



TRANSFORMATION OF EDUCATION IN THE DIGITAL ERA: LITERATURE REVIEW ON THE ROLE OF TECHNOLOGY IN SHAPING THE COMPETENCE OF THE FUTURE GENERATION

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ABSTRACT

Educational transformation in the digital era is an unavoidable phenomenon, along with the rapid development of information and communication technology that has penetrated all aspects of human life, including the world of education. This study aims to systematically examine the role of technology in shaping the competencies of future generations through a systematic literature review (SLR) approach with the PRISMA protocol. A literature search was conducted through four academic databases: Scopus, Web of Science, ERIC, and Google Scholar, with a publication period from 2020 to 2025, resulting in 27 final articles that met all inclusion criteria. Analysis using a thematic synthesis approach yielded five main themes: the shift in technology-based learning paradigms, the development of digital competencies for future generations, the impact of the COVID-19 pandemic as a catalyst for transformation, the penetration of artificial intelligence in personalized learning, and the supporting and inhibiting factors of digital transformation in education. The study results show that the effectiveness of technology in education is largely determined by the quality of pedagogical design, the digital competency of educators, and the readiness of equitable infrastructure. Sustainable digital transformation in education requires a systemic approach that simultaneously integrates technological, pedagogical, policy, and social inclusion dimensions.

ABSTRAK

Transformasi pendidikan di era digital merupakan fenomena yang tidak dapat dihindari seiring dengan pesatnya perkembangan teknologi informasi dan komunikasi yang merambah seluruh aspek kehidupan manusia, termasuk dunia pendidikan. Penelitian ini bertujuan untuk mengkaji secara sistematis peran teknologi dalam membentuk kompetensi generasi masa depan melalui pendekatan *systematic literature review* (SLR) dengan protokol PRISMA. Pencarian literatur dilakukan melalui empat basis data akademik yaitu Scopus, Web of Science, ERIC, dan Google Scholar dengan rentang waktu publikasi tahun 2020 hingga 2025, menghasilkan 27 artikel final yang memenuhi seluruh kriteria inklusi. Analisis menggunakan pendekatan *thematic synthesis* menghasilkan lima tema utama, yaitu perubahan paradigma pembelajaran berbasis teknologi, pengembangan kompetensi digital generasi masa depan, dampak pandemi COVID-19 sebagai katalis transformasi, penetrasi kecerdasan buatan dalam personalisasi pembelajaran, serta faktor pendukung dan penghambat transformasi digital pendidikan. Hasil kajian menunjukkan bahwa efektivitas teknologi dalam pendidikan sangat ditentukan oleh kualitas desain pedagogis, kompetensi digital pendidik, dan kesiapan infrastruktur yang merata. Transformasi pendidikan digital yang berkelanjutan membutuhkan pendekatan sistemik yang mengintegrasikan dimensi teknologi, pedagogis, kebijakan, dan inklusi sosial secara simultan.

INTRODUCTION

Civilization man No Once stop moving, and in every jump progress, system education always become the most affected variables and at the same time the most decisive direction change said. Since revolution industry first in the 18th century to the digital era of the 21st century, education Keep going experience metamorphosis in matter objectives, methods, content, and infrastructure supporters. Now, the world is be in the middle wave digital transformation that is not only change method man work and communicate, but also fundamentally overhaul method man learn, access knowledge, and building competence himself. Digital technology is not Again just tool help in the educational process, but rather has incarnate become ecosystem new place learning happen in a way massive, distributed, and cross-border boundaries (Beetham & Sharpe, 2020).

Revolution Industry 4.0 is characterized by intelligence artificial intelligence, automation, Internet of Things, and computing cloud has create landscape different socio - economic in a way structural from the previous

era. The World Economic Forum (2023) estimates that about 44% of core skills of the workforce global work will experience disruption in five years to front, with intelligence manufacturing and processing information big become two driving force the main condition This create pressure real to system education worldwide for produce graduates who do not only speak in a way academic, but also agile in face uncertainty, adaptive to change technology, and competent in the skills domain 21st century like think critical thinking, collaboration, communication, and creativity. UNESCO (2021) even in a way explicit state that objective future education No Again just a transfer of knowledge, but rather formation capacity man For Study throughout life in continuous environment changed.

