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THE K4F MODEL FOR DEEP LEARNING POLICIES: INTEGRATIVE FRAMEWORK FOR ADAPTIVE GOVERNANCE AND POLICY LEARNING IN EDUCATION

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Abstract

The implementation of public policies often encounters many challenges due to a lack of coordination between sectors, a lack of technological access, and a limited policy learning process. This study used the Integrative Literature Review (ILR) approach. The aim of this study is to create a conceptual model of policy implementation by combining theoretical and empirical results from five reputable international journal articles discussing cross-sector public policies. This study was conducted in four systematic stages: (1) content analysis; (2) thematic mapping; (3) creating a conceptual model; and (4) contextual analysis of education policy issues related to deep learning in Indonesia. This study has novelty in integrative literature synthesis, resulting in the K4F (Key Four Factors Framework) model by comparing four main aspects, including leadership, collaboration, adaptive justice, and sustainable learning through framing elements as a binding element of values and policy direction. The K4F model showed that the success of a policy depends on the dynamic relationship between transformational leadership, collaboration, the social justice principle, and a sustainable policy learning system. This model not only broadens theoretical discourse regarding the understanding of adaptive governance and policy learning in education but also provides a practical contribution as a tool to assess the readiness and effectiveness of the implementation of policy in Indonesia related to learning using deep learning and artificial intelligence (AI) approaches.

Keyword: K4F Model, Deep Learning Policies, Integrative Framework, Adaptive Governance And Policy Learning

Introduction

Public policy is an important instrument used by the government to address social problems and improve welfare. However, the implementation of public policies often encounters major challenges. These challenges might be from limited resources, poor coordination among institutions, or social reaction to certain policies. Martikalini (2024) stated that the success of public policies really depends on the ability of policy planners to create implementation mechanisms that can be adapted to the social and political transformations. Public policies are not only measured by the administrative efficiency but also by their ability to maintain advancement and increase the legitimacy of the government. Alamäki et al (2024) found that evidence-based policies often do not achieve the expected results. This is due to a poor implementation process and a lack of understanding of contextual variables that influence policy performance. In the middle of the complexity of the modern government system involving many stakeholders, the traditional approach that focuses on a top-down model in public policies is considered no longer relevant (Shahi & Chaudhary, 2024).

In this framework, the conceptual model of policy functions as an analytical tool to describe the relationship between various policy elements, such as implementation structure, communication mechanism, and environmental factors that influence policy achievements. Developing a policy model based on literature synthesis is really useful because it allows for finding relevant main variables (Adeleye et al., 2024). Facts that various countries experienced failure in implementing policies indicate that the distance between the formulation stage and policy implementation remains an important issue that is not fully resolved. According to the study conducted by Stracke et al (2025), approximately 60% of public policies in developing countries do not achieve their main goals. This is particularly due to poor cross-sector coordination and suboptimal monitoring and evaluation systems. The development of a policy model that is based on integrative synthesis, in this context, is increasingly important because this method allows the researcher to find and map components that influence the success and failure of policies systematically

and thoroughly (Garzón et al., 2025). This model also functions as a conceptual tool that assists policy makers to assess the effectiveness, implementation readiness, communication among components, and policy abilities to adapt to changing social dynamics. Although many studies have emphasized that leadership, cross-sector collaboration, equal access to technology, and policy learning are factors supporting technology-based educational transformation, there is no integrative model that can combine these four factors thoroughly in one framework that is contextual and adaptive to local dynamics of education policy implementation The Regulation of the Minister of Primary and Secondary Education of the Republic of Indonesia Number 13 of 2025 emphasizes that the use of artificial intelligence (AI) technology in the deep learning process is really important (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia, 2025). Until this time, this policy has not been learned thoroughly from the perspective of implementation. This study should focus on a conceptual model that can address various obstacles of implementation in the field, such as the level of human resource readiness, geographic distance, and organizational culture dynamics at the school. This situation indicates a significant difference between the reality of policy implementation at the practical level and policy design at the normative level. This result is in line with the findings of an international study that highlights the importance of implementing an adaptive governance approach and policy learning loop when creating and implementing digital educational policies to be more contextual, inclusive, and sustainable (Janssen, 2025). Therefore, the development of a more integrative, adaptive, and contextual policy implementation model is an urgent need for public policy that is not only an ideal conceptually but also able to be implemented effectively in the field.

Thus, the aim of this study is to provide a theoretical contribution to the development of public and educational policies by developing the concept of an integrative and contextual policy model. To achieve this goal, the researcher used various important approaches from previous research findings related to various aspects considered to play a role in the success of public policies. This study is expected to provide strategic guidelines for policymakers, educational institutions, and other stakeholders to make and implement deep and digital education policies that are more inclusive and responsive. This policy must also be in accordance with the community's needs and direction of sustainable national development. Moreover, the aim of this study is to make a conceptual model of educational policies. To achieve this goal, this study used approaches that combine relevant theoretical and empirical literature. To generate this model, the process of policy formulation, implementation, and evaluation is integrated into a conceptual framework that can be adapted to the dynamics and context of education in Indonesia. This objective is based on the urgent need for a policy model that can answer challenges related to the implementation of educational technology and developing a smart, flexible, and sustainable policy system.

Methods

Themain focus of this study was the Integrative Literature Review (ILR) approach. This approach was chosen due to its ability to combine empirical and theoretical results from various studies to create a comprehensive and flexible conceptual model of policy implementation for various situations. ILR is synthetic and emphasizes the development of new theory through the combination of diverse research results, both from the approach and policy context. Otherwise, the Systematic Literature Review (SLR) focuses on a quantitative approach and emphasizes methodological analysis (Armstrong & Kamieniecki, 2017). Context analysis, thematic mapping, conceptual model development, and contextual analysis were four systematic stages used to investigate educational policy issues in Indonesia regarding deep learning (Azzam & Charles, 2024). The data source of this study was from five articles published in leading international journals discussing issues and procedures of implementing public policies in various sectors. According to Alamäki et al (2024), a scientific search was conducted to obtain these articles.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were used to ensure the relevance and quality of literature from the analyzed articles, as presented in Table 1 below:

Table 1. Inclusion and Exclusion Criteria of the Literature

Aspect	Inclusion Criteria	Exclusion Criteria
Focus of the Study	Policy implementation, public policy model, and education policy	Studies that do not focus on policy implementation, public policy, or education policy
Publication	Articles published in international journals indexed by Scopus (Q1-Q4)	Articles from proceedings, books, project reports, theses, or grey literature that are not indexed by Scopus
Year	2020–2025	Before 2020
Language	English	Other than English
Database	Scopus, ScienceDirect	Not found in Scopus, ScienceDirect
Accessibility of Document	Articles available in full-text and accessible for analysis	Articles that only show abstract, not full-text

Stage 1: Content Analysis
In this stage, each articles selected were examined comprehensively. The aim of this analysis is to disclose policy strategies implemented, components that contributed to success, various constraints in implementation, and the context of policy implementation in each study. As shown by the research results, the analysis focus was to obtain a thorough understanding of the dynamics of policy evaluation, implementation, and formulation (Taeihagh, 2025).

