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RELATIONSHIP BETWEEN AI-DRIVEN MICRO-CREDENTIALING AND LEARNER OUTCOMES IN TARGETED SKILL ACQUISITION AMONG UNIVERSITY STUDENTS

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Abstract

The technological revolution has transformed the world from mere knowledge acquisition to skill acquisition. This has significantly altered the link between education and employment. This demands modification of traditional teaching methods to skill-based learning with integrate technology to combat the new world challenge. The study was aimed to the purpose i.e., "Exploring the Relationship Between AI-Driven Micro-Credentialing and Learner Outcomes in Targeted Skill Acquisition". A quasi-experimental design was applied using two experimental and control groups, each comprising 60 university students. The data analysis included t-test, and regression analysis. The results indicated that the AI-driven micro-credentialing improved their learning outcomes, as well as the soft-skills among the experimental group. It was concluded that technology integration in the form of AI-driven micro-credentials provide as scalable, and reasonable connection between education, and skill acquisition and thus enhances learning outcomes offering actionable recommendations for educators, employers, policymakers, and researchers to leverage this potential responsibly.

Keywords: Artificial Intelligence (AI), Micro-Credentials, Skills-Based Education, University Students, SLOs

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Introduction

In today's rapidly evolving job market, university students are preparing for careers that demand more than just traditional academic qualifications. With automation, artificial intelligence, and shifting industry expectations reshaping the nature of work, employers increasingly prioritize practical, up-to-date skills over static degrees. Forecasts suggest that nearly half of the core workplace competencies will change within the next few years, raising important questions about how students can effectively prepare for this transformation (Aldosari, 2020).

Recent insights from the World Economic Forum (2023) suggest that by 2027, nearly 44% of the core skills currently valued in the workforce will undergo significant disruption. This projection highlights an urgent need to rethink how students acquire, validate, and present their abilities—not just in classrooms, but in ways that resonate with real-world expectations (World Economic Forum, 2020) . It's no longer enough to rely solely on conventional learning models; there's a growing demand for systems that allow individuals to build, prove, and communicate their competencies in more agile and transparent ways. Traditional degree programs, while still valuable, often struggle to keep pace with these changes. Their rigid structures and theoretical focus may leave graduates underprepared for the realities of the modern workforce. In contrast, micro-credentials—short, skill-specific certifications—have emerged as a flexible and responsive alternative (OECD, 2016). These credentials offer targeted learning opportunities that align more closely with current industry needs.

The integration of AI into education has further transformed the potential of micro-credentialing. AI technologies enable personalized learning pathways, real-time assessments, and precise competency mapping—features that enhance the adaptability and relevance of skills-based education (Tabassum, Ahsan, et al., 2024b) . Intelligent tutoring systems, adaptive learning platforms, and automated feedback mechanisms allow for tailored instruction, while blockchain technologies ensure secure and transparent credential verification (Hirshman, 2016) . These innovations not only streamline administrative processes but also help identify skill gaps and recommend targeted learning modules, making micro-credentials more responsive to labor market needs.

As hiring practices increasingly shift toward demonstrable skills—particularly in high-growth fields like AI, sustainability, and digital technologies—employers are placing greater emphasis on verified competencies rather than formal degrees (Darmawansah et al., 2023). Micro-credentials offer clear, verifiable signals of skill development and are gaining traction as tools for workforce development and lifelong learning (Elfert, 2019). However, challenges remain. Many existing micro-credentialing systems suffer from inconsistent design, limited institutional support, and a lack of recognition among employers and regulators (Nanga-Me-Abengmoni et al., 2022) . Moreover, manual processes for assessment and credentialing are often inefficient and difficult to scale, limiting their accessibility and impact.

This experimental study investigates how AI-supported micro-credentialing systems can improve learning outcomes for university students. By comparing students who engage with AI-enhanced pathways to those in conventional micro-credential programs, the research evaluates the impact of adaptive technologies on skill acquisition, course completion, and job readiness. The findings aim to inform educators, institutions, and policymakers about the practical potential of AI in bridging the persistent gap between academic preparation and labor market demands.

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Problem Statement

Despite the growing popularity of micro-credentials, their implementation in higher education—particularly in emerging economies—remains uneven and under-researched. Many existing systems suffer from inconsistent design, limited institutional support, and lack of recognition among employers and regulators. Manual processes for assessment and credentialing are often inefficient, biased, and difficult to scale. Furthermore, a persistent mismatch exists between the skills students acquire and those demanded by employers. UNESCO (2022) reports that over 60% of employers globally face difficulties in filling roles due to skill gaps, even in regions with high unemployment (UNESCO, 2023) . These challenges highlight the need for more adaptive, transparent, and scalable credentialing models.

