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Do data science literacy and analytical thinking skill matter for developing sustainable agile leadership among Gen Z accounting students?

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ABSTRACT

This study examined the relationships between data science literacy and sustainable agility leadership among Generation Z accounting students in Thailand, with analytical thinking and creative thinking skills introduced as mediating variables. Adopting a quantitative research design, data were collected from 555 final-year undergraduate accounting students across Thai higher education institutions using a validated and reliable questionnaire. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results revealed that data science literacy had a statistically significant and positive effect on both analytical and creative thinking skills. Furthermore, data science literacy influenced sustainable agility leadership both directly and indirectly, with analytical and creative thinking serving as critical mediators. Analytical thinking also significantly enhanced creative thinking and leadership capacity. These findings contribute original insights by empirically linking digital literacy and higher-order cognitive skills with next-generation leadership development. The study underscores the importance of 21st-century competencies—particularly data fluency, analytical reasoning, and creativity—in cultivating adaptable, innovative, and sustainability-oriented leaders equipped for the demands of the digital economy.

1. Introduction

In an increasingly data-driven economy, the need for future-ready leadership among accounting professionals has become more pressing. As Generation Z students prepare to enter a workforce transformed by digitalization, developing their competencies in data science, analytical reasoning, creativity, and leadership is critical. However, while existing studies have addressed technical competencies in accounting education, less attention has been paid to how data science literacy translates into higher-order cognitive abilities and leadership readiness. This study bridges that gap by exploring the interplay between data science literacy, analytical

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thinking, creative thinking, and sustainable agility leadership. Grounded in Cognitive Theory, Transformational Leadership Theory, and Constructivist Learning Theory, the research offers a comprehensive framework for understanding how digital and cognitive skills collectively shape adaptive leadership among Thai accounting students. To investigate these relationships, the study focuses on six research questions and proposes a structural model tested using PLS-SEM. The results contribute to both theory and practice by informing curriculum development and leadership training strategies tailored to the evolving demands of the digital era.

In the digital era, where technology and data have become central drivers of economic and social development, data is increasingly recognized as a strategic resource that underpins decision-making and operations across all sectors (Javaid et al., 2024). The ability to manage and analyze data—referred to as data science literacy—has been acknowledged as one of the most essential competencies for success in the 21st century (Mikalef & Krogstie, 2019). Data science literacy encompasses the knowledge, understanding, and capacity to utilize data and related technologies to solve problems, assess complex situations, and support strategic decision-making (Overton & Kleinschmit, 2022). This competency has gained particular relevance for Generation Z, a cohort raised in a digital environment characterized by rapid innovation and constant connectivity. Members of Gen Z are uniquely positioned to leverage digital technologies and data to create opportunities across fields such as education, business, and social development (Haleem et al., 2022). However, the development of data science literacy among this group still requires structured educational support and targeted human capital development strategies that align with the shifting demands of the modern labor market (Smaldone et al., 2022). Therefore, exploring how data science literacy contributes to leadership development—particularly in the form of sustainable agility leadership—is a critical step toward preparing future leaders to meet the challenges of the digital age.

While data science literacy has been widely recognized for its role in enhancing data analysis and effective decision-making (Turiman et al., 2012; Li et al., 2023), its application in the context of leadership development—especially sustainable agility leadership—remains underexplored. Sustainable agility leadership refers to the capacity to maintain a balance between short-term responsiveness and long-term stability (Iqbal et al., 2020; Saragih et al., 2024). Accounting students, as a key talent pipeline for the future business sector, are expected to evolve into leaders capable of integrating data science literacy with analytical and creative thinking skills. These cognitive competencies are vital for interpreting complex information, formulating strategic responses, and generating innovative solutions in a rapidly changing market landscape (Imjai, Swatdikun, et al., 2024). However, existing studies on data science literacy have predominantly focused on its technical or organizational decision-making applications, with limited attention to its role in leadership capability development (Matsunaga, 2024). This has created a research gap, particularly in educational contexts like Thailand, where accounting students must be equipped not only with academic knowledge but also with applied leadership skills suited for the demands of the digital economy (Imjai, Aujirapongpan, & Yaacob, 2024).

This study is theoretically grounded in three interrelated perspectives that collectively offer a comprehensive framework for understanding the relationships among data science literacy, thinking skills, and sustainable agility leadership. Cognitive Theory, particularly higher-order thinking frameworks such as Bloom's Taxonomy, supports the interconnection between data science literacy, analytical thinking, and creative thinking by emphasizing how cognitive processes enable learners to interpret data critically and generate innovative solutions (Anderson & Krathwohl, 2001). Complementing this, Transformational Leadership Theory provides the foundation for linking thinking skills to sustainable agility leadership by highlighting the role of intellectual stimulation and creativity in shaping leaders who are adaptable, visionary, and capable of driving meaningful change (Bass, 1985). Additionally, Constructivist Learning Theory underscores how individuals actively construct knowledge through engagement with digital tools and real-world data, thereby enhancing both their problem-solving abilities and leadership competencies in complex environments (Vygotsky, 1978). Anchored in these theoretical foundations, this research aims to examine the influence of data science literacy on sustainable agility leadership among Thai Generation Z accounting students—a demographic increasingly expected to develop leadership capabilities that are responsive to the demands of a dynamic digital labor market. The study pursues three main objectives: (i) to explore the relationship between data science literacy and sustainable agility leadership, particularly how data-related competencies contribute to adaptability and long-term strategic thinking; (ii) to investigate the mediating roles of analytical and creative thinking in linking data science literacy to sustainable agility leadership; and (iii) to propose educational strategies for leadership development tailored to accounting students in Thailand, emphasizing the integration of data literacy with leadership and decision-making skills.

To achieve the objectives, the study is guided by the following research questions: (i) How does data science literacy influence analytical thinking skills among Generation Z accounting students? (ii) How does data science literacy influence creative thinking skills? (iii) What is the effect of analytical thinking skills on sustainable agility leadership? (iv) What is the effect of creative thinking skills on sustainable agility leadership? (v) Does analytical thinking mediate the relationship between data science literacy and creative thinking? (vi) Do analytical and creative thinking skills mediate the relationship between data science literacy and sustainable agility leadership?

The findings of this study are anticipated to contribute new theoretical insights into the role of data science literacy in fostering leadership attributes rooted in adaptability, sustainability, and innovation (Siregar et al., 2023). In addition to its theoretical contributions, the study offers practical implications for higher education. Specifically, the results support the development of university-level curricula that integrate data literacy, cognitive skill enhancement, and training in future-oriented leadership (Taş, 2024). These insights may inform human capital development strategies within organizational settings, particularly in sectors that demand next-generation leaders who can effectively synthesize agility and sustainability to drive strategic and impactful decision-making.

2. Literature review

The literature of this study is anchored in three primary theoretical perspectives. first, the Cognitive Theory that explains how

individuals develop higher-order thinking skills, such as analytical and creative thinking, through structured cognitive processes (Anderson & Krathwohl, 2001). These skills are essential for interpreting data and generating innovative leadership strategies in complex contexts. Second, the Transformational Leadership Theory (Bass, 1985) provides the foundation for understanding sustainable agility leadership. This theory posits that transformational leaders inspire change, encourage innovation, and align short-term actions with long-term goals—principles consistent with the constructs of adaptability, creativity, and sustainability in the current study. Recent literature increasingly supports the view that leadership is not solely an innate trait, but a competency that can be cultivated through structured learning and experience. For instance, Sawan et al. (2024) highlight how flipped classroom and blended learning models contribute to the development of essential leadership-related skills such as autonomy, communication, and teamwork in accounting students. Similarly, Al-Hajaya et al. (2025) emphasize the growing role of generative AI and data engagement in shaping soft skills and enhancing students' readiness for leadership in complex environments. These perspectives align with Constructivist Learning Theory, which underscores how leadership competencies evolve through experiential learning and digital interaction, particularly within business education settings. Consequently, this study adopts the premise that leadership can be bred—fostered through the systematic development of analytical and creative thinking in conjunction with data science literacy. Third, Constructivist Learning Theory (Vygotsky, 1978) offers insight into how learners actively construct meaning through experiences, including data analysis and digital tools. This theory supports the notion that data science literacy enables students to build applied knowledge that feeds into both cognitive development and leadership behavior. The three underlying theories used in this study provide in-depth insights into the processes and factors influencing the development of critical competencies among accounting students in Generation Z within the context of Thailand. The primary objective is to consolidate theoretical perspectives that support the construction of an appropriate conceptual framework and educational strategies designed to prepare students for leadership in an increasingly volatile and digital-driven world. The reviewed literature also emphasizes the strategic and innovative capabilities needed for sustainable success in future careers.

