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A Multidimensional Conceptual Framework of Generative AI as a Co-Instructor: Measurement Formulation for Personalized and Sustainable Higher Education

Jonathan M. Mantikayan[1], Montadzah A. Abdulgani[2]

[1]Bangsamoro Information and Communications Technology Office (BICTO-BARMM)

[2]Cotabato State University

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ABSTRACT

Generative artificial intelligence (GenAI) is transforming higher education by evolving from a content automation tool into a collaborative instructional partner. However, its conceptualization as a co-instructor remains fragmented and lacks a validated measurement structure. This study develops a multidimensional conceptual framework and measurement formulation that positions GenAI as a structured pedagogical collaborator supporting personalization, sustainability, and ethical integrity. Using a theory-building approach grounded in interdisciplinary literature, the study defines key constructs, specifies relationships, and proposes indicators for future structural equation modeling. The framework identifies three instructional domains co-planning, co-instruction, and co-assessment mediated by pedagogical implementation effectiveness and moderated by ethical governance readiness. An eight-construct model and 37-item instrument are proposed for empirical validation. The study contributes conceptual clarity by advancing a systematic, ethically grounded approach to human–AI collaboration in higher education and recommends institutionally guided, teacher-in-the-loop implementation strategies.

Keywords: generative AI, co-instructor model, measurement development, higher education, ethical AI governance

INTRODUCTION

Generative artificial intelligence (GenAI) technologies are rapidly transforming the landscape of higher education by introducing new possibilities for personalized learning, instructional scalability, and pedagogical innovation. Powered by large language models and advanced machine learning architectures, AI-driven systems can now assist with a wide range of academic functions, including curriculum design, instructional content generation, adaptive tutoring, automated assessment, and feedback provision (Dwivedi et al., 2023; Kasneci et al., 2023). These capabilities have prompted universities worldwide to explore the integration of GenAI tools into teaching and learning environments as a means to improve instructional efficiency and enhance student engagement. As higher education institutions strive to develop more personalized learning pathways and resilient academic ecosystems, GenAI is increasingly recognized as a transformative technological enabler.

Despite its growing adoption, scholarly discourse on GenAI in higher education remains conceptually fragmented. Existing research largely frames AI either as a productivity-enhancing tool that automates routine academic tasks or as a disruptive force that may undermine academic integrity, critical thinking, and authentic learning processes (Kasneci et al., 2023; Tlili et al., 2023). While these perspectives contribute valuable insights, they often overlook the potential for structured human–AI collaboration within instructional processes. Emerging pedagogical frameworks, such as the Teacher-in-the-Loop model, propose that when implemented within clearly defined instructional and governance structures, GenAI can function not merely as a supportive tool but as a collaborative partner that complements human expertise in teaching and learning activities (Shubhanshi, 2025). This evolving perspective suggests a shift from a tool-centric view of AI toward a

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partnership-based paradigm in which human instructors and AI systems jointly contribute to instructional design, delivery, and evaluation.

The conceptualization of GenAI as a co-instructor raises important theoretical and methodological questions. Currently, there is limited consensus on how to define, structure, and empirically measure the role of GenAI as a pedagogical collaborator. Without a coherent conceptual framework and validated measurement model, research on AI-assisted teaching risks remaining fragmented, descriptive, and context-specific rather than cumulative and theory-driven. A comprehensive framework is therefore needed to capture the multidimensional nature of AI-supported instruction one that integrates instructional collaboration processes, pedagogical effectiveness, ethical governance considerations, and measurable educational outcomes.

Addressing this need requires grounding the emerging role of GenAI in established theoretical perspectives. Prior research in educational technology highlights the relevance of models such as the Technology Acceptance Model, which explains users' adoption of new technologies based on perceived usefulness and ease of use (Davis, 1989); the Information Systems Success Model, which evaluates system effectiveness through dimensions such as system quality, information quality, and user satisfaction (DeLone and McLean, 2003); and Student Engagement Theory, which emphasizes the role of active participation in improving learning outcomes (Fredricks et al., 2004). In addition, pedagogical frameworks such as Formative Assessment Theory underscore the importance of continuous feedback and assessment in enhancing instructional effectiveness (Black & Wiliam, 1998), while emerging discussions on Responsible AI Governance emphasize ethical transparency, accountability, and human oversight in AI-enabled systems (Floridi et al., 2018).

Building upon these theoretical perspectives, this study addresses the conceptual gap by developing a multidimensional framework that positions GenAI as a collaborative instructional partner in higher education. Specifically, this paper aims to: (1) develop a multidimensional conceptual framework that positions Generative AI as a co-instructor in higher education, and (2) formulate a theory-grounded measurement structure that enables future empirical validation of this framework.

It is important to emphasize that the present study is intentionally conceptual in nature. Rather than empirically testing the proposed framework, the study focuses on developing a theoretically grounded conceptual model and a preliminary measurement structure that can guide future quantitative investigations. Accordingly, empirical validation of the proposed 37-item instrument including assessments of reliability, construct validity, convergent validity, discriminant validity, and factor structure through confirmatory factor analysis (CFA) and structural equation modeling (SEM) is proposed as the next phase of this research program. This staged approach is consistent with established theory-building research, in which conceptual model development and construct specification precede empirical validation and theory testing (Jaakkola, 2020; MacInnis, 2011; Whetten, 1989).

