

MODERNIZATION OF THE CONTENT OF TEACHER EDUCATION IN THE CONTEXT OF DIGITAL AND SOCIAL CHALLENGES OF OUR TIME

MODERNIZAÇÃO DOS CONTEÚDOS DA FORMAÇÃO DE PROFESSORES NO CONTEXTO DOS DESAFIOS DIGITAIS E SOCIAIS DA NOSSA ÉPOCA

MODERNIZACIÓN DE LOS CONTENIDOS DE LA FORMACIÓN DEL PROFESORADO EN EL CONTEXTO DE LOS RETOS DIGITALES Y SOCIALES DE NUESTRO TIEMPO



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ABSTRACT: The current task of teacher education is to form an integrated model aimed at modernizing the content of teacher education in the light of digital changes and social dynamics. The focus is on the problem of fragmented implementation of technologies, which limits the effectiveness of teacher training and complicates the adaptation of educational programs to new professional requirements. The methodology of our study is based on a combination of structural analysis, comparative approach and modeling of educational processes. The decomposition of functional elements of learning was applied, which made it possible to identify the relationships between technological, didactic and social components. The analytical part involved evaluating the effectiveness of various educational models using quantitative indicators. The results show that improving the quality of teacher training is associated with the transition to adaptive learning models, which consider individual educational trajectories and provide feedback based on analytical data.

KEYWORDS: Modernization of teacher education. Digital transformation of education. Pedagogical innovations. Adaptive learning. Artificial Intelligence in education.

RESUMO: *A tarefa atual da formação de professores consiste em criar um modelo integrado que vise modernizar o conteúdo da formação de professores à luz das mudanças digitais e das dinâmicas sociais. O foco está no problema da implementação fragmentada das tecnologias, o que limita a eficácia da formação de professores e complica a adaptação dos programas educacionais às novas exigências profissionais. A metodologia do nosso estudo baseia-se numa combinação de análise estrutural, abordagem comparativa e modelagem de processos educacionais. Foi aplicada a decomposição dos elementos funcionais da aprendizagem, o que possibilitou identificar as relações entre os componentes tecnológicos, didáticos e sociais. A parte analítica envolveu a avaliação da eficácia de vários modelos educacionais por meio de indicadores quantitativos. Os resultados mostram que a melhoria da qualidade da formação de professores está associada à transição para modelos de aprendizagem adaptativos, que consideram trajetórias educacionais individuais e fornecem retorno com base em dados analíticos.*

PALAVRAS-CHAVE: *Modernização da formação de professores. Transformação digital da educação. Inovações pedagógicas. Aprendizagem adaptativa. Inteligência Artificial na educação.*

RESUMEN: *La tarea actual de la formación docente consiste en elaborar un modelo integrado destinado a modernizar los contenidos de dicha formación a la luz de los cambios digitales y la dinámica social. Se presta especial atención al problema de la implementación fragmentada de las tecnologías, lo que limita la eficacia de la formación docente y complica la adaptación de los programas educativos a los nuevos requisitos profesionales. La metodología de nuestro estudio se basa en una combinación de análisis estructural, enfoque comparativo y modelización de los procesos educativos. Se aplicó la descomposición de los elementos funcionales del aprendizaje, lo que permitió identificar las relaciones entre los componentes tecnológicos, didácticos y sociales. La parte analítica consistió en evaluar la eficacia de diversos modelos educativos utilizando indicadores cuantitativos. Los resultados muestran que la mejora de la calidad de la formación docente está asociada a la transición hacia modelos de aprendizaje adaptativos, que tienen en cuenta las trayectorias educativas individuales y proporcionan retroalimentación basada en datos analíticos.*

PALABRAS CLAVE: Modernización de la formación del profesorado. Transformación digital de la educación. Innovaciones pedagógicas. Aprendizaje adaptativo. Inteligencia Artificial en la educación.

INTRODUCTION

The digital transformation of teacher education has long gone beyond spot experiments. It is gradually rebuilding the very logic of teacher training. Educational institutions are faced with an uncomfortable fact: the usual schemes for organizing the educational process simply cannot keep up with the changing information environment around them. That is why rethinking the content of teacher education today is not an academic discussion, but a practical necessity. Digital technologies have reformatted the structure of knowledge, and individualized learning is no longer optional. It is becoming increasingly clear that educational programs must be able to adapt to changing professional realities and purposefully develop new types of competencies in future teachers (Gu et al., 2025), including analytical thinking, readiness for change, and confident work in a digital environment.

