2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #50712

From Theory to Practice: Revamping a Graduate Neural Networks Course through Experiential and Industry-Aligned Learning

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Abstract - *An Introduction to Applied Neural Networks*, first introduced at the University of Houston in the 1990s, was the first graduate-level course in artificial intelligence (AI) within the Engineering Technology curriculum. Although the course content has been periodically updated, the rapid advancement of AI and machine learning (ML) in recent years necessitated a comprehensive redesign to align with current technologies and industry practices. Supported by a University of Houston Teaching Innovation Program (TIP - 2025) grant, the course has been revitalized by incorporating the latest advanced topics including Generative AI, Reinforcement Learning, Transformers, Convolutional Neural Networks, and Deep Learning - while embedding experiential learning throughout the course. The redesigned graduate-level neural networks course integrates industry-standard tools, including Amazon Web Services (AWS) and NVIDIA Deep Learning Institute (DLI) lab kits, to support authentic, data-driven project work. A hybrid delivery model combines in-person instruction with both asynchronous and synchronous online laboratory sessions, enhancing accessibility, collaboration, and instructional flexibility. Preliminary implementation of selected AWS and NVIDIA modules in Spring 2025 yielded positive student feedback and descriptive gains in self-reported familiarity with key AI concepts and tools. Full implementation in Fall 2025 expanded these efforts through project-based laboratories and real-world examples using MATLAB and Python, leveraging AWS and NVIDIA resources throughout the semester. Course learning outcomes were evaluated using a combination of student surveys and performance indicators aligned with course objectives. The findings suggest increased student-reported confidence and perceived understanding of industry-relevant AI competencies. The redesigned curriculum provides a practical framework for integrating experiential, industry-aligned tools into AI courses and engineering education.

2. Introduction

Artificial intelligence (AI) and machine learning (ML) have rapidly transformed engineering practice, creating an urgent need for curricula that move beyond foundational theory toward applied, industry-relevant competencies. Employers increasingly expect graduates to demonstrate not only conceptual understanding of neural networks but also practical experience with cloud-based platforms, GPU-accelerated computing, and modern deep learning workflows. Recent developments associated with Industry 4.0 and Education 5.0 emphasize the integration of intelligent technologies and human-centered innovation within modern educational systems [1-2]. The primary contribution of this work is a practice-oriented course redesign framework that aligns advanced AI theory with experiential and industry-aligned learning activities. Rather than claiming causal improvements in learning outcomes, this paper documents the pedagogical design, implementation strategy, and preliminary evaluation of the redesigned course using student self-assessment data. The goal is to provide insights for engineering educators seeking to modernize AI curricula while balancing theoretical foundations, hands-on experience, and workforce relevance. The redesigned course was implemented during **Fall 2025** as a graduate-level elective in the Engineering Technology program. The evaluation cohort consisted of **26 enrolled students** representing diverse academic and professional backgrounds.

3. Literature Review

Recent studies have also examined how emerging technological paradigms such as **Education 4.0 and Education 5.0** are reshaping teaching and learning environments in higher education [3-4]. These frameworks emphasize the integration of intelligent technologies, human-centered learning approaches, and digital platforms to better align educational outcomes with evolving workforce needs [5-8]. In particular, AI-supported teaching models and adaptive learning systems have been proposed as mechanisms for enhancing student engagement and enabling more personalized learning experiences in technology-focused disciplines.

Recent work in engineering education research has begun to systematically examine the integration of artificial intelligence (AI) into engineering curricula and instructional practice [9]. A work-in-progress systematic review of AI tools in engineering education highlights how AI-enhanced active learning environments can increase student engagement and conceptual understanding while identifying barriers related to faculty preparedness and resource access. Similarly, broader systematic reviews document how adaptive learning platforms, intelligent tutoring systems, and other AI applications are being implemented to personalize learning pathways and improve educational experiences in engineering contexts [10]. Complementary content analyses of the literature emphasize the evolving nature of AI use in engineering education and call for further research on both theoretical and practical impacts of AI integration [11]. In addition, domain-specific studies explore opportunities and challenges associated with AI curricular design, including its potential to support real-time feedback, simulation engagement, and workforce readiness while also highlighting ethical and equity considerations that must be addressed for sustainable implementation [12]. These studies provide an emerging foundation for understanding how AI competencies are being embedded in engineering programs and help situate the current course redesign within an evolving scholarship on AI-supported engineering education.

To conceptually frame the progression of learning outcomes in the redesigned course, a flowchart was developed based on **Bloom's Revised Taxonomy** [13-14], as shown in **Figure 1**.

