

Original article

An Integrative Model Based on Artificial Intelligence for Enhancing Integration among Sciences in Interdisciplinary Learning and Scientific Research: A Field Study on Postgraduate Students at the Libyan Academy – Janzour

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Abstract

The recent rapid advancement in artificial intelligence technologies has brought about a fundamental transformation in higher education and scientific research institutions by providing new opportunities to enhance interdisciplinary learning and cognitive integration across various scientific fields. This study aimed to propose an integrative model based on artificial intelligence to analyze the impact of using AI tools in enhancing interdisciplinary learning and scientific research among postgraduate students at the Libyan Academy–Janzour. The study adopted the descriptive-analytical approach, and data were collected from a sample of (94) master's and doctoral students using a questionnaire specifically designed for this purpose. The reliability test results indicated that the study instrument possessed a high degree of reliability, with a Cronbach's alpha coefficient of (0.912). The results of the descriptive analysis indicated that the sample members possessed a high level of digital competence, with a mean score of (3.92) and a standard deviation of (0.64). The findings also revealed a high impact of using artificial intelligence tools on improving the quality of scientific research and research productivity, with a mean score of (4.15) and a standard deviation of (0.58), in addition to a positive role in enhancing interdisciplinary integration, with a mean score of (3.88) and a standard deviation of (0.71). Furthermore, the results of the inferential analysis showed no statistically significant differences in the participants' attitudes toward the proposed model attributed to academic specialization ($F = 1.42$, $p = 0.241$) or academic level ($t = 0.85$, $p = 0.398$), which confirms the applicability of the model across various specializations and academic levels. Additionally, the findings revealed a strong, statistically significant positive correlation between digital competence and interdisciplinary research integration ($r = 0.684$, $p < 0.001$), indicating that developing digital skills directly contributes to enhancing students' ability to employ artificial intelligence tools in producing more integrated and interdisciplinary research. The study findings confirm that artificial intelligence represents an effective tool for supporting interdisciplinary integration, improving scientific research efficiency, and facilitating knowledge exchange and academic collaboration across different disciplines. This study also contributes to enriching the scientific literature related to the employment of artificial intelligence in higher education and provides a practical framework that can be utilized in developing smart academic environments that support interdisciplinary learning and scientific research.

Keywords. Artificial Intelligence, Integration of Sciences, Interdisciplinary Learning, Scientific Research.

Introduction

In recent years, the higher education sector has witnessed rapid transformation driven by successive developments in artificial intelligence technologies, particularly generative AI applications, which have become capable of supporting numerous educational and research activities, ranging from accessing knowledge and analyzing information to assisting in the production of scientific content and making academic decisions. This shift has led to the reshaping of many traditional practices within universities and scientific research institutions, opening new horizons for enhancing learning, innovation, and knowledge production [1,2].

At the same time, contemporary scientific and societal challenges have become too complex to be addressed through a single scientific discipline, which has reinforced the need to adopt research approaches based on the integration of sciences and different disciplines. Interdisciplinary cognitive integration is regarded as one of the key approaches to producing more comprehensive knowledge capable of explaining complex problems and proposing innovative solutions, as it contributes to integrating concepts, theories, and research methods derived from multiple scientific fields within a unified knowledge framework [3,4].

In this context, artificial intelligence technologies emerge as powerful tools capable of supporting this cognitive integration by facilitating access to diverse knowledge sources, analyzing vast amounts of data, and discovering relationships between scientific concepts that may be difficult to perceive through traditional methods. These technologies also offer new opportunities to enhance scientific collaboration and knowledge exchange among researchers from different disciplines, which contributes to the development of interdisciplinary scientific research and improves the quality of its outcomes [1,5].

However, effective utilization of AI applications does not depend solely on the availability of technology itself, but is rather linked to individuals possessing an adequate level of digital competence that enables them to use digital tools consciously

and effectively in learning and scientific research. Recent literature has emphasized that digital competence represents one of the fundamental determinants for the successful employment of smart technologies within academic environments, due to its role in enhancing learners' and researchers' ability to access, evaluate, analyze, and employ information effectively [6,7].

