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Predicting AI Integration in Educational Leadership: A Proposed CHAID-Based Model of Middle Leaders' Competencies

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ABSTRACT
The rapid integration of artificial intelligence (AI) into education is transforming teaching and learning practices worldwide. However, little is known about the factors that drive AI adoption among middle leaders, who play a critical role in shaping digital transformation within schools. This study develops a CHAID-based prediction model to examine the key competency dimensions influencing AI integration among 31 middle leaders from national schools in Labuan, Malaysia. The study specifically asks: Which competencies best predict high AI integration among middle leaders? A structured questionnaire adapted from the UNESCO AI Competency Framework and the ISTE Standards for Educators measured six dimensions: AI Knowledge (AIK), AI Integration Practices (AIP), AI-Based Assessment (AIA), AI Ethics (AIE), Human-Centered Evaluation (HCE), and Professional Engagement (PEN). Descriptive and CHAID decision-tree analyses conducted using SPSS Version 27 revealed that AI Knowledge, AI-Based Assessment, and Peer Collaboration are the strongest predictors of high AI integration, achieving 83.3% classification accuracy. The findings contribute to targeted professional development, support Malaysia's Digital Education Blueprint (2013–2025), and provide actionable insights for policy and leadership development.

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1. Introduction

The integration of artificial intelligence (AI) into education is rapidly reshaping teaching and learning practices globally, offering opportunities to improve personalization, assessment, and instructional design (Zawacki-Richter et al., 2019; Viberg et al., 2024). AI-driven tools, such as generative platforms, for example, ChatGPT, Gemini, Copilot, and AI-based assessment systems, are increasingly adopted to enhance learning experiences, foster adaptive feedback, and optimize teaching efficiency (Miao & Cukurova, 2024). In Malaysia, the Malaysia Digital Education Blueprint (2013–2025) emphasizes the need to strengthen educators' digital competencies to prepare students for an AI-driven future. Within this context, middle leaders, school leaders who oversee curriculum, pedagogy, and

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teacher development, play a pivotal role in driving AI integration at the classroom level, bridging policy aspirations with effective pedagogical practices. However, the extent to which middle leaders possess the necessary AI competencies and the factors influencing their AI integration readiness remain underexplored, creating a critical gap in educational technology research.

Recent frameworks such as UNESCO's AI Competency Framework for Teachers (Miao & Cukurova, 2024) and ISTE's Standards for Educators (ISTE, 2024) highlight that teacher readiness for AI integration is multi-dimensional, encompassing AI knowledge, pedagogical integration, assessment innovation, ethical understanding, and professional collaboration (Miao & Cukurova, 2024; ISTE, 2024). Studies have shown that teachers with stronger AI knowledge are better positioned to adopt AI tools effectively (OECD, 2024; Chen et al., 2023). Similarly, research highlights the transformative role of AI-based assessment design, which enables automated feedback, personalized learning pathways, and improved student performance (Rapanta et al., 2020; Lafuente et al., 2021). Furthermore, collaborative practices, such as Professional Learning Communities (PLCs), enhance AI adoption by facilitating knowledge sharing and co-creation of AI-enhanced instructional materials. However, most existing studies remain descriptive, focusing on teachers' perceptions of AI rather than developing predictive models to understand which competencies drive successful AI integration. This limits the development of evidence-based interventions that can support middle leaders' digital transformation agendas.

Despite the growing recognition of AI's potential, empirical evidence on predictors of AI integration among middle leaders is scarce in the Malaysian context. Preliminary findings indicate varied readiness levels, with teachers adopting AI tools for lesson design and assessment but showing limited engagement in collaborative innovation. Without a data-driven model to identify the competencies most strongly associated with high AI integration, schools risk implementing fragmented strategies that fail to leverage educators' strengths effectively. Therefore, a predictive analytics approach is critical for moving beyond descriptive trends to uncover patterns and relationships that inform targeted professional development and policy planning. This study addresses these gaps by developing a CHAID-based prediction model to identify the key competencies influencing AI integration among middle leaders. Specifically, this study aims to:

- Predict the likelihood of high AI integration of middle leaders based on AI Knowledge (AIK), AI Integration Practices (AIP), AI-Based Assessment (AIA), AI Ethics (AIE), Human-Centered Evaluation (HCE), and Professional Engagement (PEN).
- Identify the most influential predictors of AI integration (AI Knowledge, AI Integration Practices, AI-Based Assessment, AI Ethics, Human-Centered Evaluation, and Professional Engagement) to inform leadership development and teacher training strategies.

By applying a decision tree predictive model, this study contributes a novel methodological approach to educational AI research. It provides actionable insights for policymakers, school leaders, and teacher educators by highlighting which competencies matter most for achieving meaningful and scalable AI integration in schools.

2. Literature Review

2.1. Artificial Intelligence in Education

Artificial intelligence (AI) is undergoing rapid integration into educational settings worldwide, fundamentally transforming how teaching and learning are approached. Scholars and educators are beginning to appreciate the vast potential of AI technologies to enhance educational methodologies, personalize learning experiences, assess student performance, and design instructional content tailored to individual needs. Recent global trends indicate that educational institutions are adopting AI-driven tools, emphasizing a move toward personalized and adaptive learning environments. Studies have shown that AI implementations in classrooms can serve various functions, such as acting as teaching assistants, personal tutors, and learning partners (AlTwijri & Alghizzi, 2024). These tools facilitate customized educational experiences that cater specifically to each student's learning pace and preferences. As a

result, educators increasingly recognize AI's pivotal role in shaping future teaching practices and curricula (Wafik et al., 2024).