2.1. Data science literacy

Data science literacy refers to an individual's ability to understand, utilize, and interpret data in the context of problem-solving and decision-making. It includes proficiency in data analysis, modeling, and interpretation for practical use (Wolff et al., 2016). In an era where data has become a central asset for driving digital economies and strategic decision-making—particularly in business and education—data science literacy is increasingly recognized as a critical 21st-century skill (Novikov, 2020). Individuals who possess these skills are better equipped to make meaningful connections between complex datasets and real-world applications, such as identifying market trends, analyzing policy impacts, and improving operational efficiency.

In the leadership context, data science literacy plays an essential role in enhancing data-driven decision-making and creative problem-solving abilities (Lu, 2022; Shamsuddin & Razak, 2023). Leaders proficient in data analytics are more adept at analyzing complex situations and responding quickly to change. For example, those with strong data science literacy can apply predictive analytics to anticipate future trends or utilize real-time data to adjust operational plans during uncertain or crisis scenarios (Adesina et al., 2024). Furthermore, the ability to communicate data effectively fosters team alignment and stakeholder engagement—factors crucial to successful organizational leadership in the digital era (Kraus et al., 2022).

The core components of data science literacy encompass four key areas that are inherently interrelated and mutually reinforcing. First, data collection literacy refers to the ability to identify credible data sources, assess data quality and relevance, and systematically collect data—skills that serve as a foundation for accurate analysis (Reda et al., 2023). Second, data analysis skills involve the use of techniques such as descriptive, predictive, and causal analysis through appropriate statistical tools and software (Alem, 2020). Third, data modeling skills include the development of models to predict outcomes or generate deeper insights into complex systems—tools that directly support strategic decision-making (Brewis et al., 2023). Lastly, data communication skills involve presenting data clearly through visual tools (e.g., charts and graphs), reporting, and explaining analytical results in ways that facilitate practical action and informed decisions (Alem, 2020).

Rather than being isolated competencies, these dimensions function collectively to create a comprehensive skillset that supports both technical proficiency and strategic leadership. This integrated perspective underscores the importance of data science literacy as a critical enabler of sustainable agility leadership, especially for Generation Z accounting students. As such, the development of these competencies serves as a vital entry point for empowering future leaders to make informed, adaptive, and impactful decisions in digitally dynamic environments.

2.2. Analytical thinking skill

Analytical thinking skill is a critical cognitive ability that empowers individuals to solve problems efficiently and systematically by breaking down complex issues into simpler, more manageable components (Rasheva-Yordanova et al., 2018). It plays a fundamental role across all professional domains by enabling individuals to understand intricate information, establish logical cause-effect relationships, and project future trends with clarity and accuracy. In the context of today's digital age—characterized by the proliferation of data and increasing complexity—analytical thinking is indispensable for interpreting both qualitative and quantitative data, recognizing patterns, and identifying variable relationships that underpin evidence-based and strategic decision-making (Aldoseri et al., 2023; Brandt & Lorié, 2024).

In leadership, analytical thinking serves as a cornerstone for formulating strategic responses and making effective decisions under dynamic and uncertain conditions (Deep, 2023). Leaders equipped with strong analytical capabilities are better able to assess

multifaceted situations, weigh their implications, and devise adaptive strategies that address both immediate operational demands and long-term organizational goals (Veríssimo et al., 2024). The capacity to convey analytical insights also fosters team alignment and stakeholder trust, both of which are essential for successful execution and long-term planning (Karlsen et al., 2008). Additionally, the ability to analyze information with foresight enhances problem-solving effectiveness in unpredictable environments—thereby contributing to an organization's sustained competitive advantage (Rasheva-Yordanova et al., 2018).

This cognitive competency is particularly valuable in data-intensive environments, as it supports a wide range of functions such as data processing, forecasting, visualization design, knowledge extraction, and strategic problem-solving. As such, analytical thinking forms a foundational element in navigating big data landscapes and making informed decisions (Kim et al., 2025). Variability in this skill among human resources can result in differences in productivity and innovation outcomes, making it a critical driver of organizational performance (Veríssimo et al., 2024).

The analytical thinking process comprises four interrelated and systematic stages, each of which contributes to both rational and creative approaches to problem resolution in complex contexts (Alkhatib et al., 2019). First, Defining the Problem involves identifying the root cause, determining its scope, and setting clear analytical objectives. Accurate problem definition is crucial, as it shapes the effectiveness of all subsequent steps (Rahman, 2019). Second, Developing Possible Solutions entails generating multiple alternatives that integrate creative thinking while considering data constraints and contextual limitations—laying the groundwork for informed selection (Taherdoost & Madanchian, 2023). Third, Testing Possible Solutions involves assessing the feasibility and potential effectiveness of alternatives through simulations or real-world trials, which helps mitigate risks and inform implementation decisions (Vogel et al., 2024). Fourth, Selecting and Implementing the Best Solution requires critical comparison, rational judgment, execution, and post-implementation evaluation—reflecting leadership maturity and commitment to resolution (Taherdoost & Madanchian, 2023). Collectively, these components form a comprehensive and structured framework that enhances analytical reasoning, supports high-quality decision-making, and empowers individuals—particularly emerging leaders—to navigate complexity and drive sustainable outcomes in dynamic environments.

2.3. Creative thinking skill

Creative thinking skill is broadly defined as the cognitive capacity to generate novel, valuable, and contextually appropriate ideas that address problems or capitalize on opportunities (Ritter & Mostert, 2017). As one of the most vital competencies for navigating the complexities of the 21st century, creative thinking empowers individuals to respond flexibly to dynamic environments while simultaneously driving innovation and value creation within organizations (Van Laar et al., 2017). In academic and professional domains alike, this skill underpins effective planning, facilitates problem resolution, and supports competitive advantage by enabling individuals to develop distinctive strategies and solutions (Weng et al., 2022).

Within the sphere of leadership, creative thinking plays a central role in shaping visionary leaders capable of operating amid uncertainty and accelerating change (Gundry et al., 2014; Tagscherer & Carbon, 2023). Leaders who possess a high degree of creative thinking tend to challenge traditional paradigms, encouraging out-of-the-box ideation that aligns with evolving organizational needs and stakeholder expectations (Tang et al., 2020). Moreover, creative leaders are often instrumental in fostering an innovation-oriented culture, one that promotes collaborative ideation and continuous learning within teams (Joo et al., 2012). This inclusive and participatory environment not only elevates group performance but also contributes to the long-term sustainability of the organization (Huang et al., 2022).

The multidimensional nature of creative thinking is anchored in four core constructs. Originality, as the ability to conceive unconventional ideas, drives the generation of unique and non-routine solutions that add differentiated value (Peterson & Pattie, 2024). Cognitive flexibility entails the mental agility to shift perspectives, reinterpret problems, and tailor responses based on situational demands—an indispensable trait in volatile and complex settings (Canas et al., 2006). Idea fluency, which involves producing a wide array of ideas within constrained timeframes, broadens the cognitive landscape and enhances the likelihood of identifying optimal solutions (Oustamanolakis, 2022). Finally, creative elaboration refers to the deepening and refinement of ideas into practical, actionable strategies, thereby translating abstract concepts into tangible outcomes (Perry-Smith et al., 2017). Taken together, these interrelated elements constitute a robust framework for understanding creative thinking as a cornerstone of modern leadership. They emphasize that the skill extends beyond ideation to encompass execution, adaptability, and influence. Developing creative thinking, therefore, is not only essential for individual competence but also for cultivating agile, resilient leaders capable of thriving in today's digitally driven and innovation-centric world.

2.4. Sustainable agility leadership

In today's rapidly evolving and increasingly complex global landscape—characterized by the transformative impacts of the Fourth Industrial Revolution and heightened socioeconomic uncertainties (Lee et al., 2018)—the dual imperatives of sustainability and agility have emerged as foundational elements for ensuring long-term organizational success (Saragih et al., 2024). Sustainability encompasses the ability to meet present needs without compromising future generations, integrating social equity, environmental stewardship, and economic viability (Kuhlman & Farrington, 2010). Agility, in contrast, refers to the dynamic capability to respond swiftly and effectively to unexpected changes, including disruptive technological advancements and fluctuating market demands (Janssen & Van der Voort, 2020).

The concept of sustainable agility leadership represents a deliberate fusion of these two constructs. It aims to develop leaders capable of balancing short-term responsiveness with long-term stability and responsible value creation (Ketprapakorn & Kantabutra,

2022). Such leaders demonstrate the capacity to navigate current complexities while fostering strategic initiatives that contribute to enduring, sustainable outcomes (Siregar et al., 2023). In volatile and unpredictable environments, this form of leadership offers an adaptable, evidence-based framework that integrates agile responsiveness with foresight and sustainability considerations in environmental, social, and economic spheres (Tandon et al., 2024). For example, a sustainable agility leader may implement environmentally responsible innovations while adapting business models to meet evolving consumer expectations or regulatory requirements (Saragih et al., 2024). In this regard, sustainable agility leadership serves not only to fulfill immediate operational needs but also to advance inclusive, future-oriented growth aligned with global sustainable development goals (Rant, 2020).