At the same time, a significant gap remains. Digital educational tools are developing much faster than they are actually being integrated into teacher education. Many programs are still implementing innovations in fragments without a systematic logic and without a cross-cutting concept. This is not modernization, but its imitation. The situation is further complicated by the lack of clear models for updating the content of education, which makes pedagogical systems adapt slowly and inconsistently (Palchuk, 2025). All these points need conceptual approaches that would organically combine technological, didactic, and social dimensions in the professional training of teachers. Thus, this study addresses this gap by analyzing how these dimensions can be integrated into a coherent model for modernizing the content of teacher education.

More specifically, the article aims to develop and substantiate an integrated model for the modernization of teacher education content in response to contemporary digital and social challenges, with special attention to adaptive learning, educational analytics, artificial intelligence, and the formation of digital-social pedagogical competence. To achieve this aim, the study first systematizes the main theoretical positions on digital transformation in education; then identifies institutional and didactic conditions for updating teacher training programs; and finally proposes a multi-level framework for evaluating modernization through indicators related to digital integration, learning outcomes, personalization, program adaptability, ethical responsibility, data-driven decision-making, and teachers' professional resilience. In this sense, the contribution of the article is not limited to describing the general relevance of digital technologies, but consists in organizing these elements into an operational proposal that can

guide curriculum design, institutional management, and future empirical validation in teacher education programs.

LITERATURE REVIEW

Baidoo-Anu and Owusu Ansah (2023) have shown that digital tools change not only the form but also the logic of knowledge organization. Giannakos et al. (2025) emphasize the contradictions of generative systems: they expand possibilities but can reduce the depth of educational analysis. Mukul and Büyüközkan (2023) consider digital transformation within Education 4.0 as a combination of technological, organizational and methodological changes. Tang et al. (2025) note the gap between theoretical models of digitalization and their practical implementation, which reflects the limited adaptability of institutions. Jurčević and Horvat (2023) introduce the concept of digital pedagogy as a new logic of educational interaction. Lisova (2024) emphasizes innovation as a mechanism for educational renewal, while Bakar (2021) emphasizes the need to combine traditional and innovative approaches.

Forsström et al. (2025) argue that the effectiveness of digital learning depends on the quality of pedagogical design. Strielkowski et al. (2025) consider adaptive learning as a tool for personalization, and Tan et al. (2025) examine the role of AI in teacher professional development. Bobro (2024, 2025), Solovei et al. (2023), and Gyrevich et al. (2022) analyze the transformation of educational management in the context of digital change. Kolisnyk-Humeniuk (2023) emphasizes the multi-level nature of the modernization of teacher education and the importance of coordinating global and national strategies.

A review of the literature shows that studies often consider digital transformation in a fragmented manner, without forming an integrated model. The technological, didactic, and social aspects of teacher education remain conceptually disjointed. This justifies the need to develop an integrated model for the modernization of teacher education content that combines the digital, social, and didactic dimensions.

MATERIALS AND METHODS

The study combines analytical and applied methods to ensure a coherent study of the processes of modernization of teacher education. The methodological framework is based on a structural analysis of educational systems, a comparative approach to evaluating learning models, and a generalization of modern digital transformation practices. The decomposition

method was applied, which allowed to divide the modernization process into separate functional blocks with their subsequent analysis and synthesis into a single model. The analytical stage involved processing data on the introduction of digital technologies into curricula, as well as assessing their impact on the results of students' training. A systematic approach was used to consider the educational process as a set of interrelated components.

A comparative analysis of the performance indicators of different didactic models was used. It revealed the patterns of formation of learning autonomy and the level of personalization. The modeling method helped to build an integrated conceptual model for modernizing the content of teacher education. The results obtained were interpreted using logical generalization, which gave the validity of the formulated conclusions.

