

Comparative Study on Traditional and Digital Materials in Science Education

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Abstract — This comparative study utilized a quasi-experimental design to evaluate the effectiveness of traditional versus digital instructional materials in teaching key science concepts to Grade 8 students. Participants were divided into two groups: Group A was taught using conventional tools such as textbooks, printed worksheets, and charts, while Group B engaged with digital resources including interactive simulations, video tutorials, and online worksheets. Pre-test and post-test scores were analyzed using descriptive statistics and paired t-tests to determine the extent of learning gains. Results indicated that while both groups exhibited significant improvement, the digital group achieved a notably higher mean gain score ($p < 0.05$), suggesting superior learning outcomes. Additionally, qualitative feedback from student interviews highlighted higher engagement, increased motivation, and stronger perceived relevance of the lessons among students using digital materials. These findings point to the pedagogical value of digital resources, which leverage multimedia elements, instant feedback, and self-paced learning to support deeper conceptual understanding and student retention. However, the study also acknowledges the continued utility of traditional materials, especially in settings with limited access to technology. Ultimately, the results affirm the potential of digital tools to enrich science education but emphasize that successful integration depends on informed teacher facilitation, appropriate infrastructure, and alignment with curricular goals. This study provides evidence that strategic use of digital materials, when combined with sound pedagogical practices, can significantly enhance science instruction and student learning experiences.

Keywords — *Digital Instructional Materials, Traditional Teaching Methods, Science Education, Learning Outcomes, and Blended Learning Approach*

I. Introduction

The rapid advancement of technology has ignited a global discussion on the efficacy of traditional instructional materials versus digital media in science education. While digital tools like simulations offer enhanced engagement, their impact varies considerably based on implementation quality, teacher competence, and student adaptability. This inconsistency is reflected in global research, where some studies find no significant difference in learning outcomes between the two. In the Philippines, alarming PISA results and persistent issues with teacher quality and student performance highlight a critical need for effective instructional strategies. Locally, Northern Samar grapples with low Mean Percentage Scores and literacy challenges, prompting urgent interventions. This study addresses these issues by empirically comparing

traditional and digital materials in science instruction for Grade IV learners in the DepEd Northern Samar Division public school system. Its findings will provide critical, evidence-based insights for school administrators, curriculum designers, and teachers, contributing to both local educational reforms and broader literature on educational technology in developing countries. Ultimately, this research seeks to improve learning outcomes and support data-driven solutions responsive to the needs of marginalized learners.

Literature Review

The integration of appropriate instructional materials has long been recognized as a vital component in enhancing teaching and learning outcomes, particularly in science education where conceptual understanding often relies on visual, interactive, and contextual supports. Traditional materials, such as textbooks and printed worksheets, have historically formed the backbone of instructional delivery, offering structured content aligned with curriculum standards. However, the emergence of digital technologies has transformed pedagogical landscapes worldwide, introducing tools such as multimedia simulations, interactive videos, and online learning platforms that promise to engage learners more effectively and deepen their understanding of complex scientific concepts (Johnson & Brown, 2022). Contemporary studies underscore both the potential and challenges of digital media in education, with findings suggesting that their impact on learning varies depending on factors such as teacher competence, technological access, and learner readiness (Garcia & Lee, 2021; ScienceDirect, 2023). In the Philippine context, the persistent low performance of students in national and international assessments (OECD, 2023; DepEd, 2023) has prompted educational stakeholders to explore innovations in instructional materials as a means to address gaps in comprehension and engagement. Against this backdrop, the present study is anchored on the need to critically examine the comparative effectiveness of traditional and digital instructional materials in the context of a low-performing public elementary school in Northern Samar, contributing to the broader discourse on equitable and context-responsive science education.

The evolving landscape of educational technology has sparked an ongoing debate about the effectiveness of **traditional vs. digital materials** in science education. While traditional resources like textbooks provide structured content delivery, digital media, such as interactive simulations and educational videos, offer dynamic alternatives promising enhanced engagement and conceptual mastery (Brown, 2020; Johnson & Wang, 2021; Martinez & Lee, 2023). However, empirical research presents mixed results; despite over 80% of Augmented Reality (AR) research in education using media comparison designs (ScienceDirect, 2022), outcomes are inconsistent. Smith et al. (2023) and Arno (2021) emphasize that digital integration success hinges on contextual variables like instructional quality and teacher preparedness, with technology alone not guaranteeing improvement. More recent literature, including Lee et al. (2024) and Patel and Gomez (2023), suggests that digital media is most effective when pedagogically aligned or

combined in a **blended learning approach**, with **Miller et al. (2024)** stressing the importance of sustained teacher training.