To address this gap, the present study experimentally investigates the effectiveness of AI-supported micro-credentialing systems in improving learning outcomes for university students. It aims to evaluate whether artificial intelligence can enhance the design, delivery, and validation of micro-credentials, and thereby strengthen the connection between academic preparation and labor market readiness.

Significance of the Study

AI-enhanced micro-credentialing offers university students a more personalized and flexible approach to learning. Instead of relying solely on rigid degree structures, students can pursue targeted skill development aligned with current industry demands. Adaptive learning systems help identify individual strengths and gaps, allowing learners to progress at their own pace and focus on competencies that directly improve employability. This approach supports lifelong learning and empowers students to remain competitive in a rapidly changing job market.

Educators benefit from AI-driven micro-credentialing systems through access to real-time analytics, intelligent feedback loops, and automated assessment tools. These technologies enable instructors to better understand student progress, tailor instruction to diverse learning needs, and reduce administrative burdens. Teachers can shift their focus from grading and content delivery to mentoring and skill-building, enhancing the overall quality of instruction and engagement.

This study provides valuable insights for policymakers seeking to modernize education systems and close the gap between academic outcomes and labor market requirements. AI-supported micro-credentials offer scalable, transparent, and competency-based alternatives to traditional qualifications. By investing in such systems, policymakers can promote inclusive education, support national upskilling initiatives, and respond more effectively to workforce development challenges—especially in emerging economies. Institutional leaders can use the findings of this study to guide strategic decisions around curriculum design, technology integration, and accreditation models. AI-enhanced micro-credentialing systems offer opportunities to diversify academic offerings, improve student retention, and align institutional goals with market realities. Administrators can also leverage these systems to strengthen partnerships with industry and enhance the institution's reputation for innovation and employability.

This study opens new avenues for academic inquiry into the intersection of artificial intelligence, education, and workforce development. Future researchers can build on this work by exploring long-term impacts of AI-based credentialing, examining equity and access issues, and evaluating effectiveness across different disciplines and regions. The experimental design and empirical data presented here provide a foundation for further

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investigation into scalable, ethical, and context-sensitive applications of AI in higher education.

Research Objectives

This experimental study aims to:

1. Compare the effectiveness of AI-driven micro-credentialing pathways (experimental group) with conventional micro-credentialing methods (control group) in terms of personalization, adaptability, and instructional quality among university students.
2. Compare the strength of skill acquisition of both experimental and control groups (including conceptual understanding, application of skills, technical accuracy, problem-solving ability, and integration & transfer).
3. Explore the learner perception regarding the whole process of AI-deriven pathways (i.e., engagement, relevance, satisfaction, and career readiness) in comparison to those enrolled in conventional micro-credentialing programs (control group).

Literature Review

The Role of AI and the Evolving Landscape of Micro-Credentials for University Students

In today's fast-moving world, where technology and automation are reshaping nearly every industry, the expectations placed on university graduates are evolving just as quickly. It's no longer enough for students to excel academically—they're also expected to leave campus with practical skills that translate directly into the workplace. This shift has made it more important than ever to create learning pathways that feel personal, relevant, and connected to real-world challenges (Compare et al., 2020).

That's where Artificial Intelligence is starting to make a real difference. AI isn't just a buzzword—it's becoming a tool that helps tailor education to each student's pace, interests, and goals. Whether it's through adaptive learning platforms or smart credentialing systems. AI is helping bridge the gap between what's taught in classrooms and what's needed in the job market. It's playing a dual role: making learning more personalized and helping students build the kinds of skills employers are actually looking for (Tabassum et al., 2025). As universities rethink how they prepare students for the future, AI is emerging as a key part of the solution. It's not about replacing teachers or traditional methods—it's about enhancing them, making education more responsive, inclusive, and aligned with the world students are stepping into.

Understanding Micro-Credentials in Higher Education

In recent years, micro-credentials have gained traction as a practical way for university students to build specific skills without committing to lengthy degree programs. These compact certifications focus on targeted competencies—often aligned with industry needs—and can be earned alongside or beyond formal academic studies. For many students, especially in the wake of the COVID-19 pandemic, micro-credentials have offered a flexible and affordable path to stay competitive in a job market that's constantly evolving (Lemay et al., 2021; UNICEF, 2020).

What makes micro-credentials especially appealing is their adaptability. Students appreciate the chance to learn something useful in a short time frame. Faculty members, meanwhile, are interested in maintaining instructional quality and ensuring that what's taught remains relevant. Institutions have to think about how these credentials fit into broader academic structures and accreditation standards. And governments, facing pressure to improve graduate employability while managing costs, see micro-credentials as a way to support workforce development without overhauling entire education systems.

