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How Heutagogy-Based E-Leadership Enables 21st-Century Learning: The Mediating Role of Teacher Competence in Indonesian Public Schools

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ABSTRACT: Existing studies have largely examined e-leadership, heutagogy, teacher competence, and 21st-century learning separately, leaving the mechanism linking school leadership to classroom transformation insufficiently explained. This study examines whether teacher competence mediates the relationship between heutagogy-based e-leadership and 21st-century learning in Indonesian public senior high schools. Using a quantitative explanatory design, data were collected from 190 teachers in four public schools in West Java and analyzed using PLS-SEM with SmartPLS 4. The results show that heutagogy-based e-leadership significantly influences teacher competence ($\beta = 0.884$, $p < 0.001$) and 21st-century learning ($\beta = 0.172$, $p = 0.028$), while teacher competence strongly influences 21st-century learning ($\beta = 0.792$, $p < 0.001$). The indirect effect through teacher competence is also significant ($\beta = 0.701$, $p < 0.001$), indicating complementary partial mediation. The model explains 78.2% of the variance in teacher competence and 89.9% in 21st-century learning. Theoretically, the study extends heutagogy into an organizational leadership perspective and positions teacher competence as an organizational-to-instructional mechanism. Practically, schools should prioritize reflective digital leadership, sustained professional learning, collaborative lesson design, and evidence-based coaching to strengthen classroom transformation.

Keywords: digital pedagogy, heutagogy-based e-leadership, school leadership, teacher competence, 21st-century learning.

***ABSTRAK*:** *Penelitian terdahulu umumnya mengkaji* e-leadership, heutagogy, *kompetensi guru, dan pembelajaran abad ke-21 secara terpisah, sehingga mekanisme yang menghubungkan kepemimpinan sekolah dengan transformasi pembelajaran belum dijelaskan secara memadai. Penelitian ini menguji peran mediasi kompetensi guru dalam hubungan antara* e-leadership *berbasis* heutagogy *dan pembelajaran abad ke-21 pada SMA negeri di Indonesia. Dengan desain kuantitatif eksplanatori, data dikumpulkan dari 190 guru pada empat sekolah negeri di Jawa Barat dan dianalisis menggunakan PLS-SEM dengan* SmartPLS *4. Hasil menunjukkan bahwa* e-leadership *berbasis* heutagogy *berpengaruh signifikan terhadap kompetensi guru ($\beta = 0{,}884$; $p < 0{,}001$) dan pembelajaran abad ke-21 ($\beta = 0{,}172$; $p = 0{,}028$), sedangkan kompetensi guru berpengaruh kuat terhadap pembelajaran abad ke-21 ($\beta = 0{,}792$; $p < 0{,}001$). Pengaruh tidak langsung melalui kompetensi guru juga signifikan ($\beta = 0{,}701$; $p < 0{,}001$), yang menunjukkan mediasi parsial komplementer. Model menjelaskan 78,2% variasi kompetensi guru dan 89,9% variasi pembelajaran abad ke-21. Secara teoretis, penelitian ini memperluas* heutagogy *ke perspektif kepemimpinan organisasi dan menempatkan kompetensi guru sebagai mekanisme organisasi-ke-instruksional. Secara praktis, sekolah perlu memprioritaskan kepemimpinan digital reflektif, pembelajaran profesional berkelanjutan, perencanaan pembelajaran kolaboratif, dan* coaching *berbasis bukti.*

Kata kunci: *e-leadership berbasis heutagogy, kepemimpinan sekolah, kompetensi guru, pembelajaran abad ke-21, pedagogi digital*

INTRODUCTION

Education systems are increasingly expected to prepare students to think critically, communicate effectively, collaborate, solve complex problems, use technology responsibly, and adapt to uncertain social and professional environments. These expectations position 21st-century learning as more than the adoption of digital devices. It requires student-centered pedagogy, authentic assessment, higher-order thinking, creativity, collaboration, and meaningful technology integration. The OECD Learning Compass 2030 and the Framework for 21st Century Learning similarly emphasize agency, responsibility, communication, collaboration, critical thinking, and digital literacy as interconnected competencies required for future learning and participation (OECD, 2019).

The expansion of online and blended learning during the COVID-19 pandemic accelerated the use of digital technology in schools, but it also demonstrated that access to technology does not automatically transform teaching. Digital platforms may improve communication and administration while classroom practices remain teacher-centered. Transformative learning instead requires flexible instructional design, authentic tasks, learner agency, collaboration, and institutional support (Bozgun et al., 2023; Cochrane et al., 2022; Gillaspy & Vasilica, 2021). The central challenge is therefore not merely whether schools use technology, but whether school leaders and teachers can translate technological opportunities into meaningful learning experiences.

Teacher competence is central to this transformation. Shulman (1986) established that effective teaching requires teachers to transform subject knowledge into forms that learners can understand, while Mishra and Koehler (2006) demonstrated that meaningful technology integration depends on the interaction of technological, pedagogical, and content knowledge. Teacher competence should therefore be understood as an integrated capacity involving pedagogical, professional, social, personal, digital, reflective, and adaptive capabilities. Such competence enables teachers to design student-centered instruction, facilitate collaboration, develop higher-order thinking, conduct authentic assessment, and respond to diverse learning needs.

