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Attributes of Professional Leadership among Industrial Vocational Teachers in the Context of Industry 4.0

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ABSTRACT

This research aimed (1) to study the level of professional leadership characteristics among industrial teachers in the era of Industry 4.0, (2) to analyze key components of professional leadership, and (3) to propose guidelines for promoting leadership development among vocational instructors. A mixed-methods design was employed, collecting data from 150 industrial teachers under the Office of Vocational Education Commission in Bangkok and its vicinity. A Likert-scale questionnaire and in-depth interviews with five model teachers and two school administrators were used. Quantitative data were analyzed using descriptive statistics and Exploratory Variable Analysis (EFA), while qualitative data were analyzed through content analysis. The findings revealed that the teachers exhibited a high level of professional leadership. Major components included instructional leadership, transformational leadership, servant leadership, and coaching/mentoring roles, all positively correlated with the effectiveness of Active Learning and Project-based Learning approaches. It is recommended that leadership development programs for industrial teachers emphasize collaboration with industry partners, motivation building, and professional mentorship for learners.

Keywords: Professional Leadership, Industrial Teachers, Industry 4.0, Vocational Teacher Development

INTRODUCTION

The advancement of technology in the Industry 4.0 era has significantly transformed the context of vocational education, particularly the role of industrial teachers, who must adapt from being mere "knowledge transmitters" to becoming "learning leaders and competency developers" for students in a complex and rapidly changing technological environment (Brynjolfsson & McAfee, 2018). The emergence of Artificial Intelligence (AI), Cyber-Physical Systems (CPS), and the Internet of Things (IoT) has integrated modern industries through real-time connections between manufacturing technologies, communication systems, and data networks (Brettel et al., 2014). In this context, vocational learners are required to develop new skills such as digital literacy, analytical thinking, and collaborative problem-solving, which cannot be effectively cultivated through traditional lecture-based instruction alone (Marr, 2018). Therefore, industrial teachers must possess advanced teaching competencies that go beyond knowledge delivery to embody professional leadership, inspire students, facilitate active learning, and link education to real industrial practices (Siribanpitak, 2020). Professional leadership in this sense does not merely involve instructional management but also encompasses the ability to guide academic excellence, foster

innovation, serve learning communities, and act as a mentor or coach for both students and fellow teachers (Costa & Garmston, 2016; Hallinger & Murphy, 1985; Greenleaf, 2002). In Thailand's vocational education system, industrial teachers play a crucial role in producing a skilled workforce that meets industry demands. The Office of Vocational Education Commission (OVEC) has emphasized the development of "new-generation teachers" with five core competencies: (1) professional leadership, (2) integrated learning management, (3) collaboration and partnership with industries, (4) digital technology application in teaching, and (5) innovation in learning development (Office of Vocational Education Commission [OVEC], 2022). However, despite several policies promoting teacher leadership, in-depth research on the professional leadership characteristics of Thai industrial teachers remains limited, with most studies focusing on administrative rather than professional or instructional leadership (Petchprasert, 2019).

International studies indicate that teachers' professional leadership is a crucial factor influencing both the quality of student learning and the development of a learning culture within educational organizations (Harris & Jones, 2019; Leithwood et al., 2020). In particular, transformational leadership and servant leadership have been found to enhance teachers' motivation and job engagement (Karim, 2021). Meanwhile, instructional leadership serves as a key mechanism enabling teachers to connect learning goals with student achievement outcomes (Hallinger, 2011). Furthermore, the coaching and mentoring role has been recognized as a contemporary approach to teacher development, positioning teachers as "collaborative learning leaders" rather than merely directive supervisors (Lofthouse, 2019). However, in the Thai context, many industrial teachers continue to face constraints in resources, workload, and continuous professional development, resulting in an unsystematic promotion of professional leadership (Thongchaem, 2020). In addition, several studies have revealed that teacher development programs in vocational institutions tend to focus more on technical training than on enhancing leadership competencies (Pitiphong, 2021). At the same time, the transition to the Industry 4.0 era demands a new generation of industrial teachers who possess the ability to plan instruction through Project-based Learning (PBL) strategically and effectively utilize digital tools for assessment and learning management (Phiriyaprakob, 2022).

