

School Management in Adapting the Merdeka Curriculum for the Software Engineering (RPL) Concentration in the Era of Artificial Intelligence

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ABSTRACT

The development of artificial intelligence (AI) is reshaping competency requirements in software-development occupations, requiring vocational schools to manage curriculum adaptation as an organizational process. In Indonesian vocational high schools (SMKs), Software Engineering (RPL) is a Skills Concentration within the Software and Game Development (PPLG) Skills Program. This study analyzes the role of school management in adapting the Merdeka Curriculum in RPL to AI-driven competency changes, identifies managerial processes that support graduate quality, and proposes an AI-responsive curriculum-management model. A systematic integrative literature review and qualitative document analysis were conducted using 30 peer-reviewed publications from 2020–2026, supplemented by foundational literature, policy documents, institutional documents from SMK Wikrama 1 Kabupaten Semarang, and relevant official sources. The findings show that AI-responsive curriculum adaptation requires integration of technical competence, AI literacy, problem solving, ethics, adaptability, teacher capacity, authentic learning, and industry partnerships. Six managerial processes were identified: environmental scanning, curriculum alignment, capacity building, authentic implementation, outcome assurance, and feedback and renewal. The study proposes an AI-Responsive Adaptive Curriculum Management Model that positions school management as the driver of continuous curriculum renewal. As no primary data or independent outcome measurement were used, the model remains conceptual rather than causal.



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INTRODUCTION

The rapid development of artificial intelligence (AI), particularly generative AI, is reshaping occupations by changing work processes, decision making, and competency requirements. These changes extend beyond AI-specific occupations and increasingly affect digital, cognitive, managerial, and interpersonal skills across professions (Green, 2024). In education, this transformation requires institutions to develop appropriate regulation, human-resource capacity, and pedagogical strategies while maintaining a human-centred and ethical approach to AI (Miao & Holmes, 2023). This challenge is particularly relevant to technical and vocational education and training (TVET), whose effectiveness depends on its responsiveness to technological change and evolving labour-market demands (UNESCO-UNEVOC, 2024).

In Indonesia, the challenge is especially important for vocational high schools (Sekolah Menengah Kejuruan/SMKs), which are expected to prepare graduates with competencies aligned with employment needs. Curriculum relevance, educational resources, facilities, and industry participation remain important determinants of the capacity of vocational education to respond to labour-market demands (Suharno et al., 2020). This issue remains significant because Statistics Indonesia reported that 1,923,756 unemployed persons in August 2025 had vocational high school as their highest level of completed education (Badan Pusat Statistik, 2026). Although this figure cannot be attributed solely to curriculum quality, it reinforces the need for SMKs to continuously align competencies, learning processes, assessment, and industry engagement with changes in the world of work.

Such adaptation is particularly relevant to the Software and Game Development (Pengembangan Perangkat Lunak dan Gim/PPLG) Skills Program, especially the Software Engineering (Rekayasa Perangkat Lunak/RPL) Skills Concentration. AI has become not only a competency domain

that software graduates need to understand but also a technology increasingly embedded in software-development processes. Even before the expansion of generative AI, gaps between software-engineering education and professional competency requirements had demonstrated the need for stronger curriculum-industry alignment (Akdur, 2023). Generative AI further transforms software-engineering workflows, roles, and skill configurations, requiring education to combine technical knowledge with systems thinking, ethics, soft skills, and lifelong-learning capacity (Marlowe et al., 2026). Therefore, RPL graduate competence can no longer be limited to coding and application development but must also include problem solving, critical evaluation of AI-generated outputs, adaptability, and responsible technological decision making.

This transformation also requires broader AI literacy. Ng et al. (2021) conceptualize AI literacy through understanding AI, applying it, evaluating and creating with it, and addressing its ethical dimensions. At the school level, AI integration requires competency frameworks that can be translated into curriculum, instructional design, teacher development, and assessment (Casal-Otero et al., 2023). UNESCO similarly organizes student AI competencies around a human-centred mindset, ethics, AI techniques and applications, and AI system design (Miao et al., 2024). For the RPL Skills Concentration, these perspectives imply that graduate quality should encompass not only the ability to use AI tools but also the capacity to verify outputs, understand risks and limitations, apply engineering principles, and use AI responsibly.

Indonesian educational policy increasingly provides a foundation for this adaptation. Regulation of the Minister of Primary and Secondary Education Number 13 of 2025 amended the Merdeka Curriculum framework and introduced Coding and Artificial Intelligence as elective subjects according to institutional readiness (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025b). Within the official vocational-school skills spectrum, PPLG is classified as a Skills Program and RPL as one of its Skills Concentrations (Direktorat Sekolah Menengah Kejuruan, n.d.). Therefore, this study examines the adaptation of Merdeka Curriculum implementation within the RPL Skills Concentration rather than treating “RPL curriculum” as a separate national curriculum. Decree of the Minister of Primary and Secondary Education Number 127/P/2025 further provides implementation guidance for Coding and Artificial Intelligence (Kementerian Pendidikan Dasar dan Menengah Republik Indonesia, 2025a), including competencies related to prompt engineering, the impact of AI on employment, transparency and explainability, simple model development, and the use of models through libraries or APIs at the secondary/vocational level (Badan Standar, Kurikulum, dan Asesmen Pendidikan, 2025).

Curriculum adaptation, however, cannot be achieved merely by adding AI-related content. At the school level, curriculum change involves leadership, coordination, professional development, resource allocation, implementation, and feedback processes. Curriculum change can be understood as a distributed leadership process involving multiple actors and organizational interactions (Fasso et al., 2016). In vocational education, this process also requires sustained relationships with business and industry because curriculum relevance depends on alignment between school-based learning and workplace requirements (Tessa & Humaedi, 2024). From this perspective, school management must connect technological and labour-market scanning with curriculum alignment, teacher development, pedagogical transformation, industry collaboration, assessment, and graduate-outcome evaluation.

