

Reshaping the doctoral journey in the AI era

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ABSTRACT

This article systematically reviews how artificial intelligence (AI) systems, particularly generative AI (GenAI), are reshaping the doctoral journey. Unlike existing reviews that examine AI in higher education broadly, this review positions doctoral candidates as emerging scholars whose AI use intersects with learning, research, academic writing, authorship, and early knowledge production. Drawing on Web of Science Core Collection records from 1998 to 2026, the study followed preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines and retained 28 studies from an initial pool of 185 records. VOSviewer-based co-occurrence and co-citation analyses were integrated with full-text reading to identify five synthesized themes: AI as academic infrastructure, AI-mediated restructuring of doctoral practices, technology acceptance and negotiation, ethical risks and academic integrity, and wellbeing, adaptation, and support. The findings suggest that AI is intertwined with doctoral education not only as a tool for efficiency but also as part of a broader socio-technical and identity-forming process. The review contributes a doctoral identity-centered synthesis of how AI intersects with research practices, authorship, academic voice, supervision, academic integrity, wellbeing, and doctoral support.

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1. INTRODUCTION

The rapid development of generative artificial intelligence (GenAI) is reshaping higher education by changing how academic tasks are performed, supported, and evaluated. AI is moving beyond peripheral technical support and becoming embedded in core academic activities such as knowledge discovery, literature summarization, writing assistance, argument structuring, manuscript feedback, and research support [1]–[4]. Recent discussions further indicate that AI affects not only task-level activities but also how institutions organize learning, assess outcomes, define academic competencies, and maintain academic integrity [5], [6].

Within this landscape, doctoral candidates require distinct analysis because they occupy a transitional position between advanced learners and emerging scholars. The PhD journey is not merely the completion of advanced training but also the development of independent research capability, academic writing, critical thinking, scholarly identity, and resilience in a highly uncertain academic environment [7], [8]. Compared with many undergraduate or master's-level uses of AI, doctoral use often extends into higher-stakes research activities such as literature searches, literature review development, proposal drafting, methodological design, data interpretation, dissertation writing, manuscript preparation, academic language refinement, and responses to supervisor or reviewer feedback [9]–[16].

Doctoral candidates may therefore be among the groups for whom AI use is especially frequent, intensive, and consequential in higher education. Publication pressure, English-language writing demands, expectations of research productivity, the need for rapid feedback, and academic competition make AI an increasingly salient resource in doctoral learning and research processes [13]–[16]. For international doctoral students and doctoral writers working in a second language, AI can also support language development, argument organization, and more equitable participation in academic writing [17]–[22].

However, because doctoral candidates use AI in activities closely tied to knowledge production, they also face more complex academic and ethical challenges. These challenges include the boundary between support and substitution, dissertation originality, authorship, plagiarism, citation practices, dependence on AI, diminished critical thinking, loss of scholarly voice, and uncertainty over whether final outputs can be fully attributed to the candidate's own intellectual contribution [23]–[27]. AI may also reshape supervisor-candidate relationships, feedback practices, scholarly identity formation, and emotional experiences such as loneliness, pressure, procrastination, burnout, and research motivation [17]–[19], [26], [28].

Therefore, doctoral students should not be viewed merely as a subset of “students in higher education”. They represent a distinct academic group in which AI use is directly tied to the development of independent research capability, scholarly identity, authorship, scholarly voice, academic autonomy, and the ability to contribute new knowledge [7], [8], [29]. This distinction is important because doctoral education is not only a process of acquiring knowledge but also a process of becoming a scholar.

Although the literature on AI in higher education is rapidly expanding, research specifically addressing doctoral students remains fragmented. One stream focuses on acceptance, adoption, attitudes, and behavioral intention toward AI tools [9]–[12], while another examines academic writing, dissertation practices, proposal development, and research communication [13]–[16]. Other studies address international student adaptation and wellbeing [17]–[22], ethics, plagiarism, originality, attribution, and academic misconduct [23]–[27], and doctoral work-life balance and support [28]. However, these streams largely operate as separate discussions rather than as parts of a unified account of doctoral formation in the AI era.