Recent studies nevertheless show that teacher competence, particularly digital-pedagogical competence, remains uneven. Builes et al. (2022) found that digital competence is often treated as a technical addition rather than an integrated element of teachers' professional practice. Cepa-Rodríguez and Etxeberria Murgiondo (2024) similarly reported that prospective teachers' digital competence remained at a basic-to-intermediate level, while Fernández Luque and Ramirez-Montoya (2024) emphasized that effective digital development requires the integration of infrastructure, instructional methods, resources, and lifelong learning. In addition, teachers continue to face difficulties in designing higher-order thinking assessments and using digital data to support collaborative problem solving (Jailani et al., 2023; Liu et al., 2025). These findings indicate that

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curriculum reform and technology provision alone are insufficient without sustained professional-capacity development.

School leadership plays an important role in creating the conditions for such development. Avolio et al. (2000) define e-leadership as a social influence process mediated by information technology and shaped by the interaction among leadership, technology, and organizational structures. In educational contexts, however, digital leadership is still frequently associated with infrastructure, electronic communication, and administrative efficiency. This emphasis does not fully explain how leaders develop teachers as autonomous, reflective, and continuously learning professionals.

Heutagogy offers a relevant perspective for addressing this limitation. Introduced by Hase and Kenyon (2000), heutagogy views learning as a self-determined process characterized by agency, capability, reflection, metacognition, and flexible learning pathways. Hase and Kenyon (2007) further emphasize that learning in complex environments should be adaptive and emergent rather than completely prescribed. Applied to teacher development, heutagogy positions teachers not simply as recipients of standardized training but as professionals who identify learning needs, experiment with practice, evaluate evidence, collaborate, and reconstruct their professional knowledge. Recent studies show that heutagogy-based professional learning can strengthen digital competence and continuous professional development (Alam et al., 2024; Sherly et al., 2023). However, these studies primarily treat heutagogy as a training approach and provide limited explanation of how school leadership institutionalizes self-determined teacher learning.

This study therefore conceptualizes heutagogy-based e-leadership as a digitally enabled leadership approach that promotes teacher agency, reflection, evidence-informed decision-making, collaboration, professional autonomy, agility, innovation, and continuous capability development. This perspective extends e-leadership beyond administrative digitalization and extends heutagogy beyond individual learning design by embedding self-determined learning principles in school leadership. Leaders are expected to influence learning not only through direct policies and resources, but also by developing teachers' capacity to translate organizational support into classroom practice.

Three research gaps justify the proposed model. Conceptually, e-leadership, heutagogy, teacher competence, and 21st-century learning have generally been examined as separate areas. Limited research integrates digital leadership and self-determined professional learning into a unified leadership construct, while teacher competence is commonly treated either as a leadership outcome or as a direct predictor of teaching practice rather than as a mechanism connecting the two. Methodologically, previous studies have often relied on descriptive surveys, qualitative investigations, or evaluations of individual training programs, providing limited evidence about the indirect pathway through which leadership affects classroom learning. Empirically, heutagogy-based leadership remains underexamined among practicing teachers in public secondary schools, particularly in Indonesia and other developing-country contexts.

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Based on these gaps, the study proposes that heutagogy-based e-leadership strengthens teacher competence by creating opportunities for autonomy, reflection, collaboration, digital experimentation, and continuous professional learning. Thus: H1: Heutagogy-based e-leadership positively influences teacher competence.

Heutagogy-based e-leadership may also influence 21st-century learning directly by establishing a school culture that supports digital innovation, learner-centered practices, collaboration, evidence-informed decision-making, and instructional flexibility. Thus: H2: Heutagogy-based e-leadership positively influences 21st-century learning.

Teacher competence is expected to have a direct influence on 21st-century learning because teachers are the primary actors who translate technology, curriculum expectations, and leadership directions into pedagogical practice. Competent teachers are better able to integrate technology meaningfully, facilitate collaboration, design authentic assessments, and develop students' critical and creative thinking (Nurhidayat et al., 2024; Zamora & Zamora, 2022). Thus: H3: Teacher competence positively influences 21st-century learning.

Leadership support is unlikely to transform classroom learning fully unless teachers possess the competence to enact it. Teacher competence is therefore expected to function as the pathway through which heutagogy-based e-leadership is translated into learning practice. Thus: H4: Teacher competence mediates the relationship between heutagogy-based e-leadership and 21st-century learning.

The conceptual framework presented in Figure 1 positions heutagogy-based e-leadership as the exogenous construct, teacher competence as the mediating construct, and 21st-century learning as the outcome construct.

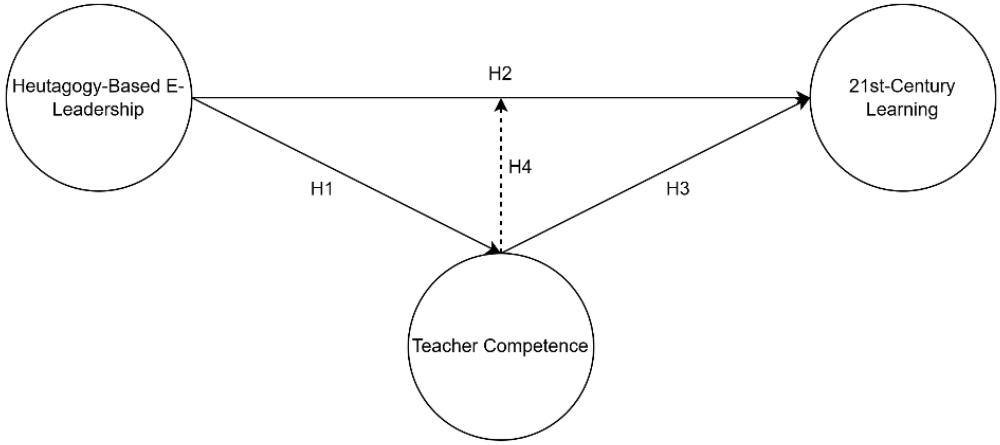


Figure 1. Conceptual Framework and Hypothesized Relationships (*Source: Authors' elaboration, 2026*)

