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MaturiKKA-SD: Development of a Maturity Assessment Instrument for CAI Implementation in Indonesian Primary Schools

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ABSTRACT

The rollout of the Coding and Artificial Intelligence (CAI) subject in Indonesian primary schools in 2025/2026 exposed a systemic gap because no validated instrument was existed to diagnose schools' institutional readiness for this curricular innovation. This study developed and validated MaturiKKA-SD, a multi-respondent maturity assessment instrument grounded in eight institutional dimensions derived from global maturity frameworks and Indonesian curriculum policy. A Design and Development Research (DDR) approach was applied through four stages consisting of content analysis of forty-one academic and policy sources, instrument design refinement through a mini focus group discussion with four experts, content validation by three independent experts using the Content Validity Index, and limited usability testing at one primary school in Bandung. Content analysis produced eight core dimensions and twenty-seven operational constructs underpinning a five-level maturity continuum. The focus group discussion confirmed the conceptual architecture while refining descriptors and terminology, yielding fifty-nine items across three respondent forms. Expert judgment returned an Item-level CVI of 1.00 for all items and a Scale-level CVI Average of 1.00. Usability testing confirmed independent readability and practical applicability while surfacing minor refinements. MaturiKKA-SD provides a theoretically grounded and policy-aligned diagnostic tool for Indonesian primary schools implementing the CAI subject.

Keywords: AI literacy, Coding and AI subject, Content validity, Maturity assessment, Primary education

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1. INTRODUCTION

Artificial intelligence, big data, the Internet of Things, and algorithmic automation have reshaped much of how societies, economies, and education systems work in the twenty-first century (OECD, 2025). The World Economic Forum (2023) projects that most of the jobs today's primary school children will eventually hold do not yet exist, and that many of those jobs will demand advanced digital competencies. Education systems around the world have responded by shifting away from knowledge transmission toward computational thinking, algorithmic reasoning, and AI literacy (Rodrigues et al., 2024; Selwyn, 2022). UNESCO (2023) argues that digital competence is no longer something reserved for higher education. It must be cultivated from the earliest years of schooling.

Indonesia responded to this push with *Permendikdasmen Nomor 13 Tahun 2025*. The regulation introduced the Coding and Artificial Intelligence (CAI) subject as an elective in primary and secondary curricula starting in the 2025/2026 academic year. Grade V was given seventy-two annual lesson hours and Grade VI sixty-four. Both grades work toward four learning outcomes, namely computational thinking, digital literacy, AI literacy and ethics, and AI utilization and development (Kemendikdasmen, 2025). With this regulation, CAI moved from being an optional enrichment to a formal curriculum component with defined outcomes, time allocations, and evaluation mechanisms.

In practice, however, Indonesian primary schools are far from uniform in their readiness for this curricular change (Pratiwi et al., 2026; Susanto et al., 2026; Zhang et al., 2026). Independent survey evidence corroborates this disparity. A nationwide mixed-methods survey of 468 Indonesian elementary school teachers found that 85.3% had received no relevant training or professional development for AI integration, and that urban teachers reported significantly higher competence than their rural counterparts across all five AI-related knowledge domains (Zhang et al., 2026). Similarly, a survey of 296 elementary teachers across three provinces recorded only a "fairly good" level of digital literacy, with pronounced deficiencies in the cognitive dimension, underscoring the uneven distribution of professional development across regions (Zulaikha et al., 2025). Further studies show that school-level

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enactment of the coding and AI policy is incremental and contingent on leadership and individual "champion" teachers (Susanto et al., 2026), that even early-adopting, well-resourced schools confront second-order barriers such as teacher beliefs (Sulasmono et al., 2026), and that teachers who use technology confidently in their personal lives rarely integrate it into instruction (Fitri, 2025). Findings from our preliminary interviews with six teachers from public and private schools in early 2025 reflected these patterns. Public-school teachers reported a lack of specific training in CAI pedagogy, whereas private-school teachers described access to internal curricula, better facilities, and regular professional development. Without a systematic way to diagnose each school's capacity, the national CAI policy could end up widening the gap between resource-rich and under-resourced schools (Pratiwi et al., 2026; Zhang et al., 2026).

Five structural challenges shape how the CAI subject can be implemented at the primary level, and they tend to reinforce one another. The most pressing is teacher competence. Unlike secondary schools that employ subject-specific informatics teachers, primary schools rely on class teachers whose digital competencies are usually elementary (Abidin et al., 2023; Isrokatun et al., 2023; Warsina, 2025). The second is uneven digital infrastructure, which limits technology-based learning particularly outside major urban centers (Zuhri et al., 2024). The third is that school-level operational curricula have not yet integrated CAI into Operational School Curricula, Learning Trajectories, or teaching modules adapted to Grade V and VI learners (Awaluddin & Hadi, 2025). The fourth is school leadership. Institutional assessments treat it as a primary variable because the commitment and managerial capacity of the principal directly shapes whether curricular innovation can happen at all (Normén-Smith et al., 2024). The fifth is cultural resistance and low psychological safety for teachers to try new pedagogical approaches. These barriers often go unnoticed but quietly determine outcomes (Selwyn, 2022). These five problems do not operate in isolation. Competent teachers cannot do much without leadership support. Infrastructure goes unused when teachers lack pedagogical capacity. Curriculum documents stall in schools that resist change.