Despite the growing number of studies addressing AI applications in higher education, most of them have focused on the impact of these technologies on improving learning or enhancing research productivity in isolation, while studies that explain the mechanisms through which AI applications contribute to enhancing interdisciplinary cognitive integration and improving the quality of scientific research remain limited, particularly in Arab and Libyan contexts. Furthermore, the mediating role of digital competence in explaining this relationship has not received sufficient attention in the current literature [2,5,7]. The current study aims to develop and test an integrative model that explains the role of using artificial intelligence tools in enhancing the quality of interdisciplinary scientific research through digital competence and interdisciplinary cognitive integration among postgraduate students at the Libyan Academy – Janzour. The study also aims to provide a scientific framework that can contribute to supporting digital transformation within higher education institutions and enhancing integration among sciences in alignment with the requirements of the knowledge economy and the innovation society.

Theoretical Framework

The rapid proliferation of artificial intelligence applications, particularly generative language models, has led to the emergence of new patterns in knowledge production and utilization within higher education institutions. The role of these applications is no longer confined to providing technical support to learners, but has extended to assisting in the review of scientific literature, generating research ideas, analyzing data, and formulating scientific reports.

Recent literature indicates that the true value of artificial intelligence lies not in replacing human effort, but rather in enhancing researchers' cognitive capabilities and expanding their potential to access and process knowledge. Dwivedi et al. argue that generative AI tools have become part of the new cognitive infrastructure of scientific research due to their ability to support analytical processes, exploration, and knowledge management. Moreover, UNESCO emphasizes that the responsible use of these technologies can contribute to improving the quality of scientific research and education, provided that it is linked to clear policies and appropriate digital skills [1,2].

Hypothesis 1 (H1)

H1: The use of artificial intelligence tools has a statistically significant positive effect on the digital competence of postgraduate students. Digital competence has become one of the central concepts in studies related to digital transformation in higher education. This concept extends beyond the ability to use technical tools to encompass skills in information seeking, evaluating credibility, analysis, and repurposing information in various educational and research contexts. Contemporary digital competence frameworks, including the DigComp 2.2 framework, indicate that individuals with high digital competence possess a greater ability to access diverse knowledge sources and engage with data and information in a critical and organized manner [3].

Hypothesis 2 (H2)

H2: Digital competence has a statistically significant positive effect on interdisciplinary cognitive integration. Contemporary scientific problems have become increasingly complex and intertwined, which has led to growing interest in interdisciplinary research as an approach to understanding and addressing complex phenomena in a more comprehensive manner. Repko and Szostak argue that the fundamental value of interdisciplinary research lies not in assembling fragmented knowledge, but rather in integrating it within a cognitive framework capable of producing new interpretations and solutions [4].

Hypothesis 3 (H3)

H3: Interdisciplinary cognitive integration has a statistically significant positive effect on the quality of interdisciplinary scientific research. A review of the literature reveals that previous studies have addressed artificial intelligence, digital competence, and interdisciplinary integration from multiple research perspectives. However, most of them have focused on the bivariate relationships among these variables. Accordingly, the current study proposes an explanatory model that links the use of artificial intelligence tools, digital competence, interdisciplinary cognitive integration, and the quality of scientific research within a single theoretical framework.

Research Methodology

The current study adopted the descriptive correlational and comparative approach. This approach is suitable for the nature of the study, as it aims to examine the nature and strength of the correlational relationships between the variables, in addition to comparing the differences between them based on the field data collected from the sample members. The study population consisted of postgraduate students at the Libyan Academy – Janzour for the academic year 2025–2026, using an electronic questionnaire. The data collection process resulted in obtaining (94) valid questionnaires for statistical analysis. The study relied on an electronic questionnaire that was developed based on the scientific literature and previous studies related to artificial intelligence, digital competence, and interdisciplinary cognitive integration.

The questionnaire consisted of two main sections:

First: General Data

This section included a set of demographic variables related to the participants, such as:

- Gender.
- Academic specialization.
- Academic level (Master's or PhD).

Second: Study Variables

The questionnaire consisted of four dimensions:

Dimension 1: Use of Artificial Intelligence Tools (8 items)

Dimension 2: Digital Competence (7 items)

Dimension 3: Interdisciplinary Cognitive Integration (6 items)

Dimension 4: Quality of Interdisciplinary Scientific Research (6 items)

All items were based on a five-point Likert scale, with responses ranging from (1) Strongly Disagree to (5) Strongly Agree.