Stage 2: Thematic Mapping
The results of content analysis were mapped in the main dimensions of public policy cycles, which included policy formulation, implementation, and evaluation. Thematic relationships between policy components were formulated for this mapping, which was conducted through axial coding and open coding (Aslipour, H, 2022).

Stage 3: Conceptual Modeling
Furthermore, all the mapping results were combined into a factor framework. This factor framework is a conceptual model of policy implementation that depends on key factors found in the content analysis. This model combined various important aspects from public policies, such as integration between policy process, actor roles, and the surrounding policy context. This model also shows the direct and indirect relationship among variables, as well as shows the mechanism of the feedback loop or the feedback relationship, which explains how changes in an element can have an impact on the dynamics of policy comprehensively. A framing component was added to increase the normative dimension and ensure that the policy process was in accordance with the principles of sustainability and justice.

Stage 4: Contextual Analysis
Policy models that have been developed were then evaluated in the context of national education policies in Indonesia. In particular, this analysis was focused on the implementation of the Regulation of the Minister of Primary and Secondary Education Number 13 of 2025 concerning learning based on deep learning and artificial intelligence (AI). The aim of this analysis stage was to evaluate the relevance and validity of model practice in the context of national educational policies in Indonesia.

By referring to the previous studies regarding transformational leadership, adaptive governance, and policy learning, the analysis was strengthened by comparing policy theory and conceptual triangulation (Žerovnik, 2024). Therefore, the ILR method combined studies from various literature sources. This also resulted in a policy model framework that can be used strategically and contextually at the level of education implementation.

Results

Four systematic stages from the Integrative Literature Review (ILR) approach were content analysis, thematic mapping, conceptual modeling, and contextual analysis. These four stages were intended to cooperate to

make a flexible and responsive public policy model that can be adapted to changes that occur in implementing educational policies based on deep learning and artificial intelligence (AI) in Indonesia.

Content Analysis

In this stage, five articles from leading international journals were collected to examine the dynamics of public policy implementation in various fields. The following are some important results from literature analysis and integration:

Table 2. Content Analysis

No	Author (Year)	Title	Journal (Index)	Method	Design	Finding	Policy Dimension
1	Rachmian, A., et al. (2025)	When and why are public policies successfully implemented? The case of "the second preschool-teacher's assistant reform"	International Journal of Child Care and Education Policy (ICEP) (Scopus Q2)	Qualitative analysis and comparative policy study based on OECD and UNESCO documents to assess teacher policies across countries.	Descriptive-analytical research design	The success of educational reform is determined by the perception of local government autonomy, with transformational leadership being a moderating variable for the role of teachers as street-level bureaucrats in interpreting and implementing policies in the field	Leadership
2	Hooker, R. S., & Cawley, J. F. (2020)	Public Policies that Shaped the American Physician Assistant	Health Policy OPEN (Scopus Q1)	Historical documentation study on policies and 18 US health policies to assess the influence of public policy on the physician assistant (PA) profession	Historical-normative qualitative design with a chronological approach	Successful implementation due to the continuity of federal policy that builds the physician assistant (PA) profession in the United States through policy adaptation and inter-institutional collaboration, especially through educational reform and the funding system	Adaptivity Collaboration
3	Losa, R. (202)	Public Policies on Circular Economy: A Systematic Review	Ecological Economics (Scopus Q1)	Systematic literature review (PRISMA) of 54 publications related to circular economic policies in the European Union to identify policy and research gaps	Systematic qualitative-synthesis research design with 9R Framework analysis	The importance of distributing the benefits of economic policy comprehensively. The success of policy really depends on whether the community feels that the policy is fair, both in terms of the economy and the decision-making process	Equity
4	Aguinis, H., et al. (2021)	The why, how, and what of	Tourism Management (Scopus Q1)	Critical literature review based on	Systematic quantitative-descriptive	The implementation of policies is effective if	Adaptivity

		public policy implications of tourism and hospitality research		the database Web of Science on 12,269 articles (2012-2021) with the focus on the dimensions of why, how, and what in tourism policies.	research design with thematic coding.	academic research is connected to the public policy practice. How policy is able to respond to the complex and changing tourism environment dynamics through adaptation, and how policy evaluation can be carried out sustainably and based on data.	Learning Sustainability
5	Vashistha, H. (2022)	Revisiting the Education Policy through Global Lens: Exploring the Missing Affirmative Actions in National Education Policy 2020	Lex Localis Journal of Local Self Government (Scopus Q3)	Comparative qualitative analysis between national and international educational policies (India, USA, UK, Finland).	Descriptive-comparative research design based on policy documents and global literature (UNESCO, OECD, SDG 4).	Criticisms of the NEP 2020 policy, especially the historical caste-based injustice, require affirmative policy and recognition of structural inequality through a distributive justice approach and explicit recognition of caste discrimination to create equal educational policies.	Equity