The key components of sustainable agility leadership can be delineated into four interrelated domains: (i) Adaptability to Change, which refers to the capacity to respond efficiently to dynamic external shifts—such as economic shocks or digital disruptions—by leveraging data-informed insights and reconfiguring strategies (Garrido-Moreno et al., 2024); (ii) Long-Term Goal Setting, the ability to formulate visionary objectives that align with sustainable development principles, encompassing initiatives like environmental conservation, community engagement, and stakeholder value enhancement (Fleacă et al., 2018); (iii) Problem Solving through Positive Thinking, characterized by the use of constructive and optimistic approaches to overcome adversity, foster collaboration, and generate innovative responses that yield durable benefits (Spoon et al., 2021); and (iv) Continuous Innovation-Oriented Learning, which reflects a proactive learning culture that embraces digital transformation, technological adoption, and capacity-building to ensure long-term competitiveness and resilience (Fuad et al., 2022). Together, these dimensions encapsulate the essence of sustainable agility leadership—equipping leaders to remain responsive in the face of volatility while steadfastly advancing long-term organizational resilience, innovation, and social responsibility. This dual capacity is especially critical in the digital age, where leadership must not only react to change but also shape it toward sustainable progress.

2.5. Hypotheses development

2.5.1. The relationship between data science literacy and analytical thinking skill

Data science literacy enhances an individual's ability to systematically gather, analyze, and interpret data, which directly supports the development of analytical thinking skills. As Ren et al. (2019) emphasize, transforming raw data into actionable insights empowers individuals to break down complex problems into smaller, manageable components—an essential characteristic of analytical thinking. Alem (2020) also highlights how evaluating data credibility and understanding relationships among variables fosters logical reasoning and supports informed decision-making. In this regard, data science literacy not only aids in understanding data patterns but also enables individuals to critically assess cause-effect dynamics and to formulate structured approaches to problem-solving. According to Sarker (2021), applying advanced techniques such as predictive analytics and statistical modeling enhances the capacity to deal with uncertainty and complexity—further reinforcing analytical thinking in both routine and strategic tasks. Therefore, data science literacy provides the cognitive tools necessary for individuals to engage in systematic analysis and solution-oriented reasoning.

H1. Data science literacy has a positive effect on analytical thinking skill.

2.5.2. The relationship between data science literacy and analytical thinking skill

Data science literacy also plays a critical role in stimulating creative thinking by enabling individuals to explore data from multiple perspectives and generate novel ideas based on empirical patterns. Virkus and Garoufallou (2020) explain that exploratory data analysis, such as trend identification and hypothesis generation, facilitates creativity by revealing previously unnoticed insights. This process not only encourages divergent thinking but also expands the range of possible solutions to complex problems. Li et al. (2023) further emphasize that individuals with strong data science literacy can utilize datasets creatively to address challenges requiring innovation-driven value creation. The application of data science literacy in creative contexts involves the construction of new models and frameworks that reflect fresh interpretations of available information. As such, creativity is not detached from structure, but is instead empowered by a deep understanding of data dynamics, promoting innovation that is both evidence-based and impactful. Hence, data science literacy serves as a catalyst for idea fluency, originality, and the practical elaboration of innovative concepts.

H2. Data science literacy has a positive effect on creative thinking skill.

2.5.3. The relationship between data science literacy and analytical thinking skill

In leadership contexts, data science literacy enhances the capacity to navigate volatile and complex environments by enabling evidence-based strategic responses. Tiwari (2024) asserts that data-literate leaders can interpret intricate scenarios and make informed decisions that align with organizational goals. This ability is particularly important for sustainable agility leadership, which requires balancing short-term adaptability with long-term sustainability planning. Pantović et al. (2024) demonstrate how data-driven decision-making can support environmental stewardship, strategic foresight, and innovation—core pillars of sustainability. Meanwhile, Dubey et al. (2023) underscore the role of data science literacy in enhancing leaders' agility, allowing them to anticipate market fluctuations and swiftly adjust organizational strategies. Thus, data science literacy strengthens the foundational competencies of sustainable agility leadership by enabling leaders to simultaneously respond to dynamic changes and uphold future-oriented, responsible decision-making.

H3. Data science literacy has a positive effect on sustainable agility leadership.

2.5.4. The relationship between analytical thinking skill and creative thinking skill

Analytical thinking and creative thinking are often perceived as two separate cognitive processes; however, they are inherently complementary in effective problem-solving. Analytical thinking entails the ability to dissect complex information, identify patterns, and formulate rational conclusions based on data and logic (Rasheva-Yordanova et al., 2018). On the other hand, creative thinking focuses on generating original ideas and alternative solutions, often requiring a departure from conventional perspectives (Ramadani et al., 2021; Wani & Hussian, 2024). The synergy between these skills becomes particularly evident when individuals are required to propose innovative yet feasible solutions. Those with high analytical thinking abilities are often capable of transforming raw information into structured insights. These insights, in turn, become fertile ground for creative ideation. Rather than relying solely on intuition or imagination, creative outputs are strengthened by data-driven understanding, thus increasing their relevance and effectiveness in real-world applications.

Moreover, analytical thinkers possess a systematic approach to evaluating creative ideas. Their capacity to assess alternatives critically ensures that novel suggestions are not only original but also strategically aligned with practical constraints and objectives. In essence, analytical thinking provides the scaffolding upon which creative thinking can flourish—guiding the ideation process through logic, structure, and evidence-based reasoning. Thus, a reciprocal relationship exists: analytical thinking enhances the depth and applicability of creative thinking, while creativity broadens the scope and adaptability of analytical thought processes. This interconnection underscores the importance of developing both capabilities in parallel, particularly in academic, organizational, and leadership contexts where innovation must coexist with rational evaluation.

H4. Analytical thinking skill has a positive effect on creative thinking skill.

2.5.5. The relationship between analytical thinking skill and sustainable agility leadership

Analytical thinking is widely recognized as a cornerstone of modern leadership, especially in environments marked by volatility, uncertainty, complexity, and ambiguity. Leaders today must constantly interpret large volumes of information, assess multidimensional variables, and make time-sensitive decisions. The capacity for analytical thinking enables such leaders to assess internal and external data and translate it into strategic actions (Pawar & Dhumal, 2024). In the context of sustainable agility leadership, analytical thinking plays a crucial role in balancing short-term agility with long-term sustainability. Through analytical reasoning, leaders can interpret indicators related to environmental, social, and economic performance and make decisions that align with sustainable development principles (Hermundsdottir & Aspelund, 2022). This includes optimizing resource allocation, evaluating the impact of organizational practices, and planning for resilient growth.

Analytical thinking also contributes to a leader's adaptive capability. By regularly reviewing performance data, anticipating risks, and adjusting strategies accordingly, leaders cultivate agility within their organizations (Thornhill-Miller et al., 2023). This proactive approach allows for informed responsiveness to change, whether in the form of technological disruption, shifting stakeholder expectations, or economic instability. Furthermore, sustainable agility leadership requires consistent alignment between day-to-day decision-making and long-term strategic vision. Analytical thinking supports this alignment by enabling leaders to identify opportunities for innovation that are both practical and forward-looking. In this regard, the integration of analytical competencies helps leaders not only react effectively to immediate demands but also to embed sustainability as a core organizational value. Collectively, these capabilities reinforce the value of analytical thinking as an enabler of both agility and sustainability—two imperatives for navigating the challenges of the digital era with vision, responsibility, and resilience.

H5. Analytical thinking skill has a positive effect on sustainable agility leadership.

2.5.6. The relationship between creative thinking skill and sustainable agility leadership

Creative thinking skill plays a pivotal role in fostering sustainable agility leadership, as it empowers leaders to develop adaptive solutions to immediate challenges while maintaining a long-term focus on sustainability (Awan et al., 2019). Leaders with high levels of creative thinking are able to think beyond conventional boundaries and design entirely new problem-solving approaches, enabling rapid and effective adaptation (Miller et al., 2021). In particular, creative thinking facilitates the development of

Table 1
Summary of hypotheses.

Hypotheses	Statements	References
H1	Data science literacy has a positive effect on analytical thinking skill.	Ren et al. (2019); Alem (2020); Sarker (2021)
H2	Data science literacy has a positive effect on creative thinking skill.	Virkus and Garoufallou (2020); Li et al. (2023)
H3	Data science literacy has a positive effect on sustainable agility leadership.	Tiwari (2024); Pantović et al. (2024); Dubey et al. (2023)
H4	Analytical thinking skill has a positive effect on creative thinking skill.	Rasheva-Yordanova et al. (2018); Ramadani et al. (2021); Wani and Hussian (2024)
H5	Analytical thinking skill has a positive effect on sustainable agility leadership.	Pawar and Dhumal (2024); Hermundsdottir and Aspelund (2022); Thornhill-Miller et al. (2023)
H6	Creative thinking skill has a positive effect on sustainable agility leadership.	Awan et al. (2019); Miller et al. (2021); Poveda-Pareja et al. (2024); Ali Taha et al. (2016); Tagscherer and Carbon (2023)

sustainability-oriented innovations—such as initiatives that reduce environmental impact or generate long-term value for stakeholders (Poveda-Pareja et al., 2024). Furthermore, it contributes to the cultivation of a learning and innovation-oriented organizational culture. This culture encourages continuous adaptation and capability development among team members, which is essential for long-term organizational resilience (Ali Taha et al., 2016).