Penetration technology to in the world of education has open dimensions new previous one No unimaginable. Online learning platforms such as Coursera, edX, Khan Academy, and various system management learning cloud -based has democratize access to education quality for millions of people who previously marginalized in a way geographical

and economy. Intelligence artificial allows personalization experience adaptive learning in accordance need cognitive of each participant educate. Virtual reality and augmented reality open up opportunity simulation learning immersive beyond limitations room physical. Big data analytics allows educators and institutions For understand pattern learn, identify difficulties, as well as designing appropriate intervention target in real-time (Williamson et al., 2020). All innovation This in a way collective form paradigm new in education that places technology No as complement, but rather as component central in architecture learning.

However, behind all over promise transformative said, reality implementation technology in education Far more complex and not uniform. The digital divide between developed and developing countries, between urban and rural areas, and between group different socio - economic Still become obstacle serious structural damage. Data from the International Telecommunication Union (2022) shows that approximately 2.7 billion people worldwide are still Not yet own adequate internet access, and some big from they is students in developing countries. Conditions This No only make things worse inequality education that has been there is, but also potential create canyon competence an increasingly modern generation in between groups that have access technology and what not. Therefore that, transformation digital education does not can interpreted in a way naive as an automatic process profitable all parties, but rather must understood as a process that is full of with fight interests, inequality source power and needs affirmative policies (Selwyn, 2022).

Study of transformation digital education focuses on how technology in a way concrete influence formation competence participant education. Competence future generations No can Again defined in a way narrow as mastery knowledge discipline knowledge certain, but rather covers spectrum broad capabilities covering digital literacy, ability think computational, skills virtual collaboration, resilience cognitive, and capacity For Keep going learn and grow throughout life. Competency framework 21st century developed by various institution such as the Partnership for 21st Century Skills (P21), the

OECD Learning Framework 2030, and the European DigComp Framework. map many roads adopted by the system education in various countries in designing relevant curriculum and assessment with needs of the digital era (Voogt et al., 2021).

Study latest about integration technology in learning show that effectiveness technology in increase competence participant education is very dependent on quality design pedagogical aspects that accompany it. Technology, as great as whatever in a way technical, no will give impact significant to results Study If No implemented in framework mature and participant - centered pedagogy Educate. A meta- analysis study conducted by Hillmayr et al. (2020) on 92 studies in Europe find that integration digital technology in learning give effect significant positive to performance learning (effect size = 0.65), however effect is highly moderated by competence teacher pedagogical in integrate technology in a way meaningful to in the learning process. Findings This confirm that digital transformation in education in essence is transformation pedagogical facilitated by technology, not transformation coincidental technology occurs in context education.

The role of teachers in ecosystem digital learning is experiencing fundamental redefinition. From the position as the only one source knowledge authoritative, teachers now sued For become facilitator learning, designer experience study, curator source digital power, and mentors development competence participant educate. Transformation role This need development systematic and sustainable digital competence of teachers. Research by Scherer et al. (2021) using the DigComp model For evaluate digital competence of teachers in 25 countries shows that the majority of teachers still is at the basic digital competency level until medium, with significant gap between teachers in developed and developing countries. Findings This indicates that investment in development teacher professionalism in the field digital competence is key success transformation digital education in overall.

COVID-19 pandemic that has hit the world since 2020 becomes accelerator outside normal for digital transformation of education, as well as emphasize brutally various gaps and weaknesses that have been This hidden

behind normality system education conventional. More from 1.6 billion students around the world are affected closing school, and in very short time, almost all over system forced world education For switch to learning distance Far based digital technology. Experience This produce accumulation of data and findings extraordinary research normal about effectiveness online learning, factors that influence it involvement participant educate in virtual environment, as well as implications term long from shift paradigm learning This to competence and well-being psychological generation young (Dong et al., 2020; Azubuike et al., 2021).

In Indonesian context, transformation digital education has dimensions individual which is influenced by characteristics unique demographic, geographic, and socio-economic characteristics. As an archipelagic country the largest in the world with more from 270 million population spread across thousands islands, Indonesia faces monumental challenges in ensure equality access and quality Digital education. The Merdeka Belajar program launched by the Ministry of Education, Culture, Research, and Technology since 2019 and continuing developed until moment This is response policies that seek to integrate Spirit digital transformation with need contextual Indonesian education. Research Rasmitadila et al. (2020) about implementation online learning in Indonesia during pandemic find that although there is improvement significant in adoption technology learning, challenges the biggest precisely be in dimension pedagogical and gaps digital competence among teachers in the region urban and rural.