Theoretical Foundations

The conceptualization of Generative Artificial Intelligence (GenAI) as a co-instructor in higher education requires grounding in established theoretical perspectives from information systems, educational psychology, and technology governance. This study integrates five complementary theoretical lenses - the Technology Acceptance Model (TAM), the Information Systems Success Model, Student Engagement Theory, Formative Assessment Theory, and Responsible AI Governance frameworks - to explain how GenAI-supported instructional collaboration may influence pedagogical effectiveness and educational outcomes. Together, these theories provide a multidimensional foundation for understanding the interaction between technology adoption, instructional practices, ethical oversight, and learning performance.

Technology Acceptance Model

The Technology Acceptance Model (TAM), originally proposed by Davis (1989), explains how users come to accept and utilize new technologies. TAM posits that perceived usefulness and perceived ease of use determine an individual's intention to adopt technological systems (Davis, 1989). In the context of higher education,

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instructors' willingness to integrate GenAI tools into teaching practices depends largely on their perception that these systems enhance instructional efficiency and improve learning outcomes.

Within this study, TAM provides the theoretical basis for understanding instructors' engagement with GenAI in collaborative instructional processes such as co-planning, co-instruction, and co-assessment. When educators perceive AI-assisted tools as useful for generating teaching materials, facilitating instructional delivery, or supporting assessment activities, they are more likely to incorporate these technologies into their pedagogical workflows. Consequently, higher levels of technology acceptance are expected to facilitate more effective human–AI instructional collaboration, thereby contributing to improved teaching performance and learning outcomes.

Information Systems Success Model

The Information Systems Success Model developed by William H. DeLone and Ephraim R. McLean provides a widely used framework for evaluating the effectiveness of information systems. The model identifies several dimensions of system success, including system quality, information quality, service quality, user satisfaction, and net benefits (DeLone and McLean, 2003).

Applied to AI-supported educational environments, this model suggests that the effectiveness of GenAI as a co-instructor depends on the reliability, accuracy, and usability of the AI system. High-quality AI-generated instructional materials, responsive feedback mechanisms, and reliable system performance can enhance both instructor satisfaction and student learning experiences. In this study, the Information Systems Success Model informs the evaluation of Pedagogical Implementation Effectiveness (PIE) and helps explain how the quality of AI-assisted instructional processes contributes to Instructor Outcomes (IO) and Student Outcomes (SO).

Student Engagement Theory

Student Engagement Theory emphasizes the importance of active participation in learning activities as a critical determinant of academic success. Scholars such as Jennifer A. Fredricks conceptualize engagement as a multidimensional construct encompassing behavioral, emotional, and cognitive components (Fredricks et al., 2004). Higher levels of engagement are associated with improved motivation, deeper learning, and stronger academic performance.

In AI-supported learning environments, GenAI tools can facilitate interactive learning experiences by generating adaptive learning materials, personalized explanations, and timely feedback. These capabilities can increase students' cognitive engagement with course content and encourage active participation in the learning process. Within the proposed framework, enhanced engagement mediated by AI-assisted instructional practices is expected to contribute directly to improved Student Outcomes, including deeper understanding, higher satisfaction, and stronger academic achievement.

Formative Assessment Theory

Formative Assessment Theory highlights the role of continuous assessment and feedback in improving teaching and learning processes. According to the seminal work of Paul Black and Dylan Wiliam, formative assessment enables instructors to monitor student progress, identify learning gaps, and adjust instructional strategies accordingly (Black and Wiliam, 1998).

Generative AI systems can enhance formative assessment practices by providing automated feedback, generating assessment questions, and assisting instructors in evaluating student work. These capabilities enable a more responsive and adaptive instructional environment in which assessment becomes an ongoing component of the learning process. In this study, Formative Assessment Theory supports the construct of Co-Assessment (CA), where instructors and AI systems collaboratively analyze student performance and provide feedback that improves both teaching effectiveness and student learning outcomes.

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Responsible AI Governance

The increasing integration of AI technologies in educational settings raises important ethical and governance considerations. Responsible AI Governance frameworks emphasize principles such as transparency, accountability, fairness, and human oversight in the design and deployment of AI systems (Floridi et al., 2018). These principles are essential to ensuring that AI technologies are implemented in ways that support educational integrity and protect the rights of learners and educators.

Within the proposed conceptual framework, responsible governance mechanisms are captured through the construct of Ethical Governance Readiness (EGR). This construct reflects the extent to which institutions establish policies, ethical guidelines, and oversight mechanisms for the responsible use of AI in teaching and learning. Strong governance frameworks help mitigate risks related to bias, misinformation, and overreliance on automated systems while ensuring that human educators retain ultimate pedagogical authority.

