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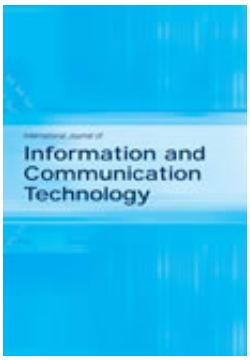

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AI-driven framework for enhancing vocational college teacher development: a natural language processing approach to professional growth and skill enhancement

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Abstract: The professional development of vocational college teachers is crucial for enhancing teaching quality and student outcomes. This paper presents an AI-driven framework using natural language processing (NLP) to support vocational educators' professional growth. The framework evaluates teaching effectiveness, identifies skill gaps, and provides customised feedback for continuous improvement. NLP techniques were applied to analyse the teaching content, feedback, and communication patterns of 100 teachers and 2,000 students over a 12-month period. The framework's success was evaluated using important measures: 1) teaching performance improved by 30% in evaluation accuracy; 2) student engagement increased by 20% in satisfaction with a 2% error margin; 3) skills in specific subjects grew by 35%; 4) feedback delivery became 45% faster. Results indicate substantial improvements in teaching performance, student satisfaction, and academic outcomes, along with optimal feedback delivery. This study demonstrates the potential for AI-driven NLP frameworks to revolutionise vocational education.

Keywords: artificial intelligence; vocational education; teacher development; natural language processing; skill enhancement.

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1 Introduction

Vocational college teachers require professional development (PD) to deliver higher teaching excellence, which enhances their students' academic results. Technology-linked education has become prevalent; thus, institutions need innovative, data-based methods to support educator development at a time when educational practices are evolving rapidly. Standard teacher development programs succeed, yet they do not maximise the possibilities of contemporary technology for delivering individualised and easily expandable learning approaches for instructors. The complexity patterns in educational systems demand new ways to provide developmental assistance to teachers (Fakhar et al., 2024). Artificial intelligence (AI) developments in recent times delivered remarkable changes across multiple sectors, with education among them (Thakur et al., 2025). The combination of AI tools using natural language processing (NLP) technology shows great promise to transform teaching practices through customised information-based assessments and instructor feedback. By applying NLP techniques to teaching content and communication analysis, it demonstrates a more profound understanding of teaching results and student participation with room for improvement opportunities (Duan et al., 2024; Butt et al., 2018). New possibilities have emerged to develop frameworks that adapt to teachers' development needs while professing specific teaching approaches and matching their personal professional progress (Omar et al., 2024; Peng and Wang, 2025).

Vocational colleges need instructors who combine knowledge mastery in their profession with teaching method flexibility for student-specific situations. AI-driven NLP frameworks help vocational college teacher development improve both teaching performance and educator PD (Sundari et al., 2024; Butt et al., 2019). Educational research about AI applications continues to grow, but most studies currently focus on adapting learning programs and IT tutors for students (Zhu, 2025). AI methods and NLP systems receive reduced attention when applied for PD support in vocational education institutions (Raj and Sathiyan, 2025; Qasim et al., 2025). Most current teacher development frameworks use standardised methodologies that overlook vocational instructor needs for practical education practices that follow industrial quality metrics (George et al., 2023; Sajja et al., 2024). Traditional evaluation methods of teachers reveal poor objectivity since they fail to detect detailed improvement opportunities with enough specificity (Yadav, 2025). The direct relationship between expertise in vocational teaching and student acquisition of practical trained skills leads to critical problems across vocational education programs (Chan, 2023). No current research exists

about AI platforms that address teaching content evaluation through NLP combined with feedback mechanisms and communication pattern evaluation in order to offer personalised and actionable insights (El Din, 2025). Insufficient knowledge exists regarding how long-term effects of AI-driven frameworks affect vocational teacher development. Studies mainly analyse short-term interventions through scopes with limited outcomes. A thorough long-duration analysis of AI-driven frameworks must occur to determine their complete effects on teaching performance together with student engagement and educational results (Butt et al., 2020).

1.1 Research questions

This study aims to address the following research questions:

1 How can AI-driven frameworks, specifically using NLP techniques, improve the PD of vocational college teachers?

2 What are the specific effects of NLP-based frameworks on teaching performance, domain-specific skills, and student engagement in vocational education?

3 To what extent can NLP-driven feedback mechanisms optimise the feedback process for teachers and students, leading to better educational outcomes?