Table (1) Demographic and Professional Distribution of the Sample Members (N=94)

Variable	Category	Frequency	Percentage
Academic Specialization	Applied and Engineering Sciences	41	43.62%
	Basic and Medical Sciences	27	28.72%
	Humanities and Social Sciences	26	27.66%
Technical Experience	Expert/Advanced	35	37.3%
	Intermediate	47	50%
	Beginner	12	12.7%
Total Sample		94	100%

The study adopted operational definitions that enable the measurement of variables in a way that is suitable for statistical analysis, as shown in Table (2).

Table (2) Variables and Their Operational Dimensions

Operational Definition	Variable
The degree to which the student employs artificial intelligence applications in searching for and analyzing information, and in supporting academic and research activities	Use of Artificial Intelligence Tools
The student's ability to access, evaluate, manage, and effectively use digital information.	Digital Competence and Academic Engagement
The student's ability to employ knowledge derived from different disciplines when addressing research issues	Interdisciplinary Cognitive Integration
The student's perception of the contribution of interdisciplinary research practices to improving the quality of scientific outcomes	Quality of Interdisciplinary Scientific Research and Academic Performance

The internal consistency of the items was tested through correlation coefficients between each item and the dimension to which it belongs. The results showed positive and statistically significant correlations, indicating that the instrument has an appropriate degree of construct validity. Reliability was verified using Cronbach's Alpha coefficient. The overall value reached (0.912), which reflects a high level of internal consistency among the instrument's items, supporting the possibility of relying on the resulting data in analysis and inference.

Data were analyzed using a set of descriptive and inferential statistical methods in accordance with the study objectives and hypotheses.

The statistical procedures included:

- Frequencies and percentages to describe the sample characteristics.
- Means and standard deviations to determine the general levels of the sample's attitudes.
- Pearson Correlation Coefficient to test the correlational hypotheses (H1, H2, H3).
- One-Way ANOVA to examine differences related to academic specialization (H4).
- Independent Samples T-Test to detect differences related to academic level (H5).

A significance level of ($\alpha \leq 0.05$) was adopted to judge the significance of the results.

The proposed model proceeds from the assumption that the positive impact of artificial intelligence in scientific research does not occur only directly, but is formed through a set of cognitive and skill-based processes that contribute to transforming technical potentials into valuable scientific outputs. From this perspective, the study assumes that digital competence, academic engagement, and interdisciplinary cognitive integration represent mechanisms through which the relationship between the use of artificial intelligence tools and the quality of scientific research can be explained.

This view is based on recent literature confirming that benefiting from artificial intelligence technologies within higher education institutions requires possessing advanced digital skills that enable the user to evaluate information, manage it, and employ it effectively. The same literature also indicates that research environments most capable of producing knowledge and innovation are those that encourage the integration of knowledge and expertise from different disciplines.

Accordingly, the model assumes that the use of artificial intelligence tools contributes to developing digital competence among postgraduate students, and that this competence helps them expand the scope of access to scientific knowledge and benefit from diverse sources, which enhances opportunities for interdisciplinary cognitive integration. This integration is expected to positively reflect on the quality of scientific research by improving the formulation of research problems, broadening analytical perspectives, and increasing the ability to produce more innovative solutions to complex problems. The model also assumes the existence of indirect effects of using artificial intelligence tools on the quality of scientific research through two sequential mediating paths: the first through digital competence, and the second through interdisciplinary cognitive integration. This sequence represents an attempt to explain how the effects of artificial intelligence transfer from the technical level to the cognitive level, and then to the level of research outputs.

The proposed model consists of four main variables:

First: Use of Artificial Intelligence Tools (AI Usage)

It represents the degree to which the student employs artificial intelligence applications in implementing academic and research activities, including searching for information, preparing scientific content, analyzing data, and organizing knowledge.

Second: Digital Competence and Academic Engagement

It refers to the student's ability to use digital resources efficiently, evaluate available information, and manage data and knowledge in a way that serves his/her research and educational goals.

Third: Interdisciplinary Knowledge Integration

It expresses the researcher's ability to integrate concepts, theories, and methods derived from more than one scientific discipline when addressing research issues.

Fourth: Interdisciplinary Research Quality

It refers to the level of quality of research outputs in terms of depth of analysis, scientific originality, and the ability to address problems from multiple cognitive angles.

