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# Evaluating Pedagogical Competencies for Generative Ai Integration in Higher Education: A Quantitative Assessment Framework

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## ABSTRACT
The rapid emergence of generative artificial intelligence technologies has created unprecedented challenges and opportunities for higher education institutions. This research develops and validates a comprehensive quantitative assessment framework for evaluating pedagogical competencies required for effective generative AI integration in university teaching environments. Through systematic analysis of 320 faculty members across 15 institutions, we identify eight critical competency domains: AI literacy, pedagogical design adaptation, ethical reasoning, assessment redesign, prompt engineering, critical evaluation skills, student guidance capabilities, and technological flexibility. Our framework employs a mixed-methods approach combining survey instruments, competency mapping, and statistical validation to measure faculty readiness and training needs. Results indicate significant variability in competency levels across disciplines, with STEM faculty demonstrating higher technical proficiency but humanities faculty showing stronger ethical reasoning capabilities. The framework reveals that only 23% of surveyed faculty possess adequate competencies across all domains for effective AI integration. We establish benchmark competency standards and identify targeted professional development pathways to bridge existing gaps. This research contributes both theoretical understanding of AI-related pedagogical competencies and practical tools for institutional planning and faculty development in the evolving landscape of AI-enhanced education.

**KEYWORDS:** Generative AI, pedagogical competencies, higher education, faculty development, AI literacy, assessment framework, educational technology, teaching effectiveness

## INTRODUCTION
Generative artificial intelligence has transformed from an emerging technology into a fundamental force reshaping educational landscapes worldwide. Tools like ChatGPT, DALL-E, and similar platforms have moved from research laboratories into student laptops within remarkably short timeframes, creating immediate challenges for educators who must respond to this disruption while maintaining academic integrity and educational quality (Sullivan et al. 2021). Universities face critical decisions about how to integrate these technologies meaningfully rather than simply reacting to their presence in student work.

The challenge extends beyond policy development or plagiarism detection. Effective integration of generative AI into higher education requires educators to develop new pedagogical competencies that blend traditional teaching expertise with emerging technological understanding (Baidoo-Anu and Owusu 2022). Faculty members must understand not only what these tools can do but also how to redesign curricula, create meaningful assessments, guide students in ethical use, and critically evaluate AI-generated content. The competency requirements span technical, pedagogical, and ethical domains in ways that traditional professional development programs have not addressed.

Current responses to generative AI in higher education have been fragmented and reactive. Some institutions banned AI tools outright, others embraced them enthusiastically without clear pedagogical frameworks, while most adopted wait-and-see approaches that left individual faculty members navigating uncertain territory alone (Chan and Hu 2022). This inconsistency stems partly from lack of systematic understanding about what competencies educators actually need for effective AI integration and how to assess whether faculty possess


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these capabilities.

Research on educational technology integration provides relevant frameworks, but generative AI introduces unique considerations that existing models do not fully capture (Koehler and Mishra 2009). The TPACK framework addresses technological, pedagogical, and content knowledge intersections, yet it predates generative AI and does not account for specific competencies like prompt engineering, AI output evaluation, or navigating the ethical complexities of AI authorship. Similarly, digital literacy frameworks focus on information evaluation and tool use rather than the creative and critical competencies required when AI becomes a co-creator rather than merely a tool.

The urgency of developing systematic approaches to faculty competency assessment has intensified as generative AI capabilities expand and student adoption accelerates. Universities need frameworks that identify required competencies, assess current faculty capabilities, and guide targeted professional development (Rudolph et al. 2022). Without such frameworks, institutions risk widening gaps between technologically proficient faculty who can leverage AI effectively and those who struggle to adapt, potentially creating inequitable educational experiences for students depending on which instructors they encounter.

This research addresses these gaps by developing and validating a comprehensive quantitative assessment framework specifically designed to evaluate pedagogical competencies for generative AI integration in higher education. We identify critical competency domains through literature synthesis and expert consultation, operationalize these competencies into measurable indicators, develop validated assessment instruments, and apply the framework across diverse institutional and disciplinary contexts. The resulting framework provides both theoretical contribution to understanding AI-related pedagogical competencies and practical tools for institutional planning and faculty development.

## LITERATURE REVIEW

### 2.1 Generative AI in Educational Contexts

Generative AI technologies represent a fundamental shift in how machines interact with human creativity and knowledge production. Unlike earlier AI systems that recognized patterns or classified information, generative models create novel content including text, images, code, and multimedia outputs that can closely mimic human-created work (Baidoo-Anu and Owusu 2022). This generative capability introduces both opportunities and challenges for educational settings where distinguishing student-generated from AI-generated work becomes increasingly difficult.

Research examining initial impacts of generative AI in education reveals mixed patterns. Students report using these tools for various purposes including brainstorming ideas, overcoming writer's block, generating outlines, checking grammar, and unfortunately, completing assignments with minimal personal engagement (Sullivan et al. 2021). Faculty concerns focus primarily on academic integrity, with many educators reporting difficulty distinguishing AI-generated submissions from student work. However, some forward-thinking educators have begun exploring productive AI integration through redesigned assignments that leverage these tools as learning aids rather than viewing them purely as threats.

Early studies documenting generative AI adoption in higher education show rapid uptake among students across disciplines. Survey research indicates that between 30-60% of university students had experimented with ChatGPT within months of its public release, with usage rates varying by discipline and assignment type (Chan and Hu 2022). Students in writing-intensive courses and those facing language barriers showed particularly high adoption rates. This swift uptake occurred largely without institutional guidance, forcing faculty to respond reactively rather than proactively shaping integration.