Five scientific articles that are relevant to the implementation and effectiveness of public policies were studied comprehensively and critically before being used for content analysis. Each article was examined comprehensively to identify the policy approach used, the elements that contribute to success, and the challenges that emerge during the implementation. The analysis results of the five articles showed that there are various methods and perspectives to understand the dynamics of public policy implementation in various institutional, social, and international contexts. Rachmian et al (2025) emphasized that the success of public policy implementation really depends on the transformational leadership and ability of local policy implementers to be empowered. This study found that feedback mechanisms from the field are really important for policy makers to adapt to changes and dynamics in the contexts of social and institutional. A case study of Second Pre-School Teacher Assistant Reform in Israel involved 174 teachers in 58 schools. The result showed that the perception of the level of local government autonomy and the implementation of transformational leadership by the main teacher are really influenced by the success of public policy implementation. This finding emphasizes that the success of policy reform not only depends on the policy design but also mainly on the quality of the implementation process and the strategic role of leadership in street-level bureaucrats. Hooker & Cawley (2020) emphasized that effective public policies emerged from the continuity between cross-decade policies, regulatory support, and stable financing. The successful implementation of the health system in the United States demonstrates the importance of political consistency and resource allocation, which become the main foundation for the success of long-term public policies. This article mapped 18 US federal policies (1996-2024) that established the Physician Assistant (PA) profession. This study emphasized how public policies gradually and consistently, from Medicare, Medicaid, to the Affordable Care Act, established the successful implementation of a more efficient health service model. The main finding showed that the success of public health policies depends on the integration between regulation, financing mechanism, and educational incentive, which are mutually reinforcing sustainably.

Losa (2025) reviewed comprehensively 54 publications that discuss circular economy (CE) policies in the European Union and found that the success rate of CE implementation really depends on how well cross-institutional

coordination and policy harmonization among sectors can be achieved. Policy fragmentation and regulatory overlap were identified as the main causes for the failure of CE implementation. This study emphasizes the importance of cooperation between stakeholders. Aguinis et al (2023) emphasized the importance of policy learning and making evidence-based policies in improving the differences between public policy practice and academic research. Sustainable policy learning is used to make policies that are more relevant, measurable, and resilient to changes. This study analyzed more than 12,000 articles in the tourism and hospitality sectors published from 2012 to 2021 and found that most of the research findings have not been implemented in concrete policy. They suggested a conceptual model of why, how, and what to connect academic theory and policy practice. In terms of implementation, this study emphasizes that policymakers, academics, and industry actors must cooperate to implement public policies effectively and have a broad impact.

Through the study on India's National Education Policy (NEP) in 2020, Vashistha (2025) found that neglect of social and local inequalities often becomes the cause of policy implementation failure. This study showed that caste discrimination in the discriminated socioeconomic group (SEDG) in India remains a problem unresolved by social inclusion policy. The results of the analysis showed that public policy can only be successful if it is affirmative and contextual. Otherwise, using a universal approach without considering social conditions will only deepen structural gaps. The five studies showed that policy design is not the only factor determining the successful implementation of public policies. It also depends on good cross-sector collaboration, the implementation of contextual equity principles, and the ability of the policy system to learn and adapt to the social, political, and technological changes.

Thematic Mapping

Based on the findings of content analysis, the five articles were categorized into three main phases of public policy cycles: formulation, implementation, and evaluation. In the Formulation stage, articles written by Aguinis et al (2023), Losa (2025), and Vashistha (2025) emphasized the urgency of formulating policies based on the empirical evidence (evidence-based) and oriented towards social equity principles (equity-based). The two studies showed that a strong policy foundation must be based on contextual data and analysis that pay attention to social disparity and real community needs. On the other hand, Hooker & Cawley (2020) emphasized that coherence and consistency of policy for ten years are really important to maintain stability and successful implementation in the long term. The results from Rachmian et al (2025) and Hooker & Cawley (2020) supported the implementation stage, which emphasized that the success of policy implementation really depends on the empowerment of implementers at the local level and effective inter-institutional collaboration. In these two articles, there is conclusive evidence that a strong coordination mechanism and active involvement of various policy actors are really important to generate adaptive and sustainable implementation. In the evaluation stage, Aguinis et al (2023) stated that a systematic policy education mechanism and continuous feedback from implementers in the field to the policy makers are ways to ensure the sustainability and resilience of public policies. This method allows a continuous cycle of policy development, which allows policies to adapt to changes in social, economic, and technological environments. Overall, the findings of this mapping showed that the success of public policy implementation requires evidence-based and equity-based policy design, strong implementation capacity, effective cross-sector coordination, and a flexible and intelligent evaluation system that considers changes in the policy environment.

Conceptual Modeling

This study resulted in a public policy model called K4F (Key Four Factors Framework). This model was made as a result of the conceptual integration of the five articles studied. Four main factors that determine the success of public policy implementation are as follows:

K1: Leadership
Emphasizing the importance of the role of transformational leadership, which can inspire the implementers, direct the policy vision, and ensure the sustainability of the implementation process.

K2: Collaboration
Referring to the active involvement of various cross-sector actors, including educational institutions, companies, and civil society, to create a synergy in policy implementation.

K3: Equity Adaptivity
Emphasizing the importance of implementing social justice principles in policies and the ability of policies to adapt to social, geographical, and technological changes.

K4: Learning Sustainability

Concentrating on the ability of the policy system to learn from the implementation experiences, improve itself reflectively, and ensure that policies remain sustainable in the long term.

F: Framing

This model has four main factors, besides framing. This element serves to unify values and policy direction, ensuring that the policy is consistent and relevant in a changing context. To remain in sync and adaptive to social, economic, and political changes that influence the public policy process, framing involves four main components: bridging, amplification, and transformation (Li et al., 2023).

The three main functions of framing are as follows:

1. Bridging: bridging the relationship between factors to create policy synergy;
2. Amplification: strengthening values, objectives, and impacts of policy in each implementation stage; and
3. Transformation: allowing policy to adapt to the complex environmental changes.