The novelty of this study lies in integrating heutagogy and e-leadership into a school-leadership construct, positioning teacher competence as an organizational-to-instructional mediating mechanism, and testing the model among teachers in Indonesian public senior high schools. The study therefore aims to examine the direct and indirect relationships among heutagogy-based e-

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leadership, teacher competence, and 21st-century learning. It addresses the following research questions: (1) Does heutagogy-based e-leadership influence teacher competence? (2) Does heutagogy-based e-leadership influence 21st-century learning? (3) Does teacher competence influence 21st-century learning? and (4) Does teacher competence mediate the relationship between heutagogy-based e-leadership and 21st-century learning?

METHODs

This article reports the quantitative phase of a sequential explanatory mixed-methods study. In the broader study, quantitative data were collected and analyzed first, followed by qualitative inquiry to explain the statistical findings in greater depth. The present article focuses exclusively on the quantitative phase, which employed an ex post facto explanatory design because the variables were observed as they naturally occurred without experimental manipulation (Creswell, 2015; Creswell & Guetterman, 2019; Sugiyono, 2016). This design is consistent with the methodological framework described in the dissertation.

The study was conducted in four public senior high schools under the coordination of Branch Office Region IV of the West Java Provincial Education Office: SMAN 1 Jatiluhur Purwakarta, SMAN 2 Subang, SMAN 1 Cikampek, and SMAN 6 Karawang. The population comprised 235 civil-service and non-civil-service teachers from different subject areas. A total of 190 teachers were selected through proportional random sampling so that each school was represented according to its proportion in the population. Sample adequacy was determined by considering the PLS-SEM guideline of approximately five to ten observations for each indicator included in the model (Hair et al., 2022).

Data were collected using a closed-ended questionnaire with a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The instrument measured three constructs. Heutagogy-based e-leadership comprised electronic, learner-centric, empirical, agile, digital, growth-oriented, reflective, open-ended, willingness, humanist, and time-bound dimensions. Teacher competence comprised pedagogical, professional, social, and personal competence, whereas 21st-century learning covered 4C skills, digital and technological literacy, student-centered learning, curriculum integration, teacher-capacity development, assessment and evaluation, innovative learning, and literacy and science skills. The dimensions were developed from the theoretical frameworks of e-leadership, self-determined learning, teacher competence, and 21st-century learning (Avolio et al., 2000; Blaschke, 2012; Hase & Kenyon, 2000).

The questionnaire items were developed through a synthesis of relevant theoretical and empirical literature. Content validity was evaluated through expert judgement involving two experts in educational leadership and research methodology. The assessment considered the relevance of each item to its construct, clarity of wording, depth of meaning, and representativeness of the measured dimensions. Construct validity was subsequently evaluated through the measurement model, while internal consistency was examined using Cronbach's alpha and composite reliability (Hair et al., 2022).

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Data were analyzed using partial least squares structural equation modeling with SmartPLS 4. PLS-SEM was appropriate because the study examined relationships among multidimensional latent constructs and tested the mediating role of teacher competence. The analysis was conducted in two stages: assessment of the measurement model and assessment of the structural model (Hair et al., 2022).

The measurement model was assessed using outer loadings, Cronbach's alpha, composite reliability, average variance extracted, the Fornell–Larcker criterion, cross-loadings, and variance inflation factors. Indicator loadings above 0.70, reliability coefficients above 0.70, and AVE values above 0.50 were used as the principal criteria for establishing indicator reliability, internal consistency, and convergent validity. Discriminant validity was assessed by comparing the square root of each construct's AVE with its correlations with other constructs and by examining whether each indicator loaded most strongly on its intended construct (Fornell & Larcker, 1981; Hair et al., 2022).

The structural model was evaluated through path coefficients, t-statistics, p-values, coefficients of determination (R^2), effect sizes (f^2), and mediation analysis. The significance of the hypothesized relationships was determined through bootstrapping in SmartPLS 4. Teacher competence was tested as a mediator by estimating the direct, specific indirect, and total effects of heutagogy-based e-leadership on 21st-century learning (Hair et al., 2022; Nitzl et al., 2016).

Participation was voluntary, and all respondents were informed about the purpose of the study, the confidentiality of their responses, and their right to withdraw at any time. Permission to conduct the study was obtained from the participating schools, and no personally identifiable information was collected.