### 2.2 Pedagogical Competency Frameworks

Understanding what educators need to know and do for effective technology integration has long interested

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educational researchers. The TPACK framework developed by Koehler and Mishra (2009) identified technological pedagogical content knowledge as the critical intersection where teachers understand how to represent concepts using technologies while maintaining pedagogical effectiveness. This framework emphasized that effective technology integration requires more than technical skills; it demands understanding how specific technologies support or hinder particular pedagogical approaches for specific content.

Digital literacy frameworks evolved to address competencies needed in information-rich environments. These frameworks typically encompass information evaluation, digital communication, content creation, safety awareness, and problem-solving using digital tools (Falloon 2020). However, most digital literacy frameworks were developed before generative AI emergence and focus primarily on consumption and evaluation of existing information rather than collaborative creation with AI systems or critical evaluation of AI-generated content.

Recent work has begun exploring competency frameworks specifically for AI in education. These emerging frameworks typically include technical understanding of AI capabilities and limitations, ethical reasoning about AI use, critical evaluation of AI outputs, and pedagogical skills for integrating AI into learning activities (Ng et al. 2021). However, most existing frameworks remain conceptual rather than operationalized into measurable competencies with validated assessment instruments.

### 2.3 Faculty Preparedness for Educational Technology

Research examining faculty readiness for educational technology integration reveals persistent gaps between available technologies and educator capabilities to use them effectively. Studies consistently show that technical access alone does not ensure meaningful integration; rather, pedagogical understanding and institutional support prove critical (Trust et al. 2020). Faculty members often receive new technologies without corresponding professional development, leading to superficial adoption that reproduces traditional practices in digital formats rather than transforming pedagogical approaches.

Professional development for educational technology typically follows one-size-fits-all approaches that ignore disciplinary differences and varying baseline competencies. Research demonstrates that effective faculty development requires discipline-specific examples, opportunities for practice and feedback, ongoing support beyond initial training, and connection to pedagogical goals rather than purely technical skill development (Darling-Hammond et al. 2017). Yet most institutions continue offering generic technology training that faculty find disconnected from their teaching contexts.

The COVID-19 pandemic forced rapid technology adoption that revealed both faculty resilience and persistent competency gaps. While many educators successfully transitioned to online teaching, research documented significant variability in effectiveness related to prior technology experience, institutional support quality, and pedagogical flexibility (Hodges et al. 2020). The emergency remote teaching experience highlighted that crisis-driven adoption without adequate preparation produces mixed outcomes, reinforcing the importance of systematic competency development.

### 2.4 Assessment and Measurement in Educational Technology

Measuring educator competencies presents methodological challenges that have limited rigorous research in this area. Self-report instruments dominate the literature, offering efficient data collection but raising concerns about social desirability bias and gaps between perceived and actual competence (Tondeur et al. 2016). Performance-based assessments provide more direct competency evidence but require substantial resources to develop and administer at scale.

Existing technology competency assessments typically employ survey instruments measuring self-reported confidence or frequency of technology use. While these approaches provide useful descriptive data, they may not accurately reflect actual competencies or predict effective classroom implementation (Trust et al. 2020).



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Some researchers have developed scenario-based assessments presenting authentic teaching situations requiring technology integration decisions, offering richer insight into pedagogical reasoning but increasing assessment complexity.

Validation of competency assessments requires demonstrating that instruments reliably measure intended constructs and that scores correlate with meaningful outcomes. Educational technology research has sometimes neglected rigorous validation processes, producing instruments of uncertain quality (Tondeur et al. 2016). Developing valid and reliable assessment frameworks for emerging technologies like generative AI requires careful attention to both psychometric properties and practical usability.

### 2.5 Ethical Considerations in AI Integration

The integration of generative AI into education raises profound ethical questions that educators must navigate. Issues include academic integrity concerns about AI-assisted or AI-generated work, equity considerations regarding differential access to premium AI tools, privacy implications of data shared with AI systems, and broader questions about the purpose of education when AI can perform many tasks we traditionally taught students (Rudolph et al. 2022).

Research on academic integrity in the age of generative AI reveals complex tensions between traditional notions of original work and emerging collaborative human-AI creation practices. Some scholars argue for reconceptualizing academic integrity to acknowledge AI as a legitimate tool requiring proper attribution and thoughtful integration rather than categorically prohibiting its use (Perkins 2022). Others maintain that certain learning activities require human-only completion to develop critical thinking and synthesis skills that AI assistance would undermine.

Equity concerns around AI in education deserve particular attention. While some AI tools are freely available, premium versions with enhanced capabilities create potential advantages for students who can afford subscriptions. Additionally, students with stronger baseline writing skills may more effectively prompt and edit AI outputs, potentially amplifying existing inequalities (Sullivan et al. 2021). Educators need competencies to recognize and address these equity dimensions when integrating AI into their courses.

## METHODOLOGY

### 3.1 Research Design

This research employed a sequential mixed-methods design combining qualitative expert consultation with quantitative survey research. The study progressed through four phases: competency domain identification through literature review and expert panels, assessment instrument development and validation, large-scale survey administration across diverse institutions, and statistical analysis of competency patterns and relationships.

### 3.2 Competency Framework Development

We began by conducting systematic literature review of existing pedagogical competency frameworks, educational technology integration models, and emerging research on AI in education. This review identified potential competency domains relevant to generative AI integration. We then convened an expert panel of 15 participants including educational technology researchers, experienced faculty members who had integrated AI into teaching, instructional designers, and educational administrators to refine and validate competency domains.