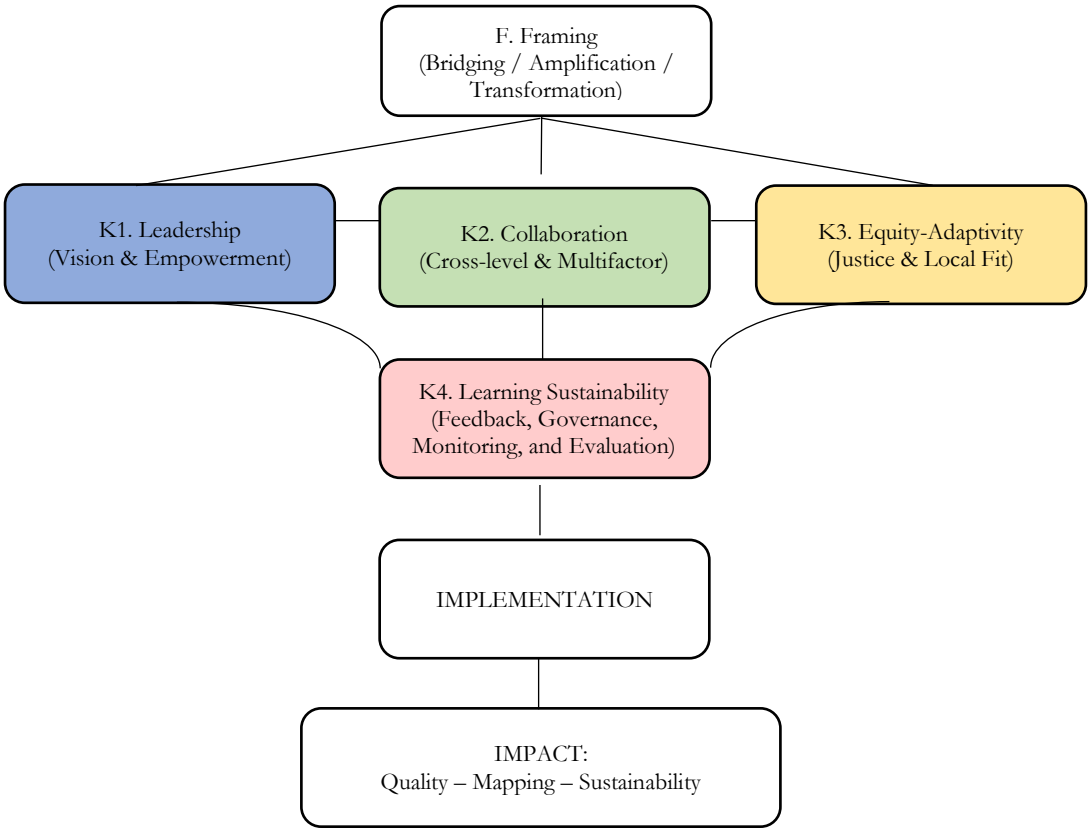

Figure 1. K4F (Key Four Factors Framework) Conceptual Model with Framing Element, Direct and Indirect Relationships, and Feedback Loop

In this framework, leadership (K1) serves as the main driver that drives cross-sector collaboration (K2), strengthens the implementation of the principles of social adaptation and equity (K3), and facilitates the sustainable policy learning process (K4). Framing (F) dimension as a binding force of value and policy direction to ensure that the meaning remains the same, social legitimacy, and policy alignment persist in the midst of the changes. Feedback mechanism, which is from K4 factors, ensures that the policy implementation process always has a continuous improvement through policy learning cycles and iterative policy reflection (Li et al., 2023). Each arrow indicates a flow of influence that occurs directly, indirectly, and through feedback in the conceptual diagram of the K4F model, which indicates the direction and intensity of the relationship between factors. Therefore, this model provides a clear overview of how mutually reinforcing variables in the formulation, implementation, and evaluation of public policies interact with each other (Moyson et al., 2017). In the K4F (Key Four Factors Framework) model, the relationship pattern shows the relationship between components. This pattern includes direct and indirect relationships, as well as a feedback mechanism. This method reflects the characteristics of a public policy system that is always changing, complex, and able to adapt to changes in social, economic, and political sectors (Bello & Jawawi, 2025). The explanation is as follows:

1. Direct Relationship
   Vertical arrow flow from Leadership (K1), Collaboration (K2), Adaptivity Equity (K3), and Sustainable Learning (K4) shows a direct relationship pattern. Visionary and transformational leadership drives effective cross-sector collaboration. Moreover, effective collaboration strengthens the implementation of social justice values and contextual adaptation, and good implementation of equity and adaptation creates a foundation for the learning system.
2. Indirect Relationship Diagonal line connects important elements, such as K1 with K3 and K4, and K2 with K4. This indicates that strategic leadership influences direct and indirect collaboration through the establishment of organizational values, culture of cooperation, and mechanisms of policy reflection. Therefore, an indirect relationship indicates a systemic interdependence that is mutually influential and nonlinear (Azzam & Charles, 2024).
3. Feedback Loop: The Feedback mechanism is illustrated with curved lines, from K4 and looping back to K1, K2, and K3. This pattern indicates that the policy learning and evaluation process carried out in the K4 stage has a significant contribution to improving leadership, increasing collaboration, and improving the ability of policy adaptation in the following cycle. This mechanism supports the idea that public policy is a learning system that is always learning, adapting, and changing according to the social, political, and technological changes (Armstrong & Kamieniecki, 2017).
4. The Relationship between Cross-Dimension and Framing (F) Framing (F) element serves as a unifying value that correlates to all main factors in two directions. Orientation, direction, and normative values of each policy factor are influenced by reframing. On the other hand, the reflective results of sustainable learning (K4) contribute to the policy reframing process in the future (Oncioiu & Bularca, 2025). This two-way relationship indicates the sustainable, reflective, and cyclical processes, where public policy continues to be updated to remain responsive and relevant to the changing contexts (Alamäki et al., 2024).
5. General Meaning of the Relationship Between Elements in the K4F Model. Overall, the relationship between elements shows that public policy is effective in a cyclical, dynamic, and layered system (McLeod & Mortimer, 2012).

Therefore, the K4F model allows policy implementation to be carried out interactively and thoughtfully. This emphasizes cross-actor collaboration, the implementation of social justice, visionary leadership, and sustainable policy learning. Delivering tangible quality, equity, and sustainability in the practice is the main objective of public policy, which is ensured by Framing (F) value dimension (Shahi & Chaudhary, 2024).

Contextual Analysis on Educational Policy Issues in Indonesia

Contextual analysis on actual issues in national education policy was carried out to evaluate the relevance of the K4F (Key Four Factors Framework) conceptual model. One of the examples is the implementation of the Regulation of the Minister of Primary and Secondary Education of the Republic of Indonesia Number 13 of 2025 concerning learning based on deep learning and artificial intelligence (AI) in secondary schools. According to Stracke et al (2025), this policy marks an important point in the transformation of the national education system towards a learning system that is integrated with smart and data-based technology. To fulfill this policy, complex and multilevel innovation of educational governance is required. The success of policy implementation really depends on how good the synergy is between policy actors at central and regional levels and how well the policy can be adapted to various contexts of social, economic, and educational infrastructure in several regions (HE Jinghua et al., 2025).