In addition, creative thinking enhances leaders' ability to make appropriate decisions and foster innovation that aligns with organizational needs in the digital era. Leaders with strong creative capacities are better positioned to manage operational and market complexities and to generate development strategies that align with sustainable economic, social, and environmental goals (Tagscherer & Carbon, 2023). Based on the reviewed literature, the following hypothesis is proposed.

H6. Creative thinking skill has a positive effect on sustainable agility leadership.

Based on the literature review and theoretical foundations presented, the research hypotheses of this study are summarized in Table 1, along with their corresponding references.

Given the theoretical foundations outlined above, this study—titled "Do data science literacy and analytical thinking skill matter for developing sustainable agile leadership among Gen Z accounting students?"—presents the conceptual framework illustrated in Fig. 1. The model proposes that data science literacy, encompassing competencies in data collection literacy and data analysis skills, directly influences analytical thinking skill and creative thinking skill. Analytical thinking skill, characterized by the abilities to develop and test possible solutions, is hypothesized to enhance creative thinking skill, which involves cognitive flexibility and idea fluency. Both analytical and creative thinking skills are expected to contribute to sustainable agility leadership, defined by adaptability to change and long-term goal setting. The framework also posits multiple mediating pathways, highlighting the roles of analytical and creative thinking skills in linking data science literacy to sustainable agility leadership.

3. Research methodology

3.1. Research design

This study employed a quantitative, cross-sectional, and correlational research design to examine the relationships between data science literacy and sustainable agility leadership among Generation Z accounting students in Thailand. Analytical thinking skill and creative thinking skill were introduced as key mediating variables. The use of a quantitative approach was deemed appropriate, as it allows for the measurement and statistical testing of hypothesized relationships among latent constructs (Creswell, 2014). The correlational design was chosen to explore the strength and direction of associations without manipulating the variables, aligning with the study's objective to investigate naturally occurring phenomena (Sekaran & Bougie, 2016).

The target population comprised undergraduate and postgraduate students currently enrolled in accounting programs at higher

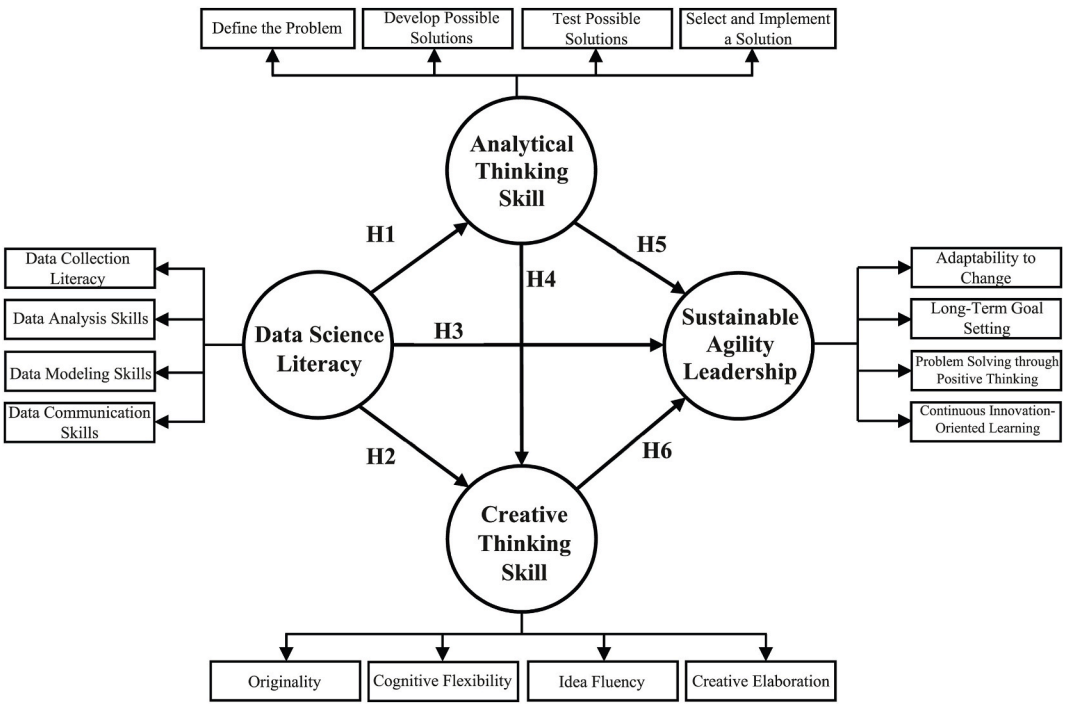

Fig. 1. Conceptual framework.

education institutions across Thailand. This population was considered suitable due to their digital-native background, which aligns with the study's context involving data usage, technology, and decision-making competencies. A cross-sectional approach allowed for data collection at a single point in time, capturing the perceptions and competencies of respondents within a defined academic period (Saunders et al., 2019). Data were collected using a structured online questionnaire distributed via email and social media platforms to ensure broad and convenient access. The questionnaire was designed to include introductory explanations of the four key constructs—data science literacy, analytical thinking skill, creative thinking skill, and sustainable agility leadership—to ensure respondent comprehension prior to answering.

A convenience sampling method was employed due to several practical considerations. First, the absence of a centralized, accessible database of all Generation Z accounting students across Thai universities rendered probability sampling infeasible. Second, academic schedules and institutional access constraints limited direct contact with physical student populations. Third, the use of online distribution platforms enabled wider geographical reach and more rapid data collection within the limited research timeframe.

Table 2
Indicators used to measure research variables.

Variables	Component variables	Indicators	References
Data Science Literacy	Data Collection Literacy	1 The ability to search and identify appropriate and credible data sources from official websites or recognized databases. 2 The ability to assess data quality, accuracy, and relevance prior to analysis.	Reda et al. (2023)
	Data Analysis Skills	3 The ability to perform basic data analysis, such as calculating means and standard deviations. 4 The ability to use data analysis software (e.g., Excel, SPSS, Python) effectively.	Alem (2020)
	Data Modeling Skills	5 The ability to develop data models to represent relationships and predict outcomes. 6 The ability to refine models to ensure their suitability in dynamic or changing conditions.	Brewis et al. (2023)
	Data Communication Skills	7 The ability to present data clearly using visual tools (e.g., bar charts, pie charts) for summarization. 8 The ability to explain analytical results in a simple and comprehensible manner.	Alem (2020)
Analytical Thinking Skill	Define the Problem	9 The ability to identify the root cause of a problem when an error occurs. 10 The ability to break down a complex issue into smaller parts for detailed analysis.	Rahman (2019)
	Develop Possible Solutions	11 The ability to design multiple solution alternatives that address existing constraints. 12 The ability to revise and improve proposed solutions to enhance effectiveness.	Taherdoost and Madanchian (2023)
	Test Possible Solutions	13 The ability to conduct preliminary testing of solutions to ensure confidence before actual implementation. 14 The ability to refine a solution after identifying flaws in trials.	Vogel et al. (2024)
	Select and Implement a Solution	15 The ability to compare different alternatives and select the most suitable solution. 16 The ability to implement the selected solution in a structured and efficient manner.	Taherdoost and Madanchian (2023)
Creative Thinking Skill	Originality	17 The ability to think outside the box and generate alternative solutions to existing problems. 18 The ability to improve traditional work processes to achieve faster and better results.	Peterson and Pattie (2024)
	Cognitive Flexibility	19 The ability to adapt effectively to changing conditions or situations. 20 The ability to view a problem from multiple perspectives and select the most appropriate solution.	Canas et al. (2006)
	Idea Fluency	21 The ability to generate multiple ideas or problem-solving options within a limited timeframe. 22 The ability to develop diverse alternatives for team decision-making.	Oustamanolakis (2022)
	Creative Elaboration	23 The ability to create detailed action plans that are practical and executable. 24 The ability to expand and deepen initial ideas for real-world application.	Perry-Smith et al. (2017)
Sustainable Agility Leadership	Adaptability to Change	25 The ability to adapt quickly to uncertain or changing situations. 26. The ability to utilize available data to support decision-making in dynamic contexts.	Garrido-Moreno et al. (2024)
	Long-Term Goal Setting	27 The emphasis on setting long-term goals over short-term ones. 28 The ability to design sustainable plans that contribute to the well-being of oneself, family, and society.	Fleacă et al. (2018)
	Problem Solving through Positive Thinking	29 The ability to apply positive thinking processes when analyzing problems to find suitable solutions. 30 The ability to inspire team members to seek creative solutions.	Spoon et al. (2021)
	Continuous Innovation-Oriented Learning	31 The value placed on continuous learning and self-development. 32 The ability to apply new technologies to improve work processes in response to digital-age demands.	Fuad et al. (2022)

Although non-probabilistic, convenience sampling is widely adopted in behavioral and educational research where targeted demographic access and time or resource limitations exist (Etikan et al., 2016). Accordingly, this method was deemed suitable for this exploratory study, which aims to investigate structural relationships among psychological and behavioral constructs.