A review of the literature reveals that several studies have examined leadership among vocational teachers across various dimensions, including administrative, technological, and innovative leadership (Chantarasombat, 2020; Suthas, 2021). However, research on professional leadership in industrial education remains limited, particularly regarding its structural components and developmental approaches suited to the Industry 4.0 context, which demands leaders who are flexible, systems-oriented, and capable of cross-sector collaboration (Wu et al., 2020). This research gap underscores the need for a systematic investigation of this issue. Furthermore, the concept of professional leadership among teachers differs from conventional administrative leadership, emphasizing professional growth, ethical responsibility, integrity, and teachers' role as moral and professional exemplars for both students and colleagues (Frost, 2019). Professional leadership is also associated with competencies such as network building and cross-cultural communication, which are essential for educators operating in a globalized era (Schein, 2017). For industrial teachers, professional leadership encompasses visionary awareness of emerging manufacturing technologies, and the integration of STEM education principles and digital pedagogy into practical learning processes (UNESCO, 2021). Nevertheless, reports from the Office of the Education Council (2022) indicate that most vocational teachers in Thailand still lack opportunities to participate in leadership development programs tailored to their specific disciplines, reflecting the urgent need for targeted research in this area. Theoretically, this study adopts a framework grounded in Instructional Leadership (Hallinger & Murphy, 1985), which emphasizes learner-centered quality improvement, integrated with Transformational Leadership (Bass & Avolio, 1994), which focuses on cultural and systemic change; Servant Leadership (Greenleaf, 2002), which centers on supporting and nurturing others; and the Coaching/Mentoring Role (Costa & Garmston, 2016), which positions teachers as facilitators of learning. This combined framework provides a holistic perspective encompassing academic, psychological, and human development dimensions, making it particularly suitable for understanding the professional leadership of industrial teachers in Thailand's vocational education context.

Although numerous studies have explored teacher leadership at the basic education level—such as instructional leadership among primary school teachers and transformational leadership among secondary school teachers (Hallinger, 2011; Leithwood et al., 2020)—there remains a lack of research addressing the dimension of professional leadership among industrial teachers, which possesses distinctive characteristics in terms of disciplinary expertise, working environments, and collaboration with industry sectors (Ma, 2020). Moreover, no studies have yet conducted an Exploratory Factor Analysis (EFA) to identify and classify the underlying components of professional leadership within the Thai vocational education context. In addition, most relevant international research has been conducted within Western contexts, where systems for teacher development and industrial collaboration differ significantly from those in Thailand (Harris & Jones, 2019). Therefore, empirical research focusing on Thai industrial teachers is essential to establish an academic knowledge base and develop

context-appropriate leadership enhancement strategies aligned with national policies for upgrading Thailand's vocational education system to meet international standards (OVEC, 2022).

In summary, the Industry 4.0 era poses challenges not only to learners but also to teachers' professional roles—particularly industrial teachers—who must evolve into creative, adaptable leaders with a spirit of collaborative learning. Hence, this research is crucial for identifying the key components of desirable professional leadership among industrial teachers and for providing a framework for leadership development, evaluation, and policy formulation to enhance the capacity of vocational educators in Thailand to effectively meet future transformations.

RESEARCH OBJECTIVES

1. To examine the extent and characteristics of professional leadership demonstrated by industrial teachers within the context of Industry 4.0.
2. To identify and analyze the core components of professional leadership that define effective industrial teachers.
3. To develop strategic guidelines for fostering and enhancing professional leadership capacity among industrial teachers in vocational education institutions.

CONCEPTUAL FRAMEWORK

This study is based on the concept of Professional Leadership, comprising the following variables:

Independent Variable – Professional Leadership: The independent variable encompasses four key dimensions: (1) Instructional Leadership — focusing on the quality of teaching and students' learning outcomes. (2) Transformational Leadership — emphasizing inspiration and systemic change in learning processes. (3) Servant Leadership — highlighting service-oriented leadership that nurtures followers and fosters a learning community. (4) Coaching and Mentoring Role — reflecting the teacher's role as a coach and mentor in guiding and enhancing students' competencies.

