Prototype development of an AI-powered conversational coaching system for graduate research supervision

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ABSTRACT

This study developed a prototype of an AI-powered conversational coaching system to address recurring challenges in graduate research supervision. Using a design-based research approach integrated with design thinking, the study engaged 49 stakeholders—comprising students, faculty, and alumni—to pinpoint critical pain points and pedagogical requirements. These insights were distilled into a robust design framework centered on three core dimensions: problems, contexts, and learner needs (P-Q-R), integrated with the goal, reality, options, will (GROW) coaching model to facilitate goal setting and reflective practice. Expert evaluations underscored the system's high utility, pedagogical relevance, and adaptability for resource-constrained academic environments. Beyond technical implementation, this study contributes empirically grounded design principles for AI-supported graduate supervision and offers a scalable evaluation framework for early-stage educational AI interventions.

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1. INTRODUCTION

In recent years, higher education institutions worldwide have increasingly emphasized the cultivation of robust research competencies among graduate students. The ability to formulate sound research problems, employ rigorous methodologies, and manage resources effectively is not only critical for academic success but also reflects institutional quality and societal contribution [1]. Despite this emphasis, many postgraduate learners continue to struggle with issues such as limited supervisory support, inadequate exposure to research tools, and challenges in maintaining research continuity [2]. These limitations are particularly evident in contexts with high student-to-faculty ratios, where personalized mentorship becomes less feasible.

Parallel to these challenges, global educational policies underscore the importance of digital transformation and inclusive research training. The European Commission, for instance, highlights the role of digital technologies in widening access to higher education and fostering lifelong learning [3]. In the Thai context, the Artificial Intelligence Readiness Assessment Report [4] underscores the urgency of strengthening artificial intelligence (AI) adoption, digital skills, and research capacity in higher education, ensuring that graduates are better prepared to thrive in increasingly complex research and professional environments. These perspectives align with the post-pandemic momentum, which has accelerated the integration of digital tools into research supervision and knowledge creation.

Amid this shift, AI and conversational interfaces have emerged as promising innovations in academic coaching. Scholars have noted that AI-powered systems can extend the availability and consistency of feedback, offering timely guidance and scaffolding that complement human supervision [5]. Rather than replacing advisors, AI has the potential to serve as a co-mentor—bridging structural gaps and supporting self-regulated learning practices. The integration of AI coaching chatbots is increasingly recognized as a scalable and cost-effective solution, particularly in high-intensity and resource-constrained environments where traditional mentoring faces time and cost barriers [6]. This study responds to such opportunities by introducing a prototype AI-powered research coaching system designed for graduate students in Thailand, emphasizing adaptability, contextual relevance, and learner empowerment. The design of the system draws upon design thinking principles, which prioritize user-centered, iterative innovation [7], and educational design research (EDR) frameworks that stress the alignment of interventions with learners' needs and institutional contexts [8]. By combining these approaches, the study seeks to formulate design principles that address persistent supervision challenges while leveraging the scalability of AI-enhanced solutions.

Although prior studies have explored AI chatbots and digital coaching in education, few have articulated empirically grounded design principles for AI-supported graduate research supervision, particularly within resource-constrained higher education contexts [9]. Moreover, limited research has examined how coaching frameworks such as goal, reality, options, will (GROW), a primary model recognized for transforming pedagogical roles into mentorship [10], can be systematically embedded into conversational AI architectures. In light of these gaps, this research aims to achieve a clear understanding of the design and initial validation of this intervention, which is operationalized through the following two core research questions. The first question focuses on the intervention's development: what are the essential design principles and functional specifications for developing a conversational AI coaching system, structured on the GROW model, intended to enhance the research competence of graduate students in resource-constrained contexts? Structured coaching interventions have demonstrated potential in improving the efficacy of educational applications by providing clear pathways for goal attainment [11]. Following the development, the second question addresses the evaluation phase: how do subject matter experts evaluate the developed conversational AI coaching system prototype in terms of its educational relevance, functional usability, and contextual adaptability? The findings derived from these questions aim to contribute to the field by demonstrating a viable, technology-enhanced model of academic supervision and by offering empirically grounded design principles for future educational AI interventions.

The contribution of this research is twofold. First, it demonstrates how conversational AI can be meaningfully integrated into graduate research training to foster autonomy and reflective engagement. Second, it proposes an inclusive model of academic supervision that can be scaled in resource-constrained environments. By advancing these goals, the study positions AI not merely as a technological tool but as a collaborative learning partner, marking an innovative step toward reimagining postgraduate research mentoring in the digital era.