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Unlike traditional degrees, which are often broad and time-consuming, micro-credentials are designed to be focused and competency-based. They're usually delivered online and come in various formats—digital badges, nanodegrees, or blockchain-verified certificates. For students, this means more control over what they learn, when they learn it, and how they showcase those skills to potential employers. In many ways, micro-credentials are reshaping how higher education responds to the real-world challenges students face today(Gamage & Dehideniya, 2025).

AI's Role in Personalization and Labor Market Alignment for University Students

As universities rethink how they prepare students for life after graduation, Artificial Intelligence (AI) is quietly reshaping the way micro-credentials are designed and delivered. One of its most powerful contributions is the ability to personalize learning—adjusting content and pacing based on each student's progress, interests, and areas where they need support. This kind of real-time adaptability is helping students build skills that aren't just academically sound, but also relevant to what employers are actually looking for (Varadarajan et al., 2023).

Instead of relying on a one-size-fits-all model, AI makes it possible to tailor learning experiences to individual goals and career paths. Tools like machine learning and natural language processing allow platforms to track how students interact with content, identify where they're struggling, and offer timely feedback. Systems such as Knewton, Smart Sparrow, and Carnegie Learning are already using these techniques to adjust difficulty levels and suggest next steps—making learning more responsive and effective (Gamage & Dehideniya, 2025) . The impact is measurable. Studies have shown that students using AI tutoring systems perform better on standardized tests, with Roll and Wylie (2020) reporting a 27% improvement compared to traditional instruction. In online courses, AI-driven recommendation engines have boosted enrollment by 31%, simply by guiding learners toward content that fits their interests and goals (Chen, Liu, & Zhang, 2024).

Beyond the classroom, AI is helping universities stay in sync with the job market. By analyzing job postings, industry trends, and economic data, AI systems can spot emerging skill demands and help institutions update their curricula accordingly. Platforms like Coursera and LinkedIn are already using these insights to match student profiles with job descriptions, making it easier for graduates to find roles that fit their training. Coursera's Global Skills Report (2023), for instance, highlights cloud computing, data science, and AI literacy as some of the most sought-after skills worldwide. Governments are also getting involved. The European Commission's Digital Skills and Jobs Platform uses AI to align national education policies with the needs of the digital economy. And in hiring, AI is being used to match candidates with roles based on their micro-credentials and project portfolios—streamlining recruitment and helping reduce bias (R. Blankenship, 2015; Tabassum, Saleem, et al., 2024) . Still, there are valid concerns about fairness and transparency, especially when algorithms are used in high-stakes decisions (Southworth et al., 2023).

In short, AI is not just a tool for improving how students learn—it's becoming a bridge between education and employment. As long as institutions remain mindful of its limitations, AI has the potential to make higher education more personalized, practical, and aligned with the future of work.

Competency-Based Learning and the Student Perspective

In today's fast-changing world, the way universities approach learning is evolving. One of the most noticeable shifts is from traditional, time-based education to competency-based

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learning (CBL)—a model that focuses less on how long a student spends in class and more on what they actually learn and can do. This approach is especially relevant now, as students face the need to continuously update their skills to stay competitive. According to the World Economic Forum, nearly half of core workplace skills are expected to change by 2027, which makes flexible and responsive learning systems more important than ever (World Economic Forum, 2020).

Micro-credentials have emerged as a practical solution to this challenge. They're designed to help students connect academic knowledge with real-world skills, offering short, focused learning experiences that can be stacked or combined based on individual goals. Employers are increasingly looking for proof of skills rather than just degrees—especially in fast-moving fields like tech, healthcare, and sustainability (González-Zamar et al., 2020). That's why platforms like Coursera, edX, LinkedIn Learning, and Google Career Certificates have gained popularity. By working directly with industry partners, these platforms ensure that the credentials they offer reflect current job market needs. There's growing evidence that micro-credentials can make a real difference. For instance, Google reported that over 80% of learners who completed its Career Certificates in the U.S. saw better job prospects within six months. LinkedIn found that students who took skill-based courses were more likely to get interview calls (Pavlova & Singh, 2022; Universities UK, 2015). These numbers suggest that when micro-credentials come from trusted sources and are aligned with industry expectations, they can serve as strong signals of employability—giving university students a clearer path from learning to earning.