A key gap is the absence of an integrated synthesis explaining how the PhD journey is being reshaped across academic, ethical, emotional, adaptive, and identity-forming dimensions. What is missing is not merely additional research on doctoral students but a framework that treats the doctoral journey as a multidimensional process in which technology, academic practices, institutional norms, and emotional experiences are continuously intertwined. Therefore, this article asks: how is the doctoral journey being reshaped in the AI era across academic, ethical, emotional, adaptive, and identity-forming dimensions?

This study pursues three objectives. It first maps the major thematic streams in current research on AI and doctoral education. It then synthesizes how AI reshapes core doctoral practices, including writing, literature review, supervision, authorship, and publication preparation. Finally, the study develops an integrated understanding of the PhD journey as a socio-technical process of scholar formation.

The novelty of this review lies in its focus on doctoral candidates as emerging scholars rather than as a general subgroup of higher education students. From this perspective, AI use is examined not only as a matter of tool adoption or learning efficiency but also as part of the development of authorship, scholarly voice, academic autonomy, ethical judgment, wellbeing, and adaptive capacity. To support this argument, the review integrates socio-technical systems theory with doctoral identity formation [29]–[31] and combines a preferred reporting items for systematic reviews and meta-analyses (PRISMA)-informed systematic review, VOSviewer-based bibliometric mapping, and full-text thematic synthesis [32]–[35].

This article therefore contributes an integrated framework for understanding AI-mediated doctoral education. It shows how AI is becoming embedded in doctoral research practices while also raising deeper questions about intellectual agency, academic integrity, supervision, emotional support, and the conditions under which doctoral candidates become independent knowledge producers. By centering the doctoral journey rather than general AI adoption, the review clarifies why doctoral candidates require distinct analytical attention in studies of AI in higher education.

2. CONCEPTUAL FRAMING

This review is grounded in a socio-technical systems perspective, which treats AI not simply as a technical tool but as part of a wider doctoral training ecosystem in which technology, individuals, academic practices, ethical norms, and institutional frameworks continuously interact [30], [31]. From this perspective, AI use in doctoral education cannot be reduced to whether a tool is useful. It must be examined within a broader ecosystem of doctoral candidates, supervisors, peer communities, graduate schools, journal policies, academic integrity norms, and support systems [26], [30], [31].

Doctoral identity formation serves as the integrative lens of this review and complements the socio-technical systems perspective. The doctoral journey involves more than completing a dissertation or publishing articles; it also entails the development of scholarly identity, academic autonomy, authorship, and

a distinctive scholarly voice [7], [8]. Doctoral candidates gradually transition from knowledge recipients to knowledge creators who can identify research problems, construct arguments, select methodologies, critique literature, publish, and participate in scholarly communities [29]. For this reason, AI use in doctoral education should be evaluated not only by efficiency but also by its effects on scholar formation.

In the context of AI, this identity formation process becomes more complex. On one hand, AI can support literature searches, idea development, argument organization, academic editing, and participation in global academic discourse [13]–[22]. On the other hand, AI raises questions about intellectual agency, control over argumentation, accountability for knowledge claims, and the formation of scholarly voice [23]–[27]. Therefore, the doctoral journey in the AI era should be understood not merely as technology adoption but as scholar formation under new technological conditions [29]–[31], [36].

Technology mediation helps explain how AI mediates academic activities such as reading, writing, feedback, supervision, and knowledge production [36]. Self-regulated learning further explains why doctoral candidates need to set goals, verify AI outputs, identify bias, reflect critically, and retain control over academic arguments [37]. Finally, the technology acceptance model is used selectively for the acceptance/adoption theme because perceived usefulness, perceived ease of use, and behavioral intention cannot fully explain the wider identity-forming nature of the doctoral journey [38].

3. METHOD

This study employs a systematic review design supported by bibliometric analysis. The research process consisted of three main steps: PRISMA-informed screening, VOSviewer-based bibliometric mapping, and in-depth thematic synthesis [32]–[35]. This design was selected because it allows the study to combine transparent document selection, quantitative mapping of bibliometric patterns, and interpretive synthesis of the reviewed literature.

Data were collected from the Web of Science Core Collection for the period 1998–2026 and were limited to English-language publications. Web of Science was selected because it provides curated scholarly records, standardized metadata, and compatibility with VOSviewer [33], [34]. The search string combined three conceptual groups: doctoral students/PhD students, doctoral journey/academic experience, and AI/GenAI/ChatGPT.