2. METHOD

This study adopted an EDR methodology, which is widely applied to create practical yet theoretically grounded educational innovations [12]. EDR is characterized by its systematic and iterative nature, possessing a dual focus on developing practical interventions and generating empirically grounded design principles. This cyclical process ensures that design principles are continually informed and validated by findings from prior phases. For this study, the research design was integrated with the design thinking process—comprising the phases empathize, define, ideate, prototype, and test [13]—to ensure a user-centered approach. This paper reports the initial EDR cycle, focusing on prototype development and expert validation; learner impact evaluation will be addressed in subsequent cycles. The full-scale test and subsequent refinement phases will be pursued in later research iterations.

2.1. Sampling and participants

The selection of all participants across the various phases of EDR was executed through a purposive sampling strategy, a non-probability technique focusing on individuals whose direct experience and specialized expertise were crucial for accurately identifying challenges and validating the prototype's design. This method ensured that the sample possessed the necessary contextual knowledge and roles relevant to the study. The sample size was determined by the objective of each phase—achieving saturation of information in the needs assessment and ensuring content validity in the expert evaluation.

2.1.1. Needs identification (empathize phase)

Structured focus group discussions were conducted with three groups of key stakeholders, totaling 49 participants (n=49): graduate students (34), faculty members (7), and alumni (8). The inclusion criteria for these groups were rigorous, targeting individuals actively engaged in or recently completed the thesis/independent study process (students and alumni) or those directly involved in graduate research supervision (faculty). The segmentation ensured a comprehensive understanding of challenges from different vantage points.

2.1.2. Prototype evaluation (prototype phase)

For the rigorous validation of the prototype, a separate cohort of five content and instructional design experts (n=5) were purposively selected. The sample size was aligned with standard practices for obtaining the content validity index (CVI). Given the early-stage nature of the intervention, CVI was selected as an appropriate validation method to establish content relevance and design coherence prior to field implementation. The stringent selection criteria for these experts were: they must be university faculty members with a minimum of 5 years of experience in both graduate-level teaching and research supervision. Their collective expertise was required to cover crucial domains, including instructional design, application of AI, and EDR, guaranteeing a multidimensional assessment of the system.

2.2. Empathize: understanding user needs

Structured focus group discussions were conducted with the three groups. The sessions explored research-related problems, contextual challenges, and specific needs for supervision support. Consistent with prior findings, students frequently reported limited methodological understanding and difficulties accessing timely guidance [14].

2.3. Define: identifying core problems and context

Data were analyzed using thematic analysis to extract patterns across participant groups [15]. The findings revealed three clusters: i) problem-related issues such as unclear research planning; ii) context-related constraints such as digital literacy gaps and time pressures; and iii) needs-related concerns emphasizing continuous feedback and exemplars. This analytical approach ensured validity and dependability, consistent with qualitative research standards [16].

2.4. Ideate: conceptualizing intervention design

Based on these insights, five experts in instructional design and educational technology engaged in collaborative workshops to generate design principles. Their contributions were guided by causal variables (P: problems, Q: contexts, R: needs) and both content- and process-oriented factors. This step reflects the significance of participatory design in enhancing intervention validity and practicality [17].

2.5. Prototype: developing and refining the coaching tool

The prototype was developed using LINE official account (LINE OA) integrated with Dialogflow, forming a conversational AI system. It was structured around the GROW model, focusing on goals, reality, options, and will [18]. To rigorously ensure the prototype's educational relevance, usability, and functional feasibility, it underwent evaluation by the five content and instructional design experts. The evaluation utilized a quantitative rating scale based on three criteria: relevance, consistency, and practicality. The data collected from this evaluation was systematically analyzed using the CVI and descriptive statistics (mean and standard deviation) to ensure methodological transparency and rigor. This systematic approach aligns with best practices for validating early-stage educational technologies [19]. The forthcoming test phase will involve field implementation with target graduate students to examine improvements in research comprehension, methodological skill application, and project completion.

3. RESULTS AND DISCUSSION

3.1. Empathize and define phases: forming the foundation

In this section, the results are presented together with interpretive discussion. This combined approach ensures that empirical findings are directly contextualized within existing scholarship, providing both evidence and theoretical significance [20], [21]. The empathize phase revealed recurring challenges faced by graduate students, faculty, and alumni: limited methodological expertise, difficulty in formulating research questions, and constraints in supervisory accessibility. Faculty particularly emphasized the limitations caused by large student numbers, while alumni highlighted the absence of digital mentoring resources. Such findings align with earlier work that has pointed out the centrality of timely, personalized supervision in preventing attrition and supporting postgraduate success [21].