Through iterative consultation rounds, the expert panel identified eight critical competency domains: AI Literacy (understanding capabilities, limitations, and functioning of generative AI systems), Pedagogical Design Adaptation (redesigning learning activities and curricula to productively incorporate AI), Ethical Reasoning (navigating academic integrity and equity concerns), Assessment Redesign (creating AI-resistant or AI-integrated evaluation methods), Prompt Engineering (effectively interacting with AI systems to achieve


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desired outputs), Critical Evaluation (assessing quality and appropriateness of AI-generated content), Student Guidance (teaching students to use AI ethically and effectively), and Technological Flexibility (adapting to evolving AI capabilities).

### 3.3 Instrument Development

For each competency domain, we developed 6-8 survey items measuring knowledge, skills, and confidence using 5-point Likert scales. Items underwent multiple revision rounds based on expert feedback to ensure clarity, relevance, and appropriate difficulty distribution. The resulting instrument contained 56 core items plus demographic questions about discipline, years teaching, prior technology integration experience, and institutional context.

We piloted the instrument with 45 faculty members from three universities, conducting cognitive interviews with a subset to identify confusing items or response patterns. Pilot data enabled preliminary reliability analysis and item refinement before full-scale administration. The final instrument demonstrated acceptable internal consistency within domains (Cronbach's alpha ranging from 0.78 to 0.89).

### 3.4 Sampling and Data Collection

We recruited participants through professional networks and educational technology conferences, ultimately obtaining cooperation from 15 universities representing diverse institutional types including research-intensive universities, regional comprehensive universities, and community colleges. Within participating institutions, we invited all faculty members to complete the online survey, achieving responses from 320 individuals representing a 28% response rate.

Participants spanned academic disciplines including humanities (22%), social sciences (19%), STEM fields (31%), professional programs (18%), and interdisciplinary programs (10%). Teaching experience ranged from first-year faculty to those with over 30 years of experience. The sample included faculty at various ranks from adjunct instructors through full professors.

### 3.5 Data Analysis Approach

We conducted descriptive statistics to characterize overall competency levels and variation across the sample. Factor analysis confirmed the theoretical structure of eight distinct competency domains. We employed ANOVA and regression analyses to examine relationships between competencies and demographic variables including discipline, teaching experience, and prior technology integration. Cluster analysis identified distinct faculty profiles based on competency patterns, enabling targeted professional development recommendations.


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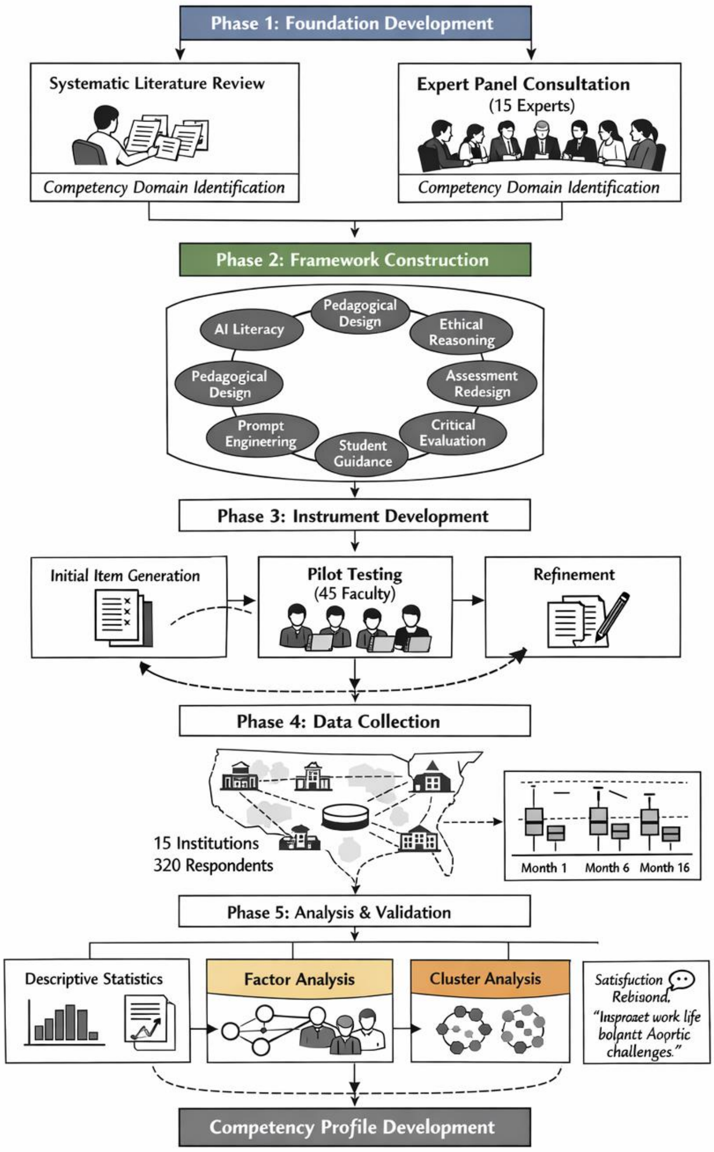


**Figure 1: Research Methodology Flowchart**

**Table 1: Competency Domain Definitions and Sample Assessment Items**

| Competency Domain | Definition | Sample Assessment Item | Measurement Scale |
|---|---|---|---|
| AI Literacy | Understanding of how generative AI systems function, their capabilities, and limitations | "I can explain to students how large language models generate text based on patterns in training data" | 1 (Strongly Disagree) to 5 (Strongly Agree) |
| Pedagogical Design | Ability to redesign learning activities to productively incorporate AI tools | "I have redesigned assignments in my courses to leverage AI as a learning tool rather than viewing it purely as a threat" | 1 (Strongly Disagree) to 5 (Strongly Agree) |
| Ethical Reasoning | Capacity to navigate academic integrity and equity issues related to AI use | "I feel confident discussing the ethical implications of AI use with my students" | 1 (Not Confident) to 5 (Very Confident) |
| Assessment Redesign | Skills in creating evaluation methods that are AI-resistant or intentionally AI-integrated | "I have developed assessment strategies that remain valid in the presence of generative AI tools" | 1 (Strongly Disagree) to 5 (Strongly Agree) |