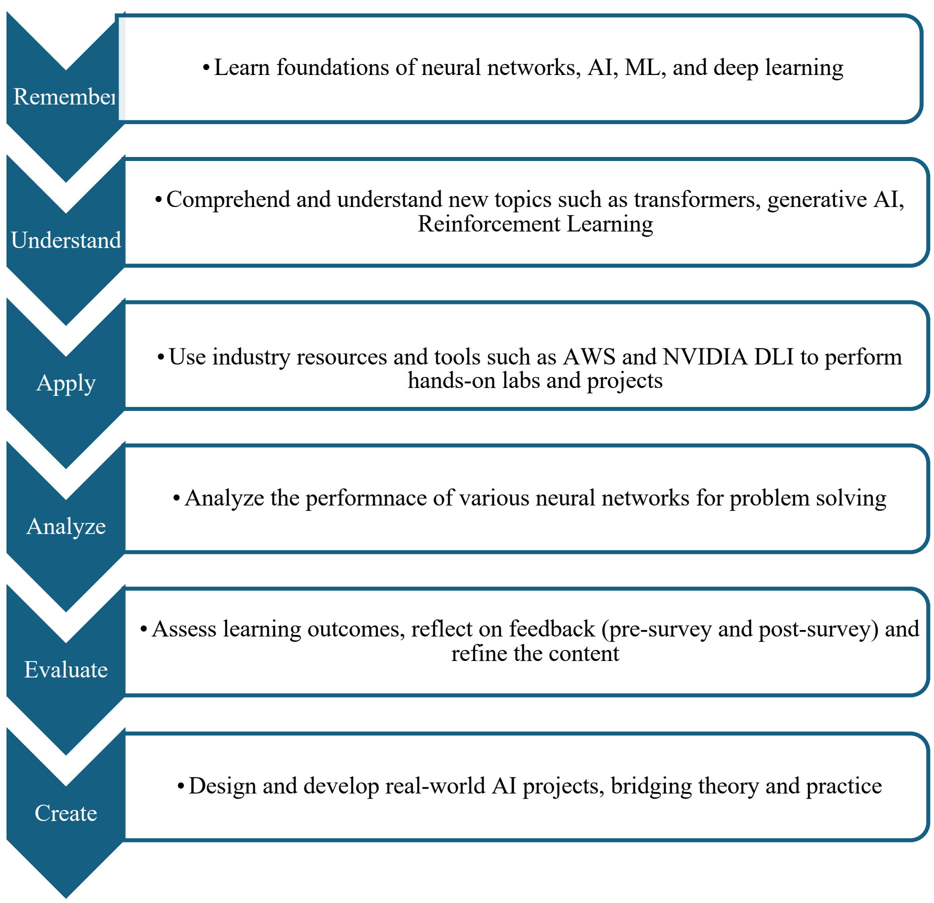

Figure 1. Mapping Course Redesign to Bloom's Revised Taxonomy.

This visualization maps the cognitive development embedded within the course - from foundational understanding of neural network principles to the creation of complex AI applications. Each stage of Bloom's hierarchy represents a corresponding phase of learning: students begin by *remembering* and *understanding* core AI concepts, then *apply* and *analyze* them through hands-on use of AWS and NVIDIA DLI environments. In advanced modules, they *evaluate* model performance and *create* original AI-driven solutions through project-based learning. The flowchart not only illustrates the pedagogical logic underlying the redesign but also demonstrates how the course intentionally guides students toward higher-order thinking, creativity, and innovation core competencies for success in AI-driven engineering applications.

4. Motivation

The motivation for the redesign of *Applied Neural Networks* stems from the unprecedented pace of advancement in artificial intelligence (AI) and machine learning (ML). Since the course's inception in the 1990s, the AI landscape has evolved from rule-based systems and simple perceptrons to large-scale deep learning architectures and generative AI models capable of complex reasoning, creativity, and automation. These developments have fundamentally transformed the expectations of both industry and academia regarding the skills graduates must possess to remain competitive in an AI-driven workforce.

Recent breakthroughs—such as generative AI, transformers, reinforcement learning from human feedback, and multimodal AI systems—have reshaped how engineers design, train, and deploy intelligent models. To ensure that students gain direct exposure to these technologies, the redesigned course incorporates **cutting-edge topics** including *Generative AI*, *Reinforcement Learning*, and *Advanced Deep Learning*. These subjects represent not only theoretical milestones but also practical competencies that define the capabilities of modern AI professionals.