The define phase systematically clarified these issues through thematic analysis, generating three categories of barriers: problem-related, context-related, and needs-related. Table 1 presents the coding structure and sample quotations across stakeholder groups. These findings echo Liardet [22], who reported that higher degree research candidates frequently struggle with transitioning into independent research planning and often require exemplars to guide their progress.

Table 1. Themes emerging from focus group analysis across stakeholders and dimensions

Dimension	Stakeholder group	Main code	Sub-codes/patterns	Example quotations
Problem-related	Students	Lack of EDR understanding	Inability to proceed with writing	"I have no grasp of EDR, so I cannot move forward with my thesis."
	Faculty	Low research readiness	Difficulty applying frameworks independently	"Students are still not able to design research projects on their own."
	Alumni	Difficulty defining research	Struggles in topic formulation	"I continue to face problems finalizing my research topic."
Context-related	Students	Incomplete database access	Limited access to full texts	"Some databases are unavailable, making it impossible to access complete articles."
	Faculty	Limited support mechanisms	Insufficient training and tool access	"We lack sufficient hands-on training and access to appropriate tools."
	Alumni	Lack of communication	Difficulty reaching advisors	"It was often hard to contact my advisor when I needed support."
Needs-related	Students	Need for research exemplars	Examples of comparable research	"Having sample research studies would be very helpful for reference."
	Faculty	Need for tracking and alerts	Notifications and progress reminders	"A system that reminds and tracks research progress would be valuable."
	Alumni	AI-based FAQ support	Automated responses to research queries	"An AI tool that can provide instant answers to my research questions would be beneficial."

3.2. Ideate phase: conceptualizing intervention design

Building on the identified insights, the ideate phase synthesized causal variables— problems (P), contexts (Q), and needs (R)—into a unified conceptual framework. This framework addresses the critical gap in traditional supervision: the limited capacity for consistent feedback, rather than mere faculty shortages [23]. By adopting a participatory co-design approach, the design ensures long-term sustainability and user acceptance [24]. Figure 1 illustrates this conceptual model, which serves as the blueprint for the system's architecture.

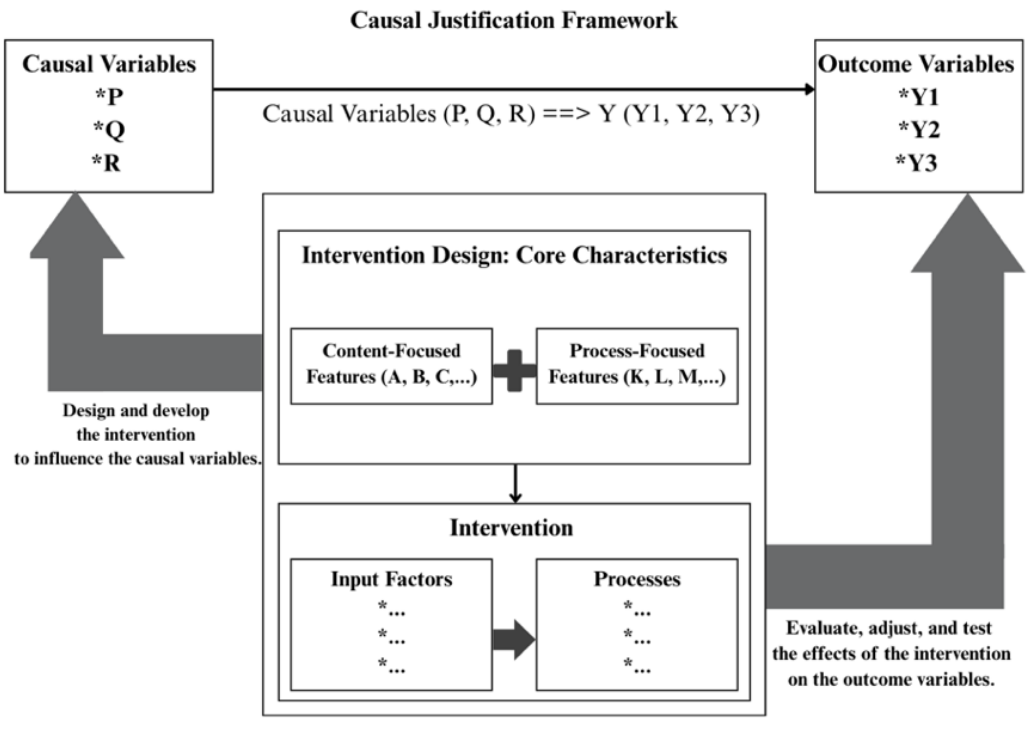

Figure 1. Conceptualizing intervention design [25]