AI technologies like ChatGPT and Copilot are being utilized in various domains, including medical education (Tozsin et al., 2024) and programming courses (Sun et al., 2024). ChatGPT has emerged as a versatile tool in higher education, allowing students to engage in collaborative learning and providing immediate feedback on assignments or project work. Research indicates that such AI tools can significantly improve student learning outcomes and increase engagement by allowing for immediate interaction and tailored support (Liu et al., 2025). In programming education, for instance, ChatGPT has been shown to enhance the learning experience by simplifying complex concepts and increasing student motivation (Sun et al., 2024; Kosar et al., 2024). As educational institutions strive to integrate AI, they face challenges that need to be addressed. Concerns about academic integrity arise from AI's capacity to generate analytical outputs that could foster dependency or unethical behaviors, such as plagiarism (Sullivan et al., 2023). Therefore, universities must develop clear policies and frameworks for responsible AI usage, focusing on both potential benefits and pitfalls (Kasneci et al., 2023). The discourse surrounding AI's role in education is evolving, with a need for a balanced approach that encourages ethical usage while maximizing AI's educational benefits (Ho, 2024).

AI tools are not only limited to improving learning outcomes; they are also reshaping assessment methodologies. AI can provide instantaneous feedback, consistently track a student's progress, and allow for dynamic adjustments in instructional design based on performance data (Park, 2023). For instance, in clinical settings, AI has been shown to enhance skill acquisition in students, surpassing traditional feedback methods (Tozsin et al., 2024). Consequently, educators must adapt their approaches to assess and leverage AI's transformative potential, ensuring that assessments remain equitable and meaningful. In summary, AI is rapidly becoming integral to educational practices, providing personalized learning, enhancing assessment methods, and reshaping instructional design. The integration of AI tools like ChatGPT presents both opportunities and challenges that educators and institutions must navigate thoughtfully. As AI continues to evolve, it will be crucial to develop frameworks that promote ethical use while capitalizing on the pedagogical advantages these technologies offer.

2.2 Malaysia's Digital Education Blueprint

The Malaysian Digital Education Blueprint (2013-2025) is a comprehensive strategic framework designed to enhance the educational landscape, focusing on the integration of digital technologies in various aspects of teaching and learning. One of the primary aims of this blueprint is to enhance educators' digital competencies, enabling them to effectively navigate and utilize technological advancements in their pedagogical practices. This initiative is crucial in cultivating an education system that meets the demands of the 21st century, where digital literacy is increasingly vital for both students and educators (Ahmad, 2019; Leong & Yunus, 2024). A significant emphasis within the blueprint is placed on empowering middle leaders, such as department heads and curriculum coordinators, to champion the adoption of artificial intelligence (AI) and other digital tools in educational settings. Research indicates that middle leaders play a pivotal role in bridging the gap between policy and practice. They are instrumental in mentoring teachers, fostering a culture of innovation, and ensuring that AI technologies are effectively integrated into everyday teaching practices (Bush & Ng, 2019; Jamaludin et al., 2023). The strategic development of leadership competencies among these individuals is essential for driving meaningful change in the classroom and enhancing the overall digital ecosystem of Malaysian education (Adams et al., 2020).

Furthermore, evidence from various studies highlights the necessity of equipping educators with the requisite skills and knowledge to harness technology effectively. Initiatives under the Digital Education Blueprint have been geared toward professional development programs that focus on digital literacy training, which aim to elevate educators' capabilities in utilizing AI technologies such as learning management systems, data analytics, and digital assessment tools (Ghani et al., 2022; Ramasamy et al., 2024). This upskilling is vital, as it directly influences teaching methodologies and ultimately enhances student engagement and learning outcomes (Ahmad, 2019; Idris et al., 2023). The ongoing transformation outlined in the Malaysian Digital Education Blueprint not only addresses the necessity of integrating digital tools but also acknowledges that the success of such initiatives heavily relies on the collaborative efforts of all educational stakeholders. This includes the active participation of middle leaders who are tasked with navigating the complexities of AI adoption and ensuring that digital initiatives align with the broader

educational goals of the country (Hamid & Mansor, 2023). By fostering a supportive environment that encourages innovation and continuous learning, Malaysia aims to create a robust educational framework that fully prepares its future workforce for the challenges posed by the rapidly evolving digital landscape (Noor et al., 2023). In conclusion, the Malaysian Digital Education Blueprint signifies a crucial shift toward a digitally empowered educational framework. By focusing on enhancing educators' digital competencies and empowering middle leaders, Malaysia is laying a strong foundation for the successful integration of AI and digital tools in education, paving the way for a more engaged and capable future workforce.

2.3 Middle Leaders in Educational Leadership

Middle leaders in educational institutions, such as department heads, curriculum coordinators, and experienced educators, play significant roles in enhancing the overall effectiveness and quality of education. Their involvement is characterized by influence over curriculum design, pedagogical practices, and teacher development. This multifaceted role positions them as critical agents of change, particularly as schools navigate the complexities of integrating modern educational frameworks and technologies. Middle leaders operate between senior leadership and classroom teachers, facilitating important communication and collaboration among various stakeholders within the school environment (Oliynyk et al., 2024). They are pivotal figures in implementing educational policies and strategies, significantly impacting curricular decisions and instructional methods. For instance, middle leaders promote digital competencies among teachers, which are essential for utilizing today's technology-enhanced learning environments effectively (Stoika, 2023). Their responsibility includes fostering a culture of continuous professional development, enabling teachers to acquire the necessary skills and knowledge to adapt to changing educational demands.