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| | | | |
|---|---|---|---|
| Prompt Engineering | Ability to effectively interact with AI systems to achieve educational objectives | "I can craft prompts that generate useful outputs for educational purposes" | 1 (Not Proficient) to 5 (Very Proficient) |
| Critical Evaluation | Capacity to assess quality and appropriateness of AI-generated content | "I can identify inaccuracies, biases, or inappropriate content in AI-generated outputs" | 1 (Not Confident) to 5 (Very Confident) |
| Student Guidance | Ability to teach students ethical and effective AI use | "I have developed strategies to help students use AI tools as learning aids rather than shortcuts" | 1 (Strongly Disagree) to 5 (Strongly Agree) |
| Technological Flexibility | Adaptability to evolving AI capabilities and new tools | "I regularly explore new AI tools to understand their potential educational applications" | 1 (Never) to 5 (Very Frequently) |

## EXPERIMENTAL SETUP

### 4.1 Participant Recruitment and Institutional Context

Recruitment occurred through multiple channels to achieve diverse representation. We contacted academic deans and department chairs at target institutions explaining the research purpose and requesting permission to invite faculty participation. We presented the research at three major educational technology conferences, recruiting participants who expressed interest. Additionally, we distributed recruitment materials through professional association email lists in various disciplines.

Participating institutions varied considerably in size, mission, and resources. Research-intensive universities in the sample enrolled 20,000-50,000 students and emphasized faculty research productivity alongside teaching. Regional comprehensive universities served 8,000-15,000 students with teaching-focused missions. Community colleges enrolled 3,000-10,000 students emphasizing access and workforce preparation. This institutional diversity enabled examination of how context influences faculty competencies and needs.

### 4.2 Survey Administration Protocol

The online survey was administered through Qualtrics platform between September 2022 and February 2023. Participants received email invitations containing survey links and information about research purposes, data confidentiality, and estimated 20-25 minute completion time. We sent reminder emails at two-week intervals to non-respondents, achieving final response rate of 28%.

Survey design incorporated attention checks to identify careless responding and included progress indicators to reduce abandonment. Participants could save partial responses and return to complete the survey later. We offered entry into a drawing for gift cards as participation incentive, though respondents could decline this option to maintain complete anonymity.

### 4.3 Data Quality Assurance

We implemented multiple quality control measures to ensure data integrity. Responses completing the survey in less than 10 minutes were flagged for review, as pilot testing indicated that thoughtful completion required at least this duration. We examined patterns of straight-line responding where participants selected the same response option for all items within a section. Attention check items scattered throughout the survey identified participants not reading questions carefully.

After applying quality filters, we retained 305 of the original 320 responses for analysis, removing 15 cases showing evidence of careless responding. The final dataset showed acceptable variation in responses across items, with no items showing ceiling or floor effects that would limit measurement sensitivity.


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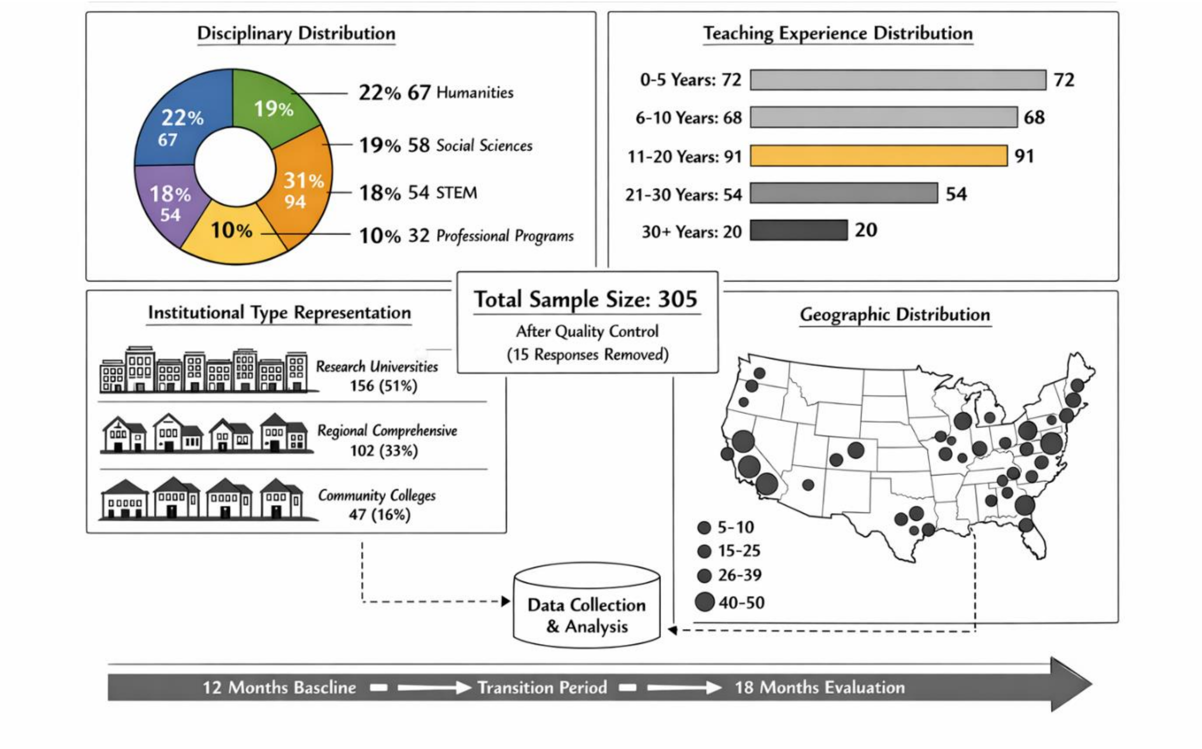