The heterogeneity of Indonesian primary schools makes the picture more complex. *Permendikdasmen Nomor 13 Tahun 2025* implicitly acknowledges this through clauses like "in accordance with available resources" and the permission to adopt unplugged approaches. That flexibility is sensible. But without a way to measure where each school stands, implementation has no clear map. Fullan et al. (2023) argues that failed curricular innovation rarely comes from poor policy. More often it comes from undetected institutional incapacity, which allows generic interventions to bypass the specific position of each school. Suharyo et al. (2024) make a similar point. Without precise diagnostic tools, capacity-building interventions tend to miss their targets and waste resources.

Maturity assessment fits this problem well. Baihaqy & Subriadi (2023) show that maturity instruments let educational organizations map their position gradually and across multiple dimensions, producing diagnostic information that can guide interventions proportionate to each institution's situation. Begicevic Redjep et al. (2024) make a complementary point. In the absence of systematic maturity assessment, digital transformation can degenerate into sporadic, unsustainable technology adoption. This is roughly the pattern Indonesian primary schools have followed in ICT adoption over the past twenty years. Maturity models also suit the heterogeneity of Indonesian schools because they treat readiness as a developmental continuum rather than a yes/no condition.

A systematic review of the international literature, together with consultation with national policy authorities, indicates a clear research gap. The maturity instruments currently available, such as the Framework for Digital Maturity in Schools (Begicevic Redjep et al., 2021), the ICT in School Education Maturity Model (Valdivia-Salazar et al., 2025), and the Maturity Model for Educational Organizations (Baihaqy & Subriadi, 2023), were developed for general schooling or for higher education in European contexts. None of them treat CAI as a formal subject with specific learning outcomes. Arriola-Mendoza and Ureña (2024) and Casal-Otero et al. (2023) report through systematic literature reviews the near absence of AI-readiness instruments aimed at primary schools. Hartikainen et al. (2023) and Yim and Su (2024) add that dimensions of ethics and human-centered AI are still missing from existing instruments. Consultation with curriculum specialists at the National Centre for Curriculum and Learning of the Indonesian Ministry confirmed that no systematic instrument or guide currently exists for diagnosing CAI implementation maturity at the primary level. The result is a kind of layered

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blindness. Schools do not know where they stand. Education offices cannot map progress. Policymakers lack the evidence to evaluate national implementation.

The present study tries to address that gap by developing MaturiKKA-SD, a multi-respondent maturity assessment instrument for CAI implementation in Indonesian primary schools. We developed it through a Design and Development Research approach (Richey & Klein, 2014). The approach combines content analysis, focus group discussion, expert judgment, and limited usability testing within a single iterative cycle. The instrument has eight institutional dimensions and twenty-seven operational constructs, organized on a five-level maturity continuum from Initial to Optimized. The contribution is novel in three ways. On the theoretical side, it offers an original synthesis of global maturity frameworks and Indonesian national curriculum policy. On the methodological side, it operationalizes DDR for instrument development through a sequence of qualitative and psychometric procedures. On the practical side, it gives schools, supervisors, and policymakers a diagnostic tool they can actually use. The study asks what configuration of dimensions, constructs, and maturity descriptors produces a valid, reliable, and applicable instrument for diagnosing the implementation of CAI at the primary education level.

2. RESEARCH METHOD

This study used the Design and Development Research (DDR) approach formulated by Richey and Klein (2014). DDR is a systematic investigation into the design, development, and evaluation of educational products. Its aim is to produce both the product itself and generalizable knowledge about how the product was developed and where it works. The choice of DDR was deliberate. We considered other options and rejected them. The ADDIE model (Branch, 2009) focuses on instructional program development rather than instrument construction. The Research and Development model of Creswell and Creswell (2023) requires extensive field cycles that are disproportionate to the present focus. Design-Based Research (Tinoca, 2022) is better suited to iterative classroom interventions than to building institutional measurement tools. DDR was the only approach that explicitly treats instrument development as a legitimate object of research that yields both a product and methodological knowledge.

Operationally, the study moved through four stages aligned with Richey and Klein's framework. Stage 1 was needed analysis through content analysis. Stage 2 was instrument design development through a mini focus group discussion. Stage 3 was design validation through expert judgment. Stage 4 was instrument evaluation and revision through limited usability testing. Each stage produced an output that fed into the next, which kept continuity across the development cycle. Figure 1 shows the four-stage procedure with the corresponding inputs, methods, and outputs.