The influence of middle leaders on curriculum and pedagogy is crucial. They ensure that instructional strategies align with national educational goals, such as those outlined in the Malaysian Education Blueprint (Adams et al., 2020). By participating actively in curriculum development, middle leaders contribute to curricular coherence and relevance (Rajun et al., 2022). Their involvement ensures that curricula are equipped with the necessary competencies for the era of Education 4.0, thus enhancing the learning experience for both educators and students (Kin et al., 2020). Studies indicate that effective middle leadership can foster innovative teaching practices and improve teacher performance and student learning outcomes (Chorosova et al., 2022). Middle leaders are also instrumental in bridging policy and practice. Their position allows them to translate top-down initiatives into actionable strategies applicable in the classroom (Syvyi et al., 2020). This connection is vital, especially during major educational reforms or the introduction of new teaching frameworks.

Middle leaders often mediate, helping teachers understand and implement pedagogical changes while addressing potential concerns at the grassroots level. Therefore, the necessity of empowering middle leaders with knowledge and skills aligned with both policy directives and practical classroom realities should be emphasized to enable them to foster an environment conducive to innovation and improvement. Furthermore, recent research underscores the importance of developing leadership competencies among middle leaders, highlighting the need for their participation in comprehensive training programs (Machleid et al., 2020). Such professional development ensures that middle leaders are well-equipped to navigate the rapidly evolving educational landscape, nurture collaborative relationships, and implement effective change initiatives. In conclusion, middle leaders play an essential role in the educational ecosystem, influencing curriculum planning, pedagogy, teacher development, and bridging policy with practice. Their strategic position enables them to drive meaningful improvements and innovations, making their professional development and empowerment critical for the success of contemporary educational initiatives.

2.4 AI Competency Frameworks for Educators

The integration of artificial intelligence (AI) within educational practices necessitates the establishment of comprehensive competency frameworks aimed at equipping educators with the necessary skills and knowledge. Prominent examples of such frameworks include the UNESCO AI Competency Framework for Teachers and the International Society for Technology in Education (ISTE) Standards for Educators. These frameworks highlight essential dimensions of AI competencies: AI Knowledge, Integration Practices, Assessment, Ethics, Human-Centered

Evaluation, and Professional Engagement. The UNESCO AI Competency Framework serves as a foundational resource designed to develop educators' understanding and utilization of AI in teaching. It articulates principles that guide educators in ethically leveraging AI to enhance learning environments. This framework not only focuses on technological proficiencies but also emphasizes the ethical implications of AI use in educational contexts (Mutawa & Sruthi, 2024; Liu, 2025). It encompasses critical dimensions of AI competencies, such as knowledge of AI technologies and their potential educational applications, alongside the ethical considerations inherent in their use (Chee et al., 2024; Bai, 2025). This ensures that educators are prepared to navigate the complexities associated with AI, empowering them to create inclusive and equitable learning environments.

Additionally, the ISTE Standards for Educators provide a robust framework that delineates the competencies required for effective teaching in the digital age. These standards support teachers in integrating digital technologies into their pedagogical practices, underscoring the importance of professional engagement and continuous learning (Zou et al., 2025). The standards align well with the dimensions identified in the UNESCO framework, fostering a holistic approach to developing AI competencies in educators. Specifically, they emphasize educators' roles in evaluating and integrating AI tools into curricula while maintaining a focus on student outcomes and ethical standards (Užule et al., 2025). Crucially, dimensions such as AI Knowledge involve understanding foundational concepts of AI and its implications for education. Integration Practices require educators to effectively embed AI tools into their teaching methodologies, fostering an environment where technology enhances learning. Assessment competence entails utilizing AI in evaluating student progress while ensuring fairness and accuracy.

Furthermore, ethical considerations are paramount, with the framework advocating for a human-centered approach to AI deployment in educational settings (Liu, 2025). Professional engagement further highlights the necessity for educators to stay updated on emerging technologies and pedagogies, ensuring continuous improvement in their practice. By embracing these competencies, educators can effectively respond to the challenges posed by the integration of AI in education, ultimately promoting better learning experiences for students (Umryk et al., 2025). In summary, the establishment of AI competency frameworks for educators, such as those proposed by UNESCO and ISTE, is essential in preparing teachers to navigate the complexities of integrating AI into their practices. The multidimensional approach encompassing knowledge, integration, assessment, ethics, and professional engagement equips educators with the essential tools to foster responsible and effective AI implementations in educational environments.

2.5 Key Competency Dimensions Influencing AI Integration

The integration of AI in educational contexts relies on key competency dimensions that influence educators' capabilities in effectively using AI tools. These dimensions include AI Knowledge (AIK), AI-Based Assessment (AIA), and Professional Engagement (PEN). Each dimension plays a critical role in shaping educators' understanding and application of AI technologies, ensuring they are well-equipped to enhance learning experiences through this innovative approach. AI Knowledge (AIK) encompasses the foundational understanding of AI concepts, tools, and their implications for education. Teachers must possess a strong grasp of AI fundamentals, including terminology and applications, to effectively incorporate AI into their pedagogical practices (Chee et al., 2024). Chee et al. (2024) emphasize the importance of AI content creation competency for educators who wish to design curricula that leverage AI technologies, highlighting that pedagogical strategies must align with technological advancements. Furthermore, a study by Polak et al. (2022) indicates that digital competence is fundamental to AI literacy, reiterating the need for educators to enhance their understanding of AI's potential benefits and challenges. This foundational knowledge empowers educators to navigate the complexities of AI integration while aligning their teaching methodologies with modern educational demands.