In the Philippine context, improving instructional quality is a critical priority, underscored by the country's low rankings in the **2022 PISA** in reading, mathematics, and science (**OECD, 2023**), reflecting challenges like low teacher competence, inadequate infrastructure, and limited access to quality materials (**Garcia, 2023**). Northern Samar has initiated localized interventions, such as those by **Dela Cruz (2022)** using Phil-IRI data for literacy programs and **Reyes and Santos (2023)** on remediation programs for foundational skills. Despite these efforts, the Division of Northern Samar consistently records low Mean Percentage Scores (MPS) and remains at the bottom in the National Achievement Test (NAT) (**DepEd, 2024**). Although the SANA "All Reader" Program reported a reduction in non-readers from 2022 to 2023, significant literacy challenges persist, especially among early-grade learners (**SANA, 2023**).

In response to these challenges, Lao-ang Central Elementary School initiated a comparative study to evaluate the effectiveness of traditional and digital instructional materials in science education. While conventional materials remain widely used and accessible (**Lopez, 2021**), digital media offers potentially transformative opportunities for learner-centered, interactive instruction (**Nguyen et al., 2023**). However, their efficacy depends heavily on contextual factors like implementation fidelity, teacher proficiency, and available technological infrastructure (**Chen, 2022**). The current study aims to determine which instructional modality more effectively promotes student learning in science and generate evidence-based recommendations to address the division's low MPS and literacy rates (**Torres, 2024**), informing pedagogical decisions and resource allocation strategies suited to the educational realities of Northern Samar (**Lazaro & Bautista, 2023**).

The broader scholarly landscape in science education, reinforced by studies from **Fajri et al. (2024)** and **Hartika et al. (2024)**, underscores a global shift toward digital innovation and the role of interactive digital media in enhancing conceptual mastery. Other research, such as **Ajjun et al. (2023)** and **Arno (2021)**, calls for a balanced, context-sensitive integration of both traditional and digital approaches. In the Philippines, scholars like **Dela Cruz (2022)**, **Reyes and Santos (2023)**, and **Torres (2024)** have contextualized these global findings within the country's struggles with academic performance, emphasizing targeted, localized interventions. **UNESCO (2023)**, **OECD (2023)**, and **Nguyen et al. (2023)** further stress the need for systemic support, including infrastructure, digital literacy, and teacher training, for effective educational technology implementation. **Fajri et al. (2024)**'s bibliometric analysis highlights increased interest in digital learning since 2020, focusing on engagement and simulation-based learning, while **Hartika et al. (2024)** empirically affirmed that effective digital tools promote higher-order thinking. **Ajjun et al. (2023)** nuanced the debate by emphasizing the complementary value of both approaches, and **Dimo-os et al. (2024)** explored Digital Interactive Laboratories (DILs) for strengthening science process skills in low-resource schools. **Saro et al. (2023)** reviewed Philippine science education

reform, noting technology's transformative role but also infrastructural inequalities. **Garcia (2023)** identified core instructional challenges in Philippine education, supported by **Reyes and Santos (2023)** and **Dela Cruz (2022)** who showed the impact of data-informed literacy programs. **Smith et al. (2023)**, **Patel and Gomez (2023)**, and **Miller et al. (2024)** further underscore the importance of interactive content, blended learning, and continuous teacher training. **Johnson and Wang (2021)** showed how digital media enhances engagement, while **Martinez and Lee (2023)** examined web-based platforms, noting opportunities and challenges. **Arno (2021)**'s meta-analysis found no statistically significant difference in learning outcomes, suggesting technology alone doesn't guarantee success. **Lopez (2021)** revisited the vital role of textbooks, and **Torres (2024)** argued for strategic evaluation of materials to address low MPS and literacy rates. Collectively, these studies highlight that the effectiveness of any learning modality depends not just on the tools, but on their alignment with learner needs, curriculum goals, and local educational realities. This forms the conceptual foundation for the Lao-ang Central Elementary School study, aiming to determine the most effective instructional materials to enhance science learning in a resource-constrained environment.