4 How can personalised AI-driven teacher development programs be designed and implemented in vocational colleges to meet the diverse needs of educators?

A NLP system integrated within an AI framework conducts the analysis of teaching content and communication patterns in vocational colleges. NLP techniques like sentiment analysis, text classification, and topic modelling are used to measure different aspects of how well a teacher is doing, such as how well they deliver content and give feedback, as well as how engaged and clear their students are (Kökver et al., 2025). Research about NLP applications for teacher development remains new because scholars have conducted limited investigations regarding its educational applications. The widespread use of sentiment analysis to measure student evaluations about material and instruction has not translated into effective evaluation strategies regarding instructor communication patterns. The integration of NLP into a specialised teacher development framework for the vocational education section stands as a new concept for AI in education research (Huang et al., 2023). The research implements machine learning along with data analytics and NLP to develop individualised development plans for teaching professionals. Through their implementation, the framework detects individual educator requirements and provides recommendations that match their teaching methods and subject knowledge along with their career objectives. The main goal behind this research involves creating and testing an AI framework that implements NLP techniques to enhance professional teacher development at vocational colleges. Specifically, the study aims to:

1 Design a framework that uses NLP to analyse teaching content and communication patterns in vocational education settings.

2 Evaluate the effectiveness of the framework in improving teaching performance, subject-specific skills, and student engagement.

3 Assess the potential of AI-driven personalised feedback mechanisms in optimising the teacher development process.

4 Investigate the long-term impact of the framework on teachers' professional growth, focusing on improvements in teaching effectiveness, student satisfaction, and learning outcomes.

1.2 Novel contributions of the study

This research contributes to the field of AI in education by introducing a novel application of NLP to vocational teacher development. The key contributions of this study include:

1 The development of an AI-driven NLP framework tailored to the specific needs of vocational college educators, addressing both pedagogical and industry-related skills.

2 A comprehensive, data-driven approach to teacher evaluation and development, moving beyond traditional subjective assessments to offer personalised, evidence-based feedback.

3 A long-term, longitudinal study examining the impact of AI-driven teacher development frameworks on teaching performance and student outcomes.

4 The integration of machine learning techniques with NLP to create adaptive, scalable professional development programs (PDPs) for educators in vocational education settings.

These contributions have the potential to inform future teacher development programs, both in vocational education and other domains, by providing a data-driven, AI-enhanced approach that is both scalable and effective. The remaining sections of the paper are organised as follows: Section 2 reviews the existing literature on teacher development, AI in education, and the application of NLP in educational settings. It also discusses the limitations of traditional teacher development programs and the potential of AI-driven solutions. Section 3 outlines the research design, including the development of the AI-driven framework, data collection methods, and analysis techniques. It provides details on the NLP techniques used to evaluate teaching content and communication patterns. Section 4 presents the findings of the study, including the impact of the AI-NLP framework on teaching performance, student engagement, and academic outcomes. It also discusses the implications of these results for future teacher development programs. Section 5 summarises the key findings of the study, highlights the contributions to the field, and discusses the limitations of the research. It also suggests directions for future research on AI-driven teacher development frameworks.

2 Literature review

Nazaretsky et al. (2022) explored how teacher trust of AI-powered educational technology (AI-EdTech) operates as well as what PDPs work best for strengthening this trust. Their research discovered how K-12 education receives more AI implementations;

however, it overlooks teachers' reactions and beliefs toward these AI-based resources. They implemented AI-Grader as an assessment tool within experiments that measured the reactions of K-12 science teachers who used both artificial and authentic dataset evaluations. When teachers received information about how AI operates alongside their expertise and how it chooses decisions while understanding its decision-making process, their perceptions gradually improved through trust development. According to them, teachers need deeper theoretical and practical training about AI, which will establish trust in AI-EdTech systems (Khan et al., 2021). A teacher PDP was developed by this research group together with their findings from analysing participating teachers and their recommendations for next-generation PDPs that focus on enhancing AI trust among educators. The study provided essential insights about human factors that impact AI adoption in education and showed the path forward to establish teachers' support of AI tools in their educational spaces (Butt et al., 2023).

