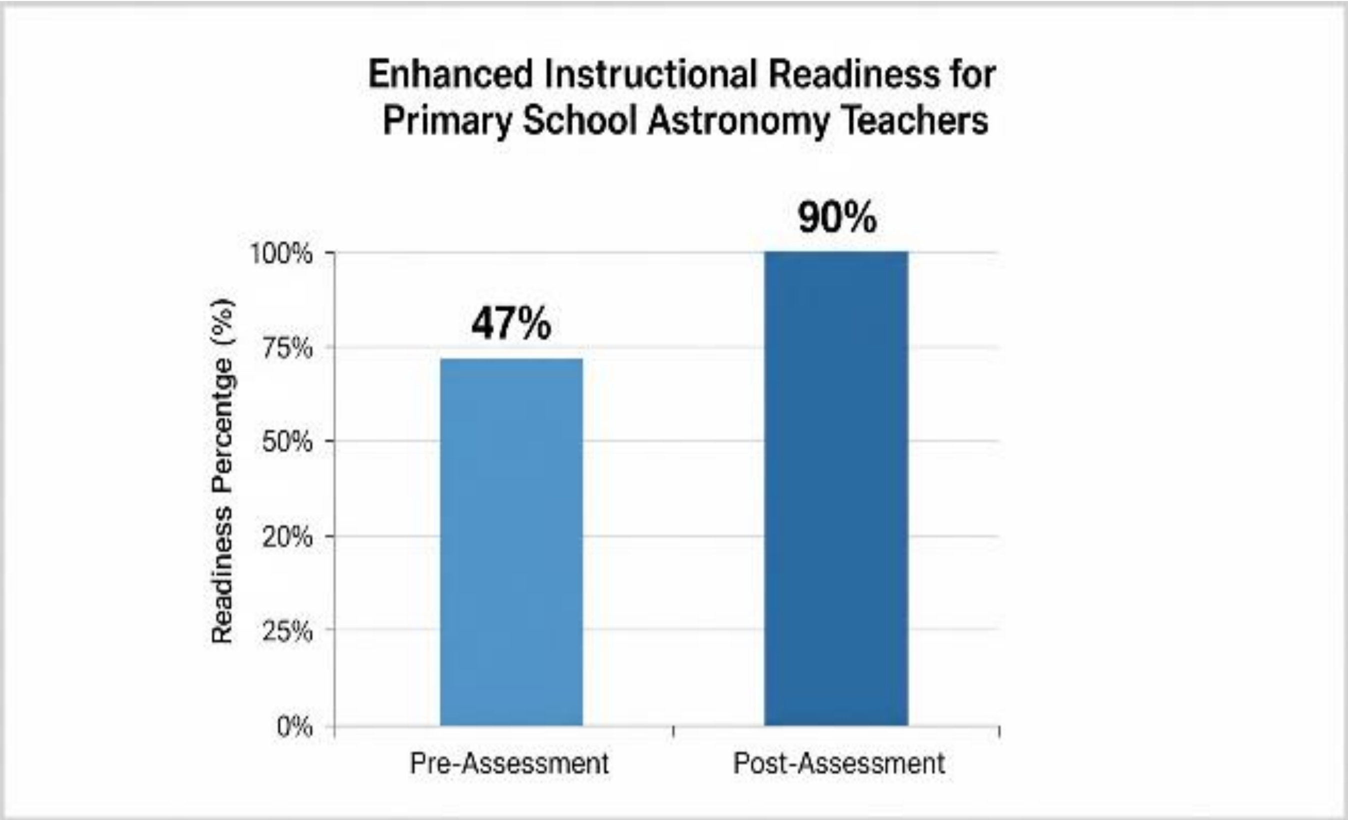

Fig. 1. Pre- and post-assessments of the effectiveness of the training intervention

The threshold reflecting that over fifty percent of participants were ill-equipped was significantly elevated following the two-day training. This quantifiable improvement provides a clear empirical foundation for the "profound enhancement" noted in the abstract, serving as direct evidence that the structured professional development successfully addressed the documented content and pedagogical deficiencies.

Quantitatively, the most compelling evidence of the training's success lies in the dramatic shift in participant performance. Table 3 shows the definitive post-assessment results, summarizing the significant enhancement in educators' instructional readiness across all measured domains. More than 90% of the teachers got scores between levels 6 and 10 on the post-assessment. This massive increase from the pre-assessment's below-average scores confirms a profound enhancement in awareness and conceptual comprehension of astronomical topics. Achieving scores in this higher range indicates that the teachers acquired foundational content knowledge and developed a deeper, more robust understanding of the complex concepts related to the cosmos and celestial mechanics.