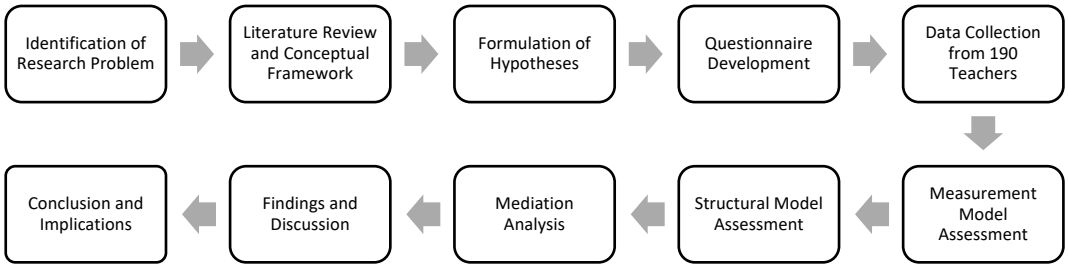


Figure 2. Research Flow Diagram (*Source: Authors' elaboration based on the quantitative procedure, 2026)*

RESULT AND DISCUSSION

Descriptive Results of the Main Constructs

The descriptive analysis showed that the implementation of 21st-century learning in the participating schools was generally high, with an overall mean score of 4.29. The 4C skills dimension, comprising critical thinking, creativity, collaboration, and communication, obtained the highest mean score of 4.45. Literacy and science skills obtained the lowest mean score of 4.12. These results

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indicate that the participating teachers reported stronger implementation of the core 4C skills than of literacy- and science-oriented learning practices.

Table 1. Descriptive Results of 21st-Century Learning

No.	Dimension of 21st-Century Learning	Mean	Category
1	4C Skills: Critical Thinking, Creativity, Collaboration, and Communication	4.45	Very High
2	Student-Centered Learning	4.38	High
3	Innovative Learning	4.29	High
4	Assessment and Evaluation	4.22	High
5	Literacy and Science Skills	4.12	Moderately High
Overall Mean		**4.29**	**High**

Source: *Primary data processed by the researcher, 2026.*

Teacher competence was also categorized as high, with an overall mean score of 4.31. Professional competence obtained the highest mean score of 4.47, followed by personal competence at 4.39 and pedagogical competence at 4.31. Social competence obtained the lowest mean score of 4.08.

Table 2. Descriptive Results of Teacher Competence

No.	Dimension of Teacher Competence	Mean	Category
1	Professional Competence	4.47	Very High
2	Personal Competence	4.39	Very High
3	Pedagogical Competence	4.31	High
4	Social Competence	4.08	High
Overall Mean		**4.31**	**High**

Source: *Primary data processed by the researcher, 2026.*

The descriptive result for heutagogy-based e-leadership showed an overall mean score of 4.30, categorized as high. Reflective leadership obtained the highest mean score of 4.48, followed by empirical leadership at 4.44 and growth-oriented leadership at 4.40. The electronic and digital dimensions obtained the two lowest scores, at 4.10 and 4.05, respectively.

Table 3. Descriptive Results of Heutagogy-Based E-Leadership

No.	Dimension of Heutagogy-Based E-Leadership	Mean	Category
1	Reflective	4.48	Very High
2	Empirical	4.44	Very High
3	Growth-Oriented	4.40	Very High
4	Open-Ended	4.35	High
5	Willingness	4.33	High
6	Humanist	4.30	High
7	Agile	4.27	High
8	Time-Bound	4.24	High
9	Learner-Centric	4.21	High

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10	Electronic	4.10	High
11	Digital	4.05	High
	Overall Mean	**4.30**	**High**

Source: *Primary data processed by the researcher, 2026.*

Measurement Model Assessment

The measurement model was evaluated using indicator loadings, composite reliability, average variance extracted, and variance inflation factors. The outer loadings ranged from 0.869 to 0.974, exceeding the minimum criterion of 0.70. The composite reliability values ranged from 0.913 to 0.981, while the AVE values ranged from 0.803 to 0.942. These values indicate adequate indicator reliability, internal consistency, and convergent validity.

The VIF values ranged from 1.000 to 4.579. Because all values were below 5.00, no critical collinearity problem was identified in the evaluated model.

Table 4. Summary of Measurement Model Assessment

Assessment	Obtained Values	Recommended Criterion	Result
Outer Loadings	0.869–0.974	> 0.70	Achieved
Composite Reliability	0.913–0.981	> 0.70	Achieved
Average Variance Extracted	0.803–0.942	> 0.50	Achieved
Variance Inflation Factor	1.000–4.579	< 5.00	No critical collinearity

Source: *Primary data processed by the researcher using SmartPLS 4, 2026.*

Discriminant validity was assessed using the Fornell–Larcker criterion and cross-loadings.

Structural Model and Hypothesis Testing

The structural model was assessed using standardized path coefficients, t-statistics, and p-values. All three direct paths were positive and statistically significant.

Heutagogy-based e-leadership had a strong positive effect on teacher competence ($\beta = 0.884\ t = 37.592\ p < 0.001$). Therefore, H1 was supported. Heutagogy-based e-leadership also had a positive direct effect on 21st-century learning ($\beta = 0.172\ t = 2.205\ p = 0.028$), supporting H2. Teacher competence had a strong positive effect on 21st-century learning ($\beta = 0.792\ t = 9.760\ p < 0.001$), supporting H3.