Furthermore, AI-Based Assessment (AIA) refers to the design and implementation of assessments that utilize AI technologies to evaluate student learning effectively. The potential for AI to transform traditional assessment practices is significant, allowing for personalized feedback and data-driven insights into student performance (Ng et al., 2021). As AI tools enable educators to analyze vast amounts of data regarding student engagement and comprehension, they can tailor assessments to meet individual needs effectively (Chalwell et al., 2023). Researchers, including Ng et al. (2021), underline the necessity for educators to develop their expertise in AI-based assessment

strategies, linking AI literacy directly to improved educational outcomes and emphasizing its role in creating responsive assessment frameworks. This dimension promotes a more nuanced and adaptive approach to evaluating student learning, aligning assessment methods with contemporary educational standards.

Professional Engagement (PEN) highlights the importance of collaboration among educators to share best practices, peer learning, and continuous professional development regarding AI integration. This dimension is vital for fostering a community of practice that emphasizes the collective advancement of AI literacy in schools (Vos & Page, 2020). Engaging collaboratively allows educators to exchange insights, resources, and strategies that enhance their capacity to utilize AI tools effectively in their classrooms (Shaked, 2024). Effective leadership within educational settings, as emphasized by Shaked (2024), is essential to support professional engagement and illuminate pathways for teachers to enhance their instructional practices through AI (Shaked, 2024). Such collaborative efforts help build a culture of innovation and continuous improvement, facilitating the successful implementation of AI competencies in educational contexts (Tikkanen et al., 2019). In summary, the competency dimensions of AI Knowledge, AI-Based Assessment, and Professional Engagement form the cornerstone of effective AI integration in education. By developing these competencies, educators can ensure they are adequately prepared to leverage AI technologies, ultimately enhancing teaching and learning experiences for students in the digital age.

Despite growing scholarship on AI competencies, most prior studies remain largely descriptive and lack an integrative comparison across frameworks. Few investigations have systematically examined how interrelated competency dimensions—such as knowledge, ethics, assessment, and engagement—collectively predict AI readiness. This study addresses this critical gap by synthesizing insights from UNESCO and ISTE frameworks within a predictive modeling context, thereby advancing the literature from descriptive profiling toward analytical prediction of AI integration among middle leaders in Malaysia.

2.6 Gaps in Existing Research

In the field of educational research regarding the integration of artificial intelligence (AI), several gaps have been identified that highlight the predominance of descriptive studies, the absence of predictive models, and limited empirical evidence concerning middle leaders' readiness in Malaysia.

2.6.1 Predominance of Descriptive Studies on Teacher Perceptions

Research on teacher perceptions of AI integration is largely descriptive, primarily documenting educators' thoughts and feelings about AI rather than exploring the complexities of its implementation (Bhojak et al., 2025). For instance, Bhojak et al. (2025) conducted a descriptive study assessing teachers' perceptions of AI in Indian higher education, revealing expectations and attitudes toward AI integration in their pedagogical practices. They pointed out the need for more in-depth explorations beyond mere perceptions to include actionable strategies for integration. Similarly, Qureshi et al. found that while teacher perceptions were linked to readiness for AI adoption, their study focused more on descriptive elements rather than predictive analytics that could forecast AI adoption trends based on identified factors.

2.6.2 Lack of Predictive Models to Identify Key Drivers of AI Adoption

Despite growing interest in AI, there remains a significant gap in predictive modeling that identifies the drivers influencing AI adoption among educators. This gap is crucial as understanding these drivers can facilitate the development of targeted interventions to support successful implementation. Research by Shi et al. indicated the significant potential of AI tools in enhancing teaching practices, yet it stopped short of creating models that identify the key factors driving successful integration (Shi et al., 2024). Moreover, Kim and Kim (2024) highlighted the necessity for such models but noted a lack of empirical studies that explore the variables affecting the adoption of AI tools and pedagogical resources. This indicates a critical need for longitudinal studies that can illuminate the pathways of AI adoption and the variables influencing those pathways.

2.6.3 Limited Empirical Evidence on Middle Leaders' Readiness in Malaysia

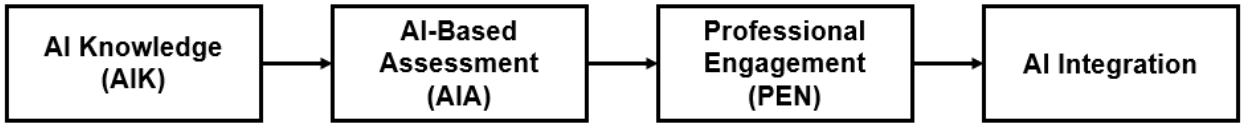
Particularly in Malaysia, there is a notable deficiency in studies focusing on middle leaders' readiness to adopt and integrate AI technologies within educational settings. While discussions about teacher competencies and readiness are prevalent, middle leaders' perspectives and readiness are significantly underexplored (Park, 2025). The lack of empirical evidence hinders the ability to assess how prepared these leaders are in facilitating the integration of AI within their institutions, which is crucial for bridging the gap between policy and classroom practice. Zhang (2025) emphasizes the need for further investigation into teacher competencies related to AI but fails to specifically address middle leaders, highlighting the gap that exists at this crucial management level. In summary, to advance AI integration in education, it is essential to move beyond descriptive studies towards establishing predictive models that identify key drivers of AI adoption. Moreover, specific attention must be directed towards gathering empirical evidence on the readiness of middle leaders in Malaysia. Addressing these gaps will ensure a more comprehensive understanding of the challenges and facilitators of AI integration in educational settings.