The following search string was used to retrieve relevant records from Web of Science. It was designed to capture studies linking doctoral education, doctoral experience, and AI-related technologies. The search terms were intentionally broad enough to include doctoral writing, supervision, adaptation, persistence, and AI-mediated academic work. The exact search string is presented: *(doctoral student* OR PhD student* OR PhD graduate* OR international doctoral student* OR international PhD student*) AND (doctoral journey OR PhD journey OR experience* OR challenge* OR opportunit* OR adaptation OR coping OR academic life OR doctoral writing OR supervision OR persistence) AND (artificial intelligence OR AI OR generative AI OR ChatGPT OR AI tool* OR AI in education OR AI in higher education)*.

The document selection process is illustrated in Figure 1. From an initial 185 records, 28 studies were retained after deduplication, title/abstract/keyword screening, relevance assessment, and full-text review. The main exclusion criteria were lack of focus on doctoral education and AI, overly technical content, weak thematic relevance, and redundant or limited contribution to the research question. This process followed PRISMA 2020 guidelines to enhance transparency and traceability in identifying, screening, and selecting documents [32].

After finalizing the corpus of 28 studies, VOSviewer was used to conduct two supplementary bibliometric analyses: co-occurrence mapping and co-citation mapping [33], [34]. Co-occurrence analysis helped identify conceptual clusters that frequently appeared together, while co-citation analysis helped identify foundational knowledge clusters that were often cited together. These maps were not treated as automated theme-generation outputs but as initial structures for subsequent thematic coding and full-text interpretation [34], [35]. The preliminary alignment between bibliometric mapping results and the five thematic areas is presented in Table 1.

The thematic coding process was conducted in three steps. First, conceptual clusters and co-citation clusters from VOSviewer were used to identify preliminary thematic areas. Next, each of the 28 studies was reviewed in full and coded based on content focus, key concepts, research subjects, methodological approach, and contribution to the review question. Finally, the content codes were cross-referenced with bibliometric mapping results and refined into five synthesized themes. Thus, the final themes were derived from the combined interpretation of bibliometric patterns and full-text content rather than from software visualizations alone.