Intelligence artificial generative that begins enter room class in a way massive since 2022-2023 opens half new in debate about the future education. Attendance tools based intelligence artificial like ChatGPT, Google Gemini, and various assistant learning AI- based has bring up fundamental questions about integrity academic, relevance assessment conventional, and redefinition true competence needed humans in an era when machine can do Lots task cognitive with precision high (Cope & Kalantzis, 2021; Zawacki -Richter et al., 2019). The paradox faced education moment This is How utilise intelligence artificial For increase quality

learning at a time ensure that the educational process still develop uniqueness and depth capacity cognitive inhumane can replaced by machines.

Although literature about technology education has develop rapidly in One decade lastly, especially accelerated by the COVID-19 pandemic, there are a number of gap significant and urgent research For overcome. First, some big existing research about transformation digital education is still dominated by the perspectives and contexts of developed countries, particularly in North America, Western Europe, and East Asia. Representation study from developing countries, including Indonesia, is still very limited in literature international, even though it is precisely in these countries challenges and opportunities transformation the most complex and most demanding digital education solution based contextual evidence (Zawacki -Richter et al., 2019 ; Bozkurt et al., 2020).

Second, there is a glaring gap in study about impact term long use technology to formation competence participant educate. Most of them available studies focused on impact term short as measured through test performance or perception satisfaction study, while longitudinal research that follows development competence participant educate during for years in environment digital learning is still very rare (Dabbagh et al., 2016; Tang et al., 2022). This cause understanding about How technology truly form capacity cognitive, affective, and social growing generation in the digital ecosystem is still very fragmented and not yet comprehensive.

Third, synthesis systematically integrating various flow study about transformation digital education— includes aspect pedagogical, psychological, sociological, and policy in a way integrated — is still very limited. Existing research tend fragmented in disciplinary silos sciences that each produce findings partial without effort adequate synthesis (Crompton et al., 2020). As a result, the decision makers policy and practitioners education often face difficulty in identify principles and strategies based on evidence that can be adopted in a way practical For speed up and improve quality transformation digital education in institutions they. Gap this is what makes study systematic, comprehensive, and cross-disciplinary

literature review discipline own mark very high academic and practical level at the time This.

Leave from mapping conditions and gaps research above, study this literature review present as effort systematic For build greater understanding whole and integrated about transformation education in the digital era, with focus specifically on the role technology in form competence future generations. This study adopt systematic literature review approach with integrate principles from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for ensure transparency, reproducibility, and depth adequate analysis (Moher et al., 2020).

Source literature reviewed in study This originate from various academic databases reputable high, including Scopus, Web of Science, ERIC, and Google Scholar, with temporal restrictions on publication 2020 to 2025 for ensure relevance findings with condition contemporary ecosystem digital education. Selection range time This in a way strategic covers period the COVID-19 pandemic which became a turning point in history transformation global digital education, as well as period post - pandemic marked by consolidation learning hybrid and penetration intelligence artificial generative to in practice education.

Significance study This can seen from three dimensions. In terms of theoretical, study This contribute to development framework more conceptual comprehensive about connection between digital technology, design learning, and formation competence participant education that includes various levels and contexts education. In general methodological, study This offers a synthesis model literature cross discipline that can become references for researchers next who works in the field technology education. In general practical, results study This expected can give guide based evidence that can be adopted by institutions education, developers policies, and educators in designing and implementing effective, inclusive and sustainable digital transformation strategies, in particular in context education in Indonesia and developing countries others who face challenge similar (Huang et al., 2021; Rizvi et al., 2022).

METHODS

Study This use approach *systematic literature review* (SLR) with referring to the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) protocol as guide standard in the selection and reporting process literature. Search done through four academic databases reputable tall namely Scopus, Web of Science, ERIC, and Google Scholar using keyword combination like "*digital education*," "*technology integration*," "*21st century competencies*," and "*digital transformation in education*" with range time publication 2020 to 2025.