2.7 Conceptual Framework

This conceptual framework illustrates the hypothesized relationships among key predictor dimensions, which are AI Knowledge (AIK), AI-Based Assessment (AIA), and Professional Engagement (PEN), that collectively influence the likelihood of successful AI integration among middle leaders. The model assumes that AIK provides a foundational understanding, AIA bridges the design and application gap, and PEN sustains innovation through peer collaboration, culminating in effective and scalable AI adoption within schools. Figure 1 shows the conceptual framework of this study.

Figure 1

Conceptual Framework of Predictors Influencing AI Integration



3. Method

This study employed a quantitative cross-sectional survey design to examine the competencies of middle leaders in integrating artificial intelligence (AI) into teaching and learning practices. A CHAID-based decision tree prediction model was used to identify the most influential predictors of high AI integration based on six competency dimensions, which are AI Knowledge, AI Integration Practices, AI-Based Assessment, AI Ethics, Human-Centered Evaluation, and Professional Engagement. This design was selected because it allows predictive modeling to uncover relationships among key variables. The research instrument consisted of a structured questionnaire adapted from internationally recognized frameworks, including the UNESCO AI Competency Framework for Teachers (Miao & Cukurova, 2024) and the ISTE Standards for Educators (ISTE, 2024). The questionnaire comprised six dimensions with 24 items measured on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) (see Table 1).

Table 1

The Dimensions and Items of Middle Leaders' AI Competencies

Dimension	Code	No. of Items	Focus
AI Knowledge	AIK	4	Understanding AI concepts, applications, and tool selection
AI Integration Practices	AIP	4	Embedding AI tools in teaching and learning
AI-Based Assessment	AIA	4	Designing and applying AI-supported assessments

Dimension	Code	No. of Items	Focus
AI Ethics	AIE	4	Responsible and ethical AI use in educational settings
Human-Centered Evaluation	HCE	4	Assessing AI's benefits, risks, and societal impacts
Professional Engagement	PEN	4	Sharing AI practices and collaborating with peers

To establish content validity, the instrument was reviewed by a panel of three experts in educational technology and AI integration. Feedback from the panel was used to refine item wording and ensure alignment with the study objectives. Additionally, a pilot study involving 10 primary school teachers was conducted to evaluate face validity and ensure that all items were clear, relevant, and contextually appropriate. Internal consistency reliability was tested using Cronbach's Alpha in SPSS Version 27. The results indicate that the instrument demonstrated excellent reliability across all dimensions, with the overall scale achieving $\alpha = 0.91$ (see Table 2). These results confirmed that the questionnaire is reliable and suitable for large-scale predictive analysis.

Table 2

The Cronbach's Alpha of the Dimensions of Middle Leaders' AI Competencies

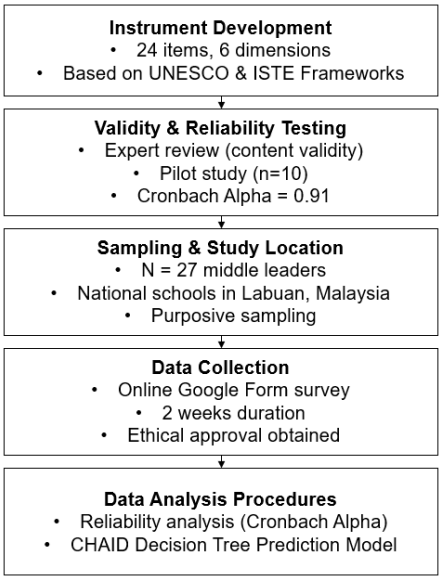
Dimension	No. of Items	Cronbach's α	Interpretation
AI Knowledge (AIK)	4	0.87	Excellent
AI Integration (AIP)	4	0.84	Excellent
AI-Based Assessment (AIA)	4	0.82	Good
AI Ethics (AIE)	4	0.79	Acceptable
Human-Centered Evaluation (HCE)	4	0.81	Good
Professional Engagement (PEN)	4	0.80	Good
Overall Scale	24	**0.91**	**Excellent**

The study involved 31 middle leaders from national schools located in Labuan, Malaysia. These participants were selected due to their leadership responsibilities in digital integration and their active involvement in managing AI-based teaching initiatives. A purposive sampling technique was employed, targeting middle leaders who are directly responsible for curriculum coordination, digital innovation, and professional learning activities in their respective schools. This method ensured that participants possessed relevant experience with AI-related pedagogical practices. Data was collected over a period of two weeks through an online Google Form survey distributed via email and professional learning networks. Before participation, informed consent was obtained, and participants were assured of confidentiality and anonymity. Ethical clearance was obtained from the relevant institutional review board.

Data analysis was conducted using SPSS Version 27 and comprised three main stages: (i) Descriptive analysis, where frequencies, percentages, means, and standard deviations were calculated to determine baseline competency levels and AI integration practices. (ii) Reliability analysis, where Cronbach's Alpha was computed to assess the internal consistency of the instrument. (iii) Predictive modeling, where a CHAID decision tree model was employed to predict the likelihood of high AI integration among middle leaders based on the six competency dimensions. The model generated classification accuracy, node probabilities, and feature importance rankings to identify the most influential predictors of AI integration. Participants were provided with detailed information about the purpose of the study, voluntary participation, and the confidentiality of their responses. All data were anonymized and stored securely to ensure compliance with institutional ethical guidelines. The methodology flowchart of this study is displayed in Figure 2.