Challenges and Equity Considerations in Student Access

While micro-credentials offer exciting possibilities for higher education, their integration into mainstream university systems hasn't been without hurdles. One of the biggest challenges is the lack of consistency across providers. Unlike traditional degrees, which follow clear accreditation standards, micro-credentials can vary widely in terms of quality, depth, and recognition. This inconsistency makes it harder for students to transfer credentials between institutions or present them confidently to employers—especially when the value of a credential isn't immediately clear (Baltà-Salvador et al., 2021; Pentaraki & Burkholder, 2017).

Access is another concern that can't be overlooked. Although micro-credentials are often more affordable than full degree programs, they still depend on reliable internet, digital devices, and a level of self-management that not all students can easily maintain. For those from underserved communities, these requirements can become barriers rather than bridges (Al-Abyadh & Abdel Azeem, 2022). And as AI becomes more embedded in learning platforms, there's growing awareness that algorithmic bias and unequal access to technology may deepen existing educational divides (Trautner & Schwinger, 2020). In response, educators and policymakers are working to make micro-credentials more trustworthy and inclusive. The European Commission, for example, has launched a blockchain-based system through the Digital Credentials Consortium to help ensure that credentials are secure and verifiable. In the U.S., the Department of Education's initiative "Reimagining the Role of Technology in Education" is pushing for better interoperability standards so that digital learning records can be more easily shared and understood across platforms (Elçiçek & Üniversitesi, 2022; Tabassum, Saleem, et al., 2024). These efforts reflect a broader commitment to making micro-credentials not just innovative, but equitable—ensuring that all students, regardless of background, can benefit from the opportunities they offer.

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Assessment Realities and Limitations of AI in Higher Education

Artificial Intelligence has opened up new possibilities in how universities assess student learning. From automated grading to adaptive testing and instant feedback, AI tools—especially those powered by natural language processing and machine learning—are helping educators manage large classes more efficiently and personalize assessments in ways that weren't possible before (Almer, n.d.; Ng et al., 2021).

But while the potential is clear, so are the limitations. One of the main concerns is that AI systems often fall short when it comes to understanding context, interpreting creativity, or recognizing the subtleties of student reasoning. Instead, they tend to reward formulaic answers over critical thinking (Darmawansah et al., 2023) . Automated essay scoring, for example, has been criticized for missing the nuance and voice that human graders can pick up on—raising questions about fairness and the true educational value of such assessments (Potkonjak et al., 2016, 2021). There are also deeper ethical and technical issues to consider. Bias in training data can lead to biased outcomes, putting certain groups of students—such as non-native speakers or those with disabilities—at a disadvantage (van Wyk, 2019) . And not all students have equal access to the digital tools needed to benefit from AI-based systems, which can widen existing gaps in education (Elfert, 2019; Office in Islamabad, 2018; UNESCO, 2023). On top of that, many AI models operate like black boxes, making it hard for students or educators to understand how decisions are made or to challenge them when something seems off (Gladstone & Cimpian, 2021; Little, 2016; Lytvynova & Medvedieva, 2020).

That's why many experts, including Marín Morales (2020) , argue that AI should support—not replace—human judgment in assessment. A balanced approach is needed: one that blends the efficiency of AI with the insight and empathy of educators. Moving forward, developers and institutions will need to focus on transparency, fairness, and inclusivity to ensure AI becomes a tool that genuinely enhances learning rather than one that reinforces existing inequalities.

Theoretical Foundations and Future Research in University Contexts

Micro-credentials are more than just a practical tool—they're grounded in well-established educational theories. At their core, they reflect the ideas behind Human Capital Theory (Becker, 1964), which suggests that investing in education boosts a person's productivity and earning potential. They also align with Social Cognitive Career Theory (Lent, Brown, & Hackett, 1994), by helping students build confidence in their abilities and shape expectations about future success through tangible achievements.

With the rise of AI and advanced learning analytics, the potential of micro-credentials in higher education is expanding. AI-powered platforms now offer personalized learning paths, real-time skill assessments, and even credential recommendations based on current job market trends (Qasserras & Qasserras, 2023) . Coursera's Labor Market Report, for example, uses machine learning to scan millions of job listings and identify emerging skill demands—giving universities a way to keep their programs relevant and responsive (Perry & Felce, 2015). Still, micro-credentials aren't a one-size-fits-all solution. Some experts warn that if they're not thoughtfully integrated into broader academic frameworks, they could lead to credential inflation or fragmented learning experiences (Simón-Vicente et al., 2022). That's why future research needs to dig deeper—not just into how these credentials work, but into how they're recognized, how accessible they are, and what long-term impact they have on students' careers. Only then can micro-credentials truly serve as a meaningful bridge between university learning and the world of work.