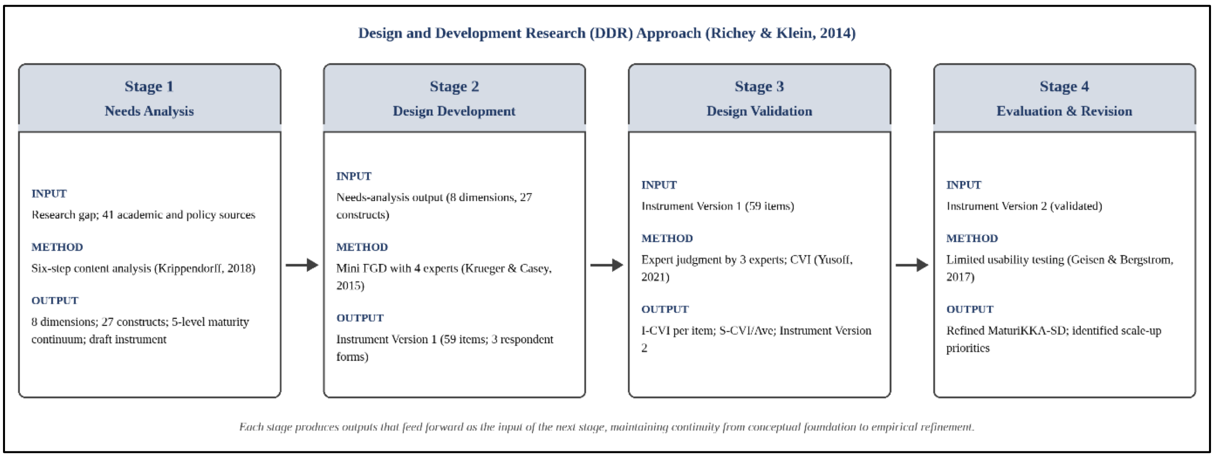

Fig 1. The Four-Stage DDR Procedure of MaturiKKA-SD

The first stage applied content analysis using the six-step procedure of Krippendorff (2018). The six steps are unitising, sampling, recording and coding, reducing, inferring, and narrating. We selected forty-one sources through purposive document sampling using three inclusion criteria. The first criterion covered peer-reviewed journal articles indexed in Scopus or SINTA on digital transformation

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maturity, ICT maturity models, AI-in-education maturity models, and educational assessment. The second covered global policy documents issued by UNESCO and the OECD on digital education and AI. The third covered Indonesian national policy instruments, namely the Academic Manuscript on CAI, *Permendikdasmen Nomor 13 Tahun 2025*, the CAI Implementation Guide, and related curriculum documents. We excluded sources that fell outside substantive relevance or relied on a single theoretical frame. Trustworthiness was secured through source triangulation and through documentation of each analytic decision in an audit trail.

The second stage used a mini focus group discussion with four expert participants. We chose them through purposive sampling on the basis of competence, experience, and direct relevance to the constructs we were developing. The four participants represented four complementary perspectives. These perspectives covered curriculum development and educational technology, computer science and artificial intelligence, evaluation and assessment of primary education, and field practice in CAI-implementing primary schools. The discussion followed the small-group format recommended by Krueger and Casey (2015). In their formulation, four to six expert participants generally produce deeper analytical engagement than larger groups when the topic is technical. Each session lasted about ninety minutes. We audio-recorded with consent and supported the recordings with field notes and verbatim transcripts. The moderator used a guide of twenty questions organized into five discussion phases. The questions covered the eight dimensions, the items per respondent, the descriptors of each maturity level, and the scoring guide. The aim was not to construct items from scratch. The aim was to validate and refine the draft instrument produced in Stage 1 through expert judgment.

The third stage involved content validation by three independent experts whose qualifications differed from those of the focus group participants. The validators represented three complementary fields. These fields were curriculum development and educational technology, evaluation and educational measurement, and substantive CAI and digital education policy. The choice of three validators followed the Content Validity Index procedure of Yusoff (2021), which sets I-CVI ≥ 0.78 and S-CVI/Average ≥ 0.90 as adequacy thresholds for a three-validator panel. Each expert evaluated all items on a four-point scale. A score of 1 meant not relevant, 2 meant somewhat relevant, 3 meant quite relevant, and 4 meant highly relevant. There was no neutral midpoint. We followed Guraya et al. (2022) in dropping the midpoint to improve decisional clarity and reduce ambivalence bias. Items receiving scores of 3 or 4 from two or more experts were considered content-valid. The validators worked independently and did not consult one another. This preserved the objectivity that the CVI procedure requires.

The fourth stage examined the usability and practical applicability of the validated instrument through a limited usability test at one primary school in Bandung. Three respondents took part. They represented the actual user roles for which the instrument was designed, namely the principal, the deputy head for curriculum, and a Grade V class teacher. The small sample was deliberate. As Swacha et al. (2025) note, three to five participants in usability testing surface most usability problems for a well-defined instrument. Data collection followed the survey usability testing framework of Geisen and Bergstrom (2017) and used three integrated techniques. The think-aloud protocol asked participants to verbalize their reasoning while reading instructions, interpreting terminology, and selecting maturity levels. Structured observation captured non-verbalized indicators of difficulty. These included hesitations longer than ten seconds, expressions of confusion, and changes of answer. A semi-structured probing interview at the end of each session gathered retrospective reflections on clarity, level differentiation, and recommendations for improvement. We analyzed findings thematically and translated them into targeted refinements of the instrument.