The Proposed Conceptual Framework

The proposed conceptual framework conceptualizes Generative Artificial Intelligence (GenAI) as a multidimensional instructional collaborator operating across interconnected pedagogical domains within higher education. Rather than viewing AI solely as a technological tool, the framework positions GenAI as a complementary instructional partner that supports instructors throughout the teaching and learning process. This perspective reflects an emerging paradigm of human–AI collaborative pedagogy, in which artificial intelligence augments human expertise while instructors retain pedagogical authority and oversight.

At the core of the framework are three primary instructional collaboration domains. The first domain, co-planning, refers to the extent to which GenAI assists instructors in instructional design and preparation activities. This includes supporting curriculum development, generating teaching materials, organizing lesson structures, and providing suggestions for instructional strategies. By facilitating these preparatory tasks, GenAI can help instructors streamline course planning processes and devote greater attention to higher-order pedagogical decisions (Zhang, 2025).

The second domain, co-instruction, represents the role of GenAI in supporting the delivery of instruction. Through capabilities such as personalized explanations, adaptive tutoring, interactive question–answering, and on-demand learning assistance, GenAI can complement traditional instructional methods and support individualized learning pathways. These capabilities enable instructors to extend instructional support beyond the physical classroom, thereby enhancing learning accessibility and responsiveness to diverse student needs (Neupane et al., 2024).

The third domain, co-assessment, captures the collaborative role of GenAI in student evaluation and feedback processes. GenAI systems can assist instructors in generating assessment questions, supporting grading processes, developing evaluation rubrics, and providing timely formative feedback. These functions allow instructors to monitor student progress more effectively and facilitate continuous improvement in learning outcomes through data-informed instructional adjustments (Xiao et al., 2024).

Beyond these core instructional domains, the framework incorporates Pedagogical Implementation Effectiveness, which represents the extent to which GenAI is integrated into teaching practices in a structured, purposeful, and pedagogically meaningful manner. Drawing on the Teacher-in-the-Loop approach, this construct emphasizes that while AI systems may support instructional processes, ultimate pedagogical authority and professional judgment remain with human instructors. This human-centered oversight ensures that AI-supported teaching practices remain aligned with educational objectives, disciplinary standards, and ethical considerations (Shubhanshi, 2025).

In addition, the framework introduces Ethical Governance Readiness as an important contextual factor influencing the responsible adoption of AI in education. Ethical governance readiness refers to the degree to which institutions establish policies, guidelines, and oversight mechanisms that ensure responsible AI

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deployment. These mechanisms include safeguards for mitigating algorithmic bias, protecting student data privacy, preserving academic integrity, and promoting transparency in AI-assisted decision-making processes (Franco et al., 2024). Strong governance structures help ensure that AI technologies are implemented in ways that support educational values while minimizing potential risks.

The combined influence of these constructs is expected to shape multiple categories of outcomes. Instructor outcomes include improvements in teaching efficiency, instructional innovation, and professional satisfaction resulting from AI-supported teaching practices. Student outcomes encompass enhanced engagement, improved academic performance, and deeper critical thinking through personalized and adaptive learning experiences. At the institutional level, institutional outcomes reflect broader organizational benefits such as digital transformation, scalable personalized education, and strengthened capacity for technology-enabled learning.

Collectively, the proposed framework provides a structured model for examining how GenAI can function as a sustainable, collaborative, and ethically governed co-instructor within higher education environments. By integrating instructional collaboration processes, implementation conditions, governance considerations, and educational outcomes, the model offers a comprehensive foundation for future empirical investigation of human–AI instructional partnerships.

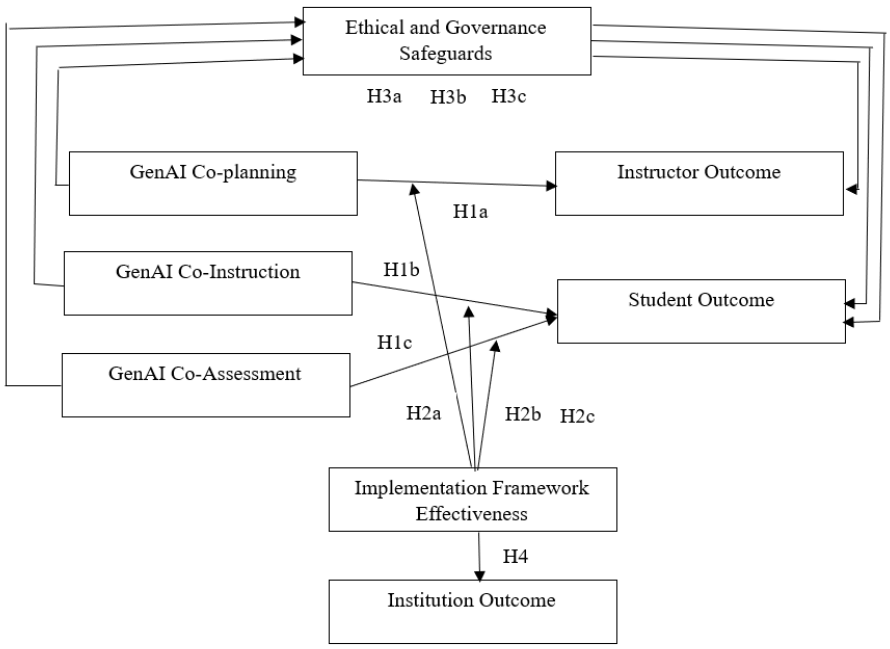

Figure 1 Conceptual framework of Generative AI as a Co-Instructor in Higher Education.