Dependent Variable – Teaching Competency and Instructional Effectiveness of Industrial Teachers in the Industry 4.0 Era: The dependent variable refers to the effectiveness of active learning and project-based learning, represented by teachers' abilities to: (1) Design and implement learner-centered instructional activities: (1) Utilize digital technologies and smart industrial tools in teaching. (2) Develop students' competencies aligned with the needs of the industrial sector. (3) Intervening / Mediating Variables – Industry Collaboration and Professional Motivation: These variables serve as mediators linking professional leadership to instructional effectiveness in the Industry 4.0 context. It is hypothesized that teachers with higher levels of professional leadership are more likely to establish effective collaboration with industry partners and possess strong professional motivation, leading to improved teaching outcomes.

Control Variables: The control variables include gender, age, teaching experience, educational qualification in industrial fields, and type of institution (Technical College, Vocational College, or Industrial and Community College).

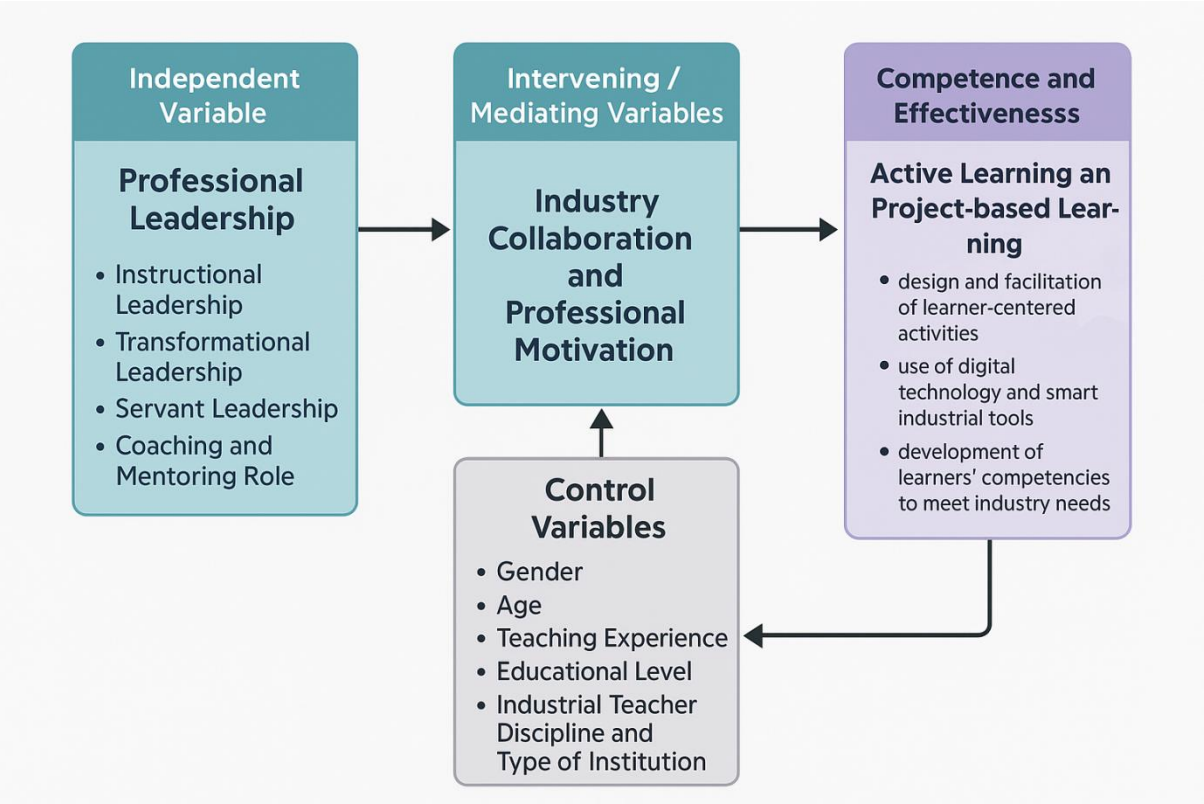

Figure 1. Conceptual framework.

RESEARCH METHODOLOGY

This study employed a mixed methods research design, integrating both quantitative and qualitative approaches to obtain comprehensive and in-depth data (Creswell & Plano Clark, 2018).The quantitative phase was conducted with a sample of 100–150 industrial teachers under the Office of Vocational Education Commission (OVEC) in Bangkok and its vicinity. Participants were selected through purposive sampling, with specific criteria requiring that respondents be teachers in industrial-related fields—such as automotive mechanics, mechanical engineering, electrical engineering, or electronics—and have at least three years of teaching experience (Patton, 2015). The qualitative phase involved in-depth interviews with five to seven key informants, comprising exemplary teachers and institutional administrators, to explore insights and perspectives on strategies for fostering professional leadership among industrial teachers.