3. RESULTS AND DISCUSSION

A. Needs Analysis and the Formation of the MaturiKKA-SD Conceptual Model

The content analysis of forty-one sources produced four cumulative findings. First, the unitizing phase classified the sources into six thematic clusters. Eleven sources dealt with digital and AI maturity models. Four covered digital and AI competency frameworks for educators. Nine dealt with digital, AI, and coding literacy. Three came from the psychology of technology adoption and scale development. Seven were international policy documents, and another seven were national policy documents. The geographic spread of these sources was wide. It covered the United States, the European Union, UNESCO, the People's Republic of China, Hong Kong, and Indonesia. The sources also combined maturity models, competency frameworks, literacy literatures, and policy instruments. This range meant the conceptual model rested on broad rather than narrow evidence.

Second, the recording and coding phase yielded four hundred and twenty-nine analytical units distributed across seven thematic sections. Three sections carried most of the weight. Curriculum and CAI Pedagogy had eighty-two units. The Concept of Maturity and Levels had seventy-eight units. Teacher Competencies had seventy-one units. These numbers tell us something simple. The themes appear often in the global and national literature. The reducing phase then consolidated more than eighty candidate dimensions into eight core dimensions and twenty-seven operational constructs, as Table 1 shows.

Table 1. The Eight Core Dimensions and Twenty-Seven Constructs of the MaturiKKA-SD Model

Code	Dimension	Constructs	n
D1	Leadership and Governance	Strategic Vision; Resource Commitment; Change Management; Program M&E	4
D2	Curriculum and CAI Pedagogy	Curriculum Planning; Computational Thinking; Digital Literacy; AI Literacy and Ethics; AI Utilization and Development; Pedagogical Strategies	6
D3	Teacher Competence and Professional Development	AI and Coding Content Knowledge; CAI Pedagogical Competence; Continuing Professional Development; Self-Efficacy and Innovation Orientation	4
D4	Infrastructure and Technology Resources	Hardware and Software Availability; Internet Connectivity; Learning Platforms; Data Security and Privacy	4
D5	AI Literacy and Ethics in CAI Use	Conceptual AI Understanding; Critical Use and Application; Ethical and Responsible AI Use	3
D6	Assessment and Quality Assurance	Student Assessment in CAI; Implementation M&E; Data Use for Improvement	3
D7	Digital Culture and School Climate	Innovation Climate; Digital Collaboration; Digital Citizenship	3
D8	Partnership and External Support	External Partnerships; Government and Regulatory Support; Sustainable Financing	3

Third, the inferring phase produced a systematic comparison between the international literature and the Indonesian policy context. The comparison surfaced twenty-nine critical gaps distributed across the eight dimensions. The Curriculum and CAI Pedagogy dimension (D2) and the Teacher Competence dimension (D3) received the highest priority because they sit at the centre of the substantive and human-resource pillars of implementation. The gaps were not only quantitative. They fell into six typological categories, namely instrument gap, standard gap, content gap, depth gap, contextual gap, and ecosystem gap. Each category implied a different demand on the instrument under development. The instrument gap in particular established the rationale for this study, since no operational instrument existed for diagnosing CAI implementation maturity in Indonesian primary schools.

Fourth, the narrating phase synthesized these outputs into the MaturiKKA-SD conceptual model. The model uses a five-level maturity continuum that runs from Initial (Level 1) through Developing (Level 2), Structured (Level 3), and Integrated (Level 4) to Optimized (Level 5). This five-level structure is consistent with the convergent architecture observed across the global maturity frameworks we reviewed. It also accommodates the heterogeneity of Indonesian primary schools by treating readiness as a developmental continuum rather than a binary condition. The architecture therefore brings together three sources of authority. These are the global maturity literature, the Indonesian

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national policy framework (specifically the four learning outcomes of CAI in Phase C and the five essential conditions stipulated by Kemendikdasmen, 2025), and the principles of human-centred AI from Hartikainen et al. (2023). Table 2 presents the conceptual configuration.

Table 2. The Conceptual Architecture of the MaturiKKA-SD Model

Functional Tier	Dimensions
Systemic Prerequisites	D1 — Leadership and Governance D4 — Infrastructure and Technology Resources
Substantive Core	D2 — Curriculum and CAI Pedagogy D3 — Teacher Competence D5 — AI Literacy and Ethics
Feedback Circuit	D6 — Assessment and Quality Assurance
Socio-Cultural Foundation	D7 — Digital Culture and School Climate
Supporting Ecosystem	D8 — Partnership and External Support

Note: The five functional tiers represent the role each dimension plays in the ecological model of CAI implementation; the tiers are interdependent rather than hierarchical.

Two principles guided the instrument design that followed. The principle of multidimensionality came first. CAI implementation is too complex to be captured by a single composite score, so measurement had to be differentiated at the dimension level. The principle of multi-respondent observation came second. No single school actor can see across all eight dimensions. Principals are best placed to observe leadership, infrastructure, climate, and partnerships. Deputy heads for curriculum can observe planning and quality assurance. Class teachers can observe classroom-level pedagogy, teacher competence, and AI literacy in practice. We distributed the items across the three respondent forms accordingly, as Table 3 shows.