As depicted in Figure 1, the intervention is operationalized through five integrated components. The causal variables (P, Q, R) consolidate stakeholder-specific challenges, such as research planning and data collection obstacles. To mitigate these, content-focused features (A, B, C) provide structured scaffolds like research exemplars and statistical guides, while process-focused mechanisms (K, L, M) utilize AI-driven guidance and centralized document management to ensure consistency.

The system's functionality is further defined by its input operations (e.g., standardized forms and curated databases) and mediated processes (e.g., AI-based notifications and reflection modules). These elements collectively target three expected outcomes (Y1, Y2, Y3): enhanced procedural understanding, strengthened technical skills, and timely project completion. This streamlined logic is translated into the concrete activity plan, as presented in Table 2.

Table 2. Intervention activity plan based on design principles

Activity planning aspect	P (Lack of tools and research examples)	Q (Partially supportive university context)	R (Need for tools and examples for research execution)
Activity focus	Provide tools and research examples	Utilize available partial resources	Deliver full research tools and examples
Rationale	Students lack understanding of planning and research design	Students lack tools and research examples	Students struggle with statistics and referencing
Content focus	Research process guidance and proposal templates	Clear examples of data collection tools	Statistics and referencing content (e.g., SPSS, citations)
Process focus	Progress tracking and post-submission reflection	Chatbot-based advisory support	Unified documentation and analytics platform
Required inputs	Templates, research samples, and databases	Software tools and digital platforms	Databases, manuals, and standardized templates
Implementation procedures	Develop research calendar and reflection system	Deploy AI chatbot and prepare digital tools	Create user guides and set up notification system
Expected outcomes	Improved research understanding and reduced errors	Enhanced data handling and analysis skills	Greater research success and accuracy in results

Furthermore, the design was mapped onto the GROW framework and aligned with program learning outcomes (PLOs). This ensured not only technical feasibility but also pedagogical coherence. Table 3 demonstrates how user challenges, coaching dimensions, and learning objectives were linked through system components. These mappings reinforce findings from Kilinc *et al.* [26], who noted that coaching-based supervision can foster reflective engagement and self-regulation in postgraduate research.

Table 3. Alignment of research coaching system

Issue dimension	User challenges and needs	GROW model focus	Aligned PLOs	System components
Problem-related	Lack of understanding of research methodology	Goals – Setting learning goals with chatbot guidance	PLO1, PLO5	Chatbot (AI coach)
	Poor time management and ineffective planning	Will – Planning and execution via calendar reminders	PLO3, PLO5	Research calendar
	Limited skills in statistics and technology	Reality – Self-assessment through guide and resources	PLO1, PLO4	System manual, research information
Context-related	Limited access to existing resources despite availability	Reality – Contextual access through structured knowledge	PLO1, PLO2	Research information, research forms
	Lack of faculty consultation opportunities	Reality – Asynchronous support through chatbot	PLO1, PLO4	Chatbot (AI coach)
	Online research instruction context	Options – Content delivery via flexible LINE OA interface	PLO2, PLO3	LINE OA platform
Needs-related	Need for immediate, automated responses	Options – Chatbot as an alternative learning channel	PLO2, PLO3	Chatbot (AI coach)
	Need for progress tracking and reflection	Goals/Reality – Monitoring progress for better direction	PLO1, PLO4, PLO5	Coaching reflection system
	Desire for mobile-friendly usability	Will – User engagement through LINE OA's intuitive design	PLO3, PLO5	LINE OA rich menu

3.3. Prototype phase: developing and refining the coaching tool

The prototype was developed on the LINE OA platform, integrated with Dialogflow to enable both natural language chatbot interaction and rich menu navigation. The chatbot allowed students to submit free-text queries, while the Rich Menu offered structured access to six primary functions: i) a system manual; ii) a research calendar; iii) research information; iv) an AI chatbot; v) reflective self-evaluation tools; and vi) a repository of research forms. This integration illustrates how conversational and structured interfaces can jointly reduce cognitive load while maintaining learner autonomy—an issue frequently reported in postgraduate supervision literature. Furthermore, this dual-mode design reflects the value of combining conversational support with multimodal access, aligning with [27], who noted that conversational agents enhance supervision by delivering scalable and asynchronous feedback.