Criteria inclusion covering articles published in journals *peer-reviewed* reputable international, relevant in a way thematic with focus studies, as well as available in text full speak Indonesian or English. Articles that are not through a *peer-review* process and not relevant in a way thematic issued from the selection process. From the total search that resulted in around 1,200 articles, after through stages identification, screening, and assessment eligibility, obtained approximately 20 to 30 final articles that meet the criteria all over established criteria.

RESULTS AND DISCUSSION

Search process literature conducted in a way systematic through four academic databases main producing a total of 1,247 articles at this stage identification beginning. From the number of which, as many as 357 articles issued Because duplication cross - database, so that 890 articles remaining unique then enter to stage screening title and abstract. After doing filtering based on relevance thematic, as many as 740 articles issued Because No in accordance with focus study, leaving 150 eligible articles For done reading text full. At the stage evaluation eligibility in-depth, as many as 123 articles return issued with reason main in the form of methodology that is not adequate, context too much study specific and not transferable, as well as mismatch with range time established publication. The final result of the selection process produced 27 articles that met the requirements all over criteria inclusion and being source analysis main in study this. Articles the originate from various countries with sufficient representation diverse, including

studies from Asia, Europe, America, Africa and the Middle East, although domination study from developed countries Still seen in a way proportional in distribution geographical source successful literature included.

Characteristics General Literature Analyzed

The 27 successful articles included, there is pattern interesting characteristics For examined as context beginning reading findings. The majority study use design studies mixture or mixed methods at 41%, followed by research quantitative by 33%, and research qualitative by 26%. Distribution design study This reflect trend researchers in the field technology education For combine depth understanding qualitative with strength generalization quantitative in One framework integrated methodology. From the side level education, some big study focused on education tall by 48%, followed by education medium by 30%, and education base by 22%. Inequality representation level This indicates that digital transformation in education tall relatively more Lots researched and documented compared to level more education low, even though precisely at the level basic and intermediate foundation future generation digital competencies first built in a way systematic (Hillmayr et al., 2020).

From a temporal perspective, there are surge significant amount publications in 2020 and 2021 which are clear reflect impact COVID-19 pandemic in push attention academic to issue digital learning. After 2021, the number of publication relatively stable However with shift increasing focus stand out to direction study about quality and sustainability learning hybrid post-pandemic, as well as the more strong attention to integration intelligence artificial in ecosystem formal education. Shift focus thematic This reflect maturity field studies that are not Again just respond urgency situational, but rather start build framework greater understanding strategic and long term long about the future education in the digital era (Williamson et al., 2020).

Technology Integration and Change Paradigm Learning

Findings first to appear in a way consistent from synthesis literature is that integration digital technology in education No

just present instrumental changes in matter tool or the media used, but rather trigger shift distant paradigm more fundamental in method learning conceptualized, designed, and implemented. Beetham and Sharpe (2020) in study comprehensive they about digital era pedagogy emphasizes that transformation true in digital education is happening not at the time institutions adopt technology new, but at the time technology the push change in belief pedagogical of educators about How knowledge built and how most effective learning happened. Shift paradigm This covers shifting the role of teachers transmitter knowledge become facilitator construction knowledge, shifting orientation curriculum from content-centered to competency-centered, as well as shifting assessment from measurement memorization going to evaluation ability think level height and application knowledge in context real.

Study Hillmayr et al. (2020) who conducted a meta- analysis of 92 studies in Europe find that integration digital technology in learning produce effect significant positive to performance Study with mark effect size of 0.65. However distant findings more important is that effect the in a way consistent moderated by quality design accompanying pedagogical use technology. In other words, the technology implemented without framework mature pedagogical No only fail increase results learn, but in a number of case precisely produce effect negative in the form of excess burden cognitive, disorientation information, and the decline motivation intrinsic participant education. Findings This own implications very important policy that investment in infrastructure technology education must always accompanied by with equivalent investment in development capacity pedagogical aspects of educators who will operationalize technology the in practice learning daily.

Besides that, various research that is also analyzed consistent show that learning model hybrid or *blended learning* which combines interaction face advance with digital activities in structured proven produce more optimal impact compared to pure online learning and learning conventional without same digital elements very. Pham and Ho (2020) in study they in Vietnam found that

learning model designed hybrid with Good capable increase flexibility learn, expand access to source Study quality, at the same time maintain depth interaction social and emotional which becomes superiority learning face face. Findings This underline importance an approach that is not dichotomous in understand technology and pedagogy face advance as two mutual things complement, not each other replace.