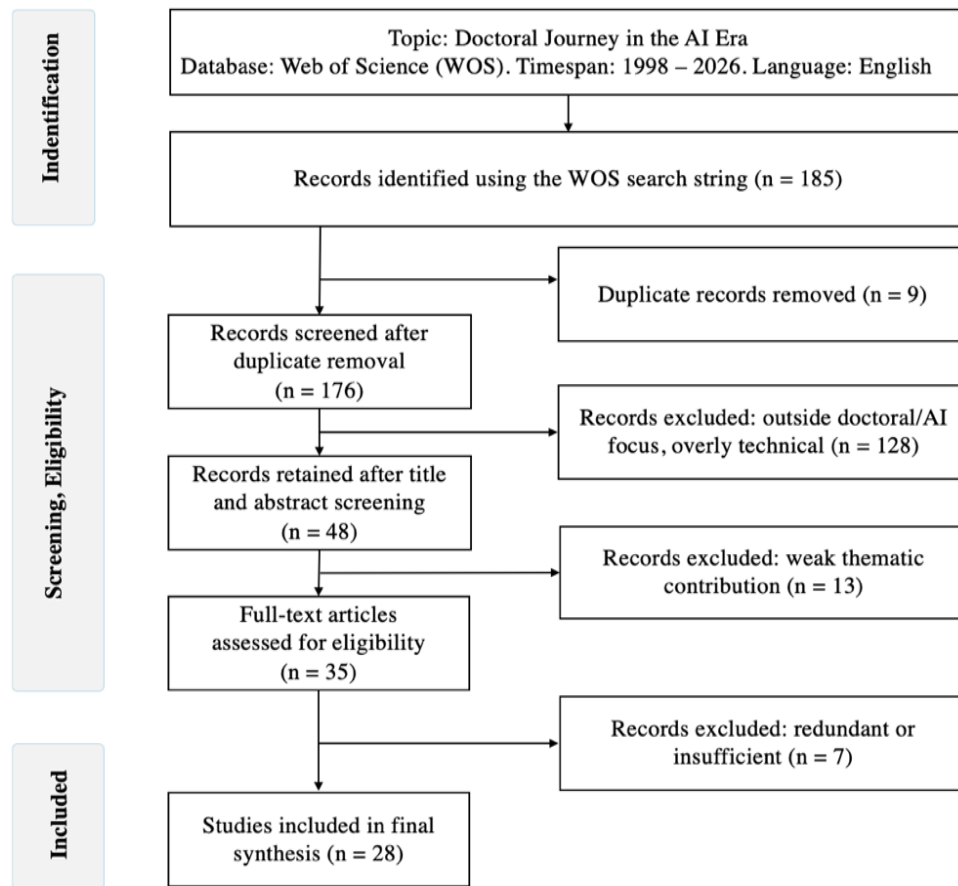


Figure 1. Study selection workflow for the systematic review

Table 1. Bibliometric mapping and synthesized themes

Conceptual cluster	Indicative bibliometric pattern	Synthesized theme
Cluster 1	AI in higher education, doctoral education, research productivity, AI literacy, and academic infrastructure	T1. AI as a new academic infrastructure in doctoral education
Cluster 2	Academic writing, dissertation writing, publication writing, literature review, feedback-seeking, and research communication	T2. Core academic practices being restructured by AI
Cluster 3	Technology acceptance, AI adoption, attitudes, perceived usefulness, behavioral intention, trust, and perceived risk	T3. Acceptance, adoption, and negotiation of technology
Cluster 4	Ethics, academic integrity, plagiarism, originality, authorship, attribution, misconduct, and responsible AI use	T4. Risks, ethics, and academic integrity
Cluster 5	Wellbeing, loneliness, work-life balance, persistence, international students, adaptation, and support systems	T5. Wellbeing, adaptation, and support in the AI era

In the final classification step, each study was assigned a primary theme if that theme reflected the main analytical focus of the paper. Secondary themes were assigned when a study made significant contributions to other dimensions of the doctoral journey. This classification approach is appropriate because research on AI and doctoral education often intersects across academic practice, authorship, integrity, scholarly voice, and wellbeing.

Alongside thematic classification, each study was evaluated for quality based on relevance and transparency. The five criteria were doctoral relevance, AI relevance, methodological/conceptual clarity, contribution strength, and thematic usefulness. Each criterion was scored from 0 to 2 points, with a maximum total score of 10. Table 2 presents the results of theme classification, research characteristics, and quality assessment for the 28 studies.

Table 2 shows that the final corpus includes quantitative, qualitative, mixed-methods, autoethnographic, commentary, and guidance studies across multiple contexts, including China, Hong Kong, the United States, the United Kingdom, Australia, Japan, Malaysia, Indonesia, the Philippines, Ukraine, Tanzania, and Vietnam. All retained studies met the review's quality threshold. However, the corpus varied

in methodological design, empirical depth, and contextual coverage. This variation suggests that the included studies were sufficiently relevant to the review focus, while also reflecting the uneven maturity of research on AI and doctoral education. Overall, the corpus demonstrates methodological and contextual diversity, yet existing evidence remains heavily concentrated on the recent phase of GenAI and requires broader exploration in non-Western contexts.