Conceptual Novelty of the GenAI Co-Instructor Model

The rapid advancement of Generative Artificial Intelligence (GenAI) has stimulated a growing body of research examining its applications in higher education. Existing studies predominantly conceptualize AI as an instructional support technology that functions as an intelligent tutor, virtual assistant, conversational chatbot, or adaptive learning system (Holmes et al., 2022; Kasneci et al., 2023; UNESCO, 2023; Zawacki-Richter et al., 2019). Within these perspectives, AI is primarily viewed as a tool that automates academic tasks, delivers personalized learning resources, answers students' questions, or facilitates individualized instruction (Dwivedi et al., 2023; Tlili et al., 2023). Although these approaches have demonstrated considerable value in improving learning efficiency, accessibility, and instructional scalability, they generally position AI as an auxiliary technology operating independently from the pedagogical responsibilities of human educators (Holmes et al., 2022).

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The present study advances this discourse by proposing a fundamentally different conceptualization of GenAI. Rather than treating AI solely as an instructional tool or automated learning assistant, this framework positions GenAI as a collaborative co-instructor that actively participates throughout the instructional process while remaining under the pedagogical authority of human educators. In this model, AI complements rather than replaces the instructor by supporting three interconnected instructional domains: co-planning, co-instruction, and co-assessment. These domains collectively represent the complete instructional lifecycle, extending AI involvement beyond isolated teaching tasks toward sustained human–AI instructional collaboration (Shubhanshi, 2025; Zhang, 2025).

Unlike conventional AI-assisted learning models that primarily emphasize student interaction with intelligent systems, the proposed framework adopts a Teacher-in-the-Loop (TiTL) perspective in which instructors retain instructional authority, professional judgment, and ethical responsibility. GenAI serves as an instructional collaborator that augments curriculum development, facilitates adaptive learning experiences, assists in formative assessment, and enhances instructional effectiveness without diminishing the central role of educators. This human-centered perspective aligns with emerging Responsible AI principles advocating meaningful human oversight, transparency, accountability, fairness, and pedagogical integrity in educational AI implementation (Floridi et al., 2018; OECD, 2019; UNESCO, 2023).

Furthermore, the proposed framework extends beyond existing conceptual models by integrating instructional collaboration processes with contextual implementation and governance mechanisms. Specifically, Pedagogical Implementation Effectiveness (PIE) is introduced as a mediating construct that explains how structured instructional integration translates AI-supported practices into meaningful educational outcomes. Simultaneously, Ethical Governance Readiness (EGR) is incorporated as a moderating construct reflecting institutional preparedness to ensure responsible, transparent, and ethical AI deployment. These additions recognize that successful AI integration depends not only on technological capability but also on pedagogically sound implementation strategies and robust institutional governance structures (Dwivedi et al., 2023; Franco et al., 2024).

Collectively, this multidimensional perspective differentiates the proposed framework from previous AI-in-education models by conceptualizing GenAI as a collaborative instructional partner operating across planning, teaching, and assessment within ethically governed and human-supervised educational environments. Consequently, the framework provides a more comprehensive theoretical foundation for examining human–AI instructional collaboration and establishes a structured basis for future empirical validation through measurement development and structural equation modeling.

The proposed framework also represents the continuation of the authors' long-term research agenda on digital transformation and technology-enabled learning. Previous studies examined the role of interactive educational technologies in enhancing classroom learning experiences (Mantikayan and Ayu, 2010) and organizational readiness for digital government transformation (Mantikayan and Abdulgani, 2017). Building upon these earlier contributions, the present study advances a new conceptual perspective by positioning Generative AI as a collaborative co-instructor supported by pedagogical implementation effectiveness and ethical governance readiness.

Hypothesis Development

Generative AI as a Co-Instructor in Higher Education

The integration of Generative Artificial Intelligence (GenAI) in higher education is increasingly conceptualized not merely as a technological tool, but as a pedagogical collaborator capable of augmenting instructional design, delivery, and assessment processes (Dwivedi et al., 2023; UNESCO, 2023). Framed as a co-instructor, GenAI supports educators through co-planning, co-instruction, and co-assessment functions. Emerging research suggests that AI systems can function as cognitive partners, enhancing teaching efficiency while preserving

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human pedagogical oversight (Holmes et al., 2022). This study advances a structural model examining how these functional roles influence instructor, student, and institutional outcomes, while accounting for implementation frameworks and ethical governance safeguards.