By referring to the K4F framework, the implementation of learning policy based on deep learning and AI can be analyzed more deeply through four main dimensions:

1. Leadership. It can be used to analyze more deeply the implementation of learning policy based on deep learning and AI. Teachers and principals are transformational leaders who can encourage and manage changes, as well as facilitate technology-based learning. Adaptive leadership is really important to foster an innovation culture and assist educational institutions to integrate AI productively and morally (Al-Omari et al., 2025).
2. Collaborative. To ensure that the curriculum, infrastructure, and digital capabilities are aligned, the government, higher education institutions, and industrial sectors must work together and collaborate (Shahi & Chaudhary, 2024). Moreover, this collaboration helps strengthen the AI ecosystem for sustainable education and policy-based research.
3. Equity Adaptivity. Policy must ensure equitable access to learning technology, especially for schools in 3T (underdeveloped, frontier, and outermost) regions through affirmative strategies and infrastructure provision

(Garzón et al., 2025). The efforts to ensure equity are in line with the vision of AI Education for All, which emphasizes digital justice and equal learning opportunities throughout Indonesia.

4. Learning Sustainability. Data-based evaluation (AI analytics) was used as a feedback system to improve the quality of sustainable policy implementation (McLeod & Mortimer, 2012). Through this approach, the results of implementation can be analyzed in real-time to strengthen the reflection of adaptive institutional learning policy.

The results of contextual analysis showed that deep learning policy shows the level of conformity with the conceptual structure of the K4F (Key Four Factors Framework) Model. This policy firmly emphasizes that adaptive leadership is really important to change education. This also includes multisector collaboration between government, educational institutions, and industrial partners, as well as the implementation of social justice and policy adaptability in different local contexts. Moreover, this policy includes a sustainable policy learning mechanism, which allows for continuous consideration and improvement in its implementation. Therefore, the K4F model not only serves as a theoretical idea but also a practical diagnostic platform that can be used to assess the sustainability, readiness, and effectiveness of the implementation of digital education policy in Indonesia (Janssen, 2025).

K4F Model on the Implementation of Deep Learning and AI in Indonesia (The Regulation of the Minister of Primary and Secondary Education No. 13 of 2025)

SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis was conducted as an evaluation step on the implementation of deep learning policy and artificial intelligence (AI) in Indonesia. This analysis examined the strengths, weaknesses, opportunities, and threats in each dimension of the K4F Model. The aim of this analysis approach is to assess the extent to which each dimension of K4F contributes to national awakening. This SWOT mapping will assist in finding which strategic elements must be strengthened. This includes transformational leadership, cross-sector synergy, technology adaptation, equitable access, a sustainable policy learning system, and a value framework that ensures policies remain relevant, inclusive, and oriented to national education transformation.

Table 3. SWOT Analysis of Deep Learning Policy Based on K4F Model

Dimension	Strengths	Weaknesses	Opportunities	Threats
K1 Leadership (Vision & Empowerment)	National leadership through the Regulation of the Minister of Primary and Secondary Education No. 13/2025 has mandated a deep learning system-based educational transformation; Some innovative pioneer principals/teachers have a strong will; Available various digital-based principal training programs.	Disparity of digital leadership capacity; Organizational culture is not yet data-based; Heavy administrative burdens hinder the role of instructional leadership.	AI leadership micro-credential program for principals; Career incentives based on implementation impact; A network of practice for AI teachers is emerging.	Resistance to change from stakeholders; Rotational changes of officials disrupt the continuity of policy; The ethical risks of using AI cause excessive caution in the implementation of learning.
K2 Collaboration (Cross-level & multi-actor)	Availability of cross-sector partners (PT, ICT industry, EdTech Community);	Coordination between the central and regional governments is not in sync;	National Consortium on AI-based curriculum; Classroom action research collaboration	Vendor interests relying on a single platform weaken national digital sovereignty;

	Collaborative platforms make the curriculum more developed.	An MoU without real implementation is more administrative than strategic.	involves cross-sectoral; Output-based partners (content, training, practical equipment).	Issues related to potential violations of students' data and the misuse of digital learning algorithms.
K3 Equity Adaptivity (Justice & Local Fit)	Commitment to equitable access to Information and Communication Technology (ICT); A more flexible curriculum allows contextualization according to local needs; AI connectivity device assistance continues to improve.	Infrastructure gap in 3T areas; Diverse students' language/computing abilities; Deep learning materials tend to be technical and are not always relevant to the local context.	The multilevel competency model applies problem-based learning; Problem-based local content; Digital affirmation for 3T areas (device assistance, offline-first).	Reproduction of inequality (school stratification); Exclusion of special students does not consider socioeconomic conditions holistically.
K4 Learning Sustainability (Feedback, Governance, Monitoring & Evaluating)	Available AI Learning Evaluation platform; Strong government commitment to establishing an evaluation system.	There is no deep evaluation data system, and its coverage is not comprehensive; Monitoring is not adaptive, still descriptive, and has not led to quick improvement.	National dashboard of AI-based policy monitoring implementation; Educational institutions can monitor the effectiveness of policy sustainably.	Additional reporting burden; Data security risk; Inappropriate performance metrics create dependency on central infrastructure and stagnation of innovation.
F Framing (Bridging / Amplification / Transformation)	The digital transformation narrative is strong nationally; Public and media support increases with relevant AI issues	The approach is still technocentric; Public communication has not emphasized the pedagogical and ethical benefits.	Back to problem-solving-based pedagogical concept; Establishing public literacy on AI that technology does not replace the role of the teacher	AI ethics/hoax controversy; Public resistance, if AI is not managed properly, concerns about dehumanization emerge.