The dynamic capabilities framework provides a useful theoretical lens for explaining this adaptive process. Dynamic capabilities refer to an organization's capacity to integrate, build, and reconfigure competencies in response to rapidly changing environments (Teece et al., 1997). These capabilities involve sensing changes, seizing opportunities through decisions and resource mobilization, and reconfiguring organizational arrangements in response to emerging conditions (Teece, 2007). Applied to vocational-school management, this framework helps explain how schools can identify changes in AI and employment, translate them into curriculum and capacity-development decisions, and subsequently revise implementation based on evidence of learning and graduate outcomes.

Despite increasing attention to AI and vocational education, the literature remains fragmented. Studies have examined the transformative potential of AI for vocational education and adaptive learning (Rosyadi et al., 2023), while more recent reviews identify changes in pedagogy, educator training, ethics, access, competencies, and workforce alignment associated with AI integration in TVET (Berigel et al., 2025). Research on K-12 education has emphasized AI-literacy frameworks and instructional implementation (Casal-Otero et al., 2023), whereas software-engineering studies have highlighted

changing professional competencies and the need for curriculum renewal (Akdur, 2023; Marlowe et al., 2026). In Indonesia, studies of vocational education have also emphasized curriculum-industry alignment through link-and-match initiatives (Tessa & Humaedi, 2024). However, these areas have rarely been integrated into a management framework explaining how technological disruption is translated into continuous adaptation of Merdeka Curriculum implementation within the RPL Skills Concentration.

SMK Wikrama 1 Kabupaten Semarang is used in this study as an analytical context based exclusively on publicly available documents, rather than as a site of primary-data collection. Its official information describes Software Engineering learning as encompassing web, desktop, and mobile software development together with ethical, social, legal, security, economic, teamwork, and software-modelling dimensions (SMK Wikrama 1 Kabupaten Semarang, n.d.-a). The school also emphasizes technology, industry needs, work readiness, and industry collaboration (SMK Wikrama 1 Kabupaten Semarang, n.d.-b), while an official publication from SMK Negeri 1 Tengaran (2024) documents its participation in an RPL teaching-factory network. These sources are used only to contextualize curriculum-management practices and are not treated as evidence of causal improvements in graduate quality.

Accordingly, the research gap lies at the intersection of school management, AI-driven competency change, vocational curriculum adaptation, software-engineering education, industry alignment, and graduate quality. Existing studies tend to position AI primarily as a learning technology, examine AI literacy and industry alignment separately, or focus on particular instructional interventions. The novelty of this study lies in conceptualizing AI as an external driver of organizational and curricular change and integrating the dynamic-capabilities perspective with school management to explain how technological and industry changes can be sensed, translated into curriculum and capacity-building decisions, and continuously renewed through outcome feedback. Based on this gap, the study aims to: (1) analyze changes in competency requirements within the RPL Skills Concentration in the AI era; (2) explain the role of school management in adapting Merdeka Curriculum implementation to technological and industry change; (3) identify managerial processes that support graduate quality; and (4) formulate an AI-responsive adaptive curriculum-management model connecting environmental scanning, curriculum alignment, teacher development, authentic learning, industry partnerships, assessment, and outcome feedback.

RESEARCH METHOD

This study employed a systematic integrative literature review combined with qualitative document analysis. An integrative approach was selected because the research questions intersect educational management, vocational education, artificial intelligence (AI), software-engineering education, graduate competencies, and labour-market needs. This design enables the systematic integration of quantitative, qualitative, mixed-methods, conceptual, and review studies to develop a comprehensive conceptual synthesis (Whittemore & Knafl, 2005; Snyder, 2019). The identification and selection of scientific literature followed the transparency principles of PRISMA 2020 (Page et al., 2021) and guidance for systematic literature reviews in social and educational research (Xiao & Watson, 2019).

Two complementary data streams were analyzed. The first comprised peer-reviewed scientific literature addressing AI-driven competency change, curriculum adaptation and school management, teacher capacity, school-industry relationships, and graduate quality or employability. The second comprised policy and publicly available institutional documents used to interpret the regulatory and institutional context. Official documents from SMK Wikrama 1 Kabupaten Semarang were used only to contextualize the orientation and reported practices of the RPL Skills Concentration and were not treated as causal evidence of graduate-quality improvement. This distinction was based on document-analysis principles concerning provenance, purpose, context, and credibility (Bowen, 2009; Dalglish et al., 2020).

The review addressed four questions concerning: (1) changes in competencies required of RPL graduates in the AI era; (2) school management of Merdeka Curriculum adaptation within the RPL Skills Concentration; (3) managerial processes supporting graduate quality; and (4) the development of an adaptive curriculum-management model. The search strategy was organized using the SPIDER framework (Cooke et al., 2012), covering vocational education/TVET and software-engineering

education as the sample; AI-driven curriculum adaptation and school management as the phenomenon of interest; quantitative, qualitative, mixed-methods, case-study, evaluation, and review designs; curriculum, teacher capacity, industry alignment, competencies, and employability as evaluation dimensions; and peer-reviewed journal articles and conference proceedings as the main research sources.

The contemporary scientific corpus was limited to publications from January 2020 to 8 September 2026. Earlier publications were retained only when they provided foundational theoretical or methodological references. Searches were conducted through ERIC, DOAJ, OpenAlex, and GARUDA, with Google Scholar used for supplementary citation tracking. Search terms combined concepts related to artificial intelligence and generative AI, vocational education/TVET and software-engineering education, and curriculum management, competencies, employability, graduate quality, teacher competence, and industry alignment. Indonesian equivalents of these terms were also used. Backward and forward citation searching was conducted to improve search sensitivity (Xiao & Watson, 2019).