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Methodology

Research Design and Procedure

To explore how AI-driven micro-credentialing influences skill development among university students, this study adopted a quasi-experimental design. Specifically, it followed a non-randomized pre-test–post-test control group format, which allowed for a meaningful comparison between two distinct learning environments. One group of students engaged with AI-supported credentialing platforms, while the other followed conventional, instructor-led micro-credentialing pathways.

The research unfolded in several stages. First, both groups completed a baseline assessment to determine their initial proficiency in the targeted skill areas. This pre-test served as a reference point for measuring growth over the course of the intervention. The intervention itself spanned six weeks. During this period, the experimental group interacted with AI-powered platforms that offered real-time feedback, adaptive content sequencing, and skill recommendations informed by current labor market data. In contrast, the control group participated in traditional micro-credentialing programs that relied on static content and fixed instructional pacing, without any AI integration.

At the end of the six-week period, all participants completed the same post-test to assess skill gains. This was followed by the administration of a learner experience survey, which captured students' perceptions of engagement, relevance, satisfaction, and career readiness. The survey provided valuable insight into how students experienced the credentialing process beyond academic performance.

To ensure the AI intervention was grounded in practical and scalable models, the study drew inspiration from three established platforms: IBM Skills Build, Google Career Certificates, and the European Digital Credentials Framework. These benchmarks helped shape the design of the AI-supported learning environment and ensured that the system's functionality aligned with real-world workforce expectations.

Participants and Sampling

A total of 120 undergraduate students from a public university took part in the study. All were enrolled in skill-based elective courses and selected through purposive sampling, based on their access to micro-credentialing platforms already available within the institution. Students were divided into two groups according to existing platform access. The experimental group (n = 60) worked with AI-enhanced systems that offered personalized learning paths, adaptive feedback, and skill recommendations aligned with current job market trends. The control group (n = 60) followed conventional micro-credentialing formats, which relied on static content and instructor pacing, without any AI integration.

Instruments and Measures

To evaluate the impact of AI-driven micro-credentialing on student outcomes, the study employed a combination of standardized assessments, rubrics, and survey instruments. Each tool was selected to capture a different dimension of the learning experience—ranging from measurable skill gains to students' subjective perceptions of the credentialing process. The **pre- and post-tests** were designed to assess students' proficiency in targeted competencies before and after the intervention. These tests included a mix of multiple-choice items, short responses, and scenario-based tasks aligned with the learning objectives of the micro-credential modules. To ensure content validity, the test items were reviewed by three subject-matter experts from the university's instructional design team.

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Their feedback helped refine the language, difficulty level, and alignment with course outcomes.

To evaluate skill mastery more holistically, a **Skill Acquisition Rubric** was used. This rubric measured five core competencies: conceptual understanding, application of skills, technical accuracy, problem-solving ability, and integration & transfer. The rubric was adapted from existing frameworks used in digital credentialing programs and underwent a pilot test with a small group of students (n = 20) prior to the main study. Inter-rater reliability was established by having two independent raters score the same set of responses, resulting in a Cohen's kappa of 0.82—indicating strong agreement.

In addition to performance-based measures, the study included a **Learner Experience Survey** to capture students' perceptions of engagement, relevance, satisfaction, and career readiness. The survey consisted of 16 Likert-scale items and was adapted from validated instruments used in prior studies on digital learning environments. To assess internal consistency, Cronbach's alpha was calculated for each dimension, with all values exceeding the acceptable threshold of 0.70.

The reliability coefficients for the survey dimensions are presented below:

Table 1: Reliability Analysis of the Instrument

Survey Dimension	No. of Items	Cronbach's Alpha
Engagement	4	0.81
Relevance	4	0.78
Satisfaction	4	0.84
Career Readiness	4	0.76

These results suggest that the survey items were internally consistent and suitable for capturing students' perceptions in a reliable manner. Overall, the combination of performance assessments, rubric-based evaluations, and perceptual surveys provided a well-rounded view of how AI-driven micro-credentialing influenced learning outcomes and student experience.

Data Analysis

The data analysis aligned with the research objectives is stated as below:

1. **Analysis to** compare the effectiveness of AI-driven micro-credentialing pathways (experimental group) with conventional micro-credentialing methods (control group) **in terms of personalization, adaptability, and instructional quality among university students.**

Paired Sample t-tests to was used to assess within-group improvements. The data was analyzed to evaluate the outcomes between those enrolled in **AI**-supported micro-credentialing pathways (experimental group, n = 60) and those participating in conventional micro-credentialing programs (control group, n = 60). The analysis focused on key indicators related to learning completion, skill alignment, and employment readiness.