Leadership (Visionary Leadership and Empowerment of Implementers)

The Regulation of the Minister of Primary and Secondary Education Number 13 of 2025, which encourages deep learning-based curriculum transformation and integration of artificial intelligence in the learning process, shows the strength of leadership dimensions. Creative teachers and principals have been pioneers in the use of this technology and have begun to use digital platforms to improve the quality of teaching (Peng & Li, 2025). Moreover, a digital leadership training program has been introduced, which provides a foundation to improve teachers' abilities to adapt to changes (Bahri et al., 2025). This indicates that regional leadership has different skill levels; for example, some educational units do not know how to use digital technology. Schools in 3T areas (underdeveloped, frontier, and outermost) have lower access to training and digital infrastructure than schools in urban areas (Li et al., 2023). Moreover, an educational organizational culture that is not yet data-based and administrative becomes a constraint to implementing contemporary educational governance. Principals often do not have enough time to act as innovative and creative instructional leaders due to heavy administrative burden (Moyson et al., 2017). The development of an AI-based micro-credential program to assist principals and master teachers to be better in digital leadership is one of the opportunities that can be used in this dimension. Furthermore, a career incentive system that focuses on educational innovation can encourage more innovative and results-based leadership. Otherwise, cross-regional

education leaders can use an AI-based community of practice network to encourage exchange of experiences, knowledge, and best practices (Behera et al., 2025). Among threats from this aspect is the emergence of resistance towards changes from conservative policy groups or actors, as well as the possibility of policy disruption that can occur due to changes in structural officials and leadership rotation. Moreover, there are ethical and dehumanization problems that emerge when artificial intelligence (AI) technology is used in the educational process. This can cause social and psychological resistance to technological transformation in education (Stracke et al., 2025).

Collaboration (Cross-Sector and Cross-Level Collaboration)

Collaboration allows the ministry, higher education, and technology industries to collaborate across sectors. The example of collaboration like this is the Ministry of Education, Culture, Research, and Technology and Google for Education, which encourages the growth of the national EdTech ecosystem (Bonny, S. et al., 2025). This is an example of a collaborative initiative, showing that all people recognize the importance of combining policy, technology, and human resource capabilities. However, the weakness of collaboration in Indonesia is clear, particularly since the relationship between the institution and stakeholders tends to be administrative rather than strategic. Policy directions are often messy, overlapping, and less integrated systemically due to the lack of a national policy center that serves as the cross-sector coordination center for AI policy for education (Stracke et al., 2025). Poor interoperability between digital learning platforms also hinders the exchange and integration of data between schools. Ultimately, this will hinder the implementation of artificial intelligence-based policy (Adeleye et al., 2024). The formation of the Deep Learning Consortium for Education, a collaborative platform involving the government, university, and private sectors, is the most effective strategic choice. According to HE Jinghua et al. (2025), the consortium serves as an integrative platform to conduct policy research, develop education technology innovation, and develop artificial intelligence-based curriculum, which are in accordance with national and global development. It is important to anticipate possible dangers, especially related to the dominance of Big Tech companies, which can lead to dependence on certain vendors and ultimately weaken the national educational digital authority. Moreover, collaboration without a strong ethical framework and data protection regulations can lead to the breach of student data privacy and algorithm abuse in digital learning (Stracke et al., 2025).

Equity Adaptivity (Equity and Contextual Adaptation)

This dimension is really strong because the government has issued policies that support technological access and AI training for schools in 3T areas (underdeveloped, frontier, and outermost). AI program for education and free-learning curriculum supports the flexibility of local context-based learning (Adeleye et al., 2024). Inadequate infrastructure and digital literacy in regions remain a problem. Artificial intelligence-based learning materials are often too technical and are not fully in accordance with the local socio-cultural environment. Otherwise, many educational institutions in rural areas still encounter constraints related to technological devices and internet connectivity (Oncioiu & Bularca, 2025). Opportunities for policy development can be found using a problem-based learning approach and a multilevel competency model, known as the multilevel learning model. Moreover, the use of offline-first devices is better to ensure the same access to digital education in areas with limited network and infrastructure (Armstrong & Kamieniecki, 2017). The possibility of a new digital gap and the possibility of schools with low capacity being marginalized are dangers that must be anticipated, particularly if the policy made does not consider the socio-economic conditions of the community comprehensively (HE Jinghua et al., 2025).

Learning Sustainability (Policy Learning and Sustainability)

Learning Sustainability (Policy Learning and Sustainability): The main strength of this dimension is the implementation of a reflective approach in digital education policy through the development of the National Education Data Warehouse and the implementation of the AI Learning Evaluation Framework. This strategic step demonstrates the government's strong commitment to establishing a data-based and useful policy evaluation system (Al-Omari et al., 2025). The current evaluation system is still descriptive and has not reached the introspection and deep analysis stages. Artificial intelligence-based feedback loop mechanisms are still limited, and evaluation data is not always used for policy updates (Shahi & Chaudhary, 2024). It is really beneficial to develop an AI-driven Policy Dashboard as an education policy monitoring system that works in real-time. This innovation allows policy makers and educational institutions to analyze, monitor, and study how policy implementation runs and continues to improve it (Alamäki et al., 2024). Excessive dependence on central infrastructure and possible stagnation in policy innovation are the risks to consider. This mainly applies if the policy learning system is not automated and integrated

systematically into the education governance ecosystem. Global study demonstrates that the innovation gap, infrastructure centralization, and inability to meet local needs increase if there is no adaptive governance and digital integration (Jian & Mustafa, 2024).

Framing (Narrative Framework and Policy Value)

The strength of the Framing dimension lies in the fact that the national narrative regarding education digital transformation is consistent with global strategies, such as UNESCO AI in Education 2023. Policy narrative emphasizing AI for inclusive and adaptive education has strengthened social and political legitimacy of the direction of national policy (Žerovnik, 2024), as well as emphasizing the position of Indonesia in the education transformation agenda. At the grassroots level, there is a difference in the understanding and implementation of policy due to the difference in framing between the central and local governments. Moreover, policy communication has not been fully engaging, inclusive, and easy to understand by teachers and implementers in the field (Wu et al., 2024). From the perspective of opportunity, establishing a policy narrative based on humanitarian values, cooperation, and the ethics of using technology can help strengthen framing. This method sees technology as an instrument to improve the learning process and strengthen human interaction in the classroom. Otherwise, it sees technology as a substitute for the role of teacher (Behera et al., 2025). An increase in public concerns about the automation of education and the possibility of dehumanization in the learning process is a danger to consider. If policy framing is not managed properly, it can reduce the social legitimacy of policy and lead to ethical and emotional resistance among the community and teachers (Xu & Wang, 2025). Table 4 below demonstrates strategic recommendations to implement a deep learning policy based on the five main dimensions of the K4F (Key Four Factors Framework) Model. The aim of this table is to strengthen the results of the analysis and offer practical steps that can be used by policymakers, educational institutions, and other stakeholders in implementing deep learning and artificial intelligence policy.