The model assumes the existence of three main direct relationships:

- The effect of using artificial intelligence tools on digital competence.
- The effect of digital competence and academic engagement on interdisciplinary cognitive integration and on academic performance.
- The effect of interdisciplinary cognitive integration on the quality of scientific research.

The model also assumes the existence of indirect effects of using artificial intelligence tools on the quality of scientific research and academic performance through digital competence and cognitive integration.

This sequence represents an attempt to explain how the effects of artificial intelligence transfer from the technical level to the cognitive level and then to the level of research and educational outputs.

This model reflects an integrative vision that considers that artificial intelligence does not affect the quality of scientific research and the improvement of academic performance independently, but rather through enhancing the cognitive and digital capabilities that help the researcher employ knowledge in a more effective and comprehensive manner.

The scientific addition of the model lies in integrating three research paths that have often been studied separately: artificial intelligence applications, digital competence, and interdisciplinary research. This integration allows for a deeper understanding of the mechanisms through which artificial intelligence can be employed to support the quality of scientific research within higher education institutions.

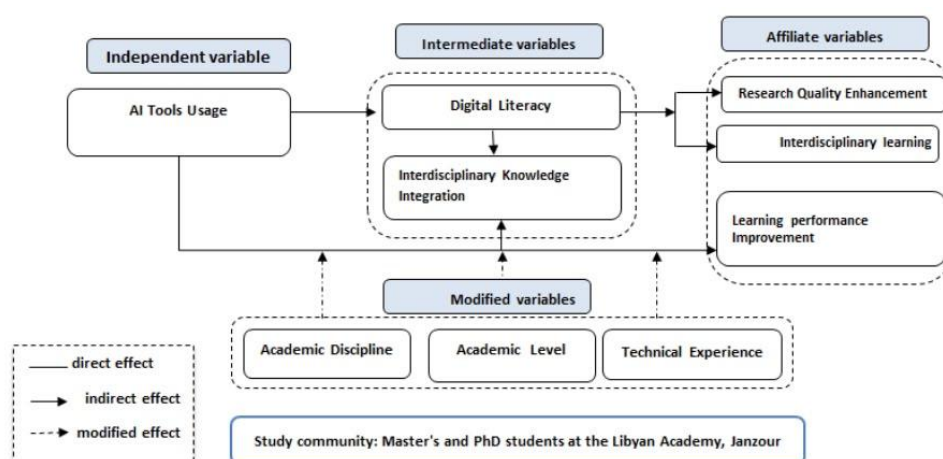


Figure (1): the Integrative Model Based on Artificial Intelligence

Results and Discussion

The statistical results shown in Table No. (3) indicate full validation of the proposed correlational hypotheses:

Table (3): Pearson Correlation Matrix for the Study Variables (N=94)

Variables	Use of AI Tools	Level of Digital Competence	Interdisciplinary Knowledge Integration	Quality of Scientific Research
Use of AI Tools	1			
Level of Digital Competence of Post-graduate Students	0.612	1		
Achieving Interdisciplinary Knowledge Integration	0.543	0.684	1	
Quality of Scientific Research Outputs	0.598	0.571	0.625	1

The data presented in Table No. (3) indicate the following:

Artificial Intelligence and Digital Competence ($r = 0.612$): There is a strong, positive (direct) and statistically significant correlation between the rate of students' use of artificial intelligence tools and their level of digital competence. This means that the continuous and daily practice of these technologies directly contributes to refining their digital skills.

Digital Competence and Integration Among Sciences ($r = 0.684$): This is the strongest correlation recorded in the model, which statistically proves that a researcher with advanced digital competence has high flexibility and greater methodological ability to navigate diverse knowledge sources and deconstruct the cognitive structures of disciplines different from his/her own precise specialization and integrate them together.

Cognitive Integration and Quality of Scientific Research ($r = 0.625$): There is a statistically significant direct relationship confirming that increased adoption of the interdisciplinary approach and the overlap of disciplines is positively and directly reflected in raising the quality and originality of research outputs among postgraduate students at the Libyan Academy. The statistical indicators listed in the above Pearson correlation matrix indicate the existence of strong positive (direct) correlation relationships.