RESULTS

Conceptual foundations of modernization of teacher education

The traditional knowledge model of teacher training is losing space to a competency-based approach that focuses on the ability to act in conditions of uncertainty. The role of the teacher is changing from a translator of knowledge to a coordinator and facilitator of learning, which meets students' expectations for interactivity and practical explanation of complex topics. Cognitive challenges are shifting from memorization to selection and critical analysis of information, which reinforces the importance of critical thinking and reflection. At the same time, these skills are difficult to formalize and assess, and generative AI, while accelerating access to answers, does not guarantee their depth, which actualizes the problem of academic integrity.

Digitalization, globalization, AI, information overload, social changes, online communication and automation are transforming the educational process and the role of the teacher in different ways—from coordinator and mentor to information filter and facilitator, while creating risks of dependence on technology, loss of context, reduction of critical thinking and formalization of learning. Educational programs are moving towards flexible individual trajectories, but not all students are ready for autonomy, which increases the workload on the teacher. In parallel, the content of digital competencies is changing since not only the mastery of technologies is becoming important, but their integration into pedagogical design and continuous professional development.

Models of modernization of teacher education content

Changes in teacher training under the influence of digitalization are no longer limited to individual courses, but involve a profound restructuring of educational programs, where digital competence is a condition for professional competence. The effectiveness of digital solutions depends not on tools, but on pedagogical coherence, quality of design, teacher training and institutional support. Digital literacy is expanding to include AI, educational data and content creation, as well as integrity mechanisms and flexible interaction formats. According to OECD (2026), digital tools are effective only when their use is pedagogically justified. There is a shift towards blended learning models with a decrease in lectures and an increase in the role of flipped learning, project work and adaptive trajectories.

However, their implementation is often formal and does not consider the real labor intensity and roles of the teacher, which simplifies learning into formal tasks without a research component. Flexible educational trajectories involve modularity, short certificate blocks, practical cases and digital portfolios. Micro-qualifications play an important role as a tool for rapid updating of competencies in accordance with professional needs. A separate direction is the partnership with the EdTech sector, which includes joint course design, technology testing and analysis of usage data. The effectiveness of such solutions is ensured by a cycle of testing, correction, evaluation and scaling (Table 1).

Table 1.

Institutional foundations for modernizing the content of teacher education and expected outcomes

No	Institutional foundations	Management action	Educational impact	Limitations	Outcome indicator
1	Digital infrastructure	Upgrading the network, platforms, and equipment	Stability of the educational process	Cost of support	Percentage of uninterrupted classes
2	Center for Digital Pedagogy	Methodological support for teachers	Course quality	Staff shortage	Number of updated courses
3	Educational analytics	Platform data collection and analysis	More accurate academic decisions	Risk of formalization	Percentage of adjusted routes
4	Microcredentials	Short certification modules	Rapid skill updates	Unequal access	Number of completed modules
5	EdTech partnerships	Joint piloting of services	Faster implementation of innovations	Vendor lock-in	Percentage of services that are scalable

6	Digital portfolio	Documentation of achievements and best practices	Transparent development trajectory	Incomplete content	Portfolio activity index
7	Professional development	Regular programs for teachers	Professional resilience of staff	Resistance to change	Percentage of certified teachers

Note. The Authors.

Therefore, the modernization of teacher training content should be assessed not by the number of digital services in the program, but by the extent to which it builds the ability to design learning, interpret data, work with flexible formats, and use AI responsibly. The rest is only external. An effective model is one in which digital competence is integrated into professional modules, didactic innovations are supported by analytics, and the educational institution performs not only a control but also a methodological function.

Conceptual model of modernization of teacher education

Universities often update digital tools without simultaneously reviewing content, methodologies, and assessments, leaving LMS, programs, and analytics separate, leaving teachers to integrate them on their own. Such fragmentation reduces the effectiveness of modernization, so changes should be built as a holistic system.

The first block of the model defines digital technologies by their functions: AI for content creation and adaptation, LMS for trajectory management and data collection, XR for simulations and practical demonstrations. At the same time, technologies quickly lose their meaning without a pedagogical scenario. OECD (2026) studies emphasize that the use of AI does not guarantee learning and that generative AI only supports meaningful learning when guided by pedagogical principles; therefore, its use should take place in pedagogically controlled scenarios.

The second block concerns adaptive updating of training content, which combines infrastructure, program updates, teacher training, and partnerships with EdTech. A dynamic update cycle is proposed based on three sources: the labor market, educational analytics, and student feedback. The mechanism works cyclically: collecting data on students' needs and difficulties, updating modules and tasks with the possible use of AI, then short testing and returning the results to the analytical cycle. Assessment in the context of digital transformation should be process-oriented, multi-criteria, and aimed at real improvement of educational practice, not just at recording formal results (Table 2).