Table 2. Thematic classification, study characteristics, and quality appraisal

No.	Study	Short title/focus	Study type/method	Context/region	Primary theme	Secondary theme(s)	Total score	Quality level
1	[6]	AI and the PhD student	News/commentary	General scientific community	T1	T4, T5	9/10	High
2	[5]	PhD training in an AI world	Editorial/perspective	Global doctoral training	T1	T2, T4	9/10	High
3	[36]	From tool to partner	Quantitative study	China	T1	T2, T3	10/10	High
4	[37]	GenAI and research output	Quantitative study	China	T1	T2, T3	10/10	High
5	[38]	AI literacy and innovation	Mixed-methods study	China	T1	T3, T5	10/10	High
6	[39]	AI-supported proposal development	Design-based/workshop study	Japan	T2	T1, T3	10/10	High
7	[13]	GenAI in writing for publication	Survey/interview study	Hong Kong	T2	T3, T4	10/10	High
8	[14]	GenAI in dissertation writing	Qualitative interview study	USA	T2	T4, T5	10/10	High
9	[40]	GenAI chatbot-assisted L2 writing	Qualitative case study	Second language doctoral writing context	T2	T3, T5	10/10	High
10	[15]	Disciplinary voice	Qualitative/textual analysis	Sweden	T2	T3, T4	10/10	High
11	[41]	GenAI in literature review	Qualitative reflection study	USA	T2	T1, T4	10/10	High
12	[9]	Acceptance of ChatGPT in writing	Quantitative TAM-based survey	China	T3	T2, T4	10/10	High
13	[10]	AI adoption in doctoral education	Collaborative autoethnography	USA	T3	T1, T2	10/10	High
14	[11]	AI tools by doctoral students	Mixed-methods study	UK	T3	T2, T4	10/10	High
15	[42]	Engineering PhD students and ChatGPT	Empirical perception study	Australia	T3	T2, T5	10/10	High
16	[43]	GenAI use and research progress	Quantitative study	Tanzania	T3	T1, T5	9/10	High
17	[23]	AI adoption and ethical perceptions	Cross-sectional comparative survey	China	T4	T3, T5	9/10	High
18	[24]	Ethical publishing standards	Guidance/professional standards	Nursing/doctoral context	T4	T2, T3	9/10	High
19	[25]	Academic misconduct and AI use	Cross-sectional online survey	Ukraine	T4	T3, T5	9/10	High
20	[26]	AI, supervision, doctoral research	Mixed-methods/conceptual study	UK	T4	T2, T5	10/10	High
21	[27]	AI, originality, attribution	Qualitative interview study	China	T4	T2, T3	9/10	High
22	[44]	AI-assisted academic cheating	Exploratory qualitative study	Vietnam	T4	T3, T5	9/10	High
23	[28]	Work-life balance	Phenomenological study	Philippines	T5	T1, T3	9/10	High
24	[45]	AI and doctoral persistence	Quantitative SEM study	Indonesia	T5	T1, T3	10/10	High
25	[17]	ChatGPT, loneliness, wellbeing	Mixed-methods study	Malaysia	T5	T3, T4	10/10	High
26	[18]	GenAI and cross-cultural adaptation	Quantitative S-O-R study	International student context	T5	T3, T1	9/10	High
27	[19]	International PhD students and AI support	Collaborative autoethnography	Australia	T5	T1, T2	10/10	High
28	[46]	Supervisory and peer dynamics	Qualitative/activity theory study	Hong Kong-linked context	T5	T2, T4	9/10	High

Note: Quality appraisal was based on five criteria: C1=doctoral relevance; C2=AI relevance; C3=methodological/conceptual clarity; C4=contribution strength; and C5=thematic usefulness. Each criterion was scored from 0 to 2, where 0=weak/not addressed, 1=partially addressed, and 2=clearly addressed. Total scores ranged from 0 to 10. Scores of 8–10 indicate high quality, 6–7 moderate quality, and below 6 low quality.

4. RESULTS AND DISCUSSION

The synthesis of 28 studies indicates five closely interconnected themes that explain how AI is being integrated into the doctoral journey. These themes should be read as mutually reinforcing dimensions rather than isolated findings. Together, they show how AI reshapes doctoral education through infrastructure, practice, negotiation, ethics, and wellbeing.

4.1. AI as emerging academic infrastructure in doctoral education

The first theme positions AI as an emerging form of academic infrastructure in doctoral education. AI appears to be moving beyond support for isolated tasks such as literature searching, text summarization, or language editing, and is increasingly involved in idea development, argument structuring, research planning, manuscript drafting, feedback reception, and academic progress management [5], [6], [36]–[38], [47], [48]. This indicates that AI may be transforming not only the speed of task execution but also the conditions under which doctoral candidates learn, write, receive feedback, and produce knowledge.

The corpus reinforces this observation across several strands of evidence. GenAI is increasingly perceived as a research partner that supports multiple doctoral research activities [36]. Empirical evidence also suggests an association between GenAI use and doctoral graduates' research output [37]. AI literacy has likewise been linked to innovative behaviors among doctoral candidates [38]. Additional evidence connects AI and digitalization with doctoral research productivity, while earlier work on digital doctorates shows that online tools had already begun reshaping doctoral work before the GenAI wave [47], [48].