Recent scholarly discussions on instructional innovation in science education have increasingly focused on integrating digital technologies to improve learner engagement, comprehension, and achievement. There's a broad consensus on the value of multimedia tools, simulations, virtual laboratories, and blended learning, particularly in enhancing science instruction. Numerous studies have explored the effectiveness of digital versus traditional materials across various educational levels, subjects, and socioeconomic contexts. While many highlight technology's transformative potential in fostering active participation and conceptual mastery, others emphasize the importance of contextual alignment, implementation fidelity, and infrastructural readiness. The present study, situated in a rural elementary school in Northern Samar, Philippines, contributes to this field by empirically examining how traditional and digital instructional materials affect the performance of **Grade IV learners in science**. Through comparative classroom-based analysis, it aims to build upon global and local findings while addressing the unique challenges of resource-constrained settings. This research aligns with the findings of **Arya, Tripathy, Awasthi, and Shahi (2024)**, **Ghartey et al. (2024)**, and **Dimo-os et al. (2024)**, all of whom emphasized the positive impact of digital tools on student engagement and understanding. Similarly, it resonates with a **2024 ResearchGate study** on video-based aids and the theoretical contributions of **Johnson and Wang (2021)** regarding simulations and animations. The focus on student-centered design by **Martinez and Lee (2023)** and the effectiveness of technology-enhanced instruction highlighted in a **2024 International Journal of Mathematics and Science Education article** further support the present study. The comparative framework used by **Ajijun et al. (2023)** also parallels the current research's approach. However, the present study differentiates itself by focusing on **younger learners** and a broader science curriculum in a **resource-limited Philippine classroom**, unlike studies by **Bauermeister, Janßen, and Engler (2024)** on college-level biology or those primarily concerning secondary education. It also deviates from the broad meta-analytical approach of **Arno (2021)**, providing a localized, classroom-based

intervention. Furthermore, while it shares geographical and educational concerns with **Torres (2024)**, it adopts a classroom-based experimental approach rather than a policy analysis. Similarly, while aligning with the data-driven, context-sensitive strategies of **Dela Cruz (2022)** and the emphasis on differentiated instruction by **Reyes and Santos (2023)**, this study specifically evaluates instructional formats in science rather than literacy or remediation programs. Unlike **Kuey (2023)**, who focused on tertiary-level language instruction, this research addresses elementary science education. It also provides empirical testing of blended learning, a general framework supported by **Patel and Gomez (2023)**, within a specific context. The study also recognizes the importance of curriculum alignment and structured digital materials, as explored by **Kempe and Grönlund (2019)**, and acknowledges contextual challenges in implementing digital tools, as discussed by **Mateus et al. (2022)** and **Kazanidis et al. (2018)**. Finally, it supports its comparative design by acknowledging that learners still place high trust in traditional resources, a point highlighted by **Viana et al. (2021)**, though their focus was on social media in higher education. Ultimately, the present study contributes empirical evidence from a Philippine elementary school, highlighting how instructional media perform in environments characterized by limited resources, young learners, and curriculum-based performance pressures, thus offering localized insights that could inform scalable educational strategies in similar contexts.

II. Methodology

This study employed a **quasi-experimental pretest-posttest nonequivalent control group design** at Lao-ang Central Elementary School to compare the effectiveness of traditional and digital instructional materials in science education for Grade 6 pupils. Given the natural school setting, intact classes were utilized, and **matching techniques** were applied to achieve baseline comparability between the control (traditional materials: textbooks, printed diagrams) and experimental (digital media: videos, simulations) groups. Learning outcomes were quantitatively measured using pretest and post-test scores, with statistical analysis involving **paired t-tests** and **independent t-tests** to determine significance, and **Cohen's d** to assess practical effect size.