To ensure sufficient statistical power, Cochran's formula for unknown population sizes was used to estimate a minimum required sample size of 384. In total, 583 responses were collected, and after screening for completeness and consistency, 555 valid responses were retained for analysis. This empirical design supports the reliability of the findings and provides a robust dataset for analyzing the structural relationships among the proposed constructs in the context of Thai Generation Z accounting students.

3.2. Measurement instruments

The primary instrument used for data collection in this study was a questionnaire, developed based on a comprehensive review of literature concerning the core constructs: data science literacy, analytical thinking skill, creative thinking skill, and sustainable agility leadership, specifically contextualized for Generation Z accounting students in Thailand. The development process began by clearly defining the variables and their dimensions, followed by the construction of observable items designed to capture specific, measurable behaviors. The draft version of the questionnaire was reviewed by three experts in the fields of data science, leadership development, and educational research to evaluate its content validity using the Index of Item-Objective Congruence (IOC) method. Feedback from the experts was used to revise item wording, enhance clarity, and ensure the appropriateness of the questions for the target population.

Subsequently, a pilot test was conducted with 30 Generation Z accounting students to assess the reliability of the instrument. Cronbach's alpha coefficients were used to evaluate the internal consistency of the items within each construct. Upon confirming adequate levels of reliability and content validity, the finalized version of the questionnaire was used for the main data collection. The questionnaire consisted of two sections. The first section gathered demographic and background information, including age, education level, prior exposure to data science, and participation in leadership development activities. The second section contained 32 items measuring the four main constructs—data science literacy, analytical thinking skill, creative thinking skill, and sustainable agility leadership—using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), with each construct represented by eight items (Table 2).

To ensure the quality and consistency of the data, the researcher conducted a nonresponse bias analysis by comparing the responses collected during the early and later stages of data collection. This procedure was performed to confirm that the timing of response submission did not significantly influence the outcomes. The questionnaire (Appendix) was disseminated via online platforms, including email and social media, allowing for broad and convenient access to the target population. All participant responses were treated with strict confidentiality in accordance with research ethics standards, ensuring that participants felt confident in providing information that would meaningfully contribute to the study.

3.3. Data analysis methods

Data analysis began with descriptive statistics to summarize the demographic characteristics of the respondents and to assess the mean scores of the indicators associated with each core variable: data science literacy, analytical thinking skill, creative thinking skill, and sustainable agility leadership. Results were presented in terms of mean values and standard deviations. Interpretation was based on five levels of mean scores: very low (0.00–1.00), low (1.01–2.00), moderate (2.01–3.00), high (3.01–4.00), and very high (4.01–5.00). For model testing, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to assess the structural relationships among variables. The measurement model was first evaluated by examining indicator loadings to ensure the alignment between observed indicators and their respective latent constructs. Internal consistency was assessed using Composite Reliability (CR),

Table 3
Demographic information.

Category	Subcategory	Frequency	Percent (%)
Gender	Male	58	10.50
	Female	497	89.50
Current Educational Institution (Public or Private)	Public Institution	466	84.00
	Private Institution	89	16.00
Internship Duration	Less than 3 months	140	25.20
	3–5 months	276	49.70
	6–8 months	39	7.00
	9–12 months	15	2.70
	More than 12 months	85	15.30
Current Cumulative GPA	Below 2.00	3	0.50
	2.01–2.50	55	9.90
	2.51–3.00	187	33.70
	3.01–3.50	192	34.60
	3.51–4.00	118	21.30
Total		**555**	**100.00**

while convergent validity was evaluated through Average Variance Extracted (AVE). Discriminant validity was tested based on the Fornell-Larcker criterion.

The structural model was then analyzed by checking for collinearity to avoid multicollinearity bias, followed by an examination of the model's explanatory power using the coefficient of determination (R^2) and predictive relevance (Q^2). Additionally, PLSpredict was conducted, following the guidelines of Hair et al. (2019), to further validate the model's predictive performance. Finally, path coefficients among all latent constructs were examined to test the hypothesized relationships proposed in the study. The findings were used to explain the causal mechanisms linking data science literacy, analytical thinking skill, creative thinking skill, and sustainable agility leadership. These insights provide a foundation for practical policy recommendations and curriculum development strategies aimed at enhancing leadership readiness among Thai Generation Z accounting students in the digital era.

4. Results

In this study, data collected from a sample of Generation Z accounting students in Thailand were analyzed to examine the relationships between data science literacy and sustainable agility leadership, with analytical thinking skill and creative thinking skill serving as mediating variables. The analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) to assess the structural associations among the key constructs. The findings provide compelling insights into how academic competencies in the digital era shape the leadership potential of next-generation students.

Table 3 presents the demographic profile of the total 555 respondents, all of whom were Generation Z accounting students in Thailand. The participants were categorized by gender, type of educational institution, internship duration, and current cumulative grade point average (GPA). The majority of respondents were female (n = 497; 89.50 %), while male students accounted for 58 individuals (10.50 %). This reflects a clear gender disparity in enrollment trends within the accounting discipline, with a significantly higher representation of female students. Regarding institutional affiliation, most participants were studying at public universities (n = 466; 84.00 %), while 89 students (16.00 %) were enrolled in private institutions. These figures suggest that public universities remain the primary source of accounting graduates in the country. In terms of internship experience, nearly half of the students (49.70 %) reported internship durations between 3 and 5 months, followed by those with less than 3 months (25.20 %) and more than 12 months (15.30 %). A smaller proportion had internship experience lasting 6–8 months (7.00 %) and 9–12 months (2.70 %). These findings indicate that most accounting students completed internships aligned with academic semester schedules or standard program requirements. As for academic performance, the data show that most students had a moderate to high GPA. Specifically, 34.60 % had a GPA between 3.01 and 3.50, followed by 33.70 % with a GPA of 2.51–3.00. A notable 21.30 % of respondents achieved a high GPA (3.51–4.00), while only 0.50 % reported a GPA below 2.00. These findings indicate that the sample possessed an overall satisfactory academic performance, making them an appropriate group for studying the link between academic competencies and leadership in a digitalized context.

Table 4 presents the results of the goodness-of-fit assessment for the structural model, using key fit indices from the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. The analysis indicated that the Standardized Root Mean Square Residual (SRMR) values for both the saturated model and the estimated model were 0.046, which is below the recommended threshold of 0.08. This suggests that the model demonstrates an acceptable overall model fit (Henseler et al., 2015). Additionally, the d_ULS and d_G values—used to evaluate the discrepancy between empirical and model-implied correlation matrices—were also low, at 0.289 and 0.279, respectively, indicating a good match between the proposed model and the observed data. Although the Chi-square value was 899.002, which tends to be sensitive to large sample sizes, it was used alongside other fit indices to verify model adequacy. Lastly, the Normed Fit Index (NFI) value was 0.901, which exceeds the benchmark of 0.90 and reflects a satisfactory model fit compared to the null model. Taken together, these indices confirm that the proposed structural model aligns well with the empirical data and is suitable for drawing meaningful conclusions.

Table 5 shows the outcome of the Confirmatory Factor Analysis (CFA) and reliability testing for the latent constructs: Data Science Literacy, Analytical Thinking Skill, Creative Thinking Skill, and Sustainable Agility Leadership. The reliability of the measurement instrument was assessed using key indicators including Cronbach's alpha (α), Composite Reliability (CR), and Average Variance Extracted (AVE), along with factor loadings and the Variance Inflation Factor (VIF) to assess multicollinearity. The results demonstrated strong reliability across all constructs, with Cronbach's α values exceeding 0.84 and CR values ranging from 0.898 to 0.952, surpassing the recommended minimum of 0.70. The AVE values ranged between 0.687 and 0.832, above the threshold of 0.50, indicating that the constructs explained a substantial amount of variance in their indicators. Factor loadings for all items exceeded 0.77 and were statistically significant at the $p < 0.001$ level, reflecting strong relationships between indicators and their respective latent constructs. Furthermore, all VIF values were between 1.592 and 4.279, below the critical threshold of 5.00, suggesting no

Table 4
Goodness of model fit.