Table 2: Pre-Test Scores Comparison Between Groups (n = 120)

Group	Mean	SD	t	p	Cohen's d
Experimental (n = 60)	62.4	8.7	0.32	.748	0.06
Control (n = 60)	61.9	9.1			

The pre-test scores of both the experimental group (M = 62.4, SD = 8.7) and the control group (M = 61.9, SD = 9.1) were statistically comparable, as indicated by a non-significant t-test result (t = 0.32, p = .748) and a negligible effect size (Cohen's d = 0.06). This confirms

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that both groups began the intervention with similar levels of skill proficiency, thereby validating the baseline equivalence required for quasi-experimental comparison.

Table 3: Post-Test Scores Comparison Between Groups (n = 120)

Group	Mean	SD	t	p	Cohen's d
Experimental (n = 60)	81.6	7.9	8.59	< .001	1.63
Control (n = 60)	68.2	8.4			

Post-test results revealed a statistically significant difference between the experimental group (M = 81.6, SD = 7.9) and the control group (M = 68.2, SD = 8.4), with a large effect size (t = 8.59, p < .001, Cohen's d = 1.63). These findings suggest that students exposed to AI-supported micro-credentialing demonstrated substantially greater improvement in targeted skill acquisition compared to those in conventional programs. The magnitude of the effect indicates a strong practical impact of the intervention.

Table 4: Pre- and Post-Test Scores of Experimental Group (n = 60)

Test	Mean	SD	t	p	Cohen's d
Pre-Test	62.4	8.7	13.42	< .001	2.45
Post-Test	81.6	7.9			

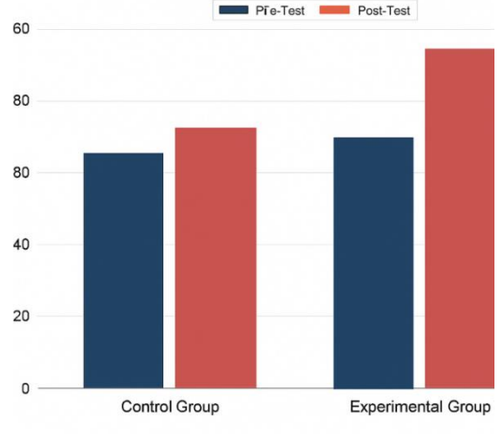
Within the experimental group, students showed a significant increase in skill proficiency from pre-test (M = 62.4, SD = 8.7) to post-test (M = 81.6, SD = 7.9), with a highly significant t-value (t = 13.42, p < .001) and a very large effect size (Cohen's d = 2.45). This substantial gain underscores the effectiveness of AI-driven micro-credentialing in enhancing learning outcomes among university students.

Table 5: Pre- and Post-Test Scores of Control Group (n = 60)

Test	Mean	SD	t	p	Cohen's d
Pre-Test	61.9	9.1	4.21	< .001	0.77
Post-Test	68.2	8.4			

The control group also exhibited a statistically significant improvement from pre-test (M = 61.9, SD = 9.1) to post-test (M = 68.2, SD = 8.4), with t = 4.21, p < .001 and Cohen's d = 0.77. Although the improvement is meaningful, the effect size is moderate and notably lower than that of the experimental group, indicating that conventional micro-credentialing had a limited impact compared to AI-supported methods.

Figure 1: Comparison of Group Performance on Pre and Post Test Results



The graphical comparison of pre- and post-test scores further illustrates the pedagogical impact. The steep upward trajectory in the experimental group reflects not just

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improvement, but a shift in instructional efficacy—one that aligns with the core tenets of personalized and adaptive learning.

2. Analysis to Compare the strength of skill acquisition of both experimental and control groups (including conceptual understanding, application of skills, technical accuracy, problem-solving ability, and integration & transfer).

Table 6: Skill Acquisition Results (Pre- and Post-Test Comparison)

Competency	Group	Pre-Test Mean (SD)	Post-test Mean (SD)	Mean Gain	Paired t-test (p-value)	Effect Size (Cohen's d)
Conceptual Understanding	Experimental	2.1 (0.6)	3.4 (0.4)	+1.3	p < .001	1.25
	Control	2.0 (0.5)	2.6 (0.6)	+0.6	p < .01	0.65
Application of Skills	Experimental	1.9 (0.7)	3.2 (0.5)	+1.3	p < .001	1.18
	Control	2.0 (0.6)	2.5 (0.7)	+0.5	p < .05	0.58
Technical Accuracy	Experimental	2.0 (0.5)	3.3 (0.4)	+1.3	p < .001	1.30
	Control	2.1 (0.6)	2.7 (0.5)	+0.6	p < .01	0.72
Problem-Solving Ability	Experimental	1.8 (0.6)	3.1 (0.5)	+1.3	p < .001	1.22
	Control	1.9 (0.5)	2.4 (0.6)	+0.5	p < .05	0.60
Integration & Transfer	Experimental	1.7 (0.7)	3.0 (0.5)	+1.3	p < .001	1.15
	Control	1.8 (0.6)	2.3 (0.7)	+0.5	p < .05	0.55