The research instruments included a five-point Likert scale questionnaire measuring professional leadership across four key dimensions: Instructional Leadership, Transformational Leadership, Servant Leadership, and Coaching and Mentoring Role (Hallinger & Murphy, 1985; Bass & Avolio, 1994; Greenleaf, 2002; Costa & Garmston, 2016). The instrument's content validity was evaluated by three experts, yielding Item-Objective Congruence (IOC) indices ranging from 0.80 to 1.00, indicating satisfactory validity (Lawshe, 1975). The wording was then refined to suit the vocational education context. A pilot test was conducted with 30 participants to assess reliability, resulting in an overall Cronbach's alpha coefficient of 0.94, with subscale reliability coefficients ranging between 0.86 and 0.92, confirming a high level of internal consistency (Nunnally & Bernstein, 1994).

For quantitative data analysis, descriptive statistics—including means and standard deviations—were used, along with Exploratory Factor Analysis (EFA) to identify the underlying dimensions of professional leadership (Hair et al., 2019). For qualitative data, content analysis was employed to categorize key themes and interpret their meanings (Krippendorff, 2018), providing a deeper understanding of leadership development among industrial teachers. The integration of both quantitative and qualitative findings led to policy recommendations and strategic guidelines for developing professional leadership among industrial teachers, aligning with the demands of modern industry and the objectives of Thailand's vocational education reform (OVEC, 2022).

RESULTS

Table 1. The mean and standard deviation of professional leadership among industrial teachers (n = 150)

No.	Professional Leadership Components	Mean	S.D	Ranking
1	Instructional Leadership	4.18	0.59	High
2	Transformational Leadership	4.32	0.52	High
3	Servant Leadership	4.21	0.55	High
4	Coaching and Mentoring Role	4.29	0.51	High
	Overview Professional Leadership Components	**4.25**	**0.56**	**High**

The quantitative analysis of data from 150 industrial teachers revealed that their overall level of professional leadership was rated as "high" (M = 4.25, SD = 0.56). When examining each dimension, Transformational Leadership had the highest mean score, followed by Coaching and Mentoring Role, Instructional Leadership, and Servant Leadership, respectively. These findings indicate that industrial teachers in the Industry 4.0 era tend to develop diverse aspects of professional leadership, particularly in terms of inspirational leadership and professional mentorship. This aligns with the characteristics of 21st-century learning leaders, who emphasize collaboration, innovation, and the holistic development of learners (King, 2019; Harris & Jones, 2019).

Table 2. Analysis of Exploratory Variable Analysis: EFA (KMO = 0.87, Bartlett's Test of Sphericity = 1456.23, p < .001).

Variables	Items	Variable Loading Value	Eigenvalue	Variance Explained (%)(%)
Variable 1: Instructional Leadership	6	0.64–0.82	6.21	28.33
Variable 2: Transformational Leadership	5	0.61–0.79	3.17	18.72
Variable 3: Servant Leadership	5	0.58–0.76	2.42	14.09
Variable 4: Coaching & Mentoring Role	4	0.60–0.83	1.96	11.34
Total	20	—	—	**72.48**

The factor analysis results indicated that the professional leadership of industrial teachers could be categorized into four main components: Instructional Leadership, Transformational Leadership, Servant Leadership, and Coaching Leadership. Each component demonstrated acceptable factor loadings (greater than 0.50) and collectively explained 72.48% of the total variance. These findings align with the conceptual framework proposed by Bass and Avolio (1994), who emphasized that transformational leadership and people-centered leadership are essential for fostering learning in modern contexts. Furthermore, the results support King's (2019) perspective that teachers in the Industry 4.0 era must serve as both instructional leaders and learning facilitators, capable of fostering collaboration between learners and industrial partners effectively.