A notable aspect of this theme is the shift from asking whether doctoral candidates use AI to asking how AI is integrated into training systems, research practices, and identity formation [30], [31]. This transition is also tied to scholarly identity formation because doctoral candidates must learn how to evaluate, coordinate, and responsibly use technology while maintaining intellectual agency. As AI becomes involved in literature searches, argument construction, and feedback, independent research capability is no longer defined simply by working without support but by the ability to use technological support critically and responsibly [29], [38], [49]. Therefore, AI literacy should be regarded as an integral component of doctoral academic competence rather than merely a supplementary technological skill.

4.2. The AI-mediated restructuring of core doctoral practices

The second theme highlights how AI directly influences the core academic practices of the doctoral journey. The corpus focuses extensively on proposal development, literature review, dissertation writing, publication writing, disciplinary voice, feedback-seeking, and research communication [13]–[16], [39]–[41]. GenAI can support interdisciplinary research proposal development among doctoral students [39], and it can also function as a tool for organization and ideation in literature review work [41].

Academic writing emerges as a prominent focus within this theme. PhD students use GenAI in publication writing to organize ideas, improve expression, and streamline drafting [13]. In dissertation writing, especially among doctoral students using English as a second language, AI offers assistance but also raises concerns about plagiarism, AI detection, and training needs [14]. GenAI chatbot-assisted second-language writing involves ongoing negotiation among the writer, the tool, and academic requirements [40]. Feedback-seeking is also central to the formation of disciplinary voice in AI-assisted doctoral writing [15]. Research on dissertation writing, multilingual writing, and English as an additional language (EAL) writing further shows that AI-mediated writing is closely tied to linguistic inequities, publication pressures, and scholarly voice development [50]–[55].

The primary significance of this theme is that AI affects not only the final product of academic writing but also the process through which doctoral writing competencies are developed. In doctoral education, writing is a space in which candidates learn to construct arguments, position contributions, critique literature, and develop a scholarly voice [15], [29]. Therefore, when AI participates in idea generation, argument structuring, or style standardization, the issue extends beyond textual improvement to the development of critical thinking, authorship, and a distinctive academic voice [14], [15], [27].

At the practical level, AI acts as an intermediary in how doctoral candidates read, write, edit, and seek feedback [56]. This intermediary role has a dual nature. AI can reduce language barriers and support multilingual writers, but without appropriate guidance it may also foster dependency, homogenized writing, or disconnection from scholarly voice development [13]–[15], [56]. Beyond writing, AI use in assessment design, scenario-based learning, and interactive writing activities also indicates that academic practices are being reorganized around increasing interaction among learners, tools, and evaluative contexts [57]–[60].

4.3. From acceptance to negotiation: doctoral engagement with AI

The third theme reflects a strong research focus on acceptance, adoption, perceived usefulness, behavioral intention, and self-efficacy. The technology acceptance model has been used to explain doctoral students' adoption of ChatGPT in writing activities [9], [61]. Related studies have further examined AI

adoption and doctoral students' use of AI tools in doctoral education [10], [11]. These studies are valuable because they explain why doctoral candidates perceive AI as useful, easy to use, or reliable in specific contexts [9]–[12].

However, an in-depth reading of the corpus shows that acceptance in the doctoral journey should not be understood as a simple or static state. Engineering PhD students experience ChatGPT through negotiation among research demands, academic communication requirements, and pedagogical expectations [42]. The effect of GenAI on research progress is also shaped by hedonic gratification and other motivational factors [43]. GenAI acceptance is shaped not only by usefulness but also by intrinsic motivation and perceived risk [12]. For international students, AI use is further associated with academic integration, belonging, language barriers, and participation in knowledge communities [17]–[22].

Therefore, doctoral AI use is not merely a matter of technology acceptance but a process of negotiating control, responsibility, and academic norms. Doctoral candidates must continuously ask whether AI effectively supports research, what level of use is appropriate, which parts of the text remain their own contribution, whether AI use should be disclosed, and what supervisors or journals expect [9], [26], [27], [61]. These questions extend beyond the logic of perceived usefulness or perceived ease of use.

This underscores that AI literacy in doctoral education must be tied to academic self-regulation. Doctoral candidates need not only to use AI tools but also to assess output quality, identify bias, cross-check sources, reflect on dependency, and maintain control over research arguments [38], [49]. In other words, AI competence at the doctoral level must include technical skill, critical thinking, and academic responsibility.