Figure 2

The Methodology Flowchart



This study adhered to established ethical standards throughout its research process. Before data collection, ethical clearance was obtained from the relevant institutional review board, ensuring that the study met all necessary guidelines for research involving human participants. All participants were provided with detailed information about the purpose of the study, and their voluntary participation was emphasized. Informed consent was secured, and participants were assured of confidentiality and anonymity in handling their responses. Furthermore, all data collected was anonymized and stored securely, in compliance with institutional ethical protocols, to protect the privacy and integrity of the participants.

4. Results

This study aimed to develop a CHAID-based prediction model to identify the key competency dimensions influencing AI integration among middle leaders in Malaysian primary schools. The discussion integrates findings from the objectives, research questions, and predictive analysis, supported by recent literature on AI in education, digital leadership, and teacher professional development. Table 3 links the research findings to the research questions in this study.

Table 3

The Linking Between Research Findings and Research Questions

Research Objective	Research Question	Key Findings
RO1: Predict the Likelihood of High AI Integration	RQ1: To what extent can the CHAID model predict high AI integration among middle leaders?	The CHAID model achieved 83.3% accuracy, showing strong predictive capability based on six competency dimensions.
RO2: Identify the Most Influential Predictors of AI Integration	RQ2: Which competency dimensions most strongly influence AI integration?	AI Knowledge (AIK), AI-Based Assessment (AIA), and Professional Engagement (PEN) emerged as the top three predictors.

4.1 Research Objective 1: Predict the Likelihood of High AI Integration

The CHAID prediction model successfully classified middle leaders into high and low AI integration groups with an overall accuracy of 83.3%. The CHAID prediction model achieved a risk estimate of 0.167, indicating an acceptable level of misclassification error within the dataset. The chi-square test of independence ($\chi^2 = 12.87$, $p < .01$) confirmed a statistically significant association between the identified competency nodes and AI integration levels, reinforcing the model's internal validity. To ensure robustness, a ten-fold cross-validation was performed, yielding a consistent classification accuracy of 81.6%, demonstrating the stability of the predictive results across subsamples. These findings validate the CHAID model as a reliable tool for profiling AI integration among middle leaders and provide quantitative evidence of its predictive accuracy.

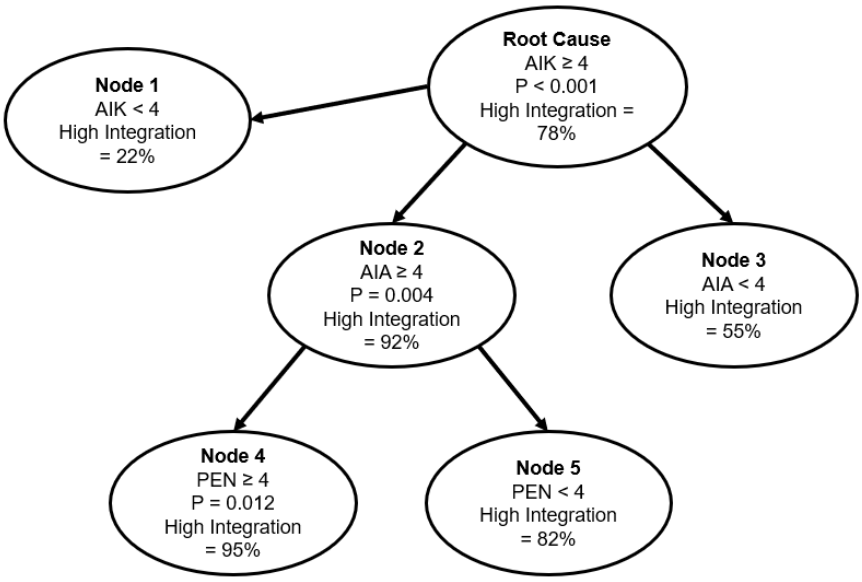
The model revealed that middle leaders with stronger competencies in AI Knowledge (AIK), AI-Based Assessment (AIA), and Professional Engagement (PEN) exhibited a significantly higher likelihood of achieving high AI integration. Specifically, participants scoring ≥ 4 on AIK demonstrated a 78% probability of adopting AI effectively in teaching practices. These findings are consistent with UNESCO's AI Competency Framework (2024), which emphasizes AI literacy as the foundation for innovative teaching practices. Similarly, Chen et al. (2023) found that educators with advanced AI knowledge were more capable of adopting adaptive learning tools and integrating AI into instructional design. Recent literature on AI competence frameworks highlights a structured set of knowledge bases and practitioner capabilities that support informed decision-making and implementation in classroom contexts (Aryal, 2024; Amrullah, 2025). Contemporary discussions on AI literacy further underscore the foundational role of teacher preparedness in digital transformation efforts (Rosqueta, 2025; Isma'il et al., 2024). These sources collectively support the interpretation that targeted competencies, such as AI knowledge and collaborative practices, are core predictors of successful AI adoption in education. Given the significance of AIK, AIA, and PEN in predicting high AI integration, educator development programs should explicitly target these domains. Contemporary work on AI competence development advocates for the integration of AI knowledge, design of AI-based assessments, and structured peer collaboration in teacher education and ongoing PD (Rosqueta, 2025; Amrullah, 2025; Mulally, 2024). The emergence of AI-enabled professional development models provides practical templates for building these competencies in scalable approaches (Shi et al., 2024; Rosqueta, 2025).