Table 3. Distribution of MaturiKKA-SD Version 1 Items by Respondent

Respondent	Dimensions Covered	Items
Principal	D1, D4, D6 (program M&E), D7, D8	22
Deputy Head for Curriculum	D2 (planning), D6 (implementation M&E), D7 (collaboration), D1 (governance)	12
Grade V/VI Class Teacher	D2 (instruction), D3, D5, D6 (student assessment), D7 (classroom climate)	25
Total	8 dimensions across the three forms	59

B. Instrument Design Refinement through the Mini Focus Group Discussion

The mini focus group discussion engaged four experts who looked at the draft instrument from distinct but complementary angles. The discussion ran in two online sessions on 29 April 2026, working through the draft option by option with the instrument shared on screen. Their combined judgment confirmed the conceptual architecture of MaturiKKA-SD. The eight dimensions, twenty-seven constructs, five-level maturity continuum, and multi-respondent design were all retained without structural changes. What the discussion contributed was at the operational layer, namely descriptors, terminology, and supporting components such as the scoring guide and the glossary. Fig 2 reproduces three sample items in their pre- and post-discussion form and shows what this operational refinement looked like in practice.

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Version Prototype (pre-FGD draft)	Version 1 (post-FGD)
Exemplar 1 · Principal Instrument, Item 1, Option a · Construct KTG-1 (CAI Vision & Strategic Policy) Revision category: splitting of compound descriptors · Source: Expert N1	
"Sekolah belum memiliki dokumen visi atau kebijakan yang menyebut KKA; kepala sekolah baru mengetahui keberadaan regulasi KKA." *"The school has no vision or policy document mentioning CAI; the principal has only just become aware that CAI regulation exists."*	"Sekolah belum memiliki dokumen visi atau kebijakan yang mencantumkan program KKA dalam bentuk apa pun." *"The school has no vision or policy document that includes a CAI programme in any form."*
Revision action. Two distinct indicators were bundled in a single response option: the existence of a policy document and the principal's personal awareness of the regulation. The revised option retains one observable institutional behaviour; individual awareness was relocated to the construct where it belongs.	
Exemplar 2 · Principal Instrument, Item 10, Option d · Construct IST-2 (Connectivity) Revision category: terminological accessibility · Source: Expert N1	
"Konektivitas internet bersifat sporadis dan tidak dapat diakses secara real time." *"Internet connectivity is sporadic and cannot be accessed in real time."*	"Konektivitas internet tidak menentu dan tidak dapat diakses secara langsung." *"Internet connectivity is unreliable and cannot be accessed directly."*
Revision action. English loan terms (sporadis, real time) were replaced with Indonesian operational equivalents, and both were subsequently entered into the operational glossary appended to the form.	
Exemplar 3 · Teacher Instrument, new Item 8 (drafted as 7a) · Construct KPK-6 (Pedagogical Strategies) Revision category: addition of a new item / plugged–unplugged equivalence · Source: Expert N4	
— Tidak terdapat butir yang mengukur penggunaan media unplugged ketika perangkat teknologi tidak tersedia. *— No item measured the use of unplugged media when technological devices are unavailable.*	"Saya menggunakan media unplugged (kartu, papan tulis, atau permainan) untuk mengajarkan konsep KKA ketika perangkat teknologi tidak tersedia." *"I use unplugged media (cards, a whiteboard, or games) to teach CAI concepts when technological devices are unavailable."*
Revision action. A measurement gap was identified: schools teaching CAI without devices had no route to demonstrate pedagogical maturity. The new item makes the unplugged approach scorable at every maturity level, removing a systematic bias against low-resource schools.	

Fig 2. Sample MaturiKKA-SD Items Before and After the Mini Focus Group Discussion

Six categories of revision emerged from the thematic analysis. First, forty-three compound descriptors that bundled two or more indicators within a single response option were split into single-indicator options. Exemplar 1 in Fig 2 is representative: one option asked simultaneously about the existence of a policy document and about the principal's personal awareness of the regulation, so a respondent whose school satisfied one condition but not the other had no accurate answer available. This sharpened the relevance of each item to the construct it was meant to measure. Second, technical terminology drawn from the global literature (terms like computational thinking, AI literacy, and AI ethics) was complemented by Indonesian-language operational glosses to accommodate the linguistic and conceptual diversity of the respondent pool, as Exemplar 2 illustrates. We appended three operational glossaries to the three respondent forms, containing thirty-four terms in total. Third, the equivalence between plugged and unplugged implementation approaches (which *Permendikdasmen Nomor 13 Tahun 2025* explicitly permits) was made visible in the descriptors of Dimension 2 and Dimension 4. This eliminated a systematic bias that would otherwise have penalized schools using unplugged approaches in their initial implementation phase. Fourth, two new items were added to fill measurement gaps identified during the discussion. One was within construct APM-2 (Implementation M&E). The other was within construct KPK-6 (Pedagogical Strategies), shown as Exemplar 3 in Fig 2. Fifth, three clarification tables explaining the logic of the two-options-per-level structure were added to help respondents navigate the five-level continuum. Sixth, the instructions for completing the instrument were rewritten with attention to register, sequencing, and clarity for users without prior familiarity with maturity assessments.