Direct Effects of GenAI Functional Roles

GenAI Co-Planning and Instructor Outcomes

GenAI-assisted co-planning enables instructors to automate lesson design, generate instructional materials, and streamline administrative preparation. Research on AI-supported instructional design indicates improvements in efficiency, instructional alignment, and creative ideation when AI is used collaboratively (Holmes et al., 2022; Luckin et al., 2016). By reducing routine cognitive workload, educators can allocate greater effort toward pedagogical innovation and student engagement, consistent with cognitive load theory (Sweller, 1988).

H1a: GenAI-supported co-planning positively influences instructor outcomes.

GenAI Co-Instruction and Student Outcomes

GenAI-enabled co-instruction provides adaptive tutoring, real-time clarification, and personalized feedback. Adaptive learning and intelligent tutoring research demonstrate that personalized scaffolding improves comprehension, engagement, and performance (VanLehn, 2011; Zawacki-Richter et al., 2019). When AI systems supplement classroom instruction, students benefit from differentiated explanations and continuous assistance.

H1b: GenAI-supported co-instruction positively influences student outcomes.

GenAI Co-Assessment and Student Outcomes

AI-driven co-assessment systems facilitate automated scoring, rubric generation, and formative feedback delivery. Timely and consistent feedback significantly enhances learning gains and conceptual understanding (Hattie, 2009; Shute, 2008). Automated feedback systems also improve scalability and responsiveness in large classes (Zawacki-Richter et al., 2019).

H1c: GenAI-supported co-assessment positively influences student outcomes.

Mediating Role of Implementation Frameworks

The effectiveness of GenAI integration depends on structured implementation models, including teacher-in-the-loop validation, hybrid human - AI collaboration, and retrieval-augmented generation (RAG). Human-centered AI frameworks emphasize complementarity between human judgment and machine efficiency (Raisch and Krakowski, 2021). Without structured implementation, AI systems risk producing biased or inaccurate outputs (UNESCO, 2023). Thus, implementation framework effectiveness is proposed as a mediating mechanism through which GenAI functional roles translate into improved outcomes.

H2a: Implementation framework effectiveness mediates the relationship between GenAI co-planning and instructor outcomes.

H2b: Implementation framework effectiveness mediates the relationship between GenAI co-instruction and student outcomes.

H2c: Implementation framework effectiveness mediates the relationship between GenAI co-assessment and student outcomes.

Moderating Role of Ethical and Governance Safeguards

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The integration of GenAI raises concerns regarding academic integrity, algorithmic bias, data privacy, and teacher autonomy (Dwivedi et al., 2023; UNESCO, 2023). Responsible AI governance frameworks stress transparency, accountability, and fairness (OECD, 2019). Strong governance safeguards are expected to strengthen positive relationships between GenAI functions and outcomes.

H3a: Ethical and governance safeguards positively moderate the relationship between GenAI co-planning and instructor outcomes.

H3b: Ethical and governance safeguards positively moderate the relationship between GenAI co-instruction and student outcomes.

H3c: Ethical and governance safeguards positively moderate the relationship between GenAI co-assessment and student outcomes.

Institutional-Level Outcomes

Structured and ethically governed GenAI integration contributes to scalable and sustainable digital transformation in higher education institutions (Raisch and Krakowski, 2021; UNESCO, 2023). Institutions embedding hybrid AI models within robust governance systems are better positioned to achieve long-term innovation and competitive advantage.

H4: Effective implementation frameworks positively influence institutional outcomes.

Table 1: Conceptual Distinction Between Existing AI-in-Education Models and the Proposed GenAI Co-Instructor Framework

Existing AI Conceptualization	Primary Focus	Role of AI	Human Instructor's Role	Limitation	Proposed GenAI Co-Instructor Framework
Intelligent Tutor	Student learning support	Personalized tutoring	Supervises instruction	Focuses mainly on student–AI interaction	AI collaborates with instructors throughout the instructional process
Virtual Assistant	Administrative and instructional assistance	Generates materials and answers queries	Primary decision-maker	Supports isolated teaching tasks	AI actively participates in planning, instruction, and assessment
Conversational Chatbot	Question answering	Information provider	Oversees AI use	Limited pedagogical integration	AI functions as a pedagogical collaborator within structured teaching practices
Adaptive Learning System	Personalized learning pathways	Adapts content to learners	Configures learning environment	Emphasizes learner adaptation rather than instructional collaboration	Integrates instructional collaboration, implementation effectiveness, and governance readiness
Proposed GenAI Co-Instructor Model	Human–AI collaborative pedagogy	Collaborative instructional partner	Retains pedagogical authority through the	Addresses instructional, pedagogical, and governance	Supports co-planning, co-instruction, and co-assessment under

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			Teacher-in-the-Loop approach	dimensions simultaneously	ethical human oversight

RESEARCH METHODOLOGY

Research Design

This study adopts a qualitative conceptual research design based on document analysis to develop a multidimensional framework that conceptualizes Generative Artificial Intelligence (GenAI) as a co-instructor in higher education. Document analysis is an established qualitative research method that involves the systematic examination and interpretation of existing scholarly materials in order to extract meaning, identify patterns, and develop theoretical insights (Bowen, 2009).