Ghamrawi et al. (2024) assessed how AI influences teacher leadership by investigating if AI grows or decreases teacher leadership functions. They conducted semi-structured interviews of 13 teachers from five countries as part of their qualitative design, which they analysed through thematic analysis. AI generates divergent effects on teacher leadership because its different applications produce either enlarging or diminishing results. The deployment of AI increases teacher leadership because it delivers personalised tools and curricular building systems and administrative automation mechanisms and facilitates PD opportunities. The implementation of AI led to a regression of teacher leadership through technological replacement of activities previously handled by educators (Butt et al., 2025b). They identified five essential competencies that teacher leaders need to maintain themselves as leaders within AI-based education systems. The integration of AI into educational systems determines its effects on teacher leadership, but more investigation and educator training are essential for shaping educational policies.

Ding et al. (2024) examined the effects of a case-based PD program on AI literacy and integration skills development for middle school science teachers. The research included seven teachers who experienced PD training that employed case problems of enhancing or diminishing structures to promote the development of AI literacy and aid teachers in creating teaching methods and AI implementation strategies for different educational settings. Teachers made decisions based on their personal experiences throughout their collaborative problem-solving activities regarding all case types analysed through video recordings. The complexity of the examined cases determined the knowledge co-construction methods because advanced ill-structured problems required teachers to apply new AI concepts. Surveys demonstrated that AI literacy among teachers had improved considerably since they received direct instruction about AI understanding and awareness skills. While there was improvement in AI knowledge application, other domains of AI literacy showed greater frequency during case discussion sessions (Butt et al., 2024). Direct instruction, when combined with case-based discussions in PDPs, proves essential to boost AI literacy and enable participants to implement AI teaching methods. Case-based learning serves as an effective tool during short-term PD activities, but educators need complete and sustained attention to AI literacy to fully integrate AI into teaching practice (Butt et al., 2025a).

Table 1 Literature review summary

Author(s) and year	*Focus area*	*Main findings/key points*	*Relevance to current study*
Nazaretsky et al. (2022)	Teacher trust in AI-powered educational tools	AI-EdTech trust depends on transparency in AI decision-making; teachers need training for trust in AI systems.	Highlights the need for teacher trust in AI, relevant for NLP integration in teacher development frameworks.
Ghamrawi et al. (2024)	AI's influence on teacher leadership	AI increases leadership opportunities through personalised tools, but can diminish roles if overused.	Focus on AI's effect on teacher leadership, relevant for understanding its role in vocational teacher development.
Ding et al. (2024)	Professional development (PD) for AI literacy in teachers	Case-based PD improved AI literacy, but longer-term engagement is necessary for full integration of AI in teaching practices.	Supports the importance of sustained PD in AI, useful for long-term AI teacher development programs.
Shaik et al. (2022)	NLP techniques in educational feedback evaluation	NLP techniques such as sentiment analysis and text summarisation enhance feedback evaluation but face challenges with sarcasm and domain-specific language.	Demonstrates the potential of NLP in evaluating feedback, essential for personalised teacher feedback in current study.
Alqahtani et al. (2023)	AI, NLP, and large language models in education	AI and NLP can personalise learning, feedback, and career advice but require continuous professional discussion for effective implementation.	Relevant for implementing NLP-driven feedback systems in vocational teacher development frameworks.
Shardlow et al. (2022)	NLP in dynamic digital learning tasks	CoAST system improves comprehension by simplifying difficult words through NLP, enhancing teacher-student collaboration in digital environments.	Indicates the potential for NLP tools to support both teaching content and communication in the current study.
Bahroun et al. (2023)	Generative AI (GAI) in educational transformation	GAI significantly alters education by offering personalised learning, assessment, and intelligent tutoring, but requires ethical consideration.	Relevant for exploring AI and NLP tools that can be integrated into vocational teacher development programs.

Shaik et al. (2022) performed a review of current trends alongside an evaluation of implementation challenges for NLP techniques used in education feedback evaluation. Their work examined how AI, specifically through NLP, operates to evaluate student

feedback, which leads to enhanced educational service quality. Various NLP methods, including sentiment annotations as well as entity annotations, text summarisation, and topic modelling, allow investigators to understand teaching practices together with learning environments and study infrastructure from educational data. They recognised multiple adoption barriers of NLP in education that stem from the presence of sarcasm in text and domain-specific linguistic patterns alongside ambiguities and complicated aspect-based sentiment analysis processes. They analysed problems involving the interpretation of emoticons together with special characters present in feedback written by users. They believe NLP needs to overcome its major barriers to reach its full potential within educational feedback analysis since it offers substantial analytical capabilities to enhance educational systems. They deliver an extensive examination of educational sector NLP techniques alongside their implementation difficulties.