Means and standard deviations were used to describe the sample members' attitudes toward the study variables. The results showed that the level of digital competence among postgraduate students was high, with a mean of (3.92) and a standard deviation of (0.64). This result indicates that participants possess a good level of digital skills necessary to deal with electronic resources and technical tools used in academic and research activities.

The variable of AI impact on supporting scientific research also recorded the highest mean among the study variables, reaching (4.15) with a standard deviation of (0.58), which reflects a positive attitude toward using artificial intelligence applications in implementing research tasks. This can be explained by the widespread use of smart tools in recent years in the areas of information retrieval, reference organization, data analysis, and scientific content formulation.

As for the variable of interdisciplinary cognitive integration, it achieved a mean of (3.88) with a standard deviation of (0.71), a level that indicates participants' awareness of the importance of benefiting from diverse knowledge when addressing research issues, although this awareness is relatively less than their awareness of the direct benefits of artificial intelligence applications.

Table (4) Descriptive Statistics for the Study Variables

Variables	Mean	Std. Deviation	Level
Digital Literacy	3.92	0.64	High
AI Impact on Research Quality	4.15	0.58	High
Interdisciplinary Integration	3.18	0.71	High

To determine whether participants' attitudes differ according to academic specialization or academic level, One-Way ANOVA and an independent-samples t-test were used. The results showed no statistically significant differences attributable to academic specialization, with an F value of (1.42) at a significance level of ($p = 0.241$). This result indicates that positive perceptions toward the use of artificial intelligence are not limited to a specific specialization, but appear to be similar across different academic fields. No statistically significant differences were also found between Master's and PhD students, with a t-value of (0.85) at a significance level of ($p = 0.398$). This reflects a degree of agreement among postgraduate students regarding the importance of artificial intelligence and its role in supporting research activities. This result is particularly important because it indicates that the proposed model can be applicable across different specializations and academic levels, which enhances the possibility of benefiting from it in diverse educational environments.

Discussion

The findings of the present study are generally consistent with previous research on the role of artificial intelligence (AI) in enhancing research performance and academic productivity. Earlier studies have demonstrated that AI technologies can facilitate access to information, streamline research processes, and improve the efficiency of knowledge production. In this regard, the current results align with the conclusions reported by Dwivedi et al. and Holmes et al., who emphasized the significant contribution of AI tools to improving research productivity and supporting academic work. However, the present study extends the existing literature by examining the cognitive and research dimensions of AI utilization rather than focusing solely on educational applications. This distinction differentiates the current findings from those of Zawacki-Richter et al., whose work primarily investigated the educational implications of AI in higher education. Therefore, the present study offers a broader perspective by highlighting the influence of AI on knowledge integration and interdisciplinary research practices in addition to its educational benefits [1,2,4].

A notable finding of the study was the strong positive relationship between digital competence and interdisciplinary cognitive integration ($r = 0.684$). This relationship suggests that researchers who possess advanced digital competencies are better equipped to navigate diverse information environments, access multidisciplinary sources, and overcome conceptual and methodological barriers that often exist between academic disciplines. Digital skills enable researchers to efficiently utilize AI-powered tools for information retrieval, analysis, synthesis, and knowledge management, thereby facilitating the integration of knowledge from multiple disciplinary perspectives. Consequently, digital competence appears to be a key factor in promoting interdisciplinary thinking and fostering more comprehensive approaches to scientific inquiry.

The study also revealed no significant differences in AI utilization, digital competence, or cognitive integration across academic specializations. This finding may reflect the transformative nature of the contemporary digital environment, where AI technologies have become widely accessible across disciplines and are increasingly integrated into routine academic activities. The widespread availability of digital tools and AI applications has contributed to the development of a shared academic culture in which researchers from different fields have comparable opportunities to benefit from technological advancements. As a result, disciplinary background may no longer represent a major determinant of researchers' engagement with AI technologies or their capacity for knowledge integration.

Overall, the findings strongly support the central assumption underlying this study, namely that the effective utilization of artificial intelligence is closely associated with researchers' digital competencies and that these competencies serve as an important mechanism for fostering interdisciplinary cognitive integration and enhancing the quality of scientific research. The current study contributes to the theoretical understanding of the relationship between artificial intelligence and scientific research within higher education institutions by proposing an integrated framework that links AI utilization, digital competence, interdisciplinary cognitive integration, and research quality. Although previous studies have examined AI in higher education, many have concentrated on technical, administrative, or instructional applications independently. In contrast, the present study conceptualizes AI as a transformative factor that influences the cognitive processes involved in knowledge creation, thereby offering a more comprehensive understanding of its role in supporting scientific research and interdisciplinary collaboration.