The purpose of employing document analysis in this study is to synthesize insights from diverse streams of literature related to artificial intelligence in education, educational technology, instructional design, assessment practices, and responsible AI governance. By systematically reviewing and interpreting these documents, the study identifies key instructional functions and contextual factors that shape the integration of GenAI within higher education teaching and learning environments.

The research process involved a structured review of peer-reviewed journal articles, conference papers, policy reports, and theoretical studies addressing AI-supported learning and digital pedagogy. The collected documents were analyzed to identify recurring themes, conceptual constructs, and relationships relevant to human-AI instructional collaboration. These insights informed the development of the proposed conceptual framework and its associated measurement constructs.

Instrument Development

Although the present study is conceptual in nature, it also proposes a measurement instrument that can support future empirical validation of the framework. The development of this instrument was guided by insights derived from the document analysis process.

First, relevant constructs related to AI-supported instruction were identified through a systematic review of existing literature on educational technology adoption, AI-enabled learning systems, instructional design, formative assessment, and ethical AI governance. Key constructs frequently discussed in prior studies were extracted and categorized according to their pedagogical roles within higher education environments.

Second, the identified constructs were synthesized and organized into a multidimensional structure that reflects the collaborative roles of GenAI across instructional planning, teaching, and assessment processes. Based on these constructs, measurement indicators were drafted to represent the conceptual dimensions of the framework.

Third, the proposed measurement items were formulated in a way that allows future researchers to operationalize the constructs within survey-based or quantitative research designs, such as structural equation modeling. In this way, the present study contributes not only a conceptual framework but also a preliminary measurement structure that can facilitate future empirical research on human–AI instructional collaboration.

Measurement Scale

To enable future empirical testing of the framework, the proposed measurement items are designed to be measured using a five-point Likert scale, a commonly used approach in educational and information systems research. The Likert scale allows respondents to express their level of agreement with statements related to AI-supported instructional practices.

The scale ranges from:

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1 – Strongly Disagree

2 – Disagree

3 – Neutral

4 – Agree

5 – Strongly Agree

Although the present study does not conduct empirical testing, the proposed measurement structure is designed to be suitable for future statistical validation using analytical techniques such as structural equation modeling (SEM). Future studies may evaluate the reliability and validity of the measurement model through procedures such as confirmatory factor analysis, reliability testing, and validity assessment.

Constructs and Measurement

Based on the document analysis, eight key constructs were identified as central to conceptualizing GenAI as a collaborative instructional partner in higher education. These constructs capture the functional roles of GenAI, the conditions supporting its implementation, and the outcomes associated with AI-supported teaching and learning.

Co-Planning (CP)

Co-planning refers to the extent to which GenAI supports instructors in instructional design and preparation activities. Document analysis of literature on AI-supported curriculum design and instructional planning indicates that AI tools can assist educators in generating teaching materials, organizing lesson structures, and developing course content.

Co-Instruction (CI)

Co-instruction represents the role of GenAI in supporting instructional delivery. Literature on intelligent tutoring systems and AI-powered learning assistants highlights the potential of AI technologies to provide personalized explanations, adaptive learning pathways, and interactive academic assistance that complement instructors' teaching efforts.

Co-Assessment (CA)

Co-assessment captures the role of GenAI in supporting student evaluation and feedback processes. Research on AI-enabled assessment systems demonstrates that AI tools can assist instructors in generating assessment questions, supporting grading processes, and providing timely formative feedback to students.

Pedagogical Implementation Effectiveness (PIE)

Pedagogical implementation effectiveness refers to the extent to which GenAI is integrated into teaching practices in a structured and pedagogically meaningful manner. Studies on human–AI collaboration in education emphasize the importance of maintaining instructor oversight to ensure that AI tools support rather than replace pedagogical decision-making.

Ethical Governance Readiness (EGR)

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Ethical governance readiness represents the institutional preparedness to ensure responsible AI deployment in educational settings. Document analysis highlights the importance of governance mechanisms that address issues such as algorithmic bias, academic integrity, data privacy, and transparency in AI-assisted decision-making.

Instructor Outcomes (IO)

Instructor outcomes refer to improvements in teaching efficiency, instructional innovation, and professional productivity that may result from the integration of GenAI into instructional practices.

Student Outcomes (SO)

Student outcomes capture improvements in learning experiences, including higher levels of engagement, improved academic performance, and enhanced critical thinking resulting from personalized and adaptive AI-supported learning environments.

Institutional Outcomes (INO)

Institutional outcomes represent broader organizational benefits associated with AI adoption in higher education, including digital transformation, scalable personalized education, and improved institutional competitiveness.

Measurement Foundations

The following table outlines the key variables underpinning the study, along with the theoretical foundations and primary sources that inform each construct. These variables ranging from co-planning and co-instruction to ethical governance readiness and outcome constructs are grounded in established frameworks, pedagogical theories, and emerging research on AI integration in education. By mapping each variable to its theoretical basis and citing seminal as well as contemporary works, the table provides a structured overview of the conceptual scaffolding that supports the research design.