Studies were included when they addressed at least two major domains of the review—AI, vocational education/RPL, curriculum or school management, teacher competence, industry alignment, or graduate quality/employability—and provided sufficient information on objectives, methods or conceptual arguments, and findings. Peer-reviewed journal articles, systematic or integrative reviews, and peer-reviewed conference proceedings in Indonesian or English were eligible. Editorials, opinion pieces, blogs, news reports, unverified preprints, technically oriented AI studies without educational implications, and sources with insufficient information were excluded. Official documents were included when their provenance, publisher, date or version, and relevance to the Merdeka Curriculum, AI, PPLG/RPL, or industry relationships could be verified.

Literature selection followed the PRISMA 2020 sequence of identification, deduplication, title-and-abstract screening, full-text assessment, and final inclusion (Page et al., 2021). Duplicate records were identified using DOI, title, author, and publication year. The final corpus comprised 30 peer-reviewed scientific publications published between 2020 and 2026. Because complete numerical records from the initial search and exclusion stages were unavailable in the archived search documentation, these figures were not retrospectively reconstructed in order to avoid reporting unverifiable PRISMA counts.

The methodological quality of heterogeneous empirical studies was appraised using the Mixed Methods Appraisal Tool (MMAT), 2018 version (Hong et al., 2018). Rather than calculating an aggregate quality score, the appraisal focused on methodological limitations that could influence interpretation, including sampling, alignment between research questions and methods, and coherence between evidence and conclusions. Systematic reviews were assessed with reference to the transparency of their review questions, databases, search procedures, eligibility criteria, screening processes, and synthesis methods (Page et al., 2021; Xiao & Watson, 2019). Conceptual studies were used to support theoretical interpretation rather than to establish causal effects or prevalence.

Document analysis covered relevant government regulations and guidelines, the official vocational-school skills spectrum, publicly available documents from SMK Wikrama 1 Kabupaten Semarang, and other official institutional sources relevant to the RPL teaching-factory and industry context. Documents were selected according to source authority, relevance, date or version, and traceability. Analysis followed Bowen's (2009) principles of document analysis and the READ framework of readying materials, extracting data, analysing data, and distilling findings (Dalglish et al., 2020). Scientific literature and institutional or policy documents were recorded separately to prevent empirical findings from being conflated with policy provisions or institutional claims.

Data were extracted into matrices containing source characteristics, research design and context, AI-related dimensions, curriculum and management issues, teacher competencies, industry relationships, graduate outcomes, major findings, limitations, and evidence quality. Analysis combined descriptive mapping with thematic synthesis using a hybrid deductive-inductive coding approach. Initial codes were derived from the research questions and subsequently refined as additional patterns emerged. Theme development followed the stages of familiarization, coding, theme generation, review, definition, and reporting proposed by Braun and Clarke (2006). Themes from scientific literature were subsequently compared with regulatory and institutional evidence to identify convergence, differences, and gaps and to construct the proposed AI-responsive adaptive curriculum-management model.

Because of substantial heterogeneity in research designs, contexts, interventions, and outcome measures, statistical meta-analysis was not conducted. The strength of the synthesis was instead assessed through consistency across sources, methodological quality, and coherence among themes. Trustworthiness was strengthened through an audit trail, source triangulation, consideration of negative or contradictory evidence, and traceability of themes to the synthesis matrix, consistent with recommendations for trustworthy thematic analysis (Nowell et al., 2017).

This study did not collect primary data from students, teachers, school leaders, alumni, or industry partners and involved no human-subject intervention. All evidence was derived from published scientific literature and publicly available documents. Accordingly, the study emphasized source traceability, accurate attribution, and clear differentiation among empirical evidence, policy provisions, and institutional claims.

RESULTS AND DISCUSSION

Descriptive Mapping of the Corpus and Appraisal Results

The main corpus comprised 30 peer-reviewed scientific publications published between 2020 and 2026. The distribution indicates increasing attention to AI, vocational education, and competency adaptation: one publication in 2020, four publications each in 2021 and 2022, five publications each in 2023, 2024, and 2025, and six publications in 2026. By substantive context, 23 publications focused on Indonesia and seven were international or global in scope. The corpus included empirical studies using quantitative, qualitative, mixed-methods, case-study, and educational-evaluation designs, together with systematic reviews and conceptual articles. The dominant areas of focus were AI literacy, vocational education/TVET, RPL and software-engineering competencies, curriculum management and change, teacher capacity, teaching factory/PjBL, link and match, and work readiness and graduate quality.

The appraisal results indicated variation in the strength of evidence that must be considered in interpretation. Systematic reviews that clearly reported their databases, search strategies, selection criteria, and synthesis methods were used primarily to identify patterns across studies. Empirical studies were used to support findings consistent with their stated contexts, designs, samples, and outcomes; context-specific studies were not treated as a sole basis for generalization. Conceptual articles were used to strengthen the explanatory framework rather than to establish effect sizes or causal relationships. Because research designs, contexts, and outcome indicators were heterogeneous, the study did not produce an aggregate MMAT score; instead, appraisal functioned as a mechanism for interpretive weighting. Consequently, the principal conclusions were built from convergence across multiple sources and triangulation with policy documents, while causal claims regarding improvements in graduate quality were deliberately avoided.