The configuration of these revisions is informative. All revisions operated at the descriptor, terminology, and supporting-element layers. The eight dimensions and twenty-seven constructs of the conceptual architecture stayed the same. This is the pattern one expects from a DDR-anchored development cycle. Stage 1 establishes the conceptual foundation. Stage 2 confirms and refines its operationalization. Stage 3 subjects the refined instrument to psychometric testing (Richey & Klein, 2014). The outcome of Stage 2 was Instrument Version 1 (Fig 3). It comprised fifty-nine items distributed across three respondent forms, four scoring guides, and three operational glossaries. Conceptually it was unchanged from the Stage 1 model. Operationally it had been sharpened.

(a)

G. BUTIR INSTRUMEN — GURU KELAS 5 DAN/ATAU 6 (GURU TIK JIKA ADA)

Petunjuk: Untuk setiap pernyataan, pilihlah SATU opsi (a sampai j) yang paling tepat menggambarkan kondisi sekolah Saudara saat ini. Beri tanda silang (X) atau lingkaran pada huruf pilihan Saudara.

D2 – KURIKULUM & PEDAGOGI KKA (Implementasi di Kelas)

Konstruk: KPK-2: Implementasi Berpikir Komputasional

1. Saya mengimplementasikan pembelajaran Berpikir Komputasional (dekomposisi, pengenalan pola, abstraksi, perancangan algoritma) secara terencana dan sistematis dalam kegiatan KKA di kelas.

Pilihlah SATU pernyataan di bawah ini yang paling tepat menggambarkan kondisi sekolah Saudara saat ini:

☐	a.	Saya belum pernah mengajarkan berpikir komputasional dalam pembelajaran apapun.
☐	b.	Saya tidak memahami konsep berpikir komputasional yang perlu diajarkan kepada murid.
☐	c.	Saya mencoba mengajarkan satu elemen berpikir komputasional (misalnya algoritma) secara tidak menentu.
☐	d.	Saya mengajarkan 1–2 elemen berpikir komputasional, belum sistematis dan tidak rutin.
☐	e.	Saya mengajarkan 2–3 elemen berpikir komputasional secara terencana dalam beberapa pertemuan KKA.
☐	f.	Saya mengajarkan keempat elemen berpikir komputasional secara terencana dengan modul ajar yang memuatnya.
☐	g.	Seluruh elemen berpikir komputasional saya ajarkan secara sistematis dan progresif dengan murid aktif terlibat.
☐	h.	Pembelajaran berpikir komputasional saya integrasikan dengan konteks kehidupan nyata murid secara bermakna.
☐	i.	Saya mengembangkan aktivitas berpikir komputasional inovatif dan aktif berbagi praktik baik dengan rekan guru.
☐	j.	Saya menjadi guru ahli berpikir komputasional yang menjadi mentor bagi rekan guru dan terus mengembangkan pendekatan.

(b)

LANGKAH 2 — Hitung DSD per Dimensi Menggunakan Rumus Pembobotan

Gunakan rumus berikut untuk masing-masing dimensi:

D1	**DSD-D1 = (0,78 × RSD-Kasek-D1) + (0,22 × RSD-Waka-D1)**
D2	**DSD-D2 = (0,57 × RSD-Guru-D2) + (0,43 × RSD-Waka-D2)**
D3	**DSD-D3 = 1,00 × RSD-Guru-D3**
D4	**DSD-D4 = 1,00 × RSD-Kasek-D4**
D5	**DSD-D5 = 1,00 × RSD-Guru-D5**
D6	**DSD-D6 = (0,375 × RSD-Kasek-D6) + (0,25 × RSD-Waka-D6) + (0,375 × RSD-Guru-D6)**
D7	**DSD-D7 = (0,50 × RSD-Kasek-D7) + (0,50 × RSD-Guru-D7)**
D8	**DSD-D8 = (0,67 × RSD-Kasek-D8) + (0,33 × RSD-Waka-D8)**

LANGKAH 3 — Hitung IMKS (Indeks Maturitas KKA Sekolah)

IMKS adalah rata-rata aritmatika dari delapan nilai DSD:

Indeks Maturitas KKA Sekolah (IMKS):

IMKS = (DSD_D1 + DSD_D2 + DSD_D3 + DSD_D4 + DSD_D5 + DSD_D6 + DSD_D7 + DSD_D8) ÷ 8

Fig 3. Samples of MaturiKKA-SD Instrument Version 1: (a) teacher-form item with five-level, two-options-per-level maturity descriptors (Construct KPK-2, Dimension 2); (b) cross-respondent weighting and IMKS computation in the integrated school-level scoring guide. The instrument is administered in Indonesian.

C. Content Validation through Expert Judgment

Instrument Version 1 was submitted for content validation to three independent experts representing curriculum development and educational technology, evaluation and educational measurement, and substantive CAI and digital education policy. The three experts were independent of the focus group panel and worked without consultation with one another, satisfying the independence requirement of the Content Validity Index procedure (Yusoff, 2021). Each expert evaluated all fifty-nine items on the four-point relevance scale recommended by Guraya et al. (2022).