As shown in Figure 2, the system architecture systematically maps chatbot-based interactions to the GROW coaching framework and PLOs. The chatbot supports learners through the stages of "goals," "reality," "options," and "will," while complementary modules—such as research calendars and reflective logs—enable structured planning and self-regulation. By embedding these features into a single mobile-accessible interface, the system transforms the supervisor's role from a primary information provider to a facilitator of self-directed inquiry, addressing the persistent gap in faculty availability. Designed for asynchronous use, the system integrates natural language understanding (NLU) with a context-aware interface, demonstrating how AI can effectively scaffold the research journey in resource-constrained environments.

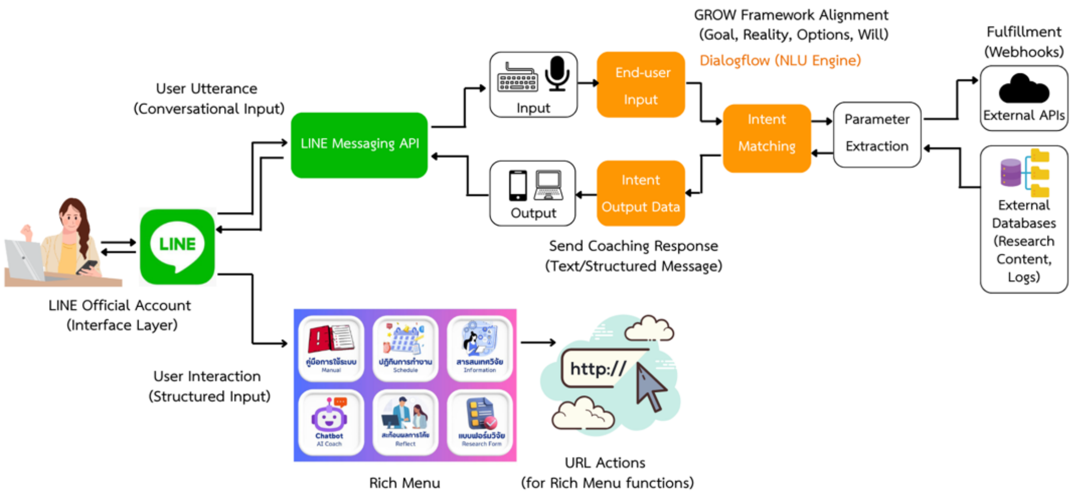

Figure 2. Architecture of the research coaching prototype

Expert evaluation comprehensively confirmed the prototype's strong validity and feasibility, yielding a CVI of 1.00 across relevance, consistency, and practicality. This perfect consensus, derived from an 11-item rubric using a 5-point Likert scale, is attributed to the homogeneity of the five-member expert panel—specialists in computer science, instructional design, and AI-supported pedagogy. According to Rahmat *et al.* [28], a CVI of 1.00 is the expected threshold for universal agreement among five experts to establish content validity in early-stage interventions. Furthermore, the system achieved a high usability mean of 4.56 (SD=0.50), demonstrating strong functional reliability. These findings, along with positive qualitative feedback, suggest the design successfully addresses persistent challenges, particularly the need for consistent, immediate, and asynchronous support. Reviewers emphasized the value of the chatbot's responsive mentoring and progress-tracking features, which aligns with literature advocating for AI as a source of scalable, timely feedback in postgraduate supervision [28]. This approach positions the AI system not as a substitute for human advisors, but as a co-mentor that functionally extends supervisory capacity—a critical need driven by the inherent limitation of human supervisors to provide continuous, on-demand support required by highly autonomous graduate students. The primary novelty of this study lies not in the use of AI chatbots perse, but in the systematic translation of supervision challenges into design principles, operationalized through the GROW coaching framework and validated via EDR [29]. Unlike prior AI tutoring studies that emphasize content delivery, this model foregrounds reflective coaching and self-regulation as core mechanisms.