The thematic synthesis of literature on vocational education, curriculum management, work readiness, learning in the RPL Skills Concentration, and AI literacy indicates that school responses to AI cannot be reduced to a decision to use or prohibit a particular application. Recurring patterns in the Indonesian literature show that the relevance of SMK graduates is shaped by the interrelationship among curriculum, school leadership, teacher capacity, work-based learning experiences, industry partnerships, and mechanisms for evaluating outcomes. At the same time, the AI literature adds a new layer of competency: understanding how AI works and its limitations, using AI productively, critically evaluating its outputs, and considering ethical and responsibility-related implications. On the basis of these patterns, the findings were organized into six themes: (1) shifts in RPL competency requirements in the AI era; (2) school management as a driver of curriculum adaptation; (3) strengthening teacher capacity and AI literacy; (4) pedagogical transformation toward authentic projects and AI-assisted development; (5) strengthening link and match and the industry ecosystem; and (6) redefining graduate quality and developing an adaptive curriculum-management model. The relationships among these themes are summarized in Table 3.

Table 3. Synthesis of Review Themes and Managerial Implications

No.	Synthesis theme	Main finding	Implications for school management in adapting the curriculum for the RPL Skills Concentration
1	Changing RPL competencies	Competence extends beyond coding; greater emphasis is placed on problem solving, verification of AI outputs, communication, adaptability, and ethics.	National Learning Outcomes remain the primary reference; schools contextualize them through learning objectives, sequences, projects, and assessments that develop the capacity to design, evaluate, and account for AI-assisted software solutions.
2	Adaptive curriculum	Curriculum alignment with industry is more effective when treated as a continuous process rather than as periodic administrative revision.	Environmental scanning, school-industry curriculum forums, periodic implementation reviews, and feedback from workplace internships, the BKK, alumni, and industry are required.
3	Teacher capacity	AI integration depends on teachers' literacy, readiness, ethical understanding, and experience in using technology for pedagogical purposes.	Teacher upskilling should form part of adaptation management, including prompting, verification, assessment, ethics, and AI use within RPL workflows.
4	Authentic learning	PjBL and teaching factories strengthen skills when tasks resemble real workplace processes and produce products or portfolios.	AI is integrated into software projects through explicit rules for use, documentation of AI contributions, code review, testing, and reflection.
5	Link and match	Industry partnerships strengthen curriculum relevance, internships, certification, and work readiness when integrated into learning.	Industry is positioned as a co-designer of instructional implementation, a source of projects, a mentor, a competency evaluator, and a provider of feedback.
6	Graduate quality	Quality is multidimensional, encompassing hard skills, AI literacy, soft skills, work readiness, portfolios, certification, and adaptability.	Quality assurance should use outcome indicators rather than relying only on subject grades or graduation.

Shifting RPL Competencies: From Coding to Human-AI Software Engineering

The first finding indicates a fundamental shift in the definition of competencies expected of RPL graduates. Indonesian literature on the alignment between SMK graduates and industry needs consistently emphasizes that mastery of technical competencies alone does not guarantee work readiness. Septyani et al. (2022) demonstrate the importance of aligning school-based competencies with industry requirements, while Hidayati et al. (2021) position competency relevance as a central issue in the relationship between vocational education and the world of work. More specifically in the RPL context, Kurniawati et al. (2023) found that start-up companies require graduates who possess not only technical skills but also critical-thinking, problem-solving, active-communication, and emotional-intelligence capabilities. This finding is particularly important because generative AI is automating some of the technical activities that previously served as primary indicators of entry-level programmer competence. Consequently, the value added by RPL graduates is increasingly shifting from the ability to produce syntax manually toward the ability to frame problems, design solution architectures, evaluate output quality, perform debugging and testing, and make responsible technical decisions.

International literature reinforces this direction. Akdur (2023) identifies a gap between the software-engineering competencies taught in education and the professional requirements of industry, whereas Marlowe et al. (2026) emphasize that the emergence of generative AI requires a systemic software-engineering curriculum in which technical skills are integrated with systems thinking, soft skills, ethics, and lifelong learning. In the context of upper-secondary vocational education, the implication is not to remove coding from instruction, but to reposition coding from an end in itself to one instrument within the broader engineering process. Students must continue to understand algorithms, data structures, databases, testing, version control, and software-design principles because such knowledge is necessary for evaluating AI-generated code. Without this foundation, AI use risks producing superficial competence: students may be able to build applications quickly but remain unable to explain dependencies, security implications, quality considerations, or the rationale underlying design decisions.

The concept of AI literacy provides an additional framework for explaining these emerging competencies. Ng et al. (2021) divide AI literacy into the dimensions of knowing and understanding,

using and applying, evaluating and creating, and ethics. In Indonesia, Ahmad et al. (2025) developed an AI-literacy instrument that positions knowledge, attitudes, and critical-thinking ability as interrelated components. Drajadi et al. (2025) further show that teachers' AI literacy is not merely associated with frequency of technology use, but also includes the capacity to understand and apply AI pedagogically. When this framework is applied to RPL, graduate competencies need to include the ability to construct effective prompts, verify the accuracy and security of outputs, explain AI-assisted code, avoid overdependence, consider licensing and privacy, and document the respective contributions of humans and AI during the development process.

This synthesis leads to an important proposition: implementation of the Merdeka Curriculum in the RPL Skills Concentration in the AI era needs to shift from a paradigm of occupational task replication toward adaptive engineering competence. Under the former paradigm, learning tends to map a list of tools, programming languages, or technical tasks that students are expected to master. Under an adaptive paradigm, priority is given to the capacity to apply software-engineering principles to solve problems using continuously evolving technologies. This shift is consistent with the findings of Ratnasari and Mudrikah (2025), who report a positive relationship between ICT skills and soft skills and work readiness. Curriculum adaptation, therefore, cannot be accomplished simply by adding a single 'AI' topic to the learning structure. Schools must continue to refer to nationally defined Learning Outcomes, while contextualizing them through learning objectives, learning sequences, project activities, assessment, and workplace experiences so that AI becomes a context for strengthening engineering reasoning rather than a shortcut that circumvents the thinking process.