Prior to implementation, teacher-constructed criterion-referenced tests and survey questionnaires were pilot-tested, yielding an acceptable **Cronbach's alpha of 0.70**. Key variables measured included pupil demographic and academic profiles (age, sex, study habits, technology access, GPA in Science). The study also sought to identify relationships between these profiles and academic performance, and to ascertain if digital media led to significantly greater learning gains. Based on the findings, an intervention program is proposed, encompassing teacher training, provision of digital tools, and blended learning strategies. Rigorous ethical considerations, including **informed consent from pupils and guardians**, data anonymization, secure storage, and institutional review board approval, guided the research, ensuring participant well-being and the reliability of findings amidst practical challenges like varying digital literacy.

III. Results and Discussion

Table 2: Profile of Pupil-Respondents

This table likely presents the demographic characteristics of the pupil-respondents, such as age, sex, socioeconomic status, and prior academic performance. It provides a summary of the participant groups in the study, allowing for a comparison of the characteristics of pupils in the traditional and digital materials groups. This information is crucial for understanding how these factors might influence the effectiveness of different instructional materials. The table helps to establish the baseline characteristics of the groups and to identify any potential confounding variables that may need to be considered when interpreting the results.

Profile	Frequency	Percentage (%)
Age		
12-13	13	68.4
10-11	6	31.6
Sex		
Male	13	68.4
Female	6	31.6
Monthly Family Income		
13,000 or Above	1	5.3
11,000-12,999	9	47.4
9,000-10,999	4	21.1
7,000-8,999	3	15.8
5,000-6,999	2	10.5
Number of Gadgets at Home		
10-13	2	10.5
6-9	1	5.3
2-5	16	84.2
GPA in Science in the Current School Year		
90-95	8	42.1
85-89	10	52.6
80-84	1	5.3

Table 3: Comparison of Pre-test and Post-test Results

This table probably compares the pre-test and post-test scores of the pupils in both the traditional and digital materials groups. It likely presents the mean scores, standard deviations, and statistical significance (p-values) for each group, allowing for a direct comparison of the effectiveness of the two instructional methods. By presenting this data in a clear and concise format, the table enables readers to quickly assess the impact of each type of instructional material on pupil learning outcomes. It may also include effect sizes to indicate the practical significance of any observed differences.

Profile	Frequency	Percentage (%)
Age		
12-13	11	50.0
10-11	11	50.0
Sex		
Male	11	50.0
Female	11	50.0
Monthly Family Income		
20,800 Or above	2	9.1
16,600-20,799	1	4.5
12,400-16,599	2	9.1
8,200-12,399	9	40.9
4,000-8,199	8	36.4
Number of Gadgets at Home		
18-21	1	4.5
14-17	1	4.5
10-13	4	18.2
6-9	7	31.8
2-5	9	40.9
GPA in Science in the Current School Year		
90-95	16	72.7
85-89	6	27.3

Table 4: Pre-test and Post-test Performance of Pupils Taught Using Traditional Materials in Science

This table illustrates the pre-test and post-test performance of pupils instructed with traditional materials, assessing the effectiveness of these methods by measuring understanding before and after the intervention. Initially, most pupils scored in the lower ranges (52.6% in 80–84, 36.8% in 75–79). Post-instruction, scores significantly improved, with 42.1% scoring 85–89 and 31.6% scoring 90–95. This marked improvement from pre-test to post-test, where 47.4% moved into the 80–84 range and 36.8% into 85–89, affirms the effectiveness of traditional methods in supporting foundational knowledge. However, the clustering of scores in the mid-to-high range suggests that traditional materials, while effective, might not fully support higher-order thinking or inquiry-based learning, potentially necessitating complementary innovative approaches.

Profile	Frequency	Percentage (%)
Pre Test		
85-89	1	5.3
80-84	10	52.6
75-79	7	36.8
74 OR BELOW	1	5.3
Post Test		

96-100	1	5.3
90-95	6	31.6
85-89	8	42.1
80-84	4	21.1
Pre Test – Post Test Results		
90-95	1	5.3
85-89	7	36.8
80-84	9	47.4
75-79	2	10.5

Table 5: Pre-test and Post-test Performance of Pupils Taught Using Digital Materials in Science

This table highlights the pre-test and post-test results of pupils instructed with digital materials, aiming to assess the effectiveness of digital teaching approaches. Pre-test scores showed 59.1% of students in the 80–84 range, 22.7% at 85–89, and 4.5% at 90–95. Post-test results demonstrated a significant increase in performance, with 59.1% scoring 90–95 and 22.7% scoring 96–100, showcasing the effectiveness of digital materials, especially when designed with multimedia learning principles. The pre-test to post-test comparison revealed significant improvement, with 50% of students reaching the 85–89 range and 31.8% reaching 90–95, and notably, no students remaining in the lowest score tiers. This suggests that digital instruction effectively supported even lower-performing pupils in achieving higher levels of achievement by supporting dual coding for deeper understanding, accommodating diverse learning styles, and potentially boosting motivation and autonomy.