Furthermore, the findings underscore the importance of digital competence as a mediating factor within the research process. The results demonstrate that digital competence should not be viewed merely as a technical requirement but rather as a strategic capability that enhances researchers' ability to access, evaluate, integrate, and apply knowledge from multiple

sources. Researchers with stronger digital competencies appear more capable of leveraging AI tools effectively, which subsequently enhances their research performance and intellectual engagement across disciplinary boundaries.

Another important contribution of the study is its emphasis on interdisciplinary cognitive integration as a mechanism connecting digital capabilities with research outcomes. This perspective reinforces the notion that scientific knowledge production depends not only on technological resources but also on the ability of researchers to synthesize diverse perspectives and establish meaningful connections among different domains of knowledge. Consequently, the interaction between digital competence and cognitive integration emerges as a critical pathway through which AI can influence research quality and innovation.

From a practical perspective, the study provides valuable implications for higher education institutions and academic policymakers. The findings suggest that universities should systematically integrate AI applications into postgraduate education and research training programs while emphasizing the ethical and responsible use of these technologies. Strengthening digital competence development initiatives is equally important, as enhanced digital capabilities can improve researchers' ability to access information, conduct analyses, and apply findings within diverse research contexts.

The results also highlight the importance of creating educational and research environments that encourage interdisciplinary collaboration. Such environments can promote cognitive integration, facilitate knowledge exchange, and contribute to the development of innovative solutions to complex scientific and societal challenges. In addition, universities may utilize the proposed framework as a guide for designing digital transformation and research innovation strategies that simultaneously address technological infrastructure, digital skill development, and interdisciplinary cooperation.

The establishment of specialized centers or units dedicated to applied artificial intelligence within higher education institutions may further support these objectives. Such units could provide training, technical support, and ethical guidance for students and researchers while promoting the responsible integration of AI technologies into academic and research activities.

The principal value of the current study lies in its ability to connect artificial intelligence and interdisciplinary knowledge integration within a unified conceptual framework. Rather than treating AI as an isolated technological tool, the study presents it as a catalyst that can strengthen cognitive interaction among different fields of knowledge. The findings indicate that maximizing the benefits of AI requires more than simply providing access to advanced technologies. It also necessitates an academic environment capable of developing digital competencies, fostering interdisciplinary collaboration, and supporting the effective integration of knowledge across disciplinary boundaries. Accordingly, the proposed framework offers a useful lens through which the role of AI in advancing interdisciplinary scientific research within higher education institutions can be better understood.

Future research may expand the scope of this work by applying the proposed framework to larger and more diverse samples drawn from different universities and academic settings. Additionally, advanced analytical techniques such as Structural Equation Modeling (SEM) or Partial Least Squares Structural Equation Modeling (PLS-SEM) could be employed to examine direct and indirect relationships among study variables and provide more robust validation of the proposed theoretical model.

Conclusion and Procedural Recommendations

The study succeeded in formulating a correlational model linking artificial intelligence, digital competence, and science integration at the Libyan Academy - Janzour. The results proved that refining digital competence represents a mandatory bridge to crossing toward real interdisciplinary research with high quality. Based on the foregoing, the researchers recommend the following:

1. **Development of Training Packages:** Requiring postgraduate students (Master's/PhD) to complete advanced courses in digital competence and responsible AI research before registering research proposals.
2. **Encouraging Joint Theses:** Establishing joint supervisory committees across scientific departments at the Academy (such as joint supervision between the Computer Science and Humanities departments) to realistically rather than theoretically support interdisciplinary research.
3. **Establishment of a Research Support Unit:** Allocating an academic unit that provides technical and methodological consultations to students on how to employ artificial intelligence tools in their research, with a focus on ethical and legal aspects.
4. **Expanding Future Research Horizons:** The researchers recommend conducting subsequent studies adopting "Multiple Regression Analysis and Structural Equation Modeling (SEM)" on representative and larger random samples to examine impact and mediation paths with greater precision.

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