Items	Saturate Model	Estimate Model
SRMR	0.046	0.046
d_ULS	0.289	0.289
d_G	0.279	0.279
Chi-Square	899.002	899.002
NFI	0.901	0.901

Table 5
CFA and reliability information.

Construct	Cronbach's α	CR (>0.7)	AVE (>0.5)	Factor Loading	VIF
Data Science Literacy	0.848	0.898	0.687		
Data Collection Literacy				0.770	1.592
Data Analysis Skills				0.865	2.304
Data Modeling Skills				0.831	1.940
Data Communication Skills				0.846	2.020
Analytical Thinking Skill	0.932	0.952	0.831		
Define the Problem				0.913	3.719
Develop Possible Solutions				0.925	4.279
Test Possible Solutions				0.925	3.974
Select and Implement a Solution				0.884	2.781
Creative Thinking Skill	0.933	0.952	0.832		
Originality				0.902	3.311
Cognitive Flexibility				0.920	3.814
Idea Fluency				0.923	4.066
Creative Elaboration				0.904	3.434
Sustainable Agility Leadership	0.923	0.945	0.811		
Adaptability to Change				0.902	3.057
Long-Term Goal Setting				0.904	3.185
Problem Solving through Positive Thinking				0.912	3.345
Continuous Innovation-Oriented Learning				0.884	2.815

multicollinearity issues in the model. In conclusion, the CFA and reliability assessments confirm that the measurement model used in this study is both valid and reliable, providing a robust foundation for subsequent structural model analysis.

Table 6 presents the results of the discriminant validity assessment for the four main latent variables: Data Science Literacy, Analytical Thinking Skill, Creative Thinking Skill, and Sustainable Agility Leadership. Two criteria were applied: the Heterotrait-Monotrait Ratio of Correlations (HTMT) and the Fornell-Larcker criterion. According to the HTMT values, all coefficients ranged from 0.879 to 0.936, which are below the critical threshold of 0.90, as recommended for conceptually related constructs (Henseler et al., 2015). This indicates that the variables in the model are sufficiently distinct from each other in terms of conceptual measurement. For the Fornell-Larcker test, the square root of the Average Variance Extracted (AVE)—reported on the diagonal of the correlation matrix—was higher than the correlation between each variable and all other constructs. For instance, the square root of AVE for Sustainable Agility Leadership was 0.901, which exceeded its correlations with other variables (e.g., 0.870 with Creative Thinking Skill). This confirms that each construct exhibits strong discriminant validity and captures a unique dimension of the overall conceptual model. Overall, both validation methods support the robustness and clarity of the measurement structure, enhancing the credibility of subsequent structural interpretations.

Table 7 summarizes the hypothesis testing results, which examined the structural relationships among the core variables: Data Science Literacy, Analytical Thinking Skill, Creative Thinking Skill, and Sustainable Agility Leadership using Partial Least Squares Structural Equation Modeling (PLS-SEM). The analysis revealed that all six hypotheses (H1–H6) were statistically supported. Each path showed a p-value below 0.01, and the t-statistics exceeded the recommended threshold of 1.96, indicating statistical significance. Specifically, H1 revealed that Data Science Literacy had a strong positive influence on Analytical Thinking Skill ($\beta = 0.831$, $t = 56.027$, $p < 0.001$), reflecting a large effect size and underscoring the crucial role of data-related competencies in shaping analytical capabilities among students. Similarly, H2 showed that Data Science Literacy had a significant positive effect on Creative Thinking Skill ($\beta = 0.267$, $t = 6.700$, $p < 0.001$), although the effect size was more moderate. Regarding H3, Data Science Literacy also had a direct, albeit smaller, positive effect on Sustainable Agility Leadership ($\beta = 0.123$, $t = 3.031$, $p = 0.003$). However, when considering indirect pathways, particularly those tested in H4 and H5, the mediating role of Analytical Thinking Skill became evident. H4 demonstrated a

Table 6
Comparative validity metrics for constructs: HTMT and Fornell-Larcker criterion.

Heterotrait-Monotrait Ratio of Correlations (HTMT)				
Construct	(1)	(2)	(3)	(4)
Data Science Literacy (1)				
Analytical Thinking Skill (2)	0.933			
Creative Thinking Skill (3)	0.908	0.935		
Sustainable Agility Leadership (4)	0.879	0.900	0.936	
Fornell-Larcker Criterion				
Construct	(1)	(2)	(3)	(4)
Data Science Literacy (1)	0.829			
Analytical Thinking Skill (2)	0.831	0.912		
Creative Thinking Skill (3)	0.808	0.872	0.912	
Sustainable Agility Leadership (4)	0.778	0.836	0.870	0.901

Table 7
Summary results.

H	Effect	Original Sample (O)	Standard Deviation (STDEV)	t-Statistic	p-Value	Results
H1	Data Science Literacy - > Analytical Thinking Skill	0.831	0.015	56.027	**0.000**	Supported
H2	Data Science Literacy - > Creative Thinking Skill	0.267	0.040	6.700	**0.000**	Supported
H3	Data Science Literacy - > Sustainable Agility Leadership	0.123	0.041	3.031	**0.003**	Supported
H4	Analytical Thinking Skill - > Creative Thinking Skill	0.650	0.042	15.610	**0.000**	Supported
H5	Analytical Thinking Skill - > Sustainable Agility Leadership	0.256	0.056	4.553	**0.000**	Supported
H6	Creative Thinking Skill - > Sustainable Agility Leadership	0.547	0.054	10.040	**0.000**	Supported

Note: **Significant at 0.01.

substantial positive effect of Analytical Thinking Skill on Creative Thinking Skill ($\beta = 0.650$, $t = 15.610$, $p < 0.001$), while H5 showed a significant influence of Analytical Thinking Skill on Sustainable Agility Leadership ($\beta = 0.256$, $t = 4.553$, $p < 0.001$). Finally, H6 confirmed that Creative Thinking Skill had a strong positive impact on Sustainable Agility Leadership ($\beta = 0.547$, $t = 10.040$, $p < 0.001$), highlighting the central role of creative capability in enabling next-generation leadership agility. In conclusion, the results presented in this table confirm the soundness of the proposed structural model and reveal meaningful direct and indirect causal relationships between data literacy, analytical thinking, creative thinking, and leadership capability in the context of Thai Gen Z accounting students. These findings reinforce the importance of 21st-century skill development as a foundation for cultivating digitally adaptive and sustainability-oriented leaders for the future workforce.

Fig. 2 illustrates the structural model representing the relationships among the four core variables: Data Science Literacy, Analytical Thinking Skill, Creative Thinking Skill, and Sustainable Agility Leadership. The model includes path coefficients and factor loadings that demonstrate statistically significant positive relationships. Notably, the path from Data Science Literacy to Analytical Thinking Skill (0.831) and the path from Creative Thinking Skill to Sustainable Agility Leadership (0.547) highlight the critical influence of data-related competencies and creative capabilities on leadership development in the digital era. These paths provide clear empirical support for the theoretical proposition that foundational 21st-century skills such as data literacy and creativity are essential for fostering adaptive and sustainable leadership among Generation Z students.

Table 8 presents the results of the indirect effects analysis based on the structural model, using the bootstrapping method to assess the statistical significance of the mediating paths. All indirect paths were statistically significant with p-values <0.001 and t-statistics ranging from 4.563 to 14.848, exceeding the conventional threshold ($t > 1.96$) for significance. The findings indicate that Data Science Literacy exerts a strong indirect influence on Creative Thinking Skill via Analytical Thinking Skill ($O = 0.541$, $t = 14.848$), confirming that analytical thinking acts as a powerful mediating mechanism linking data-related knowledge with creativity. Moreover, Data Science Literacy also indirectly influences Sustainable Agility Leadership through two key routes: first, via Analytical Thinking Skill ($O = 0.213$), and second, via Creative Thinking Skill ($O = 0.146$), both of which are statistically significant. Additionally, Analytical