The validation produced converging results. All three experts assigned a score of 4 (highly relevant) to every item across the three respondent forms. The Item-level Content Validity Index, computed as the proportion of experts rating each item at 3 or 4, was therefore 1.00 for all fifty-nine items, exceeding the 0.78 threshold of acceptability. The Scale-level Content Validity Index, computed by averaging the I-CVI values across items (S-CVI/Average), was 1.00 for each of the three respondent forms, exceeding the 0.90 threshold defining excellent scale validity. Table 4 summarizes these results.

Table 4. Content Validity Index Results for MaturiKKA-SD Version 1

Respondent Form	Items	Experts at Score ≥ 3	I-CVI	S-CVI/Ave	Decision
MaturiKKA-Principal	22	22 / 22 / 22	1.00	1.00	Content-valid
MaturiKKA-Deputy Head	12	12 / 12 / 12	1.00	1.00	Content-valid
MaturiKKA-Teacher	25	25 / 25 / 25	1.00	1.00	Content-valid
Whole instrument	59	59 / 59 / 59	1.00	1.00	Content-valid

These results need careful interpretation. A perfect S-CVI/Average of 1.00 is uncommon in instrument development and likely reflects one or a combination of three factors. First, the conceptual architecture of MaturiKKA-SD entered Stage 3 already refined through forty-one literature sources in Stage 1 and through expert refinement in Stage 2. That left little for the validators to dispute on substantive relevance grounds. Stefana et al. (2025), in a recent guide to scale development, argue that high CVI scores do not arise automatically from a well-designed instrument. They arise from instruments that have passed through a systematic exploratory phase before validation, so that the items present validators with clear judgmental tasks. Second, the four-point scale without a neutral midpoint, recommended by Guraya et al. (2022) to reduce ambivalence bias, may have encouraged validators to commit to a clear decision in either direction. Third, the panel was made up of senior experts deeply familiar with both the substantive content of CAI and the methodological logic of maturity instruments. Their judgments may therefore have been grounded in the suitability of the conceptual frame rather than in line-by-line scrutiny of phrasing.

A qualitative reading of the validation comments adds context to the quantitative results. Two of the three validators recommended the instrument for use without revision. The third endorsed the instrument with minor revisions. The third validator noted that completing the full instrument on a single sheet might cause respondent fatigue and recommended the development of a digital application to ease access. This comment does not affect content validity in the psychometric sense, but it surfaces a practicality concern that the subsequent usability testing was designed to examine. Yusoff (2021) and Zamanzadeh (2022) explicitly note that the CVI procedure addresses relevance and clarity but does not exhaust the dimensions of instrument quality. Usability and respondent burden are separately testable concerns.

Two minor refinements were made before the instrument moved to Stage 4. The phrasing of two items was lightly adjusted on the basis of the validator's narrative commentary, and the design of a future digital version of the instrument was documented as a development trajectory for subsequent

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research. The resulting Instrument Version 2 retained the fifty-nine-item structure and the eight-dimension architecture intact.

D. Limited Usability Testing

The fourth stage tested the usability of Instrument Version 2 in an authentic primary school setting. The site was selected through purposive sampling and corresponded to a public primary school in Bandung that had begun implementing the CAI subject in the 2025/2026 academic year. Three respondents participated: the principal, the deputy head for curriculum, and a Grade V class teacher. The sample size, although small, is consistent with Swacha's et al. (2025) finding that three to five participants in usability testing surface roughly eighty percent of usability problems for a well-defined instrument, and with the limited-pilot orientation of Stage 4 in the DDR framework.

The findings from the three sessions converged on four themes. The first concerns instructional clarity. All three respondents completed the instrument without external guidance. They reported that the introductory instructions, the explanation of the five maturity levels, and the two-options-per-level logic enabled them to read and respond independently. The clarification tables added at Stage 2 were spontaneously cited by two respondents as helpful for navigating the response architecture. The second theme concerns terminology. The operational glossary cleared up most ambiguities surrounding technical terms such as computational thinking and AI literacy. The deputy head for curriculum did report brief hesitations on three terms (data governance, learning analytics, and AI ethics applied to primary school contexts). These point to opportunities for further glossing.

The third theme concerns differentiation between adjacent maturity levels. Respondents found the contrast between Level 1 (Initial) and Level 5 (Optimized) unambiguous. The contrast between Level 2 (Developing) and Level 3 (Structured) required more deliberation. This finding aligns with the broader literature on maturity-rubric design, which observes that adjacent intermediate levels carry the highest interpretive load on respondents (Ten Hove et al., 2024). We therefore refined two descriptors at the Level 2–3 boundary to sharpen their distinctive markers. The fourth theme concerns completion time and respondent burden. The principal completed the twenty-two-item form in about thirty-five minutes. The deputy head completed the twelve-item form in about twenty minutes. The class teacher completed the twenty-five-item form in about forty-five minutes. All three respondents reported that the completion time was acceptable for an instrument intended for institutional reflection rather than routine survey use. They did recommend that future digital implementations include navigation aids and progress indicators. Table 5 summarizes the usability findings and the corresponding refinements.