4.4. Ethical boundary work, authorship, and academic integrity

The fourth theme focuses on ethics, authorship, originality, attribution, plagiarism, academic misconduct, and the legitimacy of scholarly contribution. Ethical perceptions are critical in evaluating and using AI in research contexts [23]. Ethical publishing standards are becoming increasingly important as AI participates in scholarly writing [24]. AI has also become part of academic misconduct debates among medical students, interns, and PhD candidates [25].

In the doctoral context, these issues are particularly sensitive because dissertations and publications serve as evidence of independent research capability. GenAI is reconfiguring supervision and doctoral research, making AI relevant not only to learners but also to supervisors, feedback practices, and the evaluation of academic contributions [26]. Originality and attribution have become central concerns in distinguishing human and AI contributions [27]. The boundary between academic support and academic misconduct has also become increasingly blurred from the perspective of postgraduate students [44].

The core of this theme is that AI requires the renegotiation of concepts previously treated as relatively stable in academia. When AI can propose ideas, rewrite sentences, organize arguments, or create drafts, the question is no longer simply whether AI should be used. More importantly, the issue is which parts of the research process AI has participated in, whether this involvement changes authorship, whether doctoral candidates retain control over their arguments, and how AI use should be disclosed [24], [26], [27], [44].

Academic integrity should therefore not be confined to the personal ethics of doctoral candidates. It encompasses institutional regulations, supervisor guidance, journal standards, assessment design, and academic culture [26], [30], [31], [57]. Consequently, doctoral education needs transparent guidelines on AI disclosure, attribution, acceptable use, and authorship responsibility [24], [27]. Such guidelines would safeguard both the quality of academic outputs and the development of academic autonomy among doctoral candidates.

4.5. Wellbeing, adaptation, and hybrid support in AI-mediated doctoral education

The fifth theme brings the doctoral journey back to the human dimensions of pressure, academic loneliness, work-life balance, persistence, support systems, and cross-cultural adaptation. Technology use is linked to work-life balance in doctoral students' experiences [28]. AI can both support and hinder doctoral persistence [45]. This indicates that AI has a non-linear impact: it can help doctoral candidates manage their work while also increasing expectations for productivity, responsiveness, and constant efficiency [28], [45].

For international doctoral students, this issue becomes even more pronounced. ChatGPT has been linked to loneliness and wellbeing among international PhD students in Malaysia [17]. GenAI also appears as a factor influencing cross-cultural adaptation [18]. AI may support international PhD students, particularly in academic communication and support systems [19]. Recent studies further suggest that AI can facilitate engagement and integration but may also have constraining effects when academic and psychological support are insufficient [20], [21].

Wellbeing and adaptation should not be treated as external to the research process. They are conditions that enable doctoral candidates to maintain motivation, belonging, academic confidence, and resilience while navigating uncertainties during scholarly identity formation [17]–[19], [28], [29]. Research on

anxiety, resilience, supervisory dynamics, mentoring relationships, and depression risk also indicates that doctoral support in AI-mediated environments should be situated within a broader framework of mental health and guidance relationships [46], [62], [63]. AI can support these processes by providing rapid feedback, language assistance, and reduced feelings of isolation in certain situations [17]–[19]. However, AI cannot replace supervisors, peer communities, mentoring relationships, and institutional care [19], [26], [46], [64], [65].

Therefore, doctoral support in the AI era should be designed as a hybrid support ecosystem. Within this ecosystem, AI can enhance access to feedback and academic assistance, while humans remain central in providing direction, reflection, validation of academic value, and emotional care [19], [26], [46], [64], [65]. This is particularly critical for international doctoral students, multilingual writers, and groups that are more vulnerable in the global academic environment [17]–[22].

4.6. Interconnections and implications for doctoral education

The five themes do not operate as isolated outcomes but as interconnected dimensions within a unified socio-technical and identity-forming process [29]–[31]. As AI increasingly becomes part of the academic infrastructure, practices such as literature review, dissertation writing, publication drafting, and feedback-seeking are being restructured [13]–[16], [36]–[41], [47], [48]. These changes at the practice level compel doctoral candidates to negotiate with technology regarding utility, risk, trust, autonomy, and academic standards [9]–[12], [42], [43].