Table 2.*Pathways for the adaptive modernization of educational content in teacher training programs*

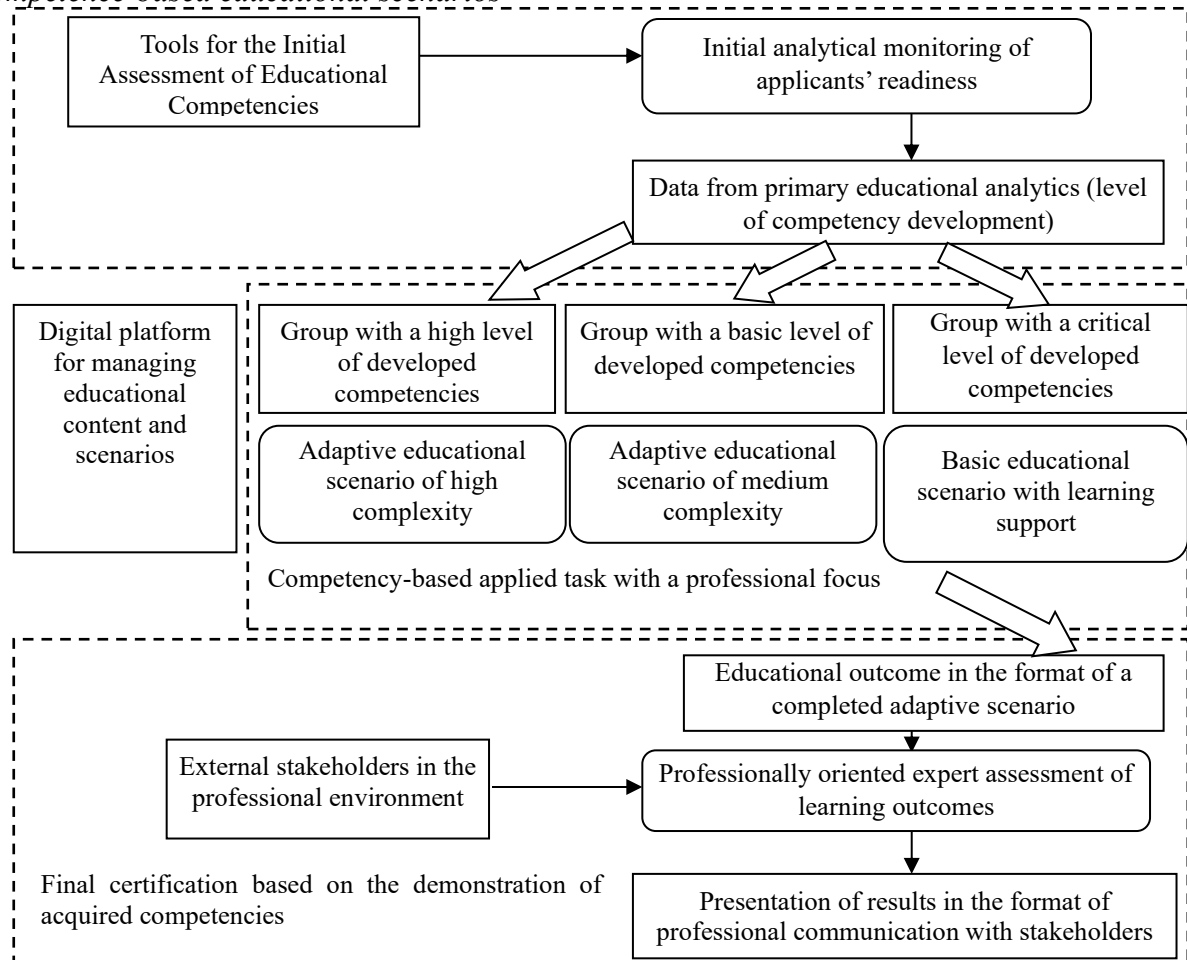
No	Source of updates	Management action	Educational effect	Evaluation criterion
1	Labor market analysis	Review of the list of competencies in the program	Aligning training with actual professional requirements	Percentage of updated program outcomes
2	LMS data	Identification of challenging topics and areas of academic risk	More precise content adjustments	Reduction in the percentage of uncompleted assignments
3	Student feedback	Revision of modules and formats of educational interaction	Increased learning engagement	Course structure satisfaction index
4	AI-generated materials	Creation of varied case studies, explanations, and exercises	Differentiation of content by difficulty level	Number of adapted content units
5	Educational analytics	Adjusting the assessment criteria and the pace of the course	Improving the accuracy of pedagogical decisions	Percentage of decisions made based on data
6	Professional expertise of instructors	Updating practical assignments and teaching methods	Strengthening the applied component of the program	Percentage of courses with updated case studies
7	Partnership with EdTech	Piloting new digital solutions	Accelerating technological renewal	Number of tested tools