Table 5. Direct Effects and Hypothesis Testing

Hypothesis	Structural Path	Path Coefficient	t-Statistic	p-Value	Decision
H1	Heutagogy-Based E-Leadership → Teacher Competence	0.884	37.592	< 0.001	Supported

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H2	Heutagogy-Based E-Leadership → 21st-Century Learning	0.172	2.205	0.028	Supported
H3	Teacher Competence → 21st-Century Learning	0.792	9.760	< 0.001	Supported

Source: *Primary data processed by the researcher using SmartPLS 4, 2026.*

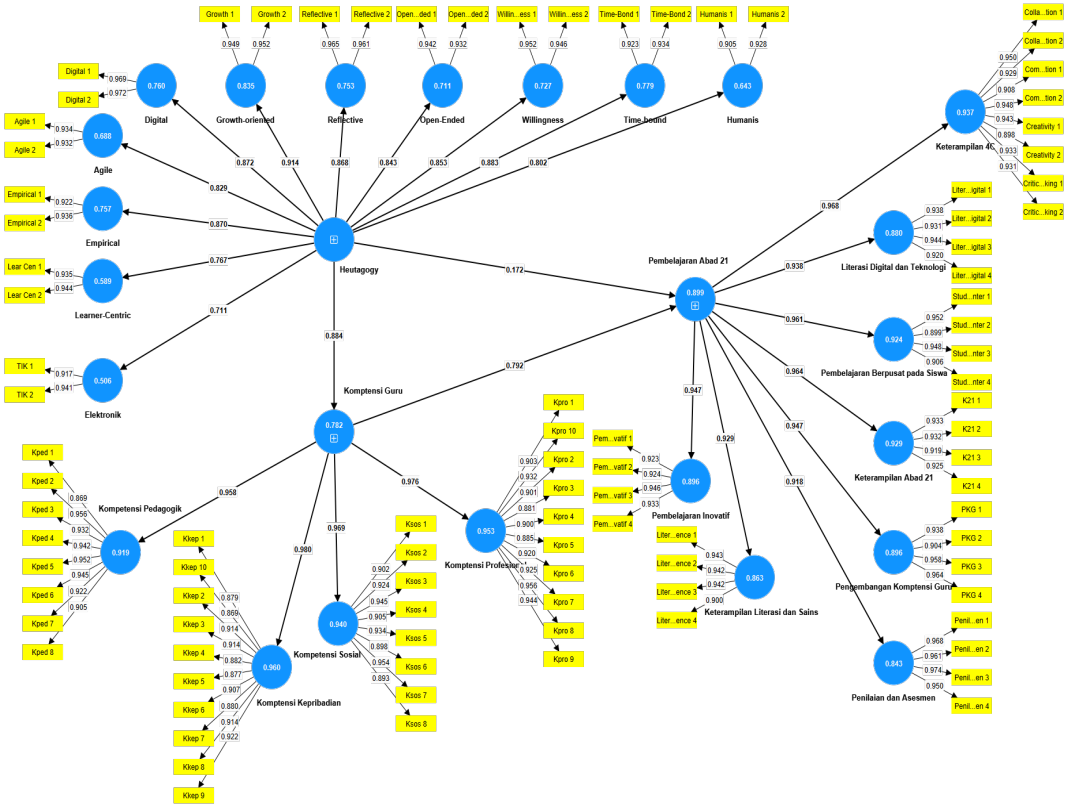


Figure 3. Structural Model Assessment (*Source: Primary data processed by the researcher using SmartPLS 4, 2026*)

Coefficient of Determination

The R^2value for teacher competence was 0.782. Thus, heutagogy-based e-leadership explained 78.2% of the variance in teacher competence. The R^2value for 21st-century learning was 0.899, indicating that heutagogy-based e-leadership and teacher competence jointly explained 89.9% of its variance. The remaining variance in each endogenous construct was attributable to factors outside the model.

Table 6. Coefficients of Determination

Endogenous Construct	R^2	Explained Variance
Teacher Competence	0.782	78.2%
21st-Century Learning	0.899	89.9%

Source: *Primary data processed by the researcher using SmartPLS 4, 2026.*

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These R^2values demonstrate the model's strong **explanatory power**. They should not, by themselves, be interpreted as evidence of out-of-sample predictive performance.

Effect Size

The effect-size analysis showed that heutagogy-based e-leadership had a small direct effect on 21st-century learning $(f^2 = 0.064)$. Teacher competence had a large effect on 21st-century learning $(f^2 = 1.356)$.

Table 7. Effect-Size Results

Structural Relationship	f^2	Interpretation
Heutagogy-Based E-Leadership → 21st-Century Learning	0.064	Small
Teacher Competence → 21st-Century Learning	1.356	Large

Source: *Primary data processed by the researcher using SmartPLS 4, 2026.*

Predictive Relevance

The Q² value was 0.877. Because this value exceeded zero, the structural model demonstrated predictive relevance for the endogenous constructs. This result indicates that the model has adequate predictive relevance.

Table 8. Predictive Relevance

Assessment	Value	Criterion	Result
Q^2	0.877	> 0	Predictive relevance established

Source: *Primary data processed by the researcher, 2026.*

Mediation Analysis

The specific indirect effect of heutagogy-based e-leadership on 21st-century learning through teacher competence was positive and significant $(\beta = 0.701\ t = 9.596\ p < 0.001)$. Therefore, H4 was supported.

Table 9. Specific Indirect Effect

Hypo-thesis	Mediation Path	Indirect Effect	t-Statistic	p-Value	Decision
H4	Heutagogy-Based E-Leadership → Teacher Competence → 21st-Century Learning	0.701	9.596	< 0.001	Supported

Source: Primary data processed by the researcher using SmartPLS 4, 2026.

The total effect of heutagogy-based e-leadership on 21st-century learning was 0.873, comprising a direct effect of 0.172 and an indirect effect of 0.701.