QUALITATIVE RESULTS

From the in-depth interviews conducted with seven key informants, comprising exemplary industrial teachers and vocational school administrators, several key themes emerged that clearly reflect the professional leadership characteristics of industrial teachers in the Industry 4.0 era. The findings can be summarized into four major themes as follows:

The Role of Teachers as "Instructional Leaders"

Most industrial teachers demonstrated strong instructional leadership by designing learner-centered learning activities and aligning technical content with modern industrial technologies such as IoT systems and automation machinery. One interviewee remarked: "Nowadays, we don't just teach students to memorize; we design tasks that help them think critically, perform effectively, and solve real-world problems." (Automotive teacher, interview on May 15, 2025). This reflects instructional leadership that emphasizes developing students' competencies to meet industrial demands, consistent with Hallinger and Murphy (1985), who asserted that instructional leaders establish a clear learning vision and foster an environment conducive to active learning.

Transformational Leadership

Teachers with high levels of professional leadership were described as inspirational figures who motivate both students and colleagues by promoting digital learning and project-based approaches. One administrator noted: "Transformational leaders are often the ones who modernize classrooms and create a culture of learning where everyone is motivated to grow together." (Technical college administrator, interview on May 20, 2025). This aligns

with Bass and Avolio (1994), who viewed transformational leaders as catalysts for development and internal motivation among others.

Servant Leadership

Many participants highlighted that industrial teachers exhibited a service-oriented mindset, caring deeply for students' ethical and professional growth. One teacher stated: "I treat my students like apprentices who need guidance not only in learning but also in their internship life. I stay with them through every step." (Electrical teacher, interview on May 22, 2025). This exemplifies servant leadership, as proposed by Greenleaf (2002), which centers on service, empathy, and the holistic development of others.

Coaching and Mentoring Role

Teachers with high leadership capacity often act as coaches and mentors, guiding students in career development and the practical application of knowledge in real workplace settings. A model teacher commented: "We have to be both teachers and coaches—helping students recognize their strengths and think through problems during their projects."

(Mechanical engineering teacher, interview on May 18, 2025). This supports Costa and Garmston (2016), who emphasized that 21st-century teacher leaders must possess coaching skills to stimulate analytical thinking and continuous learner development.

In summary, the qualitative findings indicate that industrial teachers with high professional leadership function as "learning leaders" who bridge classroom learning with industry, create innovative learning environments, and serve as mentors supporting students' holistic growth. These findings align with the principles of Servant Leadership and Coaching Leadership, which emphasize human development and the cultivation of long-term professional engagement (Harris & Jones, 2019; Frost, 2019).

DISCUSSION

Objective 1: To examine the level of professional leadership among industrial teachers in the era of Industry 4.0.

The findings revealed that the overall level of professional leadership among industrial teachers was high ($M = 4.25$, $SD = 0.56$), particularly in the dimensions of transformational leadership and coaching and mentoring roles. This indicates that vocational teachers are well-prepared to adapt to technological changes and digital learning environments. The results are consistent with Bass and Avolio (1994), who stated that transformational leaders are capable of inspiring and fostering sustainable commitment and development among their followers. Furthermore, the findings support Hallinger (2011), who emphasized that teachers exhibiting strong instructional leadership can significantly enhance students' learning quality and academic achievement.

Objective 2: To analyze the key components of professional leadership among industrial teachers.

The results of the Exploratory Factor Analysis (EFA) revealed that the professional leadership of industrial teachers can be categorized into four main components: Instructional Leadership, Transformational Leadership, Servant Leadership, and Coaching & Mentoring Role. All factor loadings were within acceptable ranges, and the model explained 72.48% of the total variance. These findings align with the conceptual framework proposed by Costa and Garmston (2016), which emphasizes the teacher's role as a "cognitive coach" who facilitates reflective learning. They also support Greenleaf's (2002) notion of servant leadership, which highlights leaders as individuals who foster motivation and a shared culture of learning. Furthermore, the findings are consistent with Leithwood et al. (2020), who suggested that visionary and collaborative leadership enhances both institutional effectiveness and student achievement.

Objective 3: To propose strategies for promoting professional leadership among vocational teachers.

The qualitative data from in-depth interviews revealed that teachers with a high level of professional leadership often act as "learning leaders," connecting students with real industrial experiences, promoting innovative learning, and serving as mentors or coaches who provide both academic and career guidance. This reflects the essence of Servant Leadership and Coaching Leadership, which focus on developing others and fostering sustainable professional engagement (Frost, 2019; Harris & Jones, 2019). These findings are also consistent with the report from the Office of Vocational Education Commission (OVEC, 2022), which recommends that modern vocational teachers develop competencies in integrated teaching, digital pedagogy, and industry collaboration.