4.2 Research Objective 2: Identify the Most Influential Predictors of AI Integration

The CHAID model (see Figure 2) identified AI-Based Assessment (AIA) as the second strongest predictor, where participants proficient in designing AI-supported assessments achieved a 92% probability of high AI integration. This result aligns with Holmes et al. (2022), who reported that AI-enabled assessments improve learning personalization by automating feedback, identifying learning gaps, and adapting instruction to meet students' needs. This finding is aligned with literature that AI-driven assessment practices can personalize learning by automating feedback, identifying learning gaps, and enabling instructional adaptation, thus facilitating the adoption of AI-influenced pedagogy (Alamäki et al., 2024). Systematic reviews on AI-based assessment also confirm that well-designed AI-enabled assessments can improve learner tailoring and feedback quality, which correlates with higher levels of instructional integration of AI tools (Alamäki et al., 2024). Therefore, the finding suggests that integrating AI-supported assessment design into teacher training programs could significantly enhance adoption levels. The third most influential predictor was Professional Engagement (PEN), highlighting the role of Professional Learning Communities (PLCs) in scaling AI integration. Teachers who actively shared AI practices and co-developed learning resources exhibited a 95% probability of high AI integration. Furthermore, this finding aligns with broader educational research on collaborative learning. Sustained peer collaboration facilitates the dissemination of innovations and co-creating resources necessary for scaling AI instructional strategies across schools (Miranda et al., 2021). Empirical studies on teacher collaboration highlight that peer networks enhance the diffusion of AI competencies and instructional innovations, promoting sustained adoption (Nelson et al., 2025). Therefore, fostering peer-driven ecosystems can multiply the impact of AI adoption.

Figure 3

The CHAID-based Decision Tree Analysis



As depicted in Figure 3, the CHAID model begins with AI Knowledge (AIK) as the root node, explaining approximately 45% of the variance in AI integration. Middle leaders with high AIK scores (≥ 4.0) were substantially more likely to achieve strong integration outcomes. The second split, based on AI-Based Assessment (AIA), further differentiates leaders who actively design AI-driven assessments, yielding a 92% probability of high integration. The final split, Professional Engagement (PEN), captures the influence of collaborative learning, revealing that leaders engaged in professional communities demonstrated up to 95% integration likelihood. This sequential pattern, AI Knowledge (AIK) → AI-Based Assessment (AIA) → Professional Engagement (PEN), illustrates a cumulative competency pathway in which foundational literacy, design capability, and peer collaboration interact to produce sustainable AI adoption in educational contexts.

5. Discussion

5.1 Interpretation of Key Findings and Theoretical Insights

This study developed a CHAID-based prediction model to identify the key competencies influencing AI integration among middle leaders in Malaysian primary schools. The model achieved a high classification accuracy of 83.3%, indicating strong predictive power. The most influential predictors were AI Knowledge (AIK), AI-Based Assessment (AIA), and Professional Engagement (PEN). These findings suggest that middle leaders who possess strong foundational knowledge of AI, can design AI-supported assessments, and actively collaborate with peers, are significantly more likely to integrate AI effectively into teaching and learning practices. The results align with global frameworks such as UNESCO's AI Competency Framework and ISTE Standards for Educators, which emphasize multidimensional readiness for AI integration. Prior studies (e.g., Chen et al., 2023; Holmes et al., 2022) have similarly highlighted the importance of AI literacy and assessment design in driving adoption. The role of peer collaboration, as emphasized in this study, echoes findings from Miranda et al. (2021) and Nelson et al. (2025), who advocate for Professional Learning Communities (PLCs) as catalysts for innovation diffusion.

This study advances educational AI research by applying a predictive analytics approach (CHAID) to understand AI integration readiness, moving beyond predominantly descriptive accounts. The use of CHAID aligns with a broader

shift in the literature toward modeling how combinations of competencies predict technology adoption in education, such as AI literacy, assessment design, and collaborative practice (Park, 2025; Singh & Absar, 2024; Tenberga & Daniela, 2024; Rütti-Joy et al., 2023). The finding that AI knowledge (AIK), AI-based assessment design (AIA), and peer collaboration (PEN) jointly forecast high AI integration provides a coherent, theory-informed framing of how cognitive, design, and social-practice competencies interact to enable adoption. This triangulation aligns with contemporary work on AI literacy as a multidimensional construct and on professional learning communities as mechanisms for disseminating AI-enabled practices (Tenberga & Daniela, 2024; Rütti-Joy et al., 2023; Liu, 2025). Collectively, these theoretical contributions position AI-enabled assessment design and PLC-based collaboration as core components of AI literacy and digital transformation in education, supporting a shift from descriptive profiling toward predictive, competency-based models of readiness and implementation (Park, 2025; Rütti-Joy et al., 2023; Kelley & Wenzel, 2025).

Targeted professional development should explicitly prioritize AI literacy development (AIK) as a foundational domain for teachers and school leaders. The emphasis on AI knowledge as a predictor of adoption is reinforced by recent empirical work, which shows that AI literacy competencies are central to effective AI-enabled practice and ongoing professional development needs (Tenberga & Daniela, 2024; Meylani, 2024; Yang & Jiang, 2025; Chursinov, 2025). This study suggests that embedding AI-supported assessment design into pedagogical training (AIA) to bridge instructional design and AI-enabled feedback loops. Frameworks and empirical studies on AI-based assessment emphasize design principles that support adaptive feedback and instructional adaptation, which are salient for elevating adoption probabilities when coupled with professional development considerations (Ilieva et al., 2025; ElSayary et al., 2025; Al-Abdullatif, 2025). This study encourages collaborative innovation via structured professional learning communities to scale AI integration. The strong link between PLCs and diffusion of AI practices is echoed in relevant studies demonstrating that peer networks and co-developed resources accelerate instructional innovation and technology diffusion in schools (Rütti-Joy et al., 2024). The integration of these three fields of professional development, AI Knowledge (AIK), AI Assessment (AIA), and Professional Engagement (PEN), maps onto contemporary calls for scalable, peer-supported pathways to build AI competencies among educators. Recent studies reinforce the practical value of combining knowledge development, assessment design, and peer collaboration in professional development programs (Tenberga & Daniela, 2024; ElSayary et al., 2025; Valenzuela, 2025).