School Management as a Driver of Curriculum Adaptation

The second theme shows that the capacity to respond to technological disruption depends substantially on the quality of school management in directing curriculum adaptation. Fahmi and Irfani (2026) conclude that strengthening industry-based curricula in SMKs requires sustained school-industry collaboration through curriculum alignment, competency-based learning, teaching factories, and work-based learning experiences. This finding is consistent with Maulina and Yoenanto (2022), who position the optimization of link and match as a strategy for improving the relevance of SMKs to business and industry. Nasution et al. (2022) show that effective implementation of link and match involves regulation-based planning, the establishment of working teams, industry cooperation, optimization of the Special Job Placement Unit (BKK), industry classes, teacher internships, competency certification, and supervision. Taken together, this literature indicates that curriculum adaptation at the school level is an organizational process requiring leadership, cross-functional coordination, resource decisions, capacity development, and evaluation mechanisms; it is not merely the responsibility of individual subject teachers.

In the AI context, this management pattern needs to be expanded into an environmental-scanning mechanism. Schools need procedures for monitoring technological developments, industry practices, development tools, skill requirements, ethical risks, and changes in occupational roles. Purnamasari et al. (2026) emphasize the importance of link-and-match-based principal leadership in integrating industry relationships into SMK quality-improvement systems. This means that school principals and curriculum managers need to transform industry partnerships from supplementary activities into sources of data for curriculum decision-making. Feedback from workplace-internship mentors, recruitment requirements, competency-test results, portfolio evaluations, tracer studies, and developments in software-development practice can serve as signals for determining which competencies should be maintained, strengthened, or updated.

The collaborative curriculum model discussed by Abdillah and Puspitasari (2025) likewise indicates that strengthening competencies in SMK Centers of Excellence requires a more substantive relationship between schools and their partners. At the management level, this shifts the concept of alignment from 'matching curriculum documents' toward co-design. Ideally, industry should be involved in identifying competency requirements, developing project briefs, reviewing portfolios, delivering guest instruction, mentoring, facilitating teacher internships, and evaluating student performance. Tessa and Humaedi (2024) emphasize that link-and-match programs can strengthen the relationship between SMKs and the world of work when curriculum alignment and instructional practices are genuinely connected to industry needs. Because change cycles in software are far faster

than formal regulatory cycles, co-design provides schools with a more responsive adaptation mechanism without requiring them to wait for comprehensive changes to the national curriculum.

From a change-management perspective, these findings indicate that an adaptive curriculum has at least four characteristics. First, it is based on external evidence, meaning that adjustment decisions are informed by data on industry needs and technological change. Second, it is iterative, with reviews conducted periodically on the basis of implementation results. Third, responsibility is distributed because adaptation involves the principal, the vice principal for curriculum, the head of the skills program, vocational-subject teachers, the BKK, industry partners, and students or alumni. Fourth, it is outcome-oriented, such that success is not defined by the completion of curriculum documents but by competencies, portfolios, certification, work readiness, and industry feedback. These four characteristics form the basis of the school-management model for curriculum adaptation proposed in the final part of the discussion.

Teacher Capacity as a Critical Point in AI Integration

The third theme positions teachers as a critical point in the transformation process. AI can be incorporated into curriculum documents relatively quickly, but the quality of implementation depends on teachers' ability to understand when, why, and how the technology should be used. Fauziah et al. (2026) found that AI-literacy training for secondary-school teachers improved perceptions, knowledge, skills, ethical understanding, innovation, and readiness to adopt AI. This finding is consistent with Drajiati et al. (2025), who demonstrate the importance of AI literacy among Indonesian teachers and the need for professional development that is not limited to tool use. At the student level, Ahmad et al. (2025) show that AI literacy is multidimensional and related to knowledge, attitudes, and critical-thinking ability. Accordingly, professional-development programs for RPL teachers need to move beyond training on 'how to use ChatGPT' toward mastery of instructional design, technical verification, assessment, ethics, and the integration of AI into software-engineering workflows.

The managerial implication is the need for systematically planned teacher capacity building. Schools need to map teachers' baseline competencies, establish minimum AI competencies for RPL vocational-subject teachers, develop communities of practice, and provide opportunities for internships or collaborative learning with industry. Agustian et al. (2024) identify teacher training and industry collaboration as important strategies for reducing the gap between vocational education and labour-market needs. Nasution et al. (2022) likewise identify teacher internships as a supporting factor in link-and-match implementation. In RPL, teacher internships are becoming increasingly important because corporate AI practices are evolving rapidly, ranging from code completion and automated documentation to test generation, code-review assistance, prototyping, and debugging analysis. Teachers who are not directly exposed to evolving professional practices risk teaching outdated workflows.

Capacity building must also include assessment literacy. When students can generate code, documentation, or designs with AI assistance, assessment that evaluates only the final product becomes less valid as a representation of individual competence. Teachers require process-oriented assessment strategies, including development logs, commit histories, oral defenses, live coding, code explanation, peer review, testing evidence, reflection on AI use, and evaluation of design decisions. Casal-Otero et al. (2023) emphasize that integrating AI literacy into K-12 education requires attention to curriculum and assessment design rather than merely to technology-use activities. In RPL, this principle means that students may use AI as a work partner, but they must remain able to account for the resulting outputs technically. In this way, schools can avoid two extremes: total prohibition that ignores industry realities and unrestricted use that obscures students' actual competencies.