In summary, the discussions under these three objectives indicate that professional leadership among industrial teachers in the Industry 4.0 era is a crucial factor in improving teaching quality and fostering classroom innovation. Encouraging teachers to serve as both academic leaders and professional mentors represents a strategic approach

to enhancing the competencies of Thailand's vocational education workforce in response to the rapidly changing industrial landscape (King, 2019; Ma, 2020; UNESCO, 2021).

CONCLUSION

Objective 1: To examine the level of professional leadership among industrial teachers in the era of Industry 4.0.

The findings revealed that industrial teachers under the Office of Vocational Education Commission (OVEC) in Bangkok and its metropolitan area demonstrated an overall high level of professional leadership ($M = 4.25$, $SD = 0.56$). In particular, Transformational Leadership and the Coaching and Mentoring Role showed the highest mean scores. This reflects that industrial teachers tend to act as "learning leaders" who can shift their role from being mere instructors to being facilitators and motivators of active learning. They are also capable of integrating technology and Project-based Learning approaches to enhance the quality of instruction in alignment with modern industrial contexts.

Objective 2: To analyze the components of professional leadership among industrial teachers.

The results of the Exploratory Factor Analysis (EFA) revealed that professional leadership among industrial teachers can be categorized into four main components: (1) Instructional Leadership — focusing on teaching quality and student achievement. (2) Transformational Leadership — inspiring and driving systemic change. (3) Servant Leadership — serving and developing others with empathy and care. (4) Coaching and Mentoring Role — guiding and mentoring learners to enhance their competencies. These four components explained 72.48% of the total variance, indicating that the developed model is both coherent and comprehensive in capturing the essential dimensions of professional leadership within the vocational education context.

Objective 3: To propose strategies for promoting professional leadership among vocational teachers.

The results from in-depth interviews revealed that teachers with high professional leadership often function as "learning leaders," capable of connecting students with real industrial experiences, promoting innovative learning processes, and inspiring students to engage in self-directed development. These teachers also serve as coaches and advisors who guide students in solving practical problems and as coordinators who strengthen partnerships between educational institutions and industry sectors. Therefore, the proposed strategies for enhancing teachers' professional leadership should focus on: Developing teachers' competencies through digital-era teaching workshops; Establishing a professional mentorship system within institutions; Promoting collaboration with industry partners to foster integrated learning experiences.

In summary, this study confirms that professional leadership is a crucial factor in driving effective learning among industrial teachers in the Industry 4.0 era. Teachers with strong leadership qualities can generate positive transformation in classrooms and play a vital role in preparing learners with the competencies required by the modern labor market.

IMPLICATIONS

The findings of this study clearly demonstrate that the professional leadership of industrial teachers serves as a critical mechanism for enhancing the quality of learning management in the Industry 4.0 era, a period marked by the growing integration of digital technology and automation in production and service systems. Among the components examined, Transformational Leadership and the Coaching and Mentoring Role were identified as the most influential factors directly contributing to the effectiveness of learner-centered pedagogies, particularly Active Learning and Project-based Learning. These approaches are essential for developing students' occupational competencies in alignment with the evolving demands of modern industries.

At the policy level, the results indicate that governing bodies—such as the Office of Vocational Education Commission (OVEC)—should prioritize the development of teachers' professional leadership rather than focusing solely on technical training. It is recommended that integrated capacity-building programs be implemented, emphasizing workshop-based training and collaborative learning exchanges with industrial enterprises. Such initiatives would foster innovative leadership skills, coaching competencies, and the effective use of digital technologies in instructional design.

At the institutional level, establishing a Professional Mentorship System within vocational institutions is a crucial step. This system would enable new-generation teachers to receive guidance from experienced mentors, thereby nurturing a collaborative learning culture and enhancing the capacity for knowledge transfer and industrial teaching practices across generations.

At the practical level, the study suggests that industrial teachers should continuously develop proactive leadership and coaching skills by transitioning from the role of a "knowledge transmitter" to that of a "learning facilitator." Through this shift, teachers can inspire learners, promote analytical thinking, and instill professional ethics, thereby contributing to the cultivation of a high-quality workforce that will become a sustainable driving force in Thailand's digital economy of the future.

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