Equally important is the integration of **industry-standard tools** that mirror professional environments. Partnerships with **Amazon Web Services (AWS)** and **NVIDIA Deep Learning Institute (DLI)** were established to embed experiential learning within cloud-based and GPU-accelerated ecosystems. Through AWS cloud resources, students engage with scalable data pipelines and deployment frameworks, while NVIDIA DLI modules provide access to high-performance computing and deep learning optimization environments. This alignment ensures that students' learning experiences are authentic, industry-relevant, and directly transferable to real-world applications.

By combining the advanced AI content with professional-grade platforms, the course bridges the gap between academic learning and industrial practice. The motivation is not merely to update course materials but to **redefine the educational experience -** preparing students to design, evaluate, and innovate within a rapidly evolving AI landscape where adaptability, creativity, and technical fluency are critical to success.

5. Course Redesign and Implementation

The redesign of the course was driven by the dual goal of integrating emerging AI technologies and embedding experiential learning across the curriculum. Guided by Kolb's Experiential Learning Cycle, students progress through iterative phases of concrete experience, reflective observation, abstract conceptualization, and active experimentation to reinforce both theoretical understanding and practical application [10]. Each module is designed to move learners from theoretical understanding toward applied, hands-on practice using **industry-standard AI platforms**.

The revised course, launching in **Fall 2025**, incorporates modules from **Amazon Web Services (AWS)** and the **NVIDIA Deep Learning Institute (DLI)** to ensure that students gain real-world, technical fluency with tools widely adopted across the AI industry. These modules complement the core theoretical lectures on neural network architectures, optimization algorithms, and advanced deep learning frameworks. Students apply these theories directly within structured, cloud-based and GPU-accelerated environments, bridging conceptual knowledge with authentic problem-solving experiences. In addition, after presenting each neural network algorithm, a real-world example is introduced using either Python or MATLAB to demonstrate network performance and illustrate how changes in model parameters affect outcomes.

The evaluation cohort consisted of **26 students enrolled in the course during Fall 2025**, representing diverse academic and professional backgrounds. To assess perceived learning gains, a pre-course and post-course self-assessment survey was administered during the first and final weeks of the semester. The instrument was developed by the instructor to align directly with the stated course learning outcomes and major content areas, including neural network fundamentals, deep learning architectures, reinforcement learning, cloud-based machine learning (AWS), and GPU-accelerated development (NVIDIA tools). Students rated their level of understanding for each topic using a **five-point Likert scale** (1 = very low familiarity, 5 = very high familiarity). Participation in the survey was voluntary and anonymous, and responses were used for course improvement and program assessment purposes.

Data analysis focused on **descriptive statistics**, including calculation of mean pre-course and post-course scores and percentage improvement for each topic area. Given the relatively small sample size (n = 26) and the exploratory nature of this course redesign study, no inferential statistical tests were conducted. The findings therefore reflect descriptive trends in student self-reported confidence and understanding rather than statistically validated causal effects. Although the instrument was not externally validated, items were reviewed for clarity and alignment with course objectives prior to administration. The survey was used for formative evaluation and program improvement rather than high-stakes assessment.

6. Revision of ELET 6303 based on AWS and NVIDIA modules

A. AWS- Machine Learning Foundations Modules

> ***Module 1:*** **Introduction to Machine Learning** – introduces core ML principles, supervised and unsupervised algorithms, and evaluation metrics, reinforcing conceptual understanding.
> ***Module 2:*** **Implementing a Machine Learning Pipeline with Amazon SageMaker -** provides an experiential application of the full ML workflow, including data preprocessing, model training, and deployment in AWS environments.
> ***Module 3:*** **Introducing Computer Vision –** explores convolutional neural networks (CNNs) and visual recognition techniques using real-world image datasets.
> ***Module 4:*** **Introducing Generative AI –** presents an overview of generative models and prompts critical reflection on the ethical implications of AI-generated content.

B. NVIDIA Deep Learning Institute (DLI) Modules

> ***Module 1: Introduction to Transformer-Based Natural Language Processing (NLP)*** – familiarizes students with transformer architectures, attention mechanisms, and fine-tuning pre-trained models.
> ***Module 2: Generative AI Explained –*** offers a conceptual and hands-on understanding of generative model development, focusing on diffusion models and Large Language Models (LLM) fundamentals.
> ***Module 3: Fundamentals of Deep Learning –*** consolidates core deep learning principles, emphasizing GPU acceleration, backpropagation, and neural architecture optimization.