TABLE 3. Summary of Post-Assessment Findings on Educators' Instructional Readiness for Astronomy Education

Assessment Area	Finding	Details
Overall Performance	Demonstrated significant enhancement across all domains.	Confirmed that the training effectively enhanced knowledge, confidence, and preparedness.
Quantitative Outcome	Over 90% of participants achieved high scores.	Scores were between levels 6 and 10.
Content Mastery	Showed a significant enhancement in awareness and conceptual comprehension.	Teachers developed a deeper, more robust understanding of complex concepts.
Pedagogical Readiness	Increased confidence in developing practical learning resources.	Improved ability to connect celestial subjects to daily life.

Furthermore, the post-assessment documented a significant enhancement in the educators' preparedness to implement astronomy in the classroom. This readiness was a direct result of the organized, experiential, and inquiry-based nature of the training, which emphasized pedagogical applications rather than just theoretical content. Participants acquired an enhanced understanding of astronomical subjects and recognized their relevance to daily life and the educational curriculum. This shift transformed teachers from uncertainty and hesitation about the subject to readiness and effectiveness in teaching it.

The training also resulted in specific qualitative enhancements in teaching materials and their practical applications. Educators showed increased confidence in developing practical learning resources, a critical skill given the abstract nature of many astronomical concepts. They also showed that they could better connect celestial topics to everyday life, which made the subject matter more relevant and easier for young learners to understand. This increased pedagogical confidence ensures that teachers are more likely to integrate astronomy lessons actively, moving beyond basic instruction to foster genuine scientific curiosity.

The analysis of the post-assessment data strongly supports the hypothesis that specialized professional development is critical for improving early childhood science education. The project successfully improved preschool teachers' understanding, confidence, and readiness to include astronomy in early education. This demonstrable success, as evidenced by over 90% achieving high competency levels, confirms that thoughtfully structured training can substantially augment instructors' abilities to provide engaging, science-oriented educational experiences, reinforcing the need for ongoing teacher training to cultivate early interest in STEM and curiosity about the cosmos.

CONCLUSION

The two-day teacher training project successfully responded to a critical need within primary education: the deficiency in knowledge, confidence, and pedagogical readiness among educators to teach astronomy. The initial diagnostics clearly established a low baseline, with more than fifty percent of participants scoring below average across all measured domains of awareness, comprehension, and preparedness. The subsequent intervention, however, demonstrated a profound and significant enhancement, confirming that thoughtfully structured professional development is the necessary catalyst for change. This success was quantitatively validated by the dramatic post-assessment outcomes, where over 90% of the preschool educators achieved high scores, signifying a powerful and widespread acquisition of core astronomical concepts and instructional readiness.

The efficacy of this project lies not merely in imparting facts but in fostering a fundamental pedagogical shift. By employing organized, experiential, and inquiry-based training methodologies, the initiative transformed abstract concepts into tangible, teachable elements. Teachers gained critical skills such as using models and simulations, enabling them to move beyond rote learning and correct persistent misconceptions—like the belief that the Sun orbits the Earth. This enhancement in content mastery was intrinsically linked to increased pedagogical confidence, ensuring that educators are now prepared to approach astronomical subjects actively and effectively, rather than avoiding them due to uncertainty.

More broadly, this study affirms the pivotal role of astronomy as a potent instrument for enhancing overall STEM education and scientific reasoning, aligning with modern educational policy in Malaysia. By connecting concepts from science, mathematics, geography, and technology, the training empowered teachers to utilize astronomy's multidisciplinary nature to foster crucial elementary-level cognitive abilities, such as spatial reasoning and critical thinking. The project serves as an empirical model demonstrating that investing in specialized training directly contributes to developing a scientifically literate citizenry with a foundational understanding of inquiry, observation, and hypothesis testing.

The lasting impression of this intervention is the practical confidence instilled in the educators to connect celestial subjects to daily life and the school curriculum. Participants developed increased confidence in designing practical learning resources, a skill vital for making abstract astronomical subjects relevant and accessible to young learners. This sustained engagement with the material ensures that the lessons learned during the two-day course will translate into engaging, science-oriented educational experiences in the classroom, thereby cultivating a continuous cycle of curiosity and discovery among students.

In conclusion, the demonstrable success of this teacher training initiative strongly validates the hypothesis that continuous, targeted professional development is critical for improving early childhood science education. The experiment underscores the urgent need to institutionalize such training programs as a fundamental element of educational strategy. Future research should concentrate on evaluating the enduring effects on student performance and curiosity to comprehensively establish this training model as a benchmark for promoting early interest in STEM and nurturing a lifelong admiration for the vast universe.

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