Table 10. Decomposition of Effects

Type of Effect	Coefficient	Significance
Direct Effect	0.172	Significant, $p = 0.028$
Specific Indirect Effect	0.701	Significant, $p < 0.001$
Total Effect	0.873	—
VAF	80.3%	—

Source: *Primary data processed by the researcher using SmartPLS 4, 2026.*

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Because the direct and indirect effects were both positive and statistically significant, teacher competence demonstrated complementary partial mediation, with the indirect pathway accounting for most of the total relationship. Thus, heutagogy-based e-leadership influenced 21st-century learning both directly and indirectly, although the pathway through teacher competence was substantially stronger.

Summary of Hypothesis Testing

Table 11. Summary of Hypothesis Decisions

Hypothesis	Proposed Relationship	Decision
H1	Heutagogy-based e-leadership positively influences teacher competence.	Supported
H2	Heutagogy-based e-leadership positively influences 21st-century learning.	Supported
H3	Teacher competence positively influences 21st-century learning.	Supported
H4	Teacher competence mediates the relationship between heutagogy-based e-leadership and 21st-century learning.	Supported: complementary partial mediation

Source: *Authors' elaboration based on the SmartPLS 4 results, 2026.*

Discussion

Descriptive Patterns of the Main Constructs

The descriptive findings indicate that heutagogy-based e-leadership, teacher competence, and 21st-century learning were perceived at high levels across the participating schools. The strongest dimension of 21st-century learning was the development of 4C skills, suggesting that teachers had begun to incorporate critical thinking, creativity, collaboration, and communication into classroom activities. This finding is consistent with studies emphasizing the centrality of the 4C competencies, technology integration, and learner participation in contemporary learning environments (Bozgun et al., 2023; Nurhidayat et al., 2024; Setuju et al., 2022; Zamora & Zamora, 2022).

Nevertheless, literacy and science skills received the lowest score among the dimensions of 21st-century learning. This difference indicates that teachers may find it easier to incorporate general collaborative and communicative activities than to design inquiry-based learning that requires evidence interpretation, scientific reasoning, and the contextual application of disciplinary knowledge. Morgado et al. (2022) similarly argued that science learning becomes meaningful when scientific concepts are connected with real-life situations, while Thuneberg et al. (2022) showed that integrating transversal competencies into subject-specific curriculum practices remains challenging. Thus, the high overall score should not be interpreted as evidence that all dimensions of 21st-century learning have been implemented equally.

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Professional competence was the strongest dimension of teacher competence, whereas social competence received the lowest score. This pattern suggests that teachers were relatively confident in subject mastery and professional responsibility but less strong in collaborative communication and wider professional interaction. This issue is important because contemporary teaching is not solely an individual instructional activity. It increasingly depends on peer collaboration, interdisciplinary planning, communication with stakeholders, and participation in professional learning communities. Adams (2022) emphasized that pedagogy is relational rather than merely technical, while Yaccob et al. (2022) demonstrated that globally oriented teaching requires communicative, collaborative, and intercultural capacities.

Reflective, empirical, and growth-oriented practices were the strongest dimensions of heutagogy-based e-leadership, while the digital and electronic dimensions obtained comparatively lower scores. This pattern implies that school leaders may already support reflection and professional improvement but have not yet used digital systems as strategically as other leadership practices. Digital leadership should therefore not be equated with the existence of electronic communication or administrative platforms. Its value depends on whether technology is used to support professional learning, instructional feedback, collaborative inquiry, and evidence-informed decisions (Avolio et al., 2000; Gillaspy & Vasilica, 2021).

Heutagogy-Based E-Leadership and Teacher Competence

The strong positive relationship between heutagogy-based e-leadership and teacher competence supports H1. The magnitude of the relationship indicates that teachers' competence is closely associated with leadership practices that encourage autonomy, reflection, experimentation, collaboration, and continuous professional learning. This relationship can be explained through the heutagogical principle that professional capacity develops when individuals are treated as active agents of their learning rather than passive recipients of standardized training (Blaschke, 2012; Hase & Kenyon, 2000, 2007).

In this context, school leaders strengthen teacher competence not merely by instructing teachers to attend training but by creating the organizational conditions in which teachers can identify professional needs, test new instructional strategies, use evidence, obtain feedback, and reflect on the outcomes of their practice. Alam et al. (2024) found that heutagogy-based e-training supported the development of teachers' digital competence, particularly in digital pedagogy. Sherly et al. (2023) likewise demonstrated that competency-based training with a heutagogical orientation can strengthen continuous professional development. The present finding extends these studies by showing that heutagogical principles may operate not only within a particular training program but also through the broader leadership environment of the school.

This finding is also consistent with the view that teacher professional learning is a complex process shaped by interactions among individual teachers, professional activities, and school contexts. Professional development is less likely

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to alter practice when it is treated as a one-directional transfer of knowledge disconnected from teachers' work and organizational environments (Opfer & Pedder, 2011). Therefore, heutagogy-based e-leadership may strengthen competence because it aligns individual agency with supportive school structures.

However, leadership support should not be assumed to produce identical outcomes in every school. Teachers' readiness, workload, access to digital infrastructure, professional beliefs, and school culture may influence how leadership opportunities are used. The relatively lower digital and electronic leadership scores reinforce this boundary condition. A school may promote reflection and professional growth while still lacking an integrated digital system that supports data-based supervision, online collaboration, and continuous access to professional resources. Thus, the strong relationship found in this study should be understood as evidence of an enabling leadership condition rather than a guarantee of uniform teacher development.