Each module concludes with a **reflective lab report or project**, encouraging students to analyze outcomes, troubleshoot models, and evaluate performance - embodying the “analyze” and “evaluate” stages of **Bloom’s Revised Taxonomy**. By the end of the term, students complete a **final project** that synthesizes their learning across theory and applications, demonstrating their ability to design, implement, and present AI-driven solutions.

7. Pre-Survey and Post-Survey Results

To establish a baseline of student preparedness and perceptions during the first week of **Fall 2025**, a pre-course survey was conducted. The survey assessed students' prior experience with neural networks, artificial intelligence (AI), and machine learning (ML), familiarity with relevant tools and frameworks, and their self-rated understanding of core topics. The pre- and post-course self-assessment results indicate notable increases in students' reported familiarity across all artificial intelligence and machine learning topics covered in the course. Prior to instruction, students reported only moderate familiarity with foundational concepts such as AI applications, supervised versus unsupervised learning, and artificial neural networks. More specialized areas—particularly cloud-based machine learning (AWS, Amazon SageMaker), NVIDIA tools, reinforcement learning, and deep learning frameworks—showed the lowest levels of initial familiarity. Most students enrolled in the course were majoring in the Engineering Data Science program and had previously completed one or two courses related to machine learning and artificial intelligence, providing a foundational background in the subject area.

Following completion of the course, all topics demonstrated improvement, with post-course ratings generally ranging between **4.0 and 5.0 on a five-point scale**. The largest relative increases occurred in areas where students initially reported limited experience, including Amazon SageMaker, NVIDIA tools, AWS fundamentals, and reinforcement learning. Improvements were also observed in core machine learning concepts such as convolutional and recurrent neural networks. Overall, the results suggest that integrating industry platforms may support student engagement and perceived understanding of both foundational and applied AI topics. The detailed pre- and post-course results are summarized in **Table 1**. The findings support the course's emphasis on **experiential learning**, **constructivist engagement** [15-16], and **Bloom's higher-order cognitive development**.

Table 1. Summary of Pre- and Post Course Student Self-Assessment of AI, AWS, and NVIDIA Topics

Topic Area	Pre Avg.	Post Avg.	Change	% Change
AI Applications	3.2	4.7	+1.5	**46.9%**
Supervised vs. Unsupervised Learning	3.0	4.5	+1.5	**50.0%**
Artificial Neural Networks	3.3	4.6	+1.3	**39.4%**
CNNs	2.8	4.4	+1.6	**57.1%**
RNNs	2.1	3.8	+1.7	**81.0%**
Deep Learning Frameworks	2.5	4.3	+1.8	**72.0%**
AWS Fundamentals	1.8	4.0	+2.2	**122.2%**
Amazon SageMaker	1.6	4.0	+2.4	**150.0%**
NVIDIA Tools	1.4	3.9	+2.5	**178.6%**
Reinforcement Learning	1.5	3.6	+2.1	**140.0%**
SVMs	2.3	4.1	+1.8	**78.3%**

8. Limitations and Future Work

This study has several limitations. The evaluation relied primarily on students' self-reported perceptions of familiarity and confidence, rather than objective performance measures such as exam scores or rubric-based project assessments. In addition, the survey instrument was developed for course feedback purposes and was not formally validated through psychometric analysis. The study was also based on a single cohort of 26 students, and the analysis was limited to descriptive statistics without inferential testing.

Future work will strengthen the evaluation of the redesigned course. The current semester includes 48 students, providing a larger dataset for analysis. With this expanded cohort, future studies will incorporate inferential statistical methods (e.g., paired t-tests) and additional objective learning measures such as assignment and project performance to more rigorously evaluate student learning outcomes.

9. Conclusions

This paper presented the redesign of a graduate-level neural networks course that integrates **experiential learning and industry-aligned tools**, including AWS and NVIDIA resources. The redesigned curriculum combines theoretical instruction with hands-on laboratory experiences to better align AI education with contemporary industry practices. Pre- and post-course survey results indicate **descriptive increases in students' self-reported familiarity and confidence** across key artificial intelligence and machine learning topics, particularly in areas related to cloud-based and GPU-accelerated development. These results suggest that integrating industry platforms and experiential learning activities can support student engagement and exposure to modern AI workflows. As discussed in Section 8, the findings are based primarily on student perception data and descriptive analysis. Nevertheless, the redesigned course provides a **practical model for integrating emerging AI technologies and industry tools into engineering education**, helping prepare students for the evolving demands of the AI workforce.

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