Table 2: Measurement Foundations by Construct

Variable	Grounded in	Primary Theoretical Sources
Co-Planning (CP)	– Technology Acceptance Model (Perceived Usefulness, Efficiency) – Instructional Design and Curriculum Development literature – AI-assisted instructional design research	Davis (1989); Venkatesh et al. (2003); Zhang (2025); Magrill et al. (2024)
2. Co-Instruction (CI)	– Personalized learning theory – Intelligent tutoring systems – AI-supported learning engagement	Dwivedi et al. (2023); Neupane et al. (2024); Jamie et al. (2024)
3. Co-Assessment (CA)	– Automated feedback systems – Formative assessment theory – Human-AI co-grading research	Xiao et al. (2024); Black and Wiliam (1998); Shubhanshi (2025)
4. Pedagogical Implementation Effectiveness (PIE)	– Teacher-in-the-Loop (TiTL) framework – Complementary Strengths Model – Constructivist pedagogy	Shubhanshi (2025); Kotsis (2025); Chaves et al. (2025)
5. Ethical Governance Readiness (EGR)	– Responsible AI frameworks – AI fairness and bias research – Educational data governance	Dwivedi et al. (2023); Franco et al. (2024); Joon et al. (2024)
6. Outcome Constructs (IO, SO, InstO)	– IS Success Model – Teaching effectiveness scales – Student engagement frameworks – Digital transformation literature	DeLone and McLean (2003); Fredricks et al. (2004); Venkatesh et al. (2003)

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Survey Instrument

The proposed survey instrument consists of 37 measurement items representing eight latent constructs derived from the conceptual framework. Consistent with established procedures for scale development, the measurement items were adapted, modified, or developed by the authors based on relevant theoretical foundations and empirical studies identified during the document analysis. Existing validated constructs were adopted where applicable, while new items were developed to operationalize the novel concept of Generative AI as a Co-Instructor, particularly for dimensions that have not yet been empirically measured in prior literature. All items are designed to be measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Future empirical studies should establish the instrument's content validity, construct validity, convergent validity, discriminant validity, and reliability through expert review, pilot testing, confirmatory factor analysis (CFA), and structural equation modeling (SEM).

Co-Planning (CP)

The extent to which Generative AI supports curriculum design, lesson planning, instructional resource development, and instructional preparation. Developed by the authors based on the Technology Acceptance Model (Davis, 1989), Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), instructional design literature, and recent studies on AI-assisted curriculum development (Magrill et al., 2024; Zhang, 2025).

Item	Statement
CP1	GenAI helps me design lessons more efficiently.
CP2	The AI-generated materials align with my course learning objectives.
CP3	Using GenAI reduces the time I spend creating instructional content.
CP4	GenAI improves the quality of my teaching materials.
CP5	GenAI assists in organizing and structuring course topics effectively.

Co-Instruction (CI)

The extent to which GenAI enhances instructional delivery, personalized learning, learner engagement, and adaptive instructional support. Adapted and modified from literature on intelligent tutoring systems, personalized learning, AI-supported learning environments, and student engagement (Fredricks et al., 2004; Dwivedi et al., 2023; Neupane et al., 2024).

CI1	GenAI provides effective clarification of complex concepts.
CI2	GenAI supports personalized learning for students.
CI3	Students receive timely assistance through AI tools.
CI4	GenAI enhances student engagement in my course.
CI5	AI-assisted tutoring improves students' understanding of course content.

Co-Assessment (CA)

The extent to which GenAI supports assessment design, grading, formative assessment, and feedback processes. Adapted and modified from Formative Assessment Theory (Black and Wiliam, 1998) and recent research on AI-assisted assessment and human–AI co-grading (Shute, 2008; Xiao et al., 2024).

CA1	GenAI enables faster feedback delivery to students.
CA2	AI-generated feedback is consistent and structured.
CA3	GenAI assists in developing effective grading rubrics.
CA4	AI tools improve formative assessment practices.
CA5	Using GenAI reduces my grading workload.

Pedagogical Implementation Effectiveness (PIE)

The extent to which GenAI is implemented using structured pedagogical practices characterized by human oversight, instructional alignment, and responsible integration. Developed by the authors based on the Teacher-in-the-Loop (TiTL) framework, complementary human–AI collaboration models, constructivist pedagogy, and Responsible AI implementation frameworks (Shubhanshi, 2025; Kotsis, 2025; Chaves et al., 2025).

PIE1	I carefully review and validate AI-generated outputs before using them.
PIE2	GenAI is used as a supplement rather than a replacement for my teaching.
PIE3	AI tools are aligned with my pedagogical approach.
PIE4	I maintain control over instructional decisions when using AI.
PIE5	AI-generated responses are grounded in course-specific materials.

Ethical Governance Readiness (EGR)

The extent to which institutional policies, governance mechanisms, and ethical safeguards support responsible AI implementation in higher education. Developed by the authors based on Responsible AI Governance literature, AI ethics frameworks, educational data governance, and institutional AI readiness models (Floridi et al., 2018; OECD, 2019; Dwivedi et al., 2023; Franco et al., 2024).