Table 5. Summary of Limited Usability Testing Findings and Refinements

Theme	Finding from Limited Usability Test	Refinement
Instructional clarity	Independent completion achieved; clarification tables endorsed by participants	Retained, with minor sequencing improvements
Terminology	Glossary effective for most terms; three terms (data governance, learning analytics, AI ethics at primary level) flagged	Glossary expanded; three additional operational definitions added
Level differentiation	Level 2–3 boundary required deliberation	Descriptors of two items refined for sharper contrast
Completion time and burden	Acceptable in the institutional reflection context; digital aids recommended	Future digital version planned; navigation aids identified for development

The limited usability test produced no findings that called into question the dimensional architecture, the constructs, or the maturity continuum of MaturiKKA-SD. All refinements operated at the descriptor and supporting-element layers, consistent with the pattern observed in Stage 2. The convergence of refinements across Stages 2 and 4 indicates that the conceptual architecture of the instrument is sufficiently robust to be tested at larger scale in subsequent research. The instrument that emerged from Stage 4, MaturiKKA-SD Version 3, is therefore proposed as ready for broader empirical examination, including reliability testing across multiple schools and the computation of inter-respondent agreement using the Intraclass Correlation Coefficient (Ten Hove et al., 2024).

E. Theoretical and Practical Implications of the MaturiKKA-SD Framework

Three implications follow from the development cycle reported in this article. On the theoretical side, MaturiKKA-SD contributes an original synthesis that brings together global maturity frameworks (Baihaqy & Subriadi, 2023; Begicevic Redjep et al., 2021; Valdivia-Salazar et al., 2025), competency frameworks (Jiménez Sierra et al., 2023; UNESCO, 2023), AI literacy literatures (Ng et al., 2021), and the Indonesian national policy framework into a coherent eight-dimension architecture grounded in twenty-seven operational constructs. The model is original in three senses. It places the four learning outcomes of CAI Phase C as substantive anchors within Dimension 2. It explicitly accommodates the plugged–unplugged duality permitted by national policy. It adopts a multi-respondent design that triangulates the differential observational capacities of school actors (Arias Valencia, 2022).

On the methodological side, the study illustrates how DDR can be operationalized through a sequence of qualitative and psychometric procedures that produce both an instrument and methodological knowledge. The four-stage cycle (content analysis, focus group discussion, expert judgment, and limited usability testing) demonstrates a replicable pathway for developing context-sensitive maturity instruments in other curriculum innovations. The combination of an S-CVI/Average above the conventional threshold and convergent qualitative findings across stages suggests that the early-stage investment in content analysis pays off in later-stage validation.

On the practical side, MaturiKKA-SD addresses a concrete and pressing need. Indonesian primary schools, supervisors, and policymakers have so far lacked an operational instrument to map CAI implementation. MaturiKKA-SD gives them a school-level diagnostic tool that produces a profile across eight dimensions and locates the school on a five-level maturity continuum. The instrument is designed for independent completion by schools without external facilitation. Its output, the School Maturity Profile, supports evidence-informed planning at the school level, program design at the district level, and policy monitoring at the national level.

Several limitations should be acknowledged. The CVI results, while above conventional thresholds, were based on a three-expert panel. Future research could extend validation to a larger panel to refine the reliability of the CVI estimates. The limited usability testing involved three respondents at one school in Bandung. That produced depth but not breadth. Subsequent research should extend usability testing across schools varying in geography, status, and CAI adoption level. The Intraclass Correlation Coefficient for inter-respondent reliability was not estimated in this cycle and remains a priority for the next development cycle. Finally, the digital version of the instrument recommended by one validator and supported by the usability findings is an important next step for widening the practical reach of MaturiKKA-SD.

4. CONCLUSION

This study developed and validated MaturiKKA-SD, a multi-respondent maturity assessment instrument for the implementation of the Coding and Artificial Intelligence subject in Indonesian primary schools. It addresses a gap left open by the rollout of *Permendikdasmen Nomor 13 Tahun 2025*. Through a Design and Development Research cycle of four stages, the study produced an instrument with eight dimensions, twenty-seven operational constructs, fifty-nine items distributed across three respondent forms, and a five-level maturity continuum from Initial to Optimized. Content validation by three independent experts produced an Item-level CVI of 1.00 and a Scale-level CVI Average of 1.00, exceeding the conventional thresholds of acceptability. Limited usability testing at one primary school confirmed that the instrument could be completed independently by its intended users. The test also yielded targeted refinements at the descriptor layer. The resulting MaturiKKA-SD framework integrates global maturity scholarship with the substantive anchors of Indonesian national policy. It offers schools, supervisors, and policymakers a diagnostic tool for evidence-informed planning of CAI implementation at the primary level. Future research should extend reliability testing across multiple schools, estimate inter-respondent agreement using the Intraclass Correlation Coefficient, and develop a digital implementation of the instrument to broaden its practical reach.

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