Heutagogy-Based E-Leadership and 21st-Century Learning

The positive direct effect of heutagogy-based e-leadership on 21st-century learning supports H2, although its magnitude was considerably smaller than the other structural relationships. The direct effect can be explained by the capacity of school leaders to shape organizational priorities, allocate resources, encourage innovation, provide instructional support, and legitimize new approaches to teaching. Leaders who promote digital experimentation, professional autonomy, and evidence-informed improvement may create a school climate that is more receptive to student-centered and technology-supported learning.

This result is consistent with e-leadership theory, which describes leadership as a technology-mediated social influence process involving the interaction of leadership practices, information technology, and organizational structures (Avolio et al., 2000). It also supports research showing that transformative digital learning requires more than access to devices. Cochrane et al. (2022) found that post-pandemic learning transformation depends on agency, authentic activities, creativity, and collaboration, while Saleem et al. (2024) showed that digital tools can support heutagogical learning when their use is pedagogically purposeful.

Nevertheless, the relatively small direct effect indicates that leadership cannot independently transform classroom practice. School leaders can establish strategic directions and enabling conditions, but teaching remains enacted by teachers through daily instructional decisions. This finding is compatible with the broader school-leadership literature, which argues that leadership effects on learning are largely indirect and operate through school conditions and teachers' professional capacity (Leithwood et al., 2020; Robinson et al., 2008). Therefore, the result does not weaken the importance of leadership; instead, it clarifies the pathway through which leadership becomes educationally consequential.

The finding also helps explain why investments in infrastructure and administrative digitalization do not always result in pedagogical transformation. Digital platforms may support school management without changing instructional

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design, assessment, or student agency. Leadership is more likely to influence 21st-century learning when digital resources are connected with teacher learning, curriculum planning, reflective supervision, and classroom experimentation. This interpretation is consistent with the descriptive result showing that digital and electronic dimensions were the weakest aspects of heutagogy-based e-leadership.

Teacher Competence and 21st-Century Learning

The strong positive effect of teacher competence on 21st-century learning supports H3 and represents the strongest direct relationship in the model. This finding confirms that teachers are the primary actors who translate curriculum expectations, leadership priorities, and technological resources into actual learning experiences. Teachers with strong pedagogical, professional, social, and personal competence are more capable of designing student-centered activities, facilitating collaboration, developing higher-order thinking, integrating technology, and using authentic assessment.

The finding supports the foundational view that effective teaching requires the transformation of subject knowledge into pedagogically accessible forms (Shulman, 1986). It also corresponds with the TPACK framework, which emphasizes that meaningful technology integration depends on the interaction of technological, pedagogical, and content knowledge rather than on technical skills alone (Mishra & Koehler, 2006). In other words, 21st-century learning requires integrated professional judgment. Technology becomes educationally valuable only when teachers understand when, why, and how to use it for particular learners and learning objectives.

The result is consistent with Nurhidayat et al. (2024), who reported that technology integration and teacher competence contributed to the development of 21st-century learning. It also supports Zamora and Zamora (2022), who connected teaching standards and 21st-century skills with teaching performance. Moreover, Jailani et al. (2023) demonstrated that even prospective teachers may experience difficulty designing tasks that require higher-order thinking, indicating that curriculum expectations alone do not ensure teachers' ability to enact complex learning.

The large effect of teacher competence should nevertheless be interpreted carefully. The teachers' high competence scores were based on self-reported perceptions, which may not be identical to competence demonstrated through classroom observation or student outcomes. In addition, professional competence was rated higher than social competence. This suggests that mastery of subject matter and professional responsibility may be more developed than the collaborative and relational capabilities required for interdisciplinary learning and professional co-creation. Therefore, strengthening teacher competence should address not only individual pedagogical and digital skills but also collaboration, communication, inclusion, and reflective inquiry.

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The Mediating Role of Teacher Competence

The significant indirect effect supports H4 and demonstrates that teacher competence mediates the relationship between heutagogy-based e-leadership and 21st-century learning. However, because both the direct effect and the indirect effect were positive and statistically significant, the appropriate interpretation is complementary partial mediation, not full mediation. The indirect pathway accounted for most of the total relationship, but leadership also retained a smaller direct association with 21st-century learning.

This result provides a more precise explanation of the leadership–learning relationship. Heutagogy-based e-leadership can directly shape school priorities and learning conditions, but most of its contribution is translated through the competence of teachers. In practical terms, reflective leadership, digital infrastructure, collaboration, and professional autonomy do not transform learning automatically. They become meaningful when they improve teachers' capacity to design, facilitate, assess, and refine learning.

The mediation finding is consistent with the proposition that successful school leadership influences learning primarily through organizational and professional conditions rather than through direct intervention in every classroom (Leithwood et al., 2020; Robinson et al., 2008). It also advances research on heutagogy by identifying an organizational-to-instructional mechanism: leadership enables self-determined professional learning, professional learning strengthens teacher competence, and teacher competence supports classroom transformation.

The complementary nature of the mediation is also theoretically important. It indicates that teacher competence is the dominant pathway but not the only pathway. Leadership may directly influence 21st-century learning through resource allocation, curriculum policy, scheduling, technological access, school-wide innovation programs, and expectations for student-centered instruction. At the same time, these organizational interventions have a greater impact when teachers possess the competence to enact them. Thus, the findings reject two overly simplified positions: that leadership alone produces learning transformation and that teacher competence develops independently from school leadership.