Digital Competence of the Future Generation

Findings the second dominant in analyzed literature related with definition, measurement, and development strategy digital competence future generations. There is sufficient convergence strong among various study that required competencies future generations Far beyond ability technical in operate digital devices. Voogt et al. (2021) in study they about challenge learning in the digital world of the 21st century identifies four cluster competence the main thing that must be built through the educational process, namely ability think critical and problem solving problem complex, ability collaborate and communicate in a way effective in digital environment as well as physical, ability create and innovate with utilise technology as a medium of expression, as well as ability digital literacy which includes evaluation critical to digital information, awareness security cyber, and understanding about implications ethical from use technology.

Research by Scherer et al. (2021) which uses framework DigComp For evaluate digital competence of teachers in 25 countries provides a pretty good picture worrying about gap existing competencies. The majority of teachers, especially in developing countries, still is at the basic digital competency level until medium, with weakest ability precisely be in dimension solution digital issues and creation digital content in a creative. Condition This own implications direct to quality development participants' digital competencies educate, remembering that teachers are the most central actor in determine quality experience digital learning received participant educate in the room class. If the teacher himself Not yet own adequate digital competence, then expectation that participant educate will

develop sophisticated digital competencies through formal education processes to become something that is not realistic.

Tang and Chaw (2022) in study they about digital literacy as prerequisite learning effective in environment *blended learning* find that participant students who have level more digital literacy tall show involvement learning that is significant more active, results learn more good, and level satisfaction learn more tall compared to participant educate with low digital literacy. Findings This emphasize position digital literacy is not just as one of the necessary competencies developed through education, but rather as fundamental prerequisites that must be met filled moreover first so that all benefit digital transformation in education can enjoyed optimally by participants education. The implication is that the development program systematic and sustainable digital literacy must become component must in every initiative transformation digital education, not something that is assumed Already owned by participants educate in a way automatic Because they born and raised in the digital era.

Impact The COVID-19 pandemic as Catalyst Transformation

Findings the third one that doesn't can ignored in discussion This is role the COVID-19 pandemic as catalyst outside normal at a time brutal stress test against readiness system global education in carry out digital transformation in massive and fast. Bozkurt et al. (2020) in study global which includes response education from more from 30 countries found that pandemic in a way simultaneously reveal two mutual things contradictory that is capacity extraordinary adaptation normal from community global educators in respond crisis, at the same time gap very deep structural in matter access technology, digital competence, and readiness institutional which during This hidden behind normality system education conventional.

Dong et al. (2020) in study they about online learning for children age early in China during pandemic find that although technology succeed maintain continuity learning formally, there are impact significant negative to dimensions social-emotional development children who do not can facilitated in a way adequate by online learning. Interaction

physique with Friend peers, development skills social through game together, and the formation of bond emotional with the teacher is dimensions very difficult learning replicated in virtual environments, especially For children age early development social-emotional development is highly dependent on interaction physique directly. Findings This become reminder important that digital transformation in education must always consider dimensions development holistic human, not only focus on the transfer of knowledge and skills technical solely.

Azubuike et al. (2021) in study they in Nigeria revealed that experience online learning during pandemic precisely make things worse gap education that has been There is previously. Participants educate from family with limited internet access and digital devices that are not adequate experience significant learning loss more big compared to colleagues they from more family prosperous. Gap This No only nature temporary during period pandemic, but rather potential create effect term long in the form of widening canyon competence between group socio-economic that can hinder mobility social and growth inclusive in term long. Findings This emphasize that policy transformation digital education that is not accompanied by with an affirmative strategy For overcome the digital divide will end as policies that are paradoxical make things worse inequality that is desired overcome.