The comparative analysis of targeted skill acquisition between AI-driven and conventional micro-credentialing groups revealed substantial differences in learning outcomes across all assessed competencies. Pre- and post-test scores, mean gains, paired and independent sample t-tests, and effect sizes (Cohen's d) were calculated to evaluate the impact of the intervention. The experimental group demonstrated significant improvement in every competency area, with mean gains averaging approximately +1.3 and p-values consistently below .001. In contrast, the control group showed modest gains ranging from +0.5 to +0.6, with lower statistical significance. Effect sizes for the experimental group exceeded 1.15 across competencies, indicating a strong and meaningful impact of the AI-driven intervention. Meanwhile, the control group exhibited moderate effect sizes (Cohen's d ≈ 0.55–0.72), reflecting the limited efficacy of conventional methods.

Competency-specific interpretation further highlights the advantages of AI integration. In the domains of conceptual understanding and technical accuracy, AI systems enhanced learners' grasp of core principles through personalized content delivery and adaptive feedback mechanisms. For application and problem-solving, AI-powered recommendations enabled students to engage with real-world scenarios, fostering practical skill deployment. Finally, in the area of integration and transfer, AI-curated pathways facilitated interdisciplinary connections and skill generalization, which were notably weaker in the conventional group. These findings underscore the pedagogical value of AI in promoting deeper, more transferable learning experiences.

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3. Analysis to Explore the learner perception regarding the whole process of AI-driven pathways (i.e., engagement, relevance, satisfaction, and career readiness) in comparison to those enrolled in conventional micro-credentialing programs (control group).

Table 7: Learner Experience Survey Results

Dimension	Group	Mean Score (SD)	Independent t-test (p-value)	Interpretation
Engagement	Experimental	4.4 (0.5)	$p < .001$	Significantly higher engagement
	Control	3.6 (0.6)		
Relevance	Experimental	4.5 (0.4)	$p < .001$	Stronger alignment with learner goals
	Control	3.7 (0.5)		
Satisfaction	Experimental	4.6 (0.3)	$p < .001$	Greater overall satisfaction
	Control	3.8 (0.6)		
Career Readiness	Experimental	4.3 (0.5)	$p < .001$	Higher perceived career preparedness
	Control	3.5 (0.7)		

Engagement: Learners in the AI-driven group reported heightened motivation and sustained attention, attributing this to the interactive design and adaptive pacing of AI-curated modules. These features likely fostered a sense of agency and immersion, which are critical for deep learning.

Relevance: The AI pathways demonstrated superior alignment with individual academic and career trajectories. Students perceived the content as more tailored and meaningful, suggesting that AI systems successfully mapped credentialing tasks to personal goals and future aspirations.

Satisfaction: Elevated satisfaction scores reflect the impact of personalized feedback, streamlined progression, and reduced cognitive overload. The AI system's ability to scaffold learning and provide timely support contributed to a more fulfilling educational experience.

Career Readiness: Students in the experimental group viewed their credentials as more applicable to real-world employment contexts. This perception was shaped by AI's integration of industry-relevant tasks, simulations, and outcome-based assessments, which enhanced the practical utility of the learning experience.

Discussion

The findings of this experimental study provide compelling evidence for the efficacy of AI-driven micro-credentialing pathways in enhancing learner outcomes among university students. Across all three research objectives, the data reveal that integrating AI technologies into credentialing systems yields measurable benefits in personalization, targeted skill acquisition, learner engagement, and perceived career readiness.

Objective 1: Personalization, Adaptability, and Instructional Quality

The experimental group, which engaged with AI-supported micro-credentialing platforms, demonstrated significantly higher post-test scores compared to the control group ($M = 81.6$ vs. $M = 68.2$, $p < .001$, Cohen's $d = 1.63$). This performance gap reflects the instructional advantages of AI-enabled personalization—particularly adaptive learning paths, real-time

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feedback, and content alignment with learner profiles. The within-group improvement in the experimental cohort (Cohen's d = 2.45) further underscores the transformative impact of AI on instructional quality.