Theoretical Contributions

This study makes three theoretical contributions. First, it extends heutagogy from an approach primarily associated with individual or course-level learning to an organizational leadership perspective. The findings suggest that self-determined learning can be institutionalized through leadership practices that provide autonomy, reflection, professional choice, experimentation, and continuous feedback. In this sense, heutagogy is not limited to how individuals learn; it also informs how leaders design professional learning environments.

Second, the study extends e-leadership theory by clarifying that the educational effect of technology-mediated leadership is not primarily generated through digital administration or infrastructure. Its stronger contribution lies in

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developing teachers' professional capacity. The integration of e-leadership and heutagogy therefore positions digital technology as an enabler of professional agency, collaborative inquiry, and reflective improvement rather than merely as an operational tool.

Third, the study repositions teacher competence as an organizational-to-instructional transmission mechanism. Previous studies have commonly treated teacher competence as an outcome of professional development or a direct predictor of teaching performance. The present model shows that competence also explains how school-level leadership becomes classroom-level practice. This contribution is supported by the complementary partial mediation result, which reveals both a dominant indirect pathway and a smaller residual direct pathway.

Practical Implications

For school leaders, the findings indicate that digital leadership initiatives should be evaluated according to their contribution to teacher learning rather than the number of platforms or devices adopted. Principals should use digital systems to facilitate reflective supervision, peer feedback, collaborative lesson planning, access to professional resources, and evidence-based instructional improvement. Teachers should also be given structured autonomy to identify professional needs, conduct instructional experiments, and reflect on their results.

For policymakers and education authorities, leadership-development programs should integrate digital leadership with heutagogical principles. Training for principals should include strategies for developing teacher agency, supporting professional learning communities, conducting data-informed coaching, and connecting digitalization with pedagogical improvement. Resource policies should also provide time, infrastructure, and institutional recognition for collaborative professional learning rather than focusing exclusively on short-term training participation.

For professional-development providers, the findings suggest replacing isolated, one-directional workshops with sustained learning cycles. Effective programs should combine needs assessment, self-determined learning goals, classroom application, peer collaboration, coaching, evidence collection, and reflection. Program evaluation should assess changes in instructional practice and teacher capability, not merely attendance or satisfaction.

Limitations and Directions for Future Research

Several limitations should be considered. First, the cross-sectional design captures relationships at one point in time and therefore cannot establish temporal causality. Second, all constructs were measured through teacher self-reports, creating possible social-desirability and common-method bias. Third, the study involved teachers from four public senior high schools in one administrative region of West Java, limiting the generalizability of the findings to other school levels, private schools, provinces, or national contexts. Fourth, 21st-century learning was measured through teachers' perceptions rather than classroom observations, student reports, or learning outcomes.

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Future studies should use longitudinal designs to examine whether changes in leadership practices precede changes in teacher competence and classroom learning. Multilevel studies are also needed because teachers are nested within schools and leadership is partly a school-level phenomenon. Comparative research could test whether the model differs between public and private schools, urban and rural settings, or countries with different educational systems. Mixed-method studies could examine how teachers experience autonomy, reflection, and digital support in daily school practice. Future models may also include moderators or additional mediators such as digital infrastructure, teacher self-efficacy, professional learning communities, organizational culture, and readiness for change.

CONCLUSION

This study demonstrates that teacher competence is the principal mechanism through which heutagogy-based e-leadership contributes to 21st-century learning in Indonesian public senior high schools. Heutagogy-based e-leadership significantly strengthens teacher competence by promoting professional autonomy, reflection, collaboration, digital experimentation, evidence-informed decision-making, and continuous professional learning. Teacher competence, in turn, has the strongest direct relationship with 21st-century learning, confirming that classroom transformation depends primarily on teachers' ability to integrate pedagogy, subject knowledge, technology, assessment, communication, and professional judgment.

The mediation analysis indicates complementary partial mediation. Heutagogy-based e-leadership influences 21st-century learning both directly and indirectly through teacher competence, although the indirect pathway is substantially stronger. This finding clarifies that leadership support and digital infrastructure do not automatically transform classroom practice. Their educational value becomes greater when they are translated into teachers' pedagogical, professional, social, and personal capabilities. Teacher competence should therefore be understood not only as an outcome of leadership development, but also as an organizational-to-instructional mechanism connecting school leadership with classroom learning.

Theoretically, this study extends heutagogy from an individual learning approach to an organizational leadership perspective, broadens e-leadership beyond administrative digitalization, and repositions teacher competence as a mediating mechanism in the leadership–learning relationship. Practically, schools should direct digital leadership toward reflective supervision, teacher-led professional learning, collaborative lesson planning, digital pedagogy development, evidence-based feedback, and sustained professional learning communities. Education authorities and professional-development providers should similarly replace isolated training activities with continuous learning cycles that connect teacher needs, classroom experimentation, coaching, collaboration, and reflection.

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These conclusions should be interpreted within the study's limitations. The cross-sectional and self-reported design does not establish temporal causality and may be affected by common-method and social-desirability bias. The study was also limited to four public senior high schools in one administrative region of West Java. Future studies should employ longitudinal, multilevel, mixed-method, comparative, and cross-country designs, incorporate classroom observations and student outcomes, and examine contextual factors such as digital infrastructure, teacher self-efficacy, organizational culture, professional learning communities, and readiness for change.

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