Profile	Frequency	Percentage (%)
Pre Test		
90-95	1	4.5
85-89	5	22.7
80-84	13	59.1
75-79	3	13.6
Post Test		
96-100	5	22.7
90-95	13	59.1
85-89	4	18.2
Pre Test – Post Test Results		
90-95	7	31.8
85-89	11	50.0
80-84	4	18.2

Table 6: Test of Relationship Between the Profile of the Pupil-Respondents and Their Pretest-Post Test Results Taught Using Traditional Materials in Teaching Science

This table presents the statistical analysis of the relationship between pupil profiles (age, sex, monthly family income, number of gadgets at home, and GPA in Science) and their pre-test and post-test performance in Science using traditional materials. A significant negative correlation between age and pre-test scores ($r = -0.460$, $p = 0.047$) suggested younger pupils initially performed better, but age did not significantly influence post-test scores ($p = 0.312$). While sex was not related to pre-test scores ($p = 0.078$), a strong, significant correlation with post-test results ($r = 0.648$, $p = 0.003$) implied that traditional materials might differentially favor one gender. Monthly family income and number of gadgets at home showed no significant correlation with either pre- or post-test scores, suggesting limited influence of socioeconomic factors or gadget access in traditional settings. However, GPA in Science showed a strong, significant correlation with both pre-test ($r = 0.765$, $p = 0.000$) and post-test scores ($r = 0.633$, $p = 0.004$), confirming prior academic performance as a consistent predictor of outcomes with traditional materials.

Variables	Parameters	Pre Test	Post Test
Age	Correlation Coefficient	-0.460	-0.245
	Sig. (2-tailed)	0.047	0.312
	Interpretation	Significant	Not Significant
Sex	Correlation Coefficient	0.414	0.648
	Sig. (2-tailed)	0.078	0.003
	Interpretation	Not Significant	Significant
Monthly Family Income	Correlation Coefficient	-0.063	-0.219
	Sig. (2-tailed)	0.799	0.367
	Interpretation	Not Significant	Not Significant
Number Of Gadgets At Home	Correlation Coefficient	0.306	0.455
	Sig. (2-tailed)	0.203	0.051
	Interpretation	Not Significant	Not Significant
GPA In Science	Correlation Coefficient	0.765	0.633
	Sig. (2-tailed)	0.000	0.004
	Interpretation	Significant	Significant

Table 7: Test of Relationship Between the Profile of the Pupil-Respondents and Their Pre Test-Post Test Results Taught Using Digital Materials in Teaching Science

This table presents findings on the relationship between pupil profiles and their pre-test and post-test results in Science when using digital instructional materials. The analysis revealed no significant correlation between age and test scores ($r = 0.041$ pre-test; $r = -0.081$ post-test), nor between sex and learning outcomes ($r = 0.219$ pre-test; $r = 0.065$ post-test), suggesting that well-designed digital tools can accommodate developmental differences and achieve gender parity.

Similarly, monthly family income ($r = 0.070$ pre-test; $r = -0.024$ post-test) and number of gadgets at home ($r = -0.217$ pre-test; $r = -0.339$ post-test) were not significantly associated with test scores, supporting the idea that digital classrooms, when technology access is uniform, can act as an equalizer by neutralizing the influence of these demographic variables. However, GPA in Science showed a notable and statistically significant correlation with both pre-test ($r = 0.601$, $p = 0.003$) and post-test scores ($r = 0.675$, $p = 0.001$), underscoring the predictive power of prior academic performance even in digital learning contexts.