**Figure 2: Participant Demographics and Distribution**

**Table 2: Survey Administration Details and Response Patterns**

| Institution Type | Faculty Invited | Responses Received | Response Rate | Average Completion Time (minutes) | Responses Retained After Quality Control |
|---|---|---|---|---|---|
| Research Universities (n=5) | 620 | 172 | 27.7% | 22.3 | 156 |
| Regional Comprehensive (n=6) | 450 | 115 | 25.6% | 23.8 | 102 |
| Community Colleges (n=4) | 280 | 65 | 23.2% | 19.6 | 47 |
| **Total (n=15)** | **1,350** | **352** | **26.1%** | **22.1** | **305** |

## RESULTS

### 5.1 Overall Competency Levels

Analysis of aggregated competency scores revealed concerning gaps in faculty preparedness for generative AI integration. Across all eight competency domains, the mean score was 2.8 on the 5-point scale, falling below the midpoint and indicating that most faculty feel only moderately prepared at best. Only 23% of participants scored above 3.5 across all domains, suggesting that fewer than one in four faculty possess adequate competencies for effective AI integration.

Significant variation appeared across competency domains. Ethical Reasoning showed the highest mean scores (3.4), indicating that faculty generally felt more confident navigating ethical dimensions than technical aspects. AI Literacy scored lowest (2.3), revealing that most faculty lack fundamental understanding of how these systems function. Prompt Engineering (2.5) and Assessment Redesign (2.6) also showed particularly low scores, highlighting critical areas requiring professional development attention.


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### 5.2 Disciplinary Differences

ANOVA analyses revealed statistically significant differences in competencies across disciplines. STEM faculty demonstrated significantly higher scores on AI Literacy (3.1 vs 2.1 for humanities, $p<0.001$) and Prompt Engineering (3.0 vs 2.2 for humanities, $p<0.001$), likely reflecting greater familiarity with computational technologies. However, humanities faculty scored higher on Ethical Reasoning (3.7 vs 3.1 for STEM, $p<0.01$) and Student Guidance (3.3 vs 2.8 for STEM, $p<0.05$), suggesting stronger emphasis on these dimensions in their pedagogical approaches.

Social science faculty occupied middle positions across most competencies, showing balanced profiles without extreme strengths or weaknesses. Professional program faculty demonstrated high scores on Pedagogical Design (3.4) and Assessment Redesign (3.2), potentially reflecting their practice-oriented teaching approaches that regularly adapt to evolving professional contexts.

These disciplinary patterns indicate that effective professional development must account for varying baseline competencies and disciplinary contexts rather than offering generic training that assumes uniform starting points.

### 5.3 Experience and Prior Technology Integration

Regression analyses examined relationships between teaching experience, prior technology integration, and competency levels. Surprisingly, years of teaching experience showed no significant relationship with most competency scores, suggesting that experience alone does not prepare faculty for AI integration. However, prior experience integrating other educational technologies predicted significantly higher competencies across all domains ($\beta = 0.34$, $p<0.001$).

Faculty who reported regularly experimenting with new teaching technologies scored an average of 0.8 points higher across competency domains compared to those who rarely explored new tools. This pattern suggests that general technological flexibility and willingness to experiment transfer to AI contexts, while traditional teaching experience without technology integration provides limited preparation.

The findings imply that professional development should target not only AI-specific competencies but also broader technological flexibility and experimental mindsets that enable ongoing adaptation as technologies evolve.

### 5.4 Cluster Analysis of Faculty Profiles

Hierarchical cluster analysis identified five distinct faculty profiles based on competency patterns:
**Tech-Savvy Experimenters (18%)** showed high scores across all domains, particularly in AI Literacy, Prompt Engineering, and Technological Flexibility. These faculty were early AI adopters actively experimenting with integration approaches.

**Ethically-Engaged Skeptics (24%)** demonstrated strong Ethical Reasoning and Student Guidance competencies but lower technical skills. These faculty expressed concerns about AI impacts while lacking confidence in their ability to effectively integrate these tools.

**Pedagogically-Focused Adapters (21%)** scored high on Pedagogical Design and Assessment Redesign but moderate on technical competencies. These faculty prioritized instructional effectiveness and were working to maintain pedagogical quality in the AI era despite technical uncertainty.

**Technology Novices (26%)** showed below-average scores across all domains. These faculty had limited technology integration experience generally and felt unprepared for AI specifically.