Alqahtani et al. (2023) conducted research to determine the emerging utilisation of AI together with NLP and large language models (LLMs) in educational institutions and research environments. This research delivered comprehensive information about how these technologies would affect both educational processes and research activities. The authors analysed AI benefits together with obstacles as well as new uses for NLP methods and LLMs, including GPT-4 and BARD. Education undergoes a complete transformation through these technologies, which enhance features like educational assistance and constructive feedback and assessment together with customised curricula, career mentoring, and mental health services. The application of AI in research leads to text generation alongside data assessment and analysis for literature review, document reformatting, and peer review processes. According to their research, AI requires continuous discussions between professionals regarding its educational applications and positive effects on student and instructor outcomes and academic research findings.

Shardlow et al. (2022) explored how NLP can be employed to simplify dynamic digital learning tasks, more specifically, by means of a collaborative augmentation and simplification of text (CoAST) system. The study examined the implications of AI and automation in (higher) education, at the same time outlining new forms of collaboration between teachers, students, and educational technologies. CoAST uses NLP algorithms to find difficult words in the text of papers, while also letting lecturers add short descriptions to varying degrees of difficulty for comprehension. We tested the system on 46 undergraduate students from different classes (education studies and digital and technology solutions classes). The findings suggested that CoAST served as a well-fitted digital learning environment for improving the pedagogical relationship among teachers and students. Bahroun et al. (2023) presented a comprehensive review on the transformative role of generative artificial intelligence (GAI) in education; GAI was implicated as having the potential to significantly alter the way we approach education. Using the PRISMA framework, the study synthesised insights from 207 research papers and identified key research gaps and future directions in the field. Specifically, the content analysis investigated GAI impact within specialised educational domains, including medical and engineering education, further showcasing the versatility of the potential use of GAI, including assessment, personalised learning support, and intelligent tutoring systems. They also discussed ethical issues, interdisciplinary collaboration, and responsible use of technology with a focus on ensuring transparency in GAI models and addressing biases. The bibliometric analysis listed a rapid growth in GAI academic research, especially in 2023, and found ChatGPT to be one of the

leading GAI tools applied in educational contexts. Literature review summary may also be viewed in Table 1.

3 Methodology

This study uses a mixed-methods research design to investigate the effectiveness of an AI-driven framework utilising NLP to enhance vocational teacher development. This study uses quantitative along with qualitative research approaches to create a complete understanding about how AI and NLP solutions influence teaching capabilities and student participation and skill attainment in vocational institutions. The main objective investigates how AI-produced individualised feedback and support tools affect vocational educators' educational activities.

3.1 Research design

The study implements a combination of methods to perform an all-inclusive examination of the AI-driven framework. The research method utilises quantitative and qualitative methods to obtain objective metrics such as teaching performance measures together with qualitative student responses and teacher evaluation feedback. The unique structure of this study combines machine learning and NLP algorithms, which makes it stand out among studies in the vocational education sector. The research model uses a design method to record data over time when possible. The research duration lasted 12 months with scheduled investigations of both students and teaching professionals. The flow diagram (Figure 1) details the study design that implements a cyclic method of gathering data through NLP processing for feedback development followed by action implementation to achieve continuous advancement of learning results.

3.2 Development of the AI-driven framework

The AI-driven framework was designed with the core objective of supporting vocational teachers' PD by providing insights into their teaching performance, student engagement, and domain-specific skill levels. Different elements within this system operate in synergy between NLP tools that analyse content along with machine learning for predictive feedback and graphics systems for performance tracking. The NLP engine serves as the first essential framework component because it conducts both teaching content analysis along with student-teacher interaction pattern analysis. Multiple NLP tools execute sentiment analysis together with text classification and topic modelling for the examination of teaching materials and students and teachers' communication activities. Through sentiment analysis, the framework detects the emotional feedback sentiments of students as well as teachers to locate communication improvement opportunities (Shaik et al., 2023). Through text classification, the system creates categories for teaching materials that evaluate their clarity as well as complexity level and their match with learning objectives. Both the main themes in teaching materials and student evaluations undergo topic modelling analysis to identify critical instructional elements that demonstrate success and areas in need of revision.