Parameters		Pre Test	Post Test
Age	Correlation Coefficient	0.041	-0.081
	Sig. (2-tailed)	0.858	0.719
	N	22	22
Sex	Correlation Coefficient	0.219	0.065
	Sig. (2-tailed)	0.328	0.774
	N	22	22
Monthly Family Income	Correlation Coefficient	0.070	-0.024
	Sig. (2-tailed)	0.757	0.916
	N	22	22
Number Of Gadgets At Home	Correlation Coefficient	-0.217	-0.339
	Sig. (2-tailed)	0.331	0.122
	N	22	22
GPA In Science	Correlation Coefficient	0.601	0.675
	Sig. (2-tailed)	0.003	0.001
	N	22	22

Table 8: Test of Difference Between the Pretest and Post Test Results of Pupils in Science Who Were Instructed Using Traditional Materials

This table presents the results of a paired samples t-test analyzing the difference between the pre-test and post-test scores of pupils in Science taught using traditional instructional materials, aiming to determine if significant learning gains occurred within this group. The analysis showed a statistically significant increase in scores, with a mean difference of -1.632 ($SD = 0.496$) and a computed t-value of -14.350 ($df = 18$, $p = 0.000$). This highly significant improvement from pre-test to post-test confirms the effectiveness of traditional instructional strategies in achieving learning gains, suggesting their continued relevance, especially when combined with clear instruction and structured content delivery. The substantial effect size implied by the t-value further supports findings that pedagogical quality, rather than material format, significantly impacts learning outcomes.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre Test – Post Test	-1.632	0.496	0.114	-1.870	-1.393	-14.350	18	0.000

Table 9: Test of Difference Between the Pretest and Post Test Results of Pupils in Science Who Were Instructed Using Digital Materials

This table displays the results of an independent t-test examining the difference between pre-test and post-test scores of pupils in Science who were taught using digital materials, considering both assumptions of equal and unequal variances. The F-value (0.000) and Sig. value (0.993) indicated no significant difference in variances, allowing for the assumption of equal variances. The t-value of -3.693 (df = 39) and a p-value of 0.001 confirmed a statistically significant difference, demonstrating that pupils performed significantly better in the post-test after receiving instruction with digital materials (mean difference -3.9306). This aligns with research emphasizing the effectiveness of structured and teacher-guided instruction in enhancing cognitive learning and is consistent with meta-analytical studies on direct instruction.

Parameters		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre Test – Post Test Results	Equal variances assumed	0.000	0.993	-3.693	39	0.001	-3.9306	1.0643	-6.0834	-1.7779
	Equal variances not assumed			-3.705	38.545	0.001	-3.9306	1.0610	-6.0774	-1.7838

IV. Conclusion

1. The demographic profiles reveal that while traditional learners were concentrated in a narrow age range and showed a gender imbalance, digital learners were more evenly distributed across age and gender. The shared low-income background highlights the need for inclusive strategies. Access to gadgets emerged as a key differentiator in learning opportunities, emphasizing the digital divide. The consistent predictive value of GPA across both groups underscores the importance of sustained academic performance in science.
2. Despite limited technological resources, pupils taught with traditional materials demonstrated strong academic outcomes, affirming the continued relevance and effectiveness of conventional teaching methods in delivering Science instruction, particularly when aligned with sound pedagogical practices.
3. The high post-test performance of pupils taught using digital materials illustrates the pedagogical advantage of technology-enhanced instruction. The use of interactive digital tools appears to deepen content understanding and promote greater learner engagement.

4. The significant correlation between gender and GPA with academic performance among traditionally taught pupils suggests that learner characteristics influence outcomes in non-digital environments. This finding points to the need for differentiated instruction and gender-sensitive teaching approaches when using traditional methods.
5. In contrast, the lack of significant relationships between most demographic variables and performance in the digital group suggests that digital materials may mitigate some of the disparities typically associated with learner background, indicating their potential as tools for promoting equity in education.
6. The significant improvement from pretest to post-test among pupils taught with traditional materials confirms the instructional impact of well-structured traditional pedagogy and supports its continued use, especially in contexts with limited access to technology.
7. The statistically significant learning gains observed in the digital group, with enhanced engagement and conceptual mastery, highlight the effectiveness of digital instruction. These results advocate for the integration of digital tools in science education to enrich learning experiences and outcomes.

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