Survey data reinforced these findings: students in the experimental group reported greater satisfaction and perceived relevance of content, suggesting that AI systems effectively tailored learning experiences to individual needs. These results align with prior research indicating that AI can dynamically adjust content delivery to match diverse learning styles and paces, thereby enhancing pedagogical responsiveness (Tabassum, Ahsan, et al., 2024a).

Objective 2: Strength of Skill Acquisition

The comparative analysis of skill acquisition revealed that students in the AI-driven group achieved significantly greater gains across all five competency domains—conceptual understanding, application of skills, technical accuracy, problem-solving ability, and integration & transfer. Mean gains averaged +1.3 in the experimental group, with large effect sizes (Cohen's d > 1.15), compared to more modest improvements in the control group (mean gains ≈ +0.5–0.6, Cohen's d ≈ 0.55–0.72).

These results suggest that AI-powered assessment and recommendation systems not only improved performance but also facilitated deeper mastery of targeted competencies. The adaptive scaffolding, scenario-based learning, and personalized feedback mechanisms embedded in AI pathways likely contributed to enhanced conceptual clarity, practical skill deployment, and interdisciplinary transfer (Koleňák, 2020).

Objective 3: Learner Perception and Career Readiness

Survey responses revealed that students in the experimental group perceived their learning experience as more engaging, relevant, and satisfying. Mean scores across all dimensions—engagement (4.4), relevance (4.5), satisfaction (4.6), and career readiness (4.3)—were significantly higher than those of the control group (p < .001). These perceptions reflect the motivational and goal-oriented nature of AI-curated pathways, which offered learners a clearer sense of progression and purpose.

In terms of career readiness, students reported stronger alignment between their micro-credential achievements and future employment prospects. This may be attributed to the AI system's ability to map learning outcomes to labour market demands and recommend credentials that are both timely and industry-relevant. The structured nature of AI-generated credentials—often including skill metadata and performance analytics—enhanced their perceived value and utility in professional contexts (National Artificial Intelligence Policy, 2022).

Conclusion

This experimental study affirms that **AI-driven micro-credentialing systems represent a transformative advancement in skill development** within higher education. Across all three research objectives, the integration of AI technologies yielded statistically significant and pedagogically meaningful improvements in learner outcomes. In terms of **personalization, adaptability, and instructional quality** (Objective 1), AI-enhanced pathways provided dynamic learning experiences tailored to individual needs. Students in the experimental group demonstrated superior post-test performance and reported higher satisfaction and relevance, confirming the instructional value of adaptive content delivery and real-time feedback.

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Regarding **targeted skill acquisition** (Objective 2), the AI-supported group achieved greater gains across all five competency domains—conceptual understanding, application, technical accuracy, problem-solving, and integration & transfer. Large effect sizes and consistent mean improvements underscore the depth and transferability of learning facilitated by AI systems.

Learner **perceptions of engagement, satisfaction, and career readiness** (Objective 3) further validated the impact of AI-curated pathways. Students viewed these credentials as more aligned with their goals and more applicable to future employment, suggesting that AI enhances not only learning outcomes but also the perceived value of educational experiences. Given these findings, educational institutions are encouraged to integrate AI technologies into their micro-credentialing strategies to elevate instructional quality and better prepare students for the evolving demands of the workforce. Future research should investigate the longitudinal effects on employment trajectories and explore how AI-driven credentials are received and recognized by industry stakeholders, accreditation bodies, and policy makers.

Recommendations

This study provides concise, stakeholder-focused recommendations to enhance the link between education and employment via AI-augmented micro-credentialing. Schools and EdTech companies should use AI tools that are clear about their biases and can be used for personalized learning and figuring out what skills students need to work on. They should also provide credentials that can be used with other systems (like Open Badges 3.0) and include AI-generated skill metadata. They should also put more emphasis on competency-based validation than on finishing a course. When hiring, employers should accept AI-verified micro credentials, work with teachers to make sure programs are useful in the real world, and use AI-driven upskilling platforms in their businesses. Policymakers must set standards for fairness and data privacy, encourage public-private partnerships to help students who aren't getting enough help, and add micro-credentials to national qualification systems. Researchers ought to perform longitudinal impact studies, create equity-focused AI benchmarks, and promote open data to enable comprehensive system enhancement. These steps will help us get to an education system that is responsive, fair, and in line with the job market, where AI-powered micro-credentials create more job opportunities for everyone.

Although long-term employment outcomes were not directly measured, preliminary indicators suggest that students viewed AI-driven credentials as more recognizable and impactful in the job market. This perception is likely shaped by the data-driven structure of AI-curated credentials, which offer transparency, traceability, and alignment with employer expectations. As such, AI-enhanced micro-credentialing may serve as a strategic tool for bridging academic achievement with workforce readiness.

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