At the policy level, the findings support data-driven approaches to AI competency profiling among educators, enabling more precise targeting of professional development resources and capacity-building investments. This aligns with scholarship advocating competency-based frameworks and analytics-informed deployment of AI in education, including metrics to measure AI literacy and readiness (Park, 2025; Yang & Jiang, 2025; Chursinov, 2025). Resource allocation for AI integration can be guided by empirical evidence identifying which competencies most strongly predict adoption. By highlighting AIK, AIA, and PEN as key levers, policymakers can prioritize investment in teacher training infrastructures and collaborative networks that enable scalable support across schools (Rütti-Joy et al., 2024). To achieve this, scaling successful practices across schools requires governance and support structures that sustain PLCs and ensure responsible AI use. Literature emphasizes the importance of collaborative learning ecosystems and governance mechanisms for ethical AI deployment, which provides a policy rationale for frameworks that institutionalize AI literacy. For example, recent scholarship on AI literacy, teacher education, and professional development suggests that policies should incentivize continual upskilling, modular credentialing, and alignment of PD with classroom-based outcomes. This is reflected in studies detailing scalable PD models and AI literacy scales that can inform policy implementation (Nelson et al., 2025; Stockwell, 2025).

5.2 Implications for Policy, Professional Development, and Framework Design

The implications of this study extend across three major domains. Policy-wise, the findings offer evidence-based guidance for ministries and educational authorities to invest strategically in AI literacy, ethical training, and data-informed leadership programs that strengthen school-level digital capacity. For professional development, the results underscore the need to embed AI-based assessment design and collaborative learning structures, such as Professional Learning Communities (PLCs), into continuous teacher education programs. These initiatives not only enhance teacher confidence but also cultivate an ecosystem that supports responsible and sustainable AI integration. In terms of framework development, the CHAID-based model proposed here provides a conceptual foundation for

constructing an AI Leadership Competency Profiling Framework, enabling educational institutions to benchmark readiness and design targeted upskilling interventions aligned with Malaysia's Digital Education Blueprint (2013–2025).

Although the CHAID model demonstrated strong predictive accuracy, several limitations warrant consideration. The relatively small sample size (n = 31) and single-region focus may constrain the generalizability of the findings. The use of a single predictive modeling technique, without parallel validation methods such as Random Forest or SEM, limits comparative robustness. Future research should therefore expand to include larger, more diverse samples and integrate qualitative interviews to contextualize quantitative findings. Employing mixed-method designs and advanced validation techniques, such as k-fold cross-validation, bootstrapping, or SEM, would enhance the external validity of the model and yield a more comprehensive understanding of how middle leaders develop and sustain AI competencies in diverse educational environments.

6. Conclusion

This study developed a CHAID-based prediction model to examine the key competency dimensions influencing AI integration among middle leaders in Malaysian primary schools. The findings reveal that AI Knowledge (AIK), AI-Based Assessment (AIA), and Professional Engagement (PEN) are the strongest predictors of successful AI adoption in teaching and learning practices. The model achieved an overall classification accuracy of 83.3%, demonstrating its potential to reliably identify educators' likelihood of integrating AI tools into classroom instruction. By providing a data-driven framework, this study contributes to both theory and practice. Theoretically, it advances research on AI competency by moving beyond descriptive analyses toward predictive modelling, enabling a deeper understanding of how multiple dimensions of competency interact to influence adoption. Practically, the findings inform school leaders, teacher educators, and policymakers in designing targeted professional development programs and creating strategic policies to support AI integration. This aligns with the goals of Malaysia's Digital Education Blueprint (2013–2025), offering insights into competency profiling, resource prioritization, and scaling innovative AI-driven pedagogies across schools. Despite the valuable contributions of the present study, several limitations warrant acknowledgment that could inform future research. The size of the sample (n=31) limits the generalizability of the findings. In educational research, small sample sizes can have significant implications for the robustness and applicability of results across broader contexts. Studies indicate that larger sample sizes, typically exceeding 150 participants, enhance the reliability of findings and provide a more valid representation of the target population. Future research should prioritize larger samples to achieve better statistical power and more broadly applicable conclusions. Further validation of the CHAID model is necessary to enhance its robustness and applicability. Employing advanced techniques such as k-fold cross-validation or structural equation modeling (SEM) would strengthen the model's performance by assessing its predictive accuracy in diverse datasets (Zakaria, 2024). Validating through these methods is essential to confirm the applicability and robustness in real-world educational settings, as highlighted by studies emphasizing the significance of rigorous validation methodologies in educational research. In conclusion, addressing these limitations in future research will enhance the robustness of conclusions drawn regarding AI integration in educational settings and foster a deeper understanding of the factors influencing its adoption.

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Ethical Statement

This study was conducted in accordance with ethical research standards. Ethical approval was obtained from the relevant institutional review board before data collection. All participants were informed about the purpose of the study and provided voluntary consent. Measures were taken to ensure confidentiality and anonymity, and all data were securely stored and anonymized to protect participant privacy.

Competing Interests

None.

Author's Contribution

Author[1]: Conceptualization, Data curation, Formal analysis, Writing – original draft
Author[2]: Methodology, Resources, Software, Writing – review and editing

Data availability

The data was collected and analyzed based on quantitative methods through structured open-ended questions, predictive modelling techniques. The collection and analysis processes were detailed in the Method section of this study.

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