The core novelty and pedagogical advantage of this model stem from its structured foundation, which integrates EDR and design thinking. This rigorous combination ensures the design principles are contextually grounded in specific institutional and learner needs, moving the innovation beyond mere technological application toward a pedagogically sound and highly relevant solution. The key structural differentiation lies in the systematic mapping of the GROW coaching framework onto the service-oriented architecture, which combines LINE OA and Google Dialogflow (as illustrated in Figure 2). Dialogflow is programmed with intents corresponding to the four stages of GROW to guide the user through a sequential and consistent coaching process. While the system incorporates some static, pre-packaged responses for foundational information, the GROW-driven flow ensures the conversation's primary purpose remains pedagogical. This design emphasizes guiding students through a reflective problem-solving cycle, while simultaneously maintaining crucial functions for retrieving stored research content and logging progress data. Figure 3 illustrates the interface design, showing how learners access key functions to support their research journey. The prototype's success in promoting structured reflection and learner autonomy resonates with global calls for hybrid, technology-augmented advisory models and aligns with recent efforts to employ LLM-powered chatbots in higher education, where conversational explainability and hybrid advisory models are emphasized [30], [31].

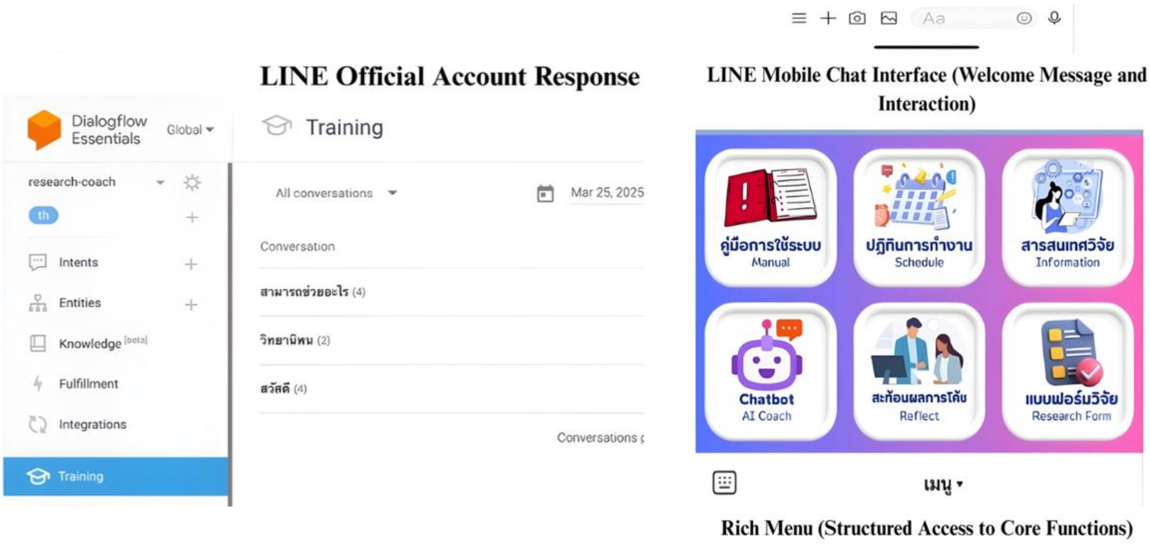

Figure 3. Prototype interface screenshots

4. CONCLUSION

This study developed a prototype AI-powered research coaching system to mitigate supervision constraints and learning challenges in graduate education. By integrating design thinking with EDR, the system translates stakeholder needs into a practical model that fosters learner autonomy and reflective practice through the GROW coaching framework. Expert evaluations confirmed the system's usability and functional relevance, affirming the feasibility of this AI-mediated approach. Theoretically, this study extends research on AI in education by demonstrating how coaching frameworks can be systematically embedded into conversational systems through an EDR lens. Methodologically, it offers a replicable process for validating early-stage educational AI prototypes, ensuring that design principles are pedagogically grounded before large-scale implementation. Practically, the system provides institutions with a scalable supervision support model that complements, rather than replaces, human advisors, thereby optimizing supervisory capacity in resource-constrained environments. While this research focuses on the prototype creation phase, subsequent iterations will involve systematic field testing to evaluate long-term educational impact and scalability. Future developments should explore adaptive analytics and cross-platform integration to further drive inclusive, data-driven innovations in graduate research supervision.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

The research involving human participants received approval from the Ethics Committee of Kalasin University (Approval No: HS KSU 052/2568). All participants gave their written informed consent prior to taking part in the study.

DATA AVAILABILITY

The datasets supporting the findings of this study are available from Kalasin University. Access to these data is restricted, as they were provided under license for the purposes of this research. Data can be obtained via [Google Drive link] with permission from Kalasin University.

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