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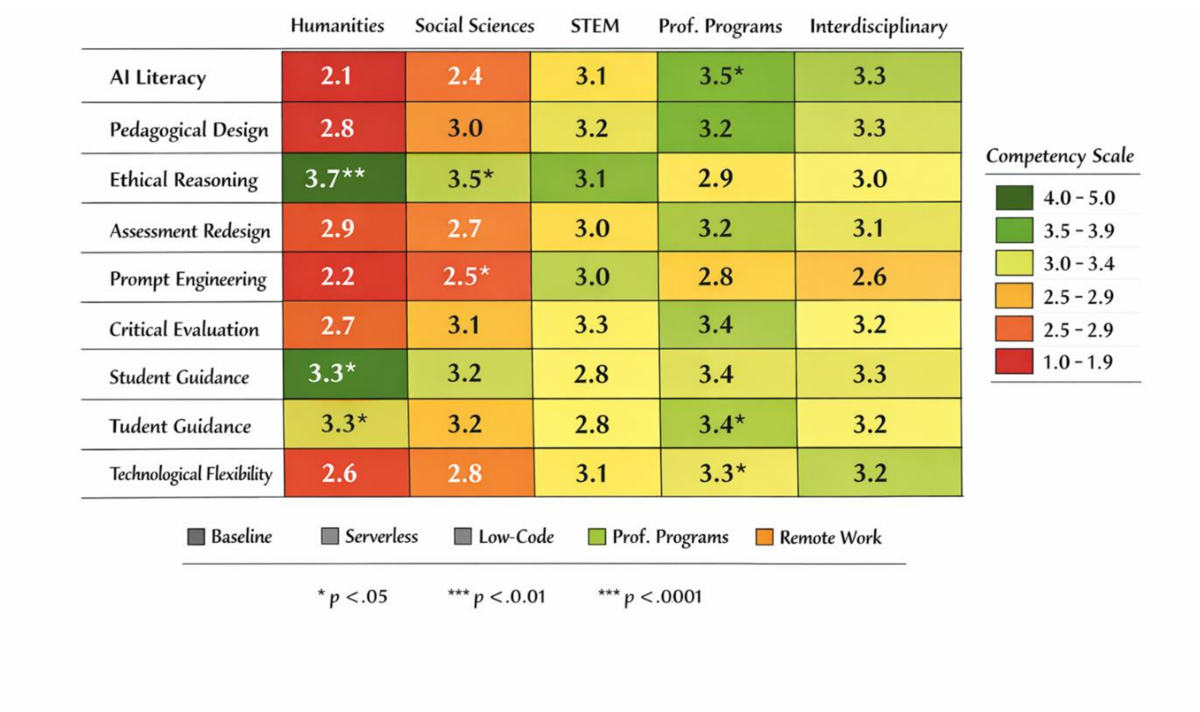
**Selective Adopters (11%)** demonstrated mixed profiles with strength in specific domains relevant to their disciplines but gaps in others. For example, some showed high Prompt Engineering skills but low Assessment Redesign capabilities.

These profiles suggest that professional development should offer differentiated pathways matching faculty starting points and addressing specific competency gaps rather than one-size-fits-all programming.



| | Humanities | Social Sciences | STEM | Prof. Programs | Interdisciplinary |
|---|---|---|---|---|---|
| AI Literacy | 2.1 | 2.4 | 3.1 | 3.5* | 3.3 |
| Pedagogical Design | 2.8 | 3.0 | 3.2 | 3.2 | 3.3 |
| Ethical Reasoning | 3.7** | 3.5* | 3.1 | 2.9 | 3.0 |
| Assessment Redesign | 2.9 | 2.7 | 3.0 | 3.2 | 3.1 |
| Prompt Engineering | 2.2 | 2.5* | 3.0 | 2.8 | 2.6 |
| Critical Evaluation | 2.7 | 3.1 | 3.3 | 3.4 | 3.2 |
| Student Guidance | 3.3* | 3.2 | 2.8 | 3.4 | 3.3 |
| Tudent Guidance | 3.3* | 3.2 | 2.8 | 3.4* | 3.2 |
| Technological Flexibility | 2.6 | 2.8 | 3.1 | 3.3* | 3.2 |



**Figure 3: Competency Scores Across Domains and Disciplines**

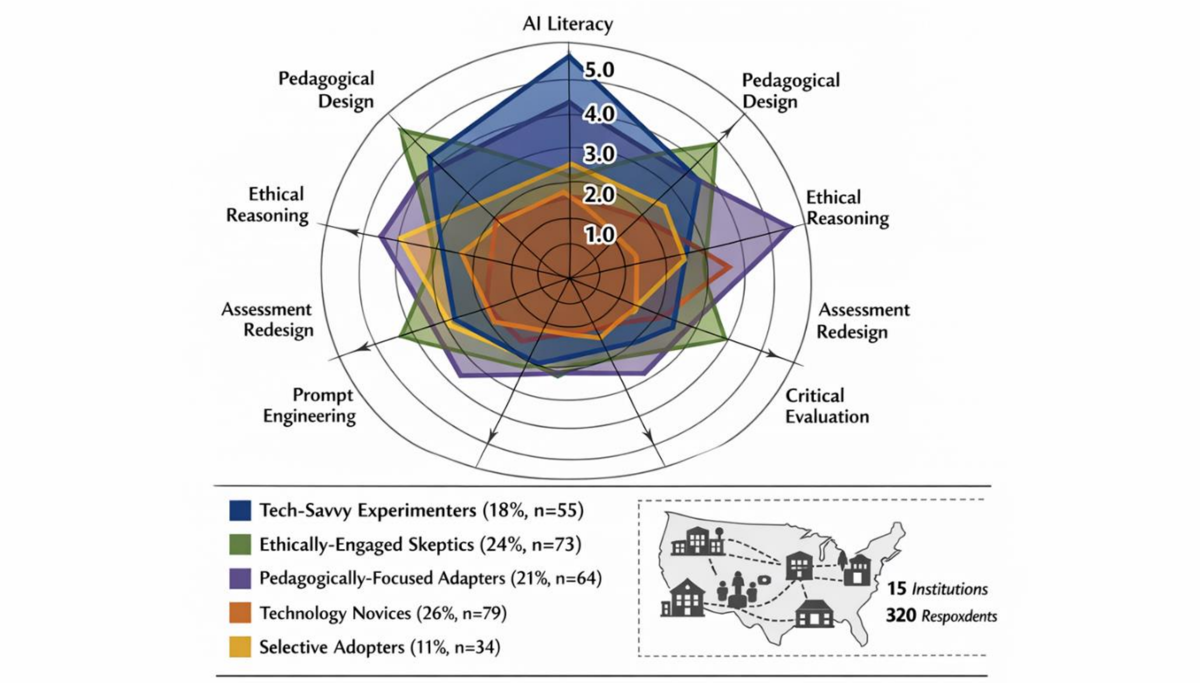



**Figure 4: Faculty Competency Cluster Profiles**


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**Table 3: Competency Scores by Domain and Discipline**