Pedagogical Transformation: Project-Based Learning, Teaching Factory, and AI-Assisted Development

The fourth theme indicates that an adaptive curriculum requires pedagogy that resembles professional practice. In basic programming instruction at SMKs, Aprilianti et al. (2021) show that Project-Based Learning (PjBL) can strengthen learning outcomes among RPL students. A more recent study by Amelia and Prismana (2026) developed a PjBL-based learning management system to improve the Junior Web Programmer competencies of RPL students, reinforcing the relevance of projects as a vehicle for developing technical competence. At the broader vocational-education level, teaching factories have been used to bring learning processes closer to industry work standards. Wijanarka et al.

(2023) show that the success of teaching factories is influenced by the quality of context, inputs, processes, and products, while Imran et al. (2024) demonstrate relationships among teaching-factory implementation, work readiness, and students' perspectives on the future of work.

AI integration creates the possibility of extending this concept into AI-assisted project-based learning. In this model, students are not merely asked to build an application; they solve authentic problems through the stages of requirements analysis, design, coding, testing, deployment, documentation, and presentation. AI may be used at each stage under clearly defined rules. For example, AI can assist with requirements brainstorming, generate alternative algorithms, suggest refactoring, create draft unit tests, or produce preliminary documentation. Students are nevertheless required to record their use of AI, verify outputs, correct errors, and explain the rationale for their decisions. This approach maintains alignment with workplace practice while preserving the learning process. Wahjusaputri et al. (2026) specifically demonstrate the potential of integrating AI into teaching factories to support adaptive learning, more real-time performance assessment, and the strengthening of vocational competencies aligned with industry standards.

The findings of Wahjusaputri et al. (2024) on a school-governance-based hybrid teaching factory are also relevant because they demonstrate that vocational learning environments can combine face-to-face interaction, technology, and collaboration to improve employability skills. For RPL, a teaching factory need not replicate a manufacturing production floor; the concept can be translated into a software studio or digital product laboratory. Students work in teams with roles such as product owner, analyst, UI/UX designer, developer, tester, and DevOps, while using version control, issue trackers, code review, sprint reviews, and product demonstrations. AI is positioned as a tool that must be managed professionally. This model is more consistent with the characteristics of the software industry than learning fragmented by topic, because problem solving, communication, collaboration, documentation, and engineering discipline emerge simultaneously.

From an analytical perspective, AI integration in PjBL and teaching factories serves two functions. First, it has a productivity function: students become familiar with tools they are likely to encounter in the workplace. Second, it has an epistemic function: AI itself becomes an object of evaluation, enabling students to learn to distinguish responses that are plausible, safe, efficient, and consistent with requirements. The second function is more important for safeguarding learning quality. If AI is used only to accelerate task completion, the curriculum risks encouraging dependency. By contrast, when students are required to critique, test, and revise AI-generated outputs, the technology can become a means of developing higher-order thinking. This reinforces the argument that AI integration should be designed into task and assessment structures rather than left as an unguided individual practice.

Table 4. Transformation of RPL Competencies and Curricular Consequences in the AI Era

Conventional competency	Expanded competency in the AI era	Learning/assessment consequences
Writing code	AI-assisted coding plus the ability to explain and verify code	Live coding, code explanation, commit history, review of AI outputs
Debugging	Human-AI debugging and root-cause diagnosis	Authentic bug cases, demonstration of causes, testing before and after correction
Application development	Problem framing, requirements, design, deployment, and product evaluation	End-to-end projects, demonstrations, oral defense, portfolios
Documentation	AI-assisted documentation with factual and consistency validation	Auditing documentation against source code and requirements
Use of digital tools	AI literacy, prompting, privacy, licensing, security, and ethics	Reflection on AI use, disclosure, risk evaluation

Conventional competency	Expanded competency in the AI era	Learning/assessment consequences
Individual work	Human-AI team collaboration and professional communication	Sprint review, peer review, issue tracking, presentation to the 'client'

Link and Match, Industry, and Curriculum Feedback Mechanisms

The fifth theme indicates that the relevance of the SMK curriculum is highly dependent on the quality of its relationship with the world of work. Maulina and Yoenanto (2022) describe link and match as an effort to align the quality, type, qualification, and timing of competency provision with industry needs. Misbahudin and Asmaul (2022) likewise emphasize that gaps in graduate competencies can be reduced through curriculum alignment and learning that is more closely connected to industry standards. Agustian et al. (2024) add that SMK-industry synergy through curriculum, internships, teacher training, certification, and the development of hard and soft skills constitutes an important component of improving graduate competitiveness. Industry relationships should therefore be understood as a governance mechanism for maintaining relevance rather than merely as the number of memoranda of understanding held by a school.

Purnamasari et al. (2026) emphasize that link-and-match-based leadership is required if collaboration with industry is to be genuinely integrated into the learning and quality-improvement system. In the RPL context, such integration can be developed through five channels: an industry curriculum forum, real projects or company briefs, engineer mentoring, workplace internships directly related to competencies, and practitioner evaluation of student portfolios. The collaborative curriculum model of Abdillah and Puspitasari (2025) further supports this need, while Tessa and Humaedi (2024) show that strengthening link and match in SMK Centers of Excellence is closely associated with curriculum alignment and school-industry relationships. As AI changes software-development workflows, these channels also function as an early-warning system through which schools can identify competencies that are increasing or decreasing in relevance.