Table 4. Strategic Recommendations for Implementing Deep Learning Policy Based on K4F Model Dimensions

Dimension (K4F Model)	Main Recommendation
K1 Leadership	Developing an 'AI Instructional Leadership' program for principals/master teachers; Establishing career incentives and implementing indicator-based performance recognition (students' achievements in AI competency, quality of project, community involvement).
K2 Collaboration	Establishing the National Deep Learning Curriculum Consortium (Ministry of Education and Culture Higher Education, Industry, Community) with learning outcome standards and resource sharing; Strengthening output-based partner scheme: open licensed content, practical modules, local dataset, and project guidance.
K3 Equity Adaptivity	Implementing a multilevel competency model with alternative pathways for 3T schools. '3T Digital Affirmation' Program: device, connectivity, offline-first content; Including AI ethics, privacy, and universal learning design as core competencies in the learning process.
K4 Learning Sustainability	Establishing an integrated learning data architecture to monitor the implementation and learning outcomes; Determining national Key Performance Indicators (KPI) and public dashboard: access, quality, relevance, equity (regional and gender disaggregation); Conducting a quarterly evaluation cycle using controlled trials.
F Framing	Narrative reframing: from 'new technology' to 'inclusive AI-based problem-solving pedagogy'; AI literacy campaign for the public and parents; communicative ethics and safety guidelines; Impact storytelling from pioneer schools to build broader social legitimacy.

In order to ensure that the implementation process of the deep learning process runs in a measurable, accountable, and sustainable way, a set of indicators that is able to describe the performance of each dimension in the policy model is required. Table 5 contains performance indicators and implementation governance adapted to the K4F Model. This

table serves as a reference for evaluation and functional purposes for stakeholders to monitor the effectiveness, consistency, and direction of strengthening digital education policy in Indonesia.

Table 5. Performance Indicators and Implementation Governance

Dimension (K4F Model)	Main Performance Indicator	Governance Mechanism
K1 Leadership	The proportion of AI Leadership certified principals; frequency of lesson study digital; and school data culture index.	Delivery of training units in local areas; principal coaching.
K2 Collaboration	The number of output-based partnerships; the availability of open-access modules and databases.	Consortium of national curriculum.
K3 Equity Adaptivity	Balanced ratio between device and students; participation of schools in 3T areas; equity and accessibility index.	Digital affirmation program; equity audit and data privacy.
K4 Learning Sustainability	Frequency of policy literacy; monitoring and evaluation reports; and adoption of good practices between schools.	National dashboard and data ethics committee.
F Framing	Public perception; AI literacy reach; and the number of stories that have a good impact on deep learning and AI	Policy communication unit; narrative and ethical guidelines for using AI.

Discussion

K4F Model, which is an abbreviation of Framework Four Factors Key, emphasizes four important factors required for the successful implementation of public policy. They are Leadership, Collaboration, Equity, Adaptivity, and Learning Sustainability, with Framing (F) serving as a value dimension that directs the process comprehensively. According to this model, the implementation of public policy can only be successful if there is a balance between the following elements: visionary leadership, cross-sector collaboration, contextual equity, and a sustainable policy learning system (Moyson et al., 2017). These four components provide a complete conceptual framework for Deep Learning Policy in Indonesia, which assists us in understanding why many previous education policies have failed to be implemented properly. As demonstrated by Bangkara et al (2022), some major obstacles in implementing education policy in Indonesia are poor education leadership, a lack of coordination within the government, and a lack of technological access. The K4F Model provides a middle group by positioning the role of leadership (K1) as the main driver of cultural change within schools to be more adaptive to deep learning and technology-based learning. A study by Herliana et al (2025) emphasized that the effectiveness of education policy is really influenced by the quality of leadership that is able to internalize sustainable values and cross-sector collaboration. Her study regarding green leadership plays a crucial role in bridging policy vision with real practices in the school environment, which not only acts as a policy manager but also as an agent of change that fosters awareness, responsibility, and a sustainable learning culture among the school community.

Value-based leadership and social collaboration are the main foundations for the successful implementation of equitable, adaptive, and sustainable digital education policies. Moreover, the collaboration (K2) dimension supports government principles through networks, where synergy between government, industries, and higher education institutions is really important to implement education technology policy (Peng & Li, 2025). This is in line with the study conducted by Hooker & Cawley (2020), which found that the continuity of cross-institutional policy plays a significant role in the success rate of public policy reform. Collaboration between the school and the education technology (EdTech) provider, the development of an adaptive data-based curriculum, and teacher training on how to use AI for contextual learning are examples of deep learning. According to the equity and adaptivity (K3) dimension, the implementation of deep learning policy should consider the digital differences between regions. Findings by Vashistha (2025) regarding education policy in India demonstrated that policy is inclusive if it is able to integrate the principles of affirmative action and support for marginalized groups. Therefore, deep learning policy in Indonesia should accommodate digital affirmation program in 3T areas (underdeveloped, frontier, and outermost)

and ensure access sustainability for all students without exception (Nahumury, 2022). Meanwhile, Learning Sustainability (K4) emphasizes the importance of the policy learning loop or the sustainable policy learning cycle. As emphasized by Asakereh, A., et al (2019), effective education policy cannot be understood merely as a set of administrative regulations, but as a social learning structure that allows for sustainable reflection, feedback, and adaptation across all levels of the educational system. Žerovnik (2024) emphasized that policies that are not accompanied by a data-based evaluation system tend to lose their effectiveness in the long term. It is implemented in deep learning policy through the use of artificial intelligence analysis in the evaluation system, the national implementation system, and the data-based learning outcome publication. Thus, policy learning not only occurs in individual teachers but also in the education governance system. This perspective indicates that policy must function as an adaptive learning mechanism, where education leaders, teachers, and policy makers collaboratively study and revise implementation strategies based on contextual evidence and reflection.