EGR1	My institution has clear policies regarding AI use in teaching.
EGR2	There are safeguards to protect student data when using AI tools.
EGR3	Measures are in place to monitor potential AI bias.
EGR4	AI use does not undermine teacher professional autonomy.
EGR5	Students are guided to use AI responsibly and ethically.

Instructor Outcomes (IO)

The perceived impact of GenAI integration on instructor effectiveness, instructional innovation, professional productivity, and teaching satisfaction. Adapted and modified from the Information Systems Success Model (DeLone and McLean, 2003), technology acceptance research, and studies examining instructional effectiveness and AI adoption in education (Venkatesh et al., 2003; Holmes et al., 2022).

IO1	GenAI improves my teaching efficiency.
IO2	GenAI enables me to focus on higher-order pedagogical activities.
IO3	My instructional innovation has increased due to AI use.
IO4	I feel empowered rather than replaced by AI tools.

Student Outcomes (SO)

The perceived impact of GenAI integration on student engagement, academic performance, self-directed learning, and critical thinking. Adapted and modified from Student Engagement Theory (Fredricks et al., 2004), adaptive learning literature, and AI-enhanced learning research (Zawacki-Richter et al., 2019; Kasneci et al., 2023).

SO1	Students demonstrate improved academic performance.
SO2	Students are more engaged in learning activities.
SO3	Students show greater self-directed learning behaviors.
SO4	Students demonstrate stronger critical thinking skills.

Institutional Outcomes (InstO)

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The institutional-level impact of GenAI implementation on digital transformation, instructional quality, organizational innovation, and sustainable educational development. Developed by the authors based on the Information Systems Success Model (DeLone and McLean, 2003), digital transformation literature, and Responsible AI implementation frameworks (UNESCO, 2023; Dwivedi et al., 2023; Raisch and Krakowski, 2021).

InstO1	**AI integration supports scalable personalized education.**
InstO2	AI use contributes to digital transformation in the institution.
InstO3	Teaching quality has improved due to AI-supported practices.
InstO4	AI implementation is aligned with ethical standards.

Expected Contributions

Theoretical Contribution

This study contributes to the emerging scholarship on artificial intelligence in education by conceptualizing generative AI as a pedagogical collaborator rather than merely a technological tool. The proposed framework integrates insights from educational technology, information systems success theory, student engagement research, and responsible AI governance into a unified model.

Methodological Contribution

The study develops a 37-item measurement instrument across eight latent constructs, providing a structured tool for empirical investigation of human–AI instructional collaboration using structural equation modeling.

Practical Contribution

The framework offers guidance for higher education institutions seeking to integrate generative AI into teaching practices while maintaining ethical governance, instructor autonomy, and pedagogical integrity.

Research Limitations

As a conceptual study, this research does not empirically validate the proposed framework or measurement instrument. The proposed constructs and indicators are derived from theoretical synthesis and document analysis rather than data collected from higher education stakeholders. Consequently, the findings should be interpreted as a theoretical foundation for future empirical investigation rather than definitive evidence of causal relationships. Future studies should validate the proposed framework across diverse institutional, disciplinary, and cultural contexts.

CONCLUSION

This study advances the discourse on transformative technologies in higher education by conceptualizing Generative Artificial Intelligence (GenAI) as a co-instructor rather than merely a productivity tool. By integrating theoretical foundations from technology acceptance, information systems success, student engagement, formative assessment, and responsible AI governance, the study proposes a multidimensional framework that situates GenAI within structured pedagogical and ethical boundaries. The framework articulates three core instructional domains—co-planning, co-instruction, and co-assessment—supported by pedagogical implementation effectiveness and moderated by ethical governance readiness, thereby offering a holistic model for sustainable and personalized AI integration.

The primary contribution of this research lies in its dual focus on conceptual clarity and measurement formulation. The development of an eight-construct model and a 37-item Likert-scale instrument provides a systematic foundation for future empirical validation using structural equation modeling. By operationalizing

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GenAI as a collaborative instructional partner, the study shifts the narrative from fragmented adoption toward strategic, accountable, and pedagogically grounded implementation.

Importantly, the findings underscore that the transformative potential of GenAI depends not solely on technological sophistication but on structured human oversight, institutional governance, and alignment with personalization goals. Sustainable academic communities are forged when AI systems enhance, rather than replace, human instructional judgment and when ethical safeguards ensure transparency, equity, and accountability.

So, this conceptual framework offers a robust theoretical and methodological basis for examining human–AI instructional collaboration in higher education. Future empirical studies should validate and refine the proposed model across diverse institutional and cultural contexts to determine its generalizability and long-term impact on personalized learning ecosystems.

Future research should prioritize validating the proposed 37-item measurement instrument using pilot testing, confirmatory factor analysis, and structural equation modeling. Cross-cultural and cross-disciplinary investigations will further establish the framework's generalizability and refine its application across diverse higher education contexts.

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