This negotiation process leads to ethical and academic integrity challenges, particularly as AI becomes involved in writing, feedback, argument organization, and text production [23]–[27], [44]. Simultaneously, these changes in infrastructure, practices, and norms affect the emotional lives and adaptive processes of doctoral candidates, including pressure, loneliness, persistence, belonging, and wellbeing [17]–[19], [28], [45], [46], [62]–[65]. Consequently, AI influences the doctoral journey through a series of interconnected mechanisms: infrastructural embedding, academic practice restructuring, technological negotiation, ethical boundary work, and emotional-adaptive recalibration.

These interconnections highlight that the practical implications of this study extend beyond managing AI tools to redesigning the support conditions for doctoral candidates. Table 3 translates the five themes into actionable recommendations for key stakeholders in doctoral education, including graduate schools, program leaders, supervisors, institutions, journals, and support units. The recommendations emphasize that doctoral AI governance should support scholar formation rather than focus only on tool permission or prohibition.

Table 3. Actionable implications for doctoral education

Theme	Main stakeholder	Actionable implications
T1. AI as academic infrastructure	Graduate schools	Integrate AI literacy into doctoral training as a core research competence
T2. Academic practices restructured by AI	Program leaders and supervisors	Develop clear guidance for AI use in proposal writing, literature reviews, dissertation writing, and publication preparation
T3. Acceptance and negotiation	Supervisors and doctoral students	Use supervision meetings to discuss acceptable AI use, risk, autonomy, and reflective self-regulation
T4. Ethics and academic integrity	Institutions and journals	Establish transparent rules for AI disclosure, attribution, authorship boundaries, and responsible use
T5. Wellbeing, adaptation, and support	Graduate schools and support units	Combine AI-based academic support with human mentoring, peer networks, and wellbeing services

5. CONCLUSION

Taken together, this review shows that AI reshapes the doctoral journey through five interconnected mechanisms: infrastructural embedding, academic practice restructuring, technological negotiation, ethical boundary work, and emotional-adaptive recalibration. These mechanisms matter because doctoral education is not only a training process but also a process of scholar formation. The primary contribution of this article is therefore its shift from general AI adoption in higher education to the doctoral journey as a socio-technical and identity-forming process. By positioning doctoral candidates as emerging scholars, the review explains how AI use intersects with authorship, scholarly voice, academic autonomy, ethical judgment, wellbeing, and support.

The article also acknowledges several limitations that shape the interpretation of its findings. First, the corpus was constructed from the Web of Science Core Collection and English-language publications, which may not comprehensively cover studies indexed in Scopus, ERIC, Google Scholar, regional databases, or non-English academic contexts. Second, the final corpus comprises 28 studies, reflecting an emerging and rapidly evolving field in which some findings are still based on preliminary evidence, commentary, perception-based studies, or specific contexts. Despite these limitations, the review suggests that doctoral

training programs should move beyond the binary approach of allowing or banning AI and instead develop clear guidelines on AI use in proposal development, literature review, dissertation writing, publication writing, supervision, attribution, and academic integrity. AI can be particularly beneficial for international doctoral students and multilingual writers, but it should complement rather than replace supervisors, peer communities, mentoring relationships, and institutional care.

Building on the review findings and limitations, future research should prioritize four directions. First, longitudinal studies are needed to track how AI integrates into each stage of the PhD journey, from topic formulation to dissertation writing, publication, and career transition. Second, more qualitative research is required on doctoral identity, authorship anxiety, scholarly voice, and academic autonomy in AI-enabled research environments. Third, further research is needed on the supervisor-student-AI relationship, including feedback practices, supervisory expectations, power dynamics, trust, responsibility, authorship negotiation, and emotional support. Fourth, research should expand to international doctoral students, multilingual writers, and non-Western contexts, particularly in Asia, to examine whether AI reduces academic inequalities or creates new forms of dependency and exclusion.

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Chung Xuan Le	✓	✓	✓	✓	✓			✓	✓	✓				
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C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : Writing - **O**riginal Draft

E : Writing - Review & **E**editing

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial, personal, academic, or professional interests that could have appeared to influence the work reported in this paper. No conflict of interest was identified during the preparation of the manuscript. The authors take responsibility for the integrity of the work.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [CXL], upon reasonable request. The review corpus was derived from the Web of Science Core Collection search and the screening procedures described in the methodology. Reasonable requests for clarification or supporting review materials will be considered by the corresponding author.

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