The Special Job Placement Unit (BKK), tracer studies, and alumni feedback occupy a strategic position within this cycle. Employment-placement data should not function solely as outcome reports; they can also be used to analyze the match between employment and field of study, technologies used by alumni, recruitment barriers, and competencies perceived by companies as insufficient. Wardoyo et al. (2024) show that the work readiness of SMK graduates is influenced by the strengthening of technical and non-technical skills, while Ratnasari and Mudrikah (2025) identify contributions of ICT skills and soft skills to work readiness. When these outcome data are fed back into curriculum forums, schools obtain a mechanism for continuous curriculum improvement: graduate outcomes become inputs for subsequent adjustments to curriculum implementation. This is the principal distinction between administrative link and match and link and match grounded in organizational learning.

Graduate Quality as the Orientation of Quality Assurance and the Adaptive Curriculum Model

The sixth theme concerns a changing definition of graduate quality. Indonesian literature shows that work readiness cannot be represented by a single academic indicator. Wardoyo et al. (2024) emphasize the importance of hard and soft skills, while Kurniawati et al. (2023) specifically identify critical thinking, problem solving, active communication, and emotional intelligence as requirements for RPL graduates entering the start-up industry. Hidayati et al. (2021) and Septyani et al. (2022) show that the alignment of competencies with industry needs remains a central issue. These findings support the use of a multidimensional graduate-quality framework comprising technical competence, AI literacy, problem solving, communication and collaboration, professional ethics, adaptability, portfolio quality, certification, and employability outcomes.

This framework changes the logic of quality assurance. Schools cannot adequately measure quality solely through report-card grades, graduation, or successful completion of projects. Evidence of quality needs to be gathered from multiple sources: competency assessments, portfolio quality, certification, workplace-internship results, industry-mentor feedback, performance in technical interviews or recruitment, tracer studies, and alumni capacity to adapt to new tools. Imran et al. (2024) and Wahjusaputri et al. (2024) show that learning experiences resembling workplace practice are associated with employability and future-of-work orientation. By incorporating outcome indicators into

the curriculum-management cycle, schools can evaluate not only whether a curriculum has been 'implemented,' but also whether it produces relevant competencies.

Based on the overall findings, this study proposes the AI-Responsive Adaptive Curriculum Management Model for adapting the Merdeka Curriculum within the RPL Skills Concentration. The model consists of six cyclical processes. The first stage is environmental scanning, which involves collecting information on developments in AI, software engineering, policy, and industry needs. The second is curriculum alignment, in which this information—while continuing to refer to national Learning Outcomes—is translated into competency priorities, learning objectives, learning sequences, projects, and contextualized assessments. The third stage is capacity building to ensure that teachers, infrastructure, and governance arrangements are prepared to implement the required adjustments. The fourth is authentic implementation through PjBL, software studios or teaching factories, workplace internships, and controlled use of AI. The fifth stage is outcome assurance through assessment, portfolios, certification, industry feedback, and tracer studies. The sixth is feedback and renewal, in which outcome data are used to determine the next cycle of adjustment. The model synthesizes findings on industry-based curriculum management (Fahmi & Irfani, 2026), link-and-match leadership (Purnamasari et al., 2026), teaching factories (Wijanarka et al., 2023; Wahjusaputri et al., 2026), and RPL competency requirements (Kurniawati et al., 2023) into a single AI-responsive adaptation mechanism.

Table 5. Operationalization of the AI-Responsive Adaptive Curriculum Management Model
Environmental Scanning → Curriculum Alignment → Capacity Building → Authentic Implementation → Outcome Assurance → Feedback & Renewal ↻

Stage	Primary inputs	Primary actors	Operational outputs/indicators	Feedback pathway
1. Environmental Scanning	Developments in AI and software engineering; policy; recruitment requirements; feedback from workplace internships, the BKK, alumni, and industry.	Principal; vice principal for curriculum; head of PPLG/RPL program; BKK; industry partners.	Map of technological change and competency requirements; list of risks/opportunities; periodic review agenda. Indicators: evidence of meetings/monitoring, skills mapping, and change priorities.	Provides the basis for Curriculum Alignment.
2. Curriculum Alignment	Scanning results and national Learning Outcomes.	Vice principal for curriculum; program head; vocational-subject teachers; industry partners.	Competency priorities, learning objectives/sequences, project briefs, rules for AI use, and contextual assessment. Indicators: alignment documents and changes in instructional design.	Identifies Capacity Building needs.
3. Capacity Building	Teacher competency gaps, infrastructure needs, and new design/assessment requirements.	School management; vocational-subject teachers; laboratory/IT managers; industry partners.	Upskilling in AI literacy and assessment literacy, communities of practice, teacher internships, ethical/AI guidelines, and resource readiness. Indicators: participation in professional development and infrastructure readiness.	Determines readiness for Authentic Implementation.
4. Authentic Implementation	Aligned curriculum design and available capacity.	Teachers; students; industry mentors; teaching-factory/software-studio managers.	PjBL, software studio/teaching factory, workplace internships, and AI-assisted development with disclosure, code review, testing, and reflection. Indicators: process logs, commit histories, portfolios, demonstrations, and oral defense.	Implementation evidence feeds into Outcome Assurance.
5. Outcome Assurance	Assessment artifacts, portfolios, certification,	Teachers/assessors; program head;	A graduate-quality profile encompassing technical competence, AI literacy, problem solving, soft	Outcome gaps are forwarded to

Stage	Primary inputs	Primary actors	Operational outputs/indicators	Feedback pathway
	workplace-internship results, mentor feedback, BKK data, and tracer studies.	BKK; industry partners.	skills, ethics, adaptability, and employability. Indicators: competency rubrics, certification, portfolios, and industry/alumni feedback.	Feedback & Renewal.
6. Feedback & Renewal	Outcome data and the latest external signals.	Principal; curriculum team; program head; teachers; BKK; industry.	Decisions to maintain, strengthen, revise, or discontinue particular practices; action plans and targets for the next cycle. Indicators: curriculum-review meetings and documented follow-up.	Returns to Environmental Scanning and, where necessary, directly to Curriculum Alignment.