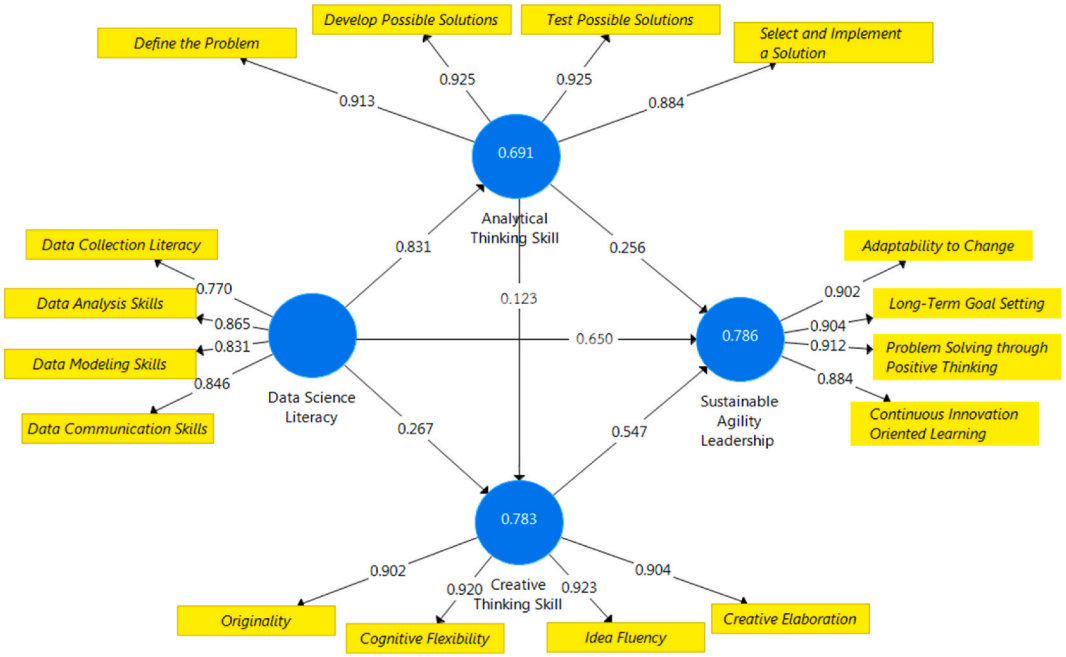

Fig. 2. The structural model.

Table 8
Indirect relationship.

Indirect Effect	Original Sample (O)	Standard Deviation (STDEV)	t-Statistic	p-Value
Data Science Literacy - > Analytical Thinking Skill - > Creative Thinking Skill	0.541	0.036	14.848	**0.000**
Data Science Literacy - > Analytical Thinking Skill - > Sustainable Agility Leadership	0.213	0.047	4.563	**0.000**
Data Science Literacy - > Creative Thinking Skill - > Sustainable Agility Leadership	0.146	0.027	5.445	**0.000**
Analytical Thinking Skill - > Creative Thinking Skill - > Sustainable Agility Leadership	0.356	0.040	8.895	**0.000**
Data Science Literacy - > Analytical Thinking Skill - > Creative Thinking Skill - > Sustainable Agility Leadership	0.296	0.034	8.811	**0.000**

Thinking Skill indirectly impacts Sustainable Agility Leadership through Creative Thinking Skill (O = 0.356, t = 8.895), indicating that creative capability enhances the strategic potential of analytical reasoning. Most importantly, the three-step indirect path from Data Science Literacy → Analytical Thinking Skill → Creative Thinking Skill → Sustainable Agility Leadership (O = 0.296, t = 8.811) reveals a complex and coherent causal structure. This structure underscores the importance of integrated skillsets—including data literacy, critical analysis, and creativity—in shaping next-generation leadership capabilities that are both agile and sustainable. These findings further validate the suitability of the proposed structural model and emphasize the relevance of 21st-century competencies in preparing digital-era leaders to navigate uncertainty and drive long-term value.

5. Discussion

The findings of this study provide robust empirical evidence supporting the theoretical propositions and previous literature, particularly regarding the influence of Data Science Literacy on both Analytical Thinking Skill and Creative Thinking Skill among students. These results align with the conceptual arguments presented by Wolff et al. (2016), Novikov (2020), and Shamsuddin and Razak (2023), who assert that the ability to comprehend and apply data is a foundational component of logical reasoning and effective decision-making in the digital age. Specifically, the results related to Hypothesis 1 confirm that Data Science Literacy has a strong positive impact on Analytical Thinking Skill (β = 0.831), reflecting how competencies in managing, analyzing, and communicating data can significantly enhance students' capacity for strategic analytical reasoning. Similarly, Hypotheses 2 and 4, which explore the pathways from Data Science Literacy and Analytical Thinking Skill to Creative Thinking Skill, were both statistically supported (β = 0.267 and β = 0.650, respectively). These findings correspond with the work of Ramadani et al. (2021) and Wani and Hussian (2024), who argue that analytical thinking serves as a catalyst for creative thinking—particularly when individuals are required to interpret complex data and transform it into novel ideas or innovative strategies. Furthermore, the significant influence of Creative Thinking Skill on Sustainable Agility Leadership (β = 0.547; H6) reinforces the perspective of Poveda-Pareja et al. (2024), Miller et al. (2021), and Tagscherer and Carbon (2023), who emphasize the critical role of creativity in enabling leaders to navigate rapidly evolving and uncertain environments.

The results of Hypotheses 3, 5, and 6 also underscore the importance of academic competencies as key predictors of Sustainable Agility Leadership, particularly among Generation Z accounting students who must prepare for transitions into a data-driven economy. The ability to analyze data (Analytical Thinking) and interpret it to formulate innovative solutions (Creative Thinking) emerges as a vital bridge to adaptability with vision—a core feature of sustainable and agile leadership. These findings reflect the conceptual insights of Ketprapakorn and Kantabutra (2022), Tandon et al. (2024), and Fuad et al. (2022), who propose that digital-era leadership must balance agility (in responding to short-term changes) with sustainability (in long-term goal orientation). In summary, the research findings are strongly supported by established theoretical frameworks and prior empirical studies. They validate the coherence of the proposed structural model and confirm that the path from Data Science Literacy → Analytical Thinking → Creative Thinking → Sustainable Agility Leadership is not only theoretically sound but also empirically significant. This pathway illustrates the dynamic interconnection between essential 21st-century competencies and leadership development in a digital context—especially among Thai Gen Z accounting students, who are poised to become the driving force behind organizations operating in a world fueled by data and innovation.

These findings also have meaningful implications for accounting education, particularly in the development of next-generation leadership. As highlighted by Sawan et al. (2024) and Alshhadat and Al-Hajaya (2023), leadership in the post-pandemic era requires adaptability, innovation, and resilience—skills that can be embedded into the curriculum through interdisciplinary learning, cognitive development, and the integration of digital tools. The implementation of blended and flipped classroom approaches (Sawan et al., 2024) and the use of AI-enhanced platforms (Al-Hajaya et al., 2025) provide promising pathways for sharpening leadership potential, especially among Generation Z learners. By treating leadership as a dynamic skillset shaped by educational interventions, universities can better prepare students for evolving organizational challenges.

5.1. Theoretical implications

The findings contribute to the theoretical development of sustainable agility leadership by incorporating data science literacy as a foundational enabler. By positioning analytical and creative thinking as mediating variables, the study provides a nuanced understanding of how cognitive capabilities interact with digital competencies to influence adaptive leadership behavior. This integrative approach expands current models of leadership theory by aligning them with data-centric perspectives in the digital era, especially

within Gen Z populations.

5.2. Practical implications

From a practical standpoint, the study offers valuable insights for curriculum designers, educators, and organizational leaders. Higher education institutions may consider integrating data science and critical thinking modules into accounting programs to foster essential leadership skills. Employers can also benefit by designing training interventions that enhance data-driven decision-making and agile thinking among early-career professionals. These strategies are vital for preparing future leaders capable of navigating uncertainty and driving innovation.

5.2.1. Curriculum design for developing data-driven and creative young leaders

The findings of this study offer significant implications for curriculum development in higher education, particularly within the field of accounting, which is currently facing rapid technological disruptions and evolving expectations from the digital-era labor market. The results indicate that Data Science Literacy has a statistically significant influence on both Analytical Thinking and Creative Thinking, suggesting that a curriculum integrating data-related competencies with higher-order thinking development can enhance not only students' technical knowledge but also their foundational leadership capacities for the digital age. In line with these findings, curriculum design should emphasize integrative learning, incorporating courses and activities that cultivate analytical and creative thinking through real-world data application, case analysis, and project-based learning focused on systematic problem solving. To this end, students should be provided opportunities to use analytical tools such as Excel, SPSS, or Python, in conjunction with tasks involving critical questioning, solution development, and creative data presentation. Such an approach helps foster a comprehensive leadership capability aligned with the principles of Sustainable Agility Leadership, which emphasizes both adaptability and long-term vision in leadership development.

Moreover, the study highlights that Analytical Thinking plays a mediating role between Data Science Literacy and Creative Thinking, and ultimately impacts leadership outcomes. This interpretation suggests that in order to genuinely foster students' leadership potential, academic programs should begin by strengthening the foundations of Data Science Literacy and Analytical Thinking, which serve as internal drivers for higher-order capabilities such as creativity and effective leadership. Therefore, this study contributes not only to the theoretical understanding of interrelated 21st-century competencies but also provides practical guidance for designing curricula that empower students to become "data-driven leaders"—individuals capable of analyzing, adapting, and innovating in a world increasingly shaped by data and technology. In the context of accounting education, these findings are particularly timely, as the profession is undergoing a transformation from traditional bookkeeping to a more strategic, insight-driven role in digital organizations. Thus, the results support the need for a paradigm shift in accounting curricula that prepares students not just for technical compliance, but for leadership in data-enabled decision-making and innovation.