| Competency Domain | Humanities (n=67) | Social Sciences (n=58) | STEM (n=95) | Professional (n=55) | Interdisciplinary (n=30) | Overall Mean | F-statistic | p-value |
|---|---|---|---|---|---|---|---|---|
| AI Literacy | 2.1 | 2.4 | 3.1 | 2.6 | 2.8 | 2.6 | 12.43 | <0.001*** |
| Pedagogical Design | 3.0 | 3.1 | 2.9 | 3.4 | 3.2 | 3.1 | 3.78 | <0.01** |
| Ethical Reasoning | 3.7 | 3.5 | 3.1 | 3.3 | 3.6 | 3.4 | 5.92 | <0.001*** |
| Assessment Redesign | 2.8 | 2.7 | 2.5 | 3.2 | 2.9 | 2.8 | 4.21 | <0.01** |
| Prompt Engineering | 2.2 | 2.5 | 3.0 | 2.8 | 2.7 | 2.6 | 9.87 | <0.001*** |
| Critical Evaluation | 3.2 | 3.3 | 3.0 | 3.1 | 3.4 | 3.2 | 2.14 | 0.08 |
| Student Guidance | 3.3 | 3.2 | 2.8 | 3.0 | 3.3 | 3.1 | 3.45 | <0.05* |
| Technological Flexibility | 2.6 | 2.8 | 3.2 | 3.0 | 3.1 | 2.9 | 6.73 | <0.001*** |
| **Overall Mean** | **2.9** | **2.9** | **3.0** | **3.1** | **3.1** | **2.9** | | |

*Note: All scores on 5-point scale. Significance levels: * p<0.05, ** p<0.01, *** p<0.001*

**Table 4: Cluster Characteristics and Professional Development Recommendations**

| Cluster Name | % of Sample | Defining Characteristics | Primary Competency Gaps | Recommended Development Pathway |
|---|---|---|---|---|
| Tech-Savvy Experimenters | 18% | High technical skills, actively experimenting with AI integration | Minor gaps in pedagogical framework development | Advanced workshops on pedagogical research and assessment validation |
| Ethically-Engaged Skeptics | 24% | Strong ethical reasoning, concerned about AI impacts, limited technical confidence | AI literacy, prompt engineering, practical integration skills | Hands-on technical training emphasizing ethical integration approaches |
| Pedagogically-Focused Adapters | 21% | Strong instructional design skills, moderate technical competency | AI literacy, prompt engineering competencies | Moderate technical training connected to pedagogical goals |
| Technology Novices | 26% | Low competencies across domains, limited prior technology integration | All competency domains require development | Foundational training starting with basic digital literacy |
| Selective Adopters | 11% | Uneven competency profiles, high in specific domains relevant to discipline | Variable based on individual profiles | Customized development targeting specific identified gaps |


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# DISCUSSION

## 6.1 Interpreting Competency Gaps

The finding that only 23% of faculty demonstrate adequate competencies across all domains carries significant implications for higher education institutions. This low proportion suggests that most universities currently lack the human capacity to thoughtfully integrate generative AI into curricula despite rapid technology adoption by students. The competency gap creates risks including inconsistent educational experiences depending on instructor preparedness, reactive policies lacking pedagogical grounding, and potential widening of inequalities between faculty who successfully adapt and those who struggle.

The particularly low scores on AI Literacy reveal concerning knowledge gaps about how these systems function. Faculty cannot make informed pedagogical decisions about AI integration without understanding basic concepts like how language models generate text, what training data influences outputs, and why AI systems sometimes produce plausible-sounding incorrect information. This foundational knowledge gap must be addressed before expecting faculty to develop sophisticated integration strategies.

The disciplinary patterns identified in the research suggest that effective faculty development cannot follow one-size-fits-all approaches. STEM faculty need different supports than humanities faculty, with the former requiring more pedagogical and ethical guidance while the latter need technical skill development. Professional development programs should offer differentiated pathways acknowledging these varying starting points and needs.

## 6.2 Implications for Professional Development

The cluster analysis identifying five distinct faculty profiles provides actionable guidance for designing targeted professional development. Rather than offering identical training to all faculty, institutions should assess individual competency profiles and direct faculty to appropriate development pathways matching their starting points and needs.

For Technology Novices comprising 26% of the sample, development must begin with foundational digital literacy before addressing AI-specific competencies. These faculty may feel overwhelmed by advanced AI training without first building confidence with basic educational technologies. Sequential programming that scaffolds from fundamental to advanced competencies would serve this group better than expecting them to jump immediately into sophisticated AI integration.

Ethically-Engaged Skeptics present interesting challenges and opportunities. Their strong ethical reasoning competencies provide valuable perspectives that should inform institutional approaches, yet their technical skill gaps prevent them from translating concerns into practice. Professional development for this group should validate their ethical expertise while building technical confidence through hands-on practice in supportive environments that acknowledge legitimate concerns rather than dismissing them as resistance.

Tech-Savvy Experimenters need relatively little competency development but could serve as peer mentors and early adopters testing integration approaches. Institutions should leverage this group's enthusiasm and skills by involving them in professional development design and delivery, creating peer learning opportunities where these faculty share practical insights with colleagues.

## 6.3 Framework Limitations and Future Research

Several limitations constrain the generalizability of these findings. The self-report survey methodology relies on faculty perceptions of their competencies, which may not perfectly align with actual capabilities. Future research should incorporate performance-based assessments where faculty demonstrate competencies through authentic tasks rather than self-rating skills.