Note. The Authors.

A separate block of proposals concerns the concept of digital-social pedagogical competence, which more accurately reflects the modern role of the teacher than the traditional “digital literacy”. The teacher no longer only transfers knowledge, but also coordinates learning, motivates, organizes interaction, develops critical thinking, while AI remains only a tool. This competence encompasses six key components: digital literacy; pedagogical flexibility; social and communication skills; ethical responsibility in the digital environment; critical evaluation of AI results; and interpretation of educational data for informed decision-making (Figure 1).

Figure 1.

Model of adaptive modernization of teacher education based on digital diagnostics and competence-based educational scenarios



Note. The Authors.

Hence the system for assessing the effectiveness of modernization should be understood as a pedagogical and managerial instrument, not as a simple technological audit. It is not limited to counting laptops, platforms, or webinars. It is on this basis that we are introducing a multi-level system of criteria. It will be able to track not only the technological implementation, but also the quality of the learning outcome, the level of personalization, and the program's ability to adapt (Bobro, 2025; OECD, 2025) (Table 3).

Table 3.

Multi-level system for evaluating the effectiveness of teacher education modernization

No	Assessment area	Calculation indicator	Calculation formula	Data source	Performance criterion
1	Level of digital integration	Course Digitalization Index (CDI), %	$DCI = (DC / TC) \times 100,$	Syllabi, LMS	$\geq 75\%$

			where Kc is the number of courses with a digital scenario, and Kz is the total number of courses.		
2	Quality of learning outcomes	Competency Growth Index (CGI), %	$CGI = ((Fn - Bn) / Bn) \times 100$, where Fn is the final level, Bn is the baseline level.	Assessment, portfolio	$\geq 20\%$ increase
3	Personalization Level	Personalization coefficient (Kp), %	$Pc = (Ki / Kz) \times 100$, where Ki is the number of individual learning paths, Kz is the total number of students.	LMS analytics	$\geq 60\%$
4	Program Adaptability	Content Update Index (CI), %	$CI = (U / T) \times 100$, where U is the number of updated modules, and T is the total number of modules.	Departmental reports	$\geq 30\%$ annually
5	Social and ethical component	Integrity Index (Id), %	$Id = (1 - (V / T)) \times 100$, where V is the number of violations, and N is the total number of inspections.	Inspection reports	$\geq 95\%$
6	Analytical maturity	Data-driven decision coefficient (Kd), %	$Kd = (Pd / Pz) \times 100$, where Pd is the number of data-driven decisions, and Pz is the total number of decisions.	Analytical reports	$\geq 70\%$
7	Teacher's professional resilience	Pedagogical Adaptability Index (PAI), %	$PAI = (Ba / Bz) \times 100$, where Ba – teachers with updated courses, Bz – total number of teachers.	Certification, course audit	$\geq 65\%$

Note. The Authors.

The indicators presented in Table 3 were constructed to translate the conceptual model into a sequence of observable dimensions. The Course Digitalization Index evaluates whether digital resources are integrated into actual course scenarios, rather than appearing as isolated tools. The Competency Growth Index connects modernization to demonstrable learning progress by comparing baseline and final levels of competence. The personalization coefficient, in turn, measures the extent to which the program moves beyond a single standardized route and offers differentiated learning paths supported by LMS analytics and adaptive pedagogical design.