5.2.2. The role of 21st-century skills in developing Thai youth leadership potential in a data-driven economy

The findings of this study underscore the systemic importance of developing Thai youth within the context of the emerging data-driven economy, where 21st-century skills are no longer optional but have become fundamental prerequisites for leadership. Leaders today must be capable of navigating rapid change, maintaining flexibility, and driving sustainable outcomes. The concept of Sustainable Agility Leadership, employed as the outcome construct in this study, highlights how students with the ability to analyze data, think strategically, and generate innovative solutions are more likely to become leaders who can respond effectively to modern societal and labor market challenges. The results demonstrate a robust and statistically significant causal pathway from Data Science Literacy through Analytical Thinking and Creative Thinking to Sustainable Agility Leadership—particularly the three-step indirect effect ($O = 0.296$, $t = 8.811$). This provides empirical confirmation that developing future leaders requires more than technical training or theoretical instruction; it necessitates the integration of knowledge, analytical capability, and creative potential. These findings resonate with the perspectives of Ketprapakorn and Kantabutra (2022) and Tiwari (2024), who emphasize that future leaders must be thinkers, change agents, and socially responsible communicators. At the policy level, this suggests an urgent need to develop training programs and learning support systems that strengthen data science and creative thinking competencies among youth, especially in disciplines that have traditionally focused solely on logical or procedural learning, such as accounting, finance, or economics. A shift in perspective—from "record-keepers" to "data-driven leaders"—can lay the groundwork for nurturing mindsets aligned with digital economic development and enhancing the competitiveness of the Thai workforce on a global stage. Moreover, cross-sectoral collaboration among academia, government, and industry is essential for building these skills systematically. Initiatives could include platforms for student data analysis training, Work-Integrated Learning (WIL) programs that expose students to real-world data-driven decision-making, and leadership assessment systems that incorporate agility, sustainability, and innovation as core dimensions.

In conclusion, this study provides a clear model of the leadership development pathway for the next generation—beginning with data science knowledge, advancing through thinking skills, and culminating in sustainable, adaptive leadership for the 21st century. Supporting Thai youth in this trajectory represents not only an investment in national human capital, but also a strategic foundation for building a resilient, future-ready economy and society.

5.3. Limitation, recommendations and future research directions

This study provides meaningful insights into the interplay between data science literacy, analytical and creative thinking skills, and

sustainable agility leadership among Generation Z accounting students in Thailand. However, several limitations must be acknowledged to contextualize the findings and guide future research. First, the study employed a cross-sectional design and relied exclusively on self-reported data, which may be subject to common method bias and may not fully capture the dynamic nature of learning and leadership development. Longitudinal studies would be beneficial to observe the evolution of competencies over time and to establish stronger causal inferences. Second, the use of convenience sampling, while appropriate for exploratory research, limits the generalizability of the results beyond the current sample. Future studies should consider more probabilistic sampling techniques to enhance representativeness across institutional types and regions.

Third, while this research focused on accounting students—chosen for their alignment with the digital and analytical focus of the study—it is important to explore whether the findings hold across other academic domains. Future research should broaden the population scope to include students from disciplines such as engineering, communications, and social sciences, to investigate whether different educational backgrounds influence the development of sustainable agility leadership. Comparative studies across disciplines could uncover unique developmental pathways and inform more tailored curriculum interventions.

Fourth, while this study used quantitative methods to test the proposed model, integrating qualitative approaches—such as in-depth interviews, reflective journals, or classroom observations—would enrich the understanding of the mechanisms through which data science literacy and cognitive skills foster sustainable leadership. Such mixed-methods approaches could provide a more nuanced exploration of how students perceive, internalize, and apply the competencies in academic and real-world settings. Additionally, future investigations should explore contextual and environmental variables that may moderate or mediate these relationships. Factors such as teaching quality, the use of educational technologies, institutional culture, or internship experiences could significantly shape how students acquire and utilize data and leadership skills. Understanding these contextual influences would enable a more holistic and accurate model of leadership development in the digital age.

From a practical standpoint, the findings underscore the need for higher education institutions—especially those offering business, accounting, and management programs—to embed data science literacy alongside analytical and creative thinking development into both core and co-curricular structures. Curricula should emphasize experiential learning methods, project-based learning, and real-world data applications to cultivate agile and sustainable leadership mindsets. Furthermore, fostering data-driven decision-making through integrated teaching of systems thinking will better prepare students for strategic roles in increasingly complex, data-rich organizational environments.

6. Conclusion

The findings of this study affirm the pivotal role of Data Science Literacy as a foundational competence for developing both Analytical Thinking Skills and Creative Thinking Skills, which are essential in cultivating Sustainable Agility Leadership among Generation Z accounting students in Thailand. The structural model analysis confirmed that data science literacy not only has a direct effect on analytical thinking, creative thinking, and sustainable leadership, but also exerts indirect effects mediated through analytical and creative thinking processes. These results highlight the emergence of a deeply integrated learning structure shaped by the evolving demands of the digital era.

All six proposed hypotheses were statistically supported, with particularly strong effects observed in the pathways from Data Science Literacy to Analytical Thinking Skills, and from Creative Thinking Skills to Sustainable Agility Leadership. These outcomes underscore the significance of 21st-century skills in enhancing the leadership potential of today's youth. Notably, Analytical Thinking emerged as a critical mediating factor linking data literacy to both creative thinking and leadership capacity in complex environments.

Theoretically, these findings reinforce key principles from Cognitive Theory and Transformational Leadership Theory, demonstrating how digital competencies foster higher-order thinking that enables sustainable leadership. Additionally, the study contributes to the literature by offering empirical support for the interconnected development of digital literacy, cognitive capability, and adaptive leadership among students. From a policy perspective, these insights carry important implications for curriculum design, instructional strategies, and broader educational initiatives aimed at preparing students to become visionary, resilient, and responsible leaders equipped to navigate and shape a sustainable future.

CRediT authorship contribution statement

Narinthon Imjai: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Kanokwan Meesook:** Writing – original draft, Validation, Resources, Methodology, Formal analysis, Conceptualization. **Thanaporn Homlaor:** Writing – original draft, Validation, Resources, Investigation, Data curation. **Berto Usman:** Writing – review & editing, Visualization, Validation, Software, Investigation. **Somnuk Aujirapongpan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Ethical statement

The study was approved by an ethical committee with ID: NMCEC-0040/2567. Informed consent was obtained from all participants, and their privacy rights were strictly observed.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to assist with improving the readability and language of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Appendix

Research questionnaire

Section 1: Data Science Literacy

1. You are able to effectively search for data from official websites or reputable databases for data analysis purposes.
2. You can evaluate the quality of data—such as assessing its accuracy or relevance—before using it for analysis.
3. You are proficient in performing basic data analysis, such as calculating averages and standard deviations.
4. You can effectively use software such as Excel, SPSS, or Python for data analysis.
5. You are capable of developing data models to represent relationships and forecast future outcomes.
6. You are able to refine data models to suit changing scenarios or contexts.
7. You can present data visually using clear and effective formats such as bar charts or pie charts in Excel to summarize findings.
8. You can clearly explain the results of data analysis to others in an understandable way.

Section 2: Analytical Thinking Skill

9. You can identify the root causes of a problem when an error occurs.
10. You are able to break down a problem into smaller components for detailed analysis.
11 You can design multiple solution approaches to address constraints effectively.
12. You are capable of refining your proposed solutions to improve their efficiency and suitability.
13. You routinely test proposed solutions to ensure reliability before actual implementation.
14. You can revise solutions effectively when initial testing reveals flaws.
15. You are able to compare various alternatives to select the most appropriate one.
16. You can implement your chosen solution systematically and effectively.

Section 3: Creative Thinking Skill

17. You often think outside the box to discover alternative ways to solve problems.
18. You regularly improve existing workflows to achieve better results more efficiently.
19. You can adapt effectively to changing circumstances or conditions.
20. You are capable of viewing problems from multiple perspectives and selecting the most suitable approach.
21. You can generate multiple ideas or solutions within a limited timeframe.
22. You are able to develop a variety of alternatives for your team to choose the best-fit solution.
23. You can create comprehensive and actionable plans.
24. You are able to elaborate on initial ideas into more in-depth and practical applications.

Section 4: Sustainable Agility Leadership

25 You can adapt quickly to uncertain or changing situations.
26. You are able to use available information to support decision-making in dynamic contexts.
27. You prioritize long-term goals over short-term outcomes.
28. You can plan sustainably to improve the quality of life for yourself, your family, and society.
29. You apply positive thinking processes to analyze problems and identify suitable solutions.
30. You can inspire your team to seek creative solutions to challenges.
31. You place great importance on lifelong learning and continuous personal development.

32. You are capable of adopting new technologies to enhance your work in response to changes in the digital era.

Data availability

Data will be made available on request.

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