The model also clarifies the position of school management within curriculum adaptation. The principal is responsible for ensuring strategic direction and partnerships; the vice principal for curriculum translates that direction into structures and procedures; the head of the skills program facilitates the alignment of technical competencies; vocational-subject teachers design learning experiences and assessment; the BKK and industry-relations functions provide outcome and labour-market data; and industry partners serve as co-designers of instructional implementation, mentors, and evaluators. This division of functions reduces dependence on a single teacher who happens to be enthusiastic about AI and embeds the cycle of change within the school's organizational system. The operationalization presented in Table 5 also creates opportunities for empirical testing because each stage has observable inputs, actors, output artifacts, and indicators that can be examined through curriculum documents, assessment data, portfolios, tracer studies, interviews, observations, and evaluations by industry partners.

In the context of SMK Wikrama 1 Kabupaten Semarang, the model is used as an analytical framework rather than as a claim regarding the school's internal effectiveness. Official school documents that use the RPL-major label indicate an orientation toward web, desktop, and mobile software development using current technologies, teamwork, modelling, and attention to ethical, social, legal, security, and economic dimensions (SMK Wikrama 1 Kabupaten Semarang, n.d.-a). In this study, that institutional label is positioned within the official nomenclature as the RPL Skills Concentration under the PPLG Skills Program. Official school documents also position technology, industry needs, graduate readiness for employment, school leadership and performance, and industry collaboration as part of the institution's orientation (SMK Wikrama 1 Kabupaten Semarang, n.d.-b). For external triangulation, SMK Negeri 1 Tengaran (2024) identifies SMK Wikrama 1 Kabupaten Semarang as a network school in an RPL teaching-factory program involving coordination with business and industry. These linkages indicate that the school context is relevant for discussing curriculum alignment, authentic implementation, and industry partnership.

Overall, the results and discussion indicate that the principal challenge for education in the RPL Skills Concentration in the AI era is not a lack of technology, but the capacity of school management to manage changing competency requirements in a structured manner within the applicable curriculum framework. The addition of AI tools without corresponding adjustments to learning objectives, teacher capacity, project design, assessment, and industry relationships produces only superficial digitalization. By contrast, school management that manages the curriculum adaptively uses AI as a trigger for systemic improvement: the school identifies external changes, aligns competencies, develops teachers, creates authentic learning, evaluates outcomes, and renews curriculum implementation on the basis of evidence. Under this logic, stronger graduate quality is not positioned as an automatic consequence of AI use, but as an outcome orientation of curriculum governance capable of continuously connecting technology, pedagogy, human-resource development, and labour-market needs.

Theoretical and Practical Implications for School Management

Theoretically, the synthesis shifts curriculum management from an administrative function toward a dynamic capability of the school. The dynamic-capabilities framework emphasizes an organization's capacity to identify change, capture opportunities through decisions and resource mobilization, and reconfigure competencies as the environment changes (Teece et al., 1997; Teece,

2007). An adaptive curriculum does not mean that schools replace the national curriculum; rather, it reflects the organization's ability to sense, seize, and renew in implementing the curriculum in response to technological and labour-market change. In operational terms for vocational education, sensing is manifested through technology monitoring, tracer studies, industry feedback, and evaluation of workplace internships; seizing is manifested through decisions to align learning objectives, projects, resources, and teacher development while continuing to refer to national Learning Outcomes; and renewing is reflected in repeated revisions of implementation strategies on the basis of outcome data. Indonesian literature on link and match indicates that schools derive greater benefit when industry relationships are integrated with curriculum and learning rather than operating as ceremonial programs (Maulina & Yoenanto, 2022; Nasution et al., 2022; Purnamasari et al., 2026). The conceptual novelty of this study therefore lies in positioning AI as an external pressure that activates a cycle of adaptive school capabilities rather than merely as a new instructional medium.

Practically, the proposed model can be translated into an annual management agenda for the PPLG Skills Program and the RPL Skills Concentration. The curriculum team, managers of the PPLG Skills Program, and RPL vocational-subject teachers can conduct technology-and-industry reviews to map changes in tools, software-engineering practices, and recruitment requirements. The results can then be translated—while maintaining alignment with national Learning Outcomes—into learning objectives, learning sequences, cross-subject projects, and assessment indicators and subsequently tested in collaboration with industry partners. Following implementation, schools can collect evidence through project rubrics, code reviews, workplace-internship outcomes, certification, portfolios, company feedback, BKK data, and tracer studies. These data can be discussed in curriculum-review meetings to determine actions for improving implementation.

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CONCLUSION

This study concludes that adapting the Merdeka Curriculum within the Software Engineering (RPL) Skills Concentration in the AI era requires school management to move beyond the mere adoption of AI tools toward continuous and systematic curriculum adaptation. The synthesis identifies six interconnected managerial processes: environmental scanning, curriculum alignment, capacity building, authentic implementation, outcome assurance, and feedback and renewal. These processes form the proposed AI-Responsive Adaptive Curriculum Management Model, which positions graduate quality as a multidimensional outcome encompassing technical competence, AI literacy, problem solving, soft skills, ethics, adaptability, and work readiness. Schools are therefore encouraged to strengthen teacher AI literacy, integrate authentic project- and industry-based learning, involve industry partners in curriculum alignment and evaluation, and use graduate and industry feedback for continuous improvement. Because the proposed model is conceptual and based on literature and public documents rather than primary empirical data, future studies should test and refine the model through case studies, interviews, observations, tracer studies, and graduate-outcome evaluation in vocational schools.

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