Intelligence Artificial and Future Personalization Learning

Findings the fourth one that is increasingly stand out in literature latest is about penetration intelligence artificial to in ecosystem education and its implications to personalization learning as well as redefinition competence humane. Zawacki -Richter et al. (2019) in review systematic they about application intelligence artificial in education tall identify four main areas use of AI in education, namely profiling and prediction performance participant educate, adaptive intelligent tutoring system, assessment and evaluation automatic, and development content personalized learning. Each of these areas offer potential improvement efficiency and effectiveness very significant learning, but

at a time bring up questions ethical issues that have not been fully answered about data privacy, algorithmic bias, and implications pedagogical from handover decision learning to system intelligence artificial.

Cope and Kalantzis (2021) in study they about intelligence artificial and future education argue that the increasing presence of generative AI advanced forcing the world of education For do fundamental redefinition of what is real become mark unique education humans in an era when machine can do Lots task cognitive with precision that goes beyond ability average human being. They argue that answer on question This lies in strengthening dimensions capacity humanely which inherent No can duplicated by machine, namely creativity based on experience authentic living, empathy and intelligence emotional, ability consideration ethical in ambiguous context, and capacity For find meaning and purpose in existence humane. The implications for curriculum is that future education must the more focused on development qualities here it is as core competencies, not on memorization fact or mastery procedures that have been can done more either by machine.

Factor Supporters and Inhibitors Digital Transformation of Education

Synthesis literature also produces sufficient mapping comprehensive about factors that are consistent appear as supporters and inhibitor success digital transformation in education. From the side factor supporters, three the most frequent factors confirmed in a way cross studies is commitment leadership institutional to vision clear and long-term digital transformation long, investment sustainable in development digital professionalism of teachers, as well as availability infrastructure reliable and equitable technology. Huang et al. (2021) in study they about practice education open in China during pandemic find that previous institutions has build culture strong digital innovation capable adapt with transformation distance learning more fast and effective compared to new institutions start digital transformation as response crisis solely.

From the side factor inhibitors, van Dijk (2020) identified four dimensions digital divide

which is systemic hinder equality benefit transformation digital education, namely gap motivation in adopt technology, gap access physique to devices and connectivity, gaps digital skills, and the gap meaningful use. Fourth dimensions This each other related and forming circle difficult inequality disconnected only with intervention on one dimensions only. Williamson et al. (2020) added that commercialization of technology platforms education by companies technology big is also factor inhibitor frequent structural ignored, because dependence institutions education on commercial platforms create data privacy risks, vendor dependency that is not healthy, and distorted orientation from objective pedagogical going to objective commercial in design technology learning.

Implications For Education Policy and Practice

Based on synthesis comprehensive from all over themes found, there are a number of implications important things that can withdrawn for development policies and practices education. First, transformation digital education must conceptualized as transformation system in a way comprehensive which includes dimensions pedagogical, institutional, policy, and infrastructure in a way simultaneous and integrated, not as addition technology to in existing system without change fundamental structural development. Second, the development of teachers' digital competence must be prioritized as investment strategic term length that is not Can postponed or done in a way partial, because teacher quality is determinant main quality experience digital learning received participant educate. Third, policy digital transformation in education must in a way explicit and proactive integrating digital inclusion strategies for ensure that transformation This No make things worse the existing gap, but rather become instrument equality access and quality more education democratic for all over layer society (Rizvi et al., 2022; UNESCO, 2021). Fourth, the system education need quick develop framework curriculum and assessment that are explicit put development competence inhumane replaced by intelligence artificial as priority main, so that the graduates produced truly Ready For contribute in a way meaningful in the world of

work and life increasingly social dominated by automation and intelligence made in decades upcoming.

CONCLUSION

Based on results synthesis systematic of the 27 articles analyzed, it can be concluded that transformation education in the digital era is not just instrumental changes in use tool technology, but rather shift fundamental paradigm in method learning conceptualized and implemented. Technology proven give impact significant positive to development competence participant educate, but its effectiveness depends heavily on the quality design pedagogical and digital competencies of educators who implement it. The COVID-19 pandemic has accelerate adoption technology education globally at once emphasize the digital divide that still exists become obstacle structural main in equality benefit transformation This.

Required competencies future generations covers digital literacy, thinking critical, creativity, and collaboration that are not can replaced by intelligence artificial. Therefore that, the system education sued For designing curriculum that is explicit develop dimensions humanity the in a way sustainable research furthermore recommended For explore more in impact term long technology to development competence participant educate, especially in the context of developing countries like Indonesia which has challenge unique and complex digital transformation.

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