The remaining criteria broaden the assessment beyond individual performance. The Content Update Index verifies whether curricular modules are revised regularly in response to labor-market demands, student feedback, analytics, and emerging technologies. The Integrity Index is included because the use of AI and automated tools increases the need for transparent rules, verification practices, and ethical responsibility in the digital environment. The data-driven decision coefficient measures the institutional capacity to transform educational analytics into pedagogical decisions, while the Pedagogical Adaptability Index links

modernization to teachers' professional development and their ability to redesign courses, tasks, and assessment practices. Taken together, these criteria connect the proposal to the literature on adaptive learning, digital pedagogy, teacher agency, and the responsible use of AI, showing that modernization depends on the articulation between infrastructure, curriculum, pedagogy, ethics, and institutional decision-making.

The conceptual model of modernization of teacher education should work as a connected system, where digital technologies support didactics, social competencies restrain technocratic bias, and the analytical circuit translates changes into sustainable development.

DISCUSSION

The results obtained are consistent with the conclusions of Baidoo-Anu and Owusu Ansah (2023) on the growing role of AI in the personalization of learning. The proposed model refines this approach by introducing an analytical loop that provides not only content automation, but also quality control of the results. The positions of Giannakos et al. (2025) on the risks of cognitive simplification are confirmed and supplemented by mechanisms of verification and pedagogical support. The conclusions of Mukul and Büyüközkan (2023) on the complexity of digital transformation are specified by structuring the process into interconnected blocks with measurable indicators. The results of Tang et al. (2025) on the gap between models and practice are also confirmed and refined through the mechanism of adaptive content updating. The positions of Jurčević and Horvat (2023), Lisova (2024) on the transformation of the teacher's role are consistent with the results and supplemented by the concept of digital-social competence.

The positions of Forsström et al. (2025) and Strielkowski et al. (2025) on the dependence of teaching effectiveness on pedagogical design are confirmed and detailed through analytical criteria. Tan et al. (2025) consider AI as a tool for teacher development, which is also confirmed, but supplemented by its integration into the structure of educational content. The novelty of the study lies in the transition from descriptive approaches to a formalized integrated model that combines technological, didactic, social and analytical components into a single system with clear evaluation criteria. This allows overcoming the fragmentation of existing approaches. The practical significance lies in the possibility of using the model for designing educational programs, managing their development and increasing the effectiveness of teacher training.

FINAL CONSIDERATIONS

The modernization of teacher education is taking on the character of a structural restructuring. It has covered not only the instrumental level but also changes in the cognitive and professional orientations of participants in the educational process. There is a shift in emphasis from the reproduction of knowledge to the ability to select, interpret and apply it in practice in the context of information overload. The study has shown that the transformation of the role of the teacher towards the facilitation of learning is accompanied by uneven adaptation of the educational environment. The effectiveness of modernizing the content of teacher education is determined by the level of integration of digital competencies into professional modules, not by the fact of using technology as such. The most effective educational models are formed by combining adaptive didactic approaches, analytical support of the educational process and flexible educational trajectories. The principles of transition to an operational description of didactic models through the parameters of load, interaction and control are substantiated, which ensures an increase in the quality of learning outcomes and the growth of students' autonomy.

The main limitation of this study is that the proposed model has a predominantly theoretical and conceptual character. Although it is grounded in current literature and organized through operational indicators, it has not yet been tested through longitudinal application in specific teacher education programs. Therefore, the criteria presented in the model should be understood as a structured proposal for implementation and evaluation, rather than as evidence of already measured institutional effects. Another limitation concerns contextual variability: the effectiveness of digital infrastructure, AI-supported activities, microcredentials, educational analytics, and EdTech partnerships depends on institutional resources, teachers' preparation, data governance policies, and students' access to technologies. These conditions may vary considerably across countries, universities, and programs.

Future research should apply the proposed model empirically in teacher education curricula, comparing different institutional contexts and observing how the indicators behave over time. It would also be important to investigate how students and teacher educators perceive the ethical, pedagogical, and cognitive implications of AI-supported learning, especially with regard to academic integrity, critical thinking, and professional autonomy. Further expansion of the study may include the development of rubrics for each assessment area, the validation of the proposed indicators through expert review, and the design of pilot interventions in courses that combine adaptive learning, digital portfolios, data-informed feedback, and supervised use

of generative AI. Such developments would make it possible to move from conceptual modeling to evidence-based evaluation of modernization processes in teacher education.

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