By providing ideological direction and narrative meaning for education policy, the framing (F) dimension completes the overall model. According to Taeihagh (2025), framing has developed to be an important instrument to strengthen public legitimacy and bridge perceptions between policy actors. Deep learning policy should not be focused on learning technology. However, focus should shift to problem-solving strategies and the development of inclusive digital literacy. Reframing is important to avoid a technological view and ensure that policy is directed to improve students' education. K4F Model can be considered as a theoretical representation of adaptive governance (Armstrong & Kamieniecki, 2017) and a learning organization (Oncioiu & Bularca, 2025) approach, both of which are relevant for the future of technology-based public policy. In this model, the leadership concept is rooted in transformational theory (Garzón et al., 2025). According to this theory, a leader is expected to encourage organizational behavior to shift towards digital adaptation and innovation. In contrast, the network governance paradigm reflects a collaborative aspect (Shahi & Chaudhary, 2024), which emphasizes cross-sector collaboration in public decision-making. Social justice theory in education establishes the adaptivity justice dimension (K3). This theory states that equitable education policy should include recognition of social differences and redistribution of resources (Al-Omari et al., 2025). This is relevant to the deep learning policy, which still encounters infrastructure differences between urban and rural schools. In terms of sustainable learning, policy learning theory states that a good policy system should be able to include the evaluation results in the next policy formulation process (Adeleye et al., 2024). Therefore, empirically, deep learning policy can be considered as an innovation-based public policy that requires a multi-actor leadership approach, a political feedback system, and adaptive leadership. This policy becomes a real policy laboratory for 21st-century education in Indonesia in the K4F framework.

Theoretical and Practical Implications

By combining elements of leadership, teamwork, adaptive justice, and sustainable learning in an adaptive governance framework, the K4F model offers a new theoretical perspective to understand and analyze the implementation of education policy based on deep learning and artificial intelligence. By viewing education policy as a dynamic learning system, this conceptual synthesis expands the discussion of policy learning theory. Moreover, this model strengthens adaptive governance theory by emphasizing the feedback mechanism and the ability to respond context contextually in each stage of policy implementation. Furthermore, the K4F Model improves the difference between leadership and social justice theories. This helps various parties understand the governance of digital education reform. In terms of implementation, the K4F Model can serve as an instrument for diagnosis and evaluation for policy makers, educational leaders, and institutions that strive to implement learning-based education policy. This model can be utilized to assess the level of readiness, consistency, and sustainability of policy implementation through measurable indicators, such as the capacity of leadership, effectiveness of collaboration, assurance of equity, and sustainability of policy learning. K4F Model provides practical guidelines for central government, local government, and schools in designing education governance system based on deep learning and artificial intelligence that is inclusive, adaptive, and able to be a foundation for the development of capacity building program, including AI-based instructional leadership certification, which aims to encourage transformational changes in educational environment and strengthen school ecosystem oriented towards deep learning.

Limitations and Directions for Further Research

In this study, the K4F model provides a complete conceptual framework to understand the implementation of learning policy based on deep learning and artificial intelligence (AI). However, there are several limitations that must be considered when developing further research. One of the dimensions of K4F, equity adaptivity (K3), has not been fully able to address diverse educational problems in Indonesia. However, K3 aims to uphold equity in access and enhance adaptive ability toward digital learning. Other factors may be needed to complement it, such as

equity in learning outcomes. Equality of learning outcomes indicates the equality of the quality of learning outcomes across educational sectors, regions, and social groups. Without this equality, national education policy will only focus on the equality of facilities and will not ensure the equality of pedagogical understanding, learning outcomes, and the community's ability to integrate. This condition can lead to new inequalities, where access has been equalized but utilization remains limited. This is in line with the mandate of the 1945 Constitution of the Republic of Indonesia Article 31 and Sustainable Development Goal (SDG 4), which emphasizes the importance of inclusive and high-quality education for all groups. Equality reflects the fundamental right of every citizen to obtain high-quality education without discrimination. Therefore, it is really important to ensure that digital education transformation provides the same opportunities for all students to achieve competitive and excellent academic outcomes without being limited by social, economic, or geographical differences. It is suggested that this model be expanded to include aspects of justice, besides other aspects that may be related to the principles and characteristics of education equity in Indonesia. This will be a step forward toward further development. Moreover, because the methodology in this study is based on a conceptual Integrative Literature Review, it has not undergone an empirical validation process in the field. Due to this limitation, we are unable to clearly observe various real practices, differences in policy implementation, and social and institutional dynamics that occur in various educational contexts in Indonesia. Therefore, further research should examine the empirical validity of the K4F model using mixed methods to obtain more accurate and comprehensive results. Moreover, an international study is required to improve our understanding of how the concept of legal learning and governance adaptation is applied in various technological, cultural, and institutional contexts. An international study is expected to be able to enhance the external validity of the K4F model and contribute to building a digital education policy framework that is more equitable, inclusive, and sustainable.

Conclusion

This study found that the successful implementation of education policy based on deep learning and artificial intelligence (AI) is really influenced by the quality of wise, collaborative, equitable, and sustainable policy governance. This study resulted in the K4F Model (Key Four Factors Framework), which combines four main dimensions of leadership, collaboration, adaptivity equity, and sustainable learning. The K4F Model also uses a cross-farming element as a conceptual binding that unites value direction and policy orientation. K4F Model indicates that empowering and visionary leadership are the main factors in encouraging policy reform, and cross-sector collaboration helps strengthen resource synergy and public policy legitimacy. The existence of access equality, equal opportunity, and policy relevance to geographical and social diversity is guaranteed by the adaptivity equity dimension. However, sustainable learning emphasizes that using a feedback mechanism to learn policies consciously and sustainably is really important. In the transformation process of digital education, a framing element is useful for maintaining consistent narratives, strengthening social legitimacy, and establishing common meaning among policy actors.Transformative leadership, synergistic multi-actor collaboration, equitable technology access, and a sustainable and adaptive policy learning cycle to technology dynamics and social context will be the key to education digital transformation. The K4F Model is expected to be used as a policy diagnostic tool to assess the level of readiness, effectiveness, and sustainability of education policy implementation at various levels of government and educational institutions. Moreover, the K4F Model can serve as a national strategic guideline to ensure that deep learning policy and artificial intelligence policy are implemented properly across the country.

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