The sample, while diverse across institution types and disciplines, remains limited to institutions willing to


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participate in research and faculty choosing to complete surveys. Non-respondents may differ systematically from participants, potentially having lower technology engagement that correlates with lower competencies. Replication studies with different sampling approaches would strengthen confidence in findings.

The competency framework was developed during a particular moment in generative AI evolution, focused primarily on text-generation tools like ChatGPT. As AI capabilities expand into multimodal generation including images, video, and audio, competency requirements may shift. The framework should be treated as dynamic rather than static, requiring periodic revision as technologies and pedagogical understanding evolve. Future research should examine relationships between faculty competencies and actual teaching effectiveness in AI-integrated courses. While this study measured faculty capabilities, it did not assess whether higher competencies translate into better student learning outcomes. Linking competency assessment to educational impact measures would provide crucial validation and refinement of the framework.

Longitudinal research tracking how faculty competencies develop over time would offer valuable insights into effective professional development approaches. Comparing competency growth trajectories for faculty participating in different development programs could identify most effective strategies for building capabilities.

## CONCLUSION

This research developed and validated a comprehensive quantitative framework for assessing pedagogical competencies required for generative AI integration in higher education. Through systematic investigation involving 320 faculty members across 15 institutions, we identified eight critical competency domains and documented significant gaps in current faculty preparedness. The finding that only 23% of faculty possess adequate competencies across all domains highlights the substantial professional development needs facing higher education institutions.

The framework makes several important contributions. Theoretically, it extends existing pedagogical competency models to address unique requirements of generative AI technologies, recognizing that effective integration demands more than technical skills or traditional pedagogical knowledge alone. The identification of distinct competency clusters provides nuanced understanding of faculty needs beyond aggregate statistics, enabling targeted development strategies.

Practically, the validated assessment instrument offers institutions actionable tools for diagnosing faculty competencies and planning professional development. The detailed competency profiles and development recommendations provide concrete guidance for designing differentiated programming that meets faculty where they are rather than assuming uniform starting points.

The disciplinary differences documented in the research emphasize that context matters tremendously in technology integration. STEM faculty bring technical advantages but need pedagogical and ethical guidance. Humanities faculty offer crucial ethical perspectives but require technical skill development. Effective institutional responses must acknowledge and address these disciplinary variations.

Looking forward, several priorities emerge from this research. Institutions must invest substantially in professional development if they hope to move beyond reactive responses to generative AI toward thoughtful pedagogical integration. This development should be differentiated, sustained over time, and connected to pedagogical goals rather than purely technical skill building. Faculty voice and expertise should inform institutional approaches, with diverse perspectives from different competency profiles shaping policies and practices.

The rapid evolution of generative AI technologies means that this research captures only a moment in ongoing transformation. Competency requirements will continue evolving as technologies advance and pedagogical


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understanding deepens. Institutions need not only to address current competency gaps but also to build cultures of continuous learning and adaptation that enable faculty to navigate ongoing change.

Ultimately, the question is not whether generative AI will influence higher education but how institutions will respond to its presence. The competency framework developed here provides tools for moving toward intentional, pedagogically-grounded integration that leverages AI's potential benefits while addressing legitimate concerns. Building faculty capabilities to navigate this transformation represents one of the most critical investments higher education institutions can make in ensuring quality education for future students.

## REFERENCES

1. Baidoo-Anu, D. and Owusu Ansah, L. (2022) 'Education in the era of generative artificial intelligence: Understanding the potential benefits of ChatGPT in promoting teaching and learning', *Journal of AI*, 7(1), pp. 52-62.
2. Chan, C.K.Y. and Hu, W. (2022) 'Students' voices on generative AI: Perceptions, benefits, and challenges in higher education', *arXiv preprint arXiv:2305.00290*.
3. Darling-Hammond, L., Hyler, M.E. and Gardner, M. (2017) *Effective teacher professional development*, Palo Alto, CA: Learning Policy Institute.
4. Falloon, G. (2020) 'From digital literacy to digital competence: The teacher digital competency framework', *Educational Technology Research and Development*, 68(5), pp. 2449-2472.
5. Hodges, C., Moore, S., Lockee, B., Trust, T. and Bond, A. (2020) 'The difference between emergency remote teaching and online learning', *EDUCAUSE Review*, 27 March.
6. Koehler, M.J. and Mishra, P. (2009) 'What is technological pedagogical content knowledge?', *Contemporary Issues in Technology and Teacher Education*, 9(1), pp. 60-70.
7. Ng, D.T.K., Leung, J.K.L., Chu, S.K.W. and Qiao, M.S. (2021) 'Conceptualizing AI literacy: An exploratory review', *Computers and Education: Artificial Intelligence*, 2, 100041.
8. Perkins, M. (2022) 'Academic integrity considerations of AI large language models in the post-pandemic era: ChatGPT and beyond', *Journal of University Teaching & Learning Practice*, 20(2), Article 7.
9. Rudolph, J., Tan, S. and Tan, S. (2022) 'ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?', *Journal of Applied Learning and Teaching*, 6(1), pp. 342-363.
10. Sullivan, M., Kelly, A. and McLaughlan, P. (2021) 'ChatGPT in higher education: Considerations for academic integrity and student learning', *Journal of Applied Learning and Teaching*, 4(2), pp. 1-10.
11. Tondeur, J., Van Braak, J., Sang, G., Voogt, J., Fisser, P. and Ottenbreit-Leftwich, A. (2016) 'Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence', *Computers & Education*, 59(1), pp. 134-144.
12. Trust, T., Krutka, D.G. and Carpenter, J.P. (2016) 'Together we are better: Professional learning networks for teachers', *Computers & Education*, 102, pp. 15-34.


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