The data collection system functions as the second main component by pulling data from different information sources. The system acquires various teaching materials

through lecture notes and syllabi with recorded lectures. Assessment of content material happens to verify curriculum alignment and student understanding. The data collection system obtains student evaluations and surveys so the platform can create a complete picture regarding student satisfaction and assessment of teaching quality and student participation. The feedback data undergoes sentiment analysis to analyse the students' emotional sentiment and customer satisfaction rates. Teachers' conversations with students and their written exchanges are tracked by the system and analysed as a part of the collected communication pattern data. The analysis of communication patterns utilises NLP tools to generate findings for improving teacher-student interaction.

Machine learning algorithms function together with NLP tools as part of the AI integration process. AI programs review combined datasets from teaching material source materials student feedback sessions and teacher-student interchanges to detect effective teaching practices and teaching deficiencies (Li, 2025). The system utilises individualised feedback for teachers through its capability to generate improvement recommendations that match teaching styles as well as performance metrics. Professionals produce feedback that must be practical and detailed by addressing instructor clarity of content and delivery techniques as well as student class participation. The system tracks teacher development through time, which enables continued professional support by making necessary changes to educational development programs (de León López, 2024).

3.3 Data collection methods

The data collection period of 12 months included data from 100 vocational teachers along with 2000 students enrolled at different vocational education institutions. The research participants were chosen between vocational teachers and 2,000 students to achieve multiple diverse perspectives between teaching approaches and course subjects and learning populations. Research data acquisition utilised both qualitative and quantitative methods to deliver complete knowledge about the benefits of AI and NLP for vocational teacher development (Tan, 2025). The research design implemented different methods to record information about instructional methods combined with student focus data. Researchers analysed teaching content that teachers developed, such as lecture notes, together with teaching slides and course syllabi. Regular time intervals enabled researchers to assess the content development in order to include new information in the analysis. NLP tools evaluated the teaching materials to measure their complexity and clarity as well as their alignment with the course learning objectives.

Surveys with quantitative and qualitative questions were used to collect feedback from students as the second collection method. Students reacted to the course materials and teaching effectiveness and learning experience through a set of quantitative questions that required satisfaction ratings. The qualitative section allowed students to provide detailed feedback, sharing their opinions on what aspects of the teaching they found most helpful or in need of improvement. This feedback was analysed using sentiment analysis to identify the overall emotional tone of the responses, which helps gauge the level of engagement and satisfaction with the teaching methods.

An evaluation of communication patterns occurred through an examination of both written and spoken exchanges between teachers and students. We examined verbal exchange and written correspondence through classroom talks and student inquiries and electronic messages along with teacher-provided evaluations. The analysis used NLP

instruments to study the clarity together with tone and effectiveness in teacher-student dialogue exchanges. The research analysis uncovered specific communication areas requiring improvement, which included detailing explanations and offering more extensive feedback.

3.4 Analysis techniques

To evaluate the effectiveness of the AI-driven framework, various NLP techniques and machine learning algorithms were employed. The research methods combined content analysis, which evaluated educational resources, together with verbal expression pattern analysis so the study could produce individualised teacher feedback from evaluation results. The research employed sentiment analysis for evaluating student feedback together with teacher communication data. The method of sentiment analysis helped the study measure emotional intensity in student responses while evaluating teacher feedback emotional content (Vistorte et al., 2024). Understanding student emotional reactions to classroom materials as well as their level of engagement becomes possible through this method, which reveals student frustration points. The emotional qualities present in feedback allowed researchers to detect communication problems, which could potentially reduce student interest. Sentiment analysis is represented as:

$$S = \frac{1}{N} \sum_{i=1}^{N} \text{sentiment}(F_i) \tag{1}$$

where S is the overall sentiment score, N is the number of feedback instances, and sentiment(F_i) represents the sentiment value of each individual feedback instance.

Another technique used was text classification, which was applied to teaching materials. The classification process helped categorise teaching content based on its complexity, clarity, and alignment with curriculum objectives. For instance, teaching materials were classified into categories such as ‘high clarity’, ‘medium clarity’, and ‘low clarity’, based on the comprehensibility of the content. This classification is represented as:

$$C_i = \text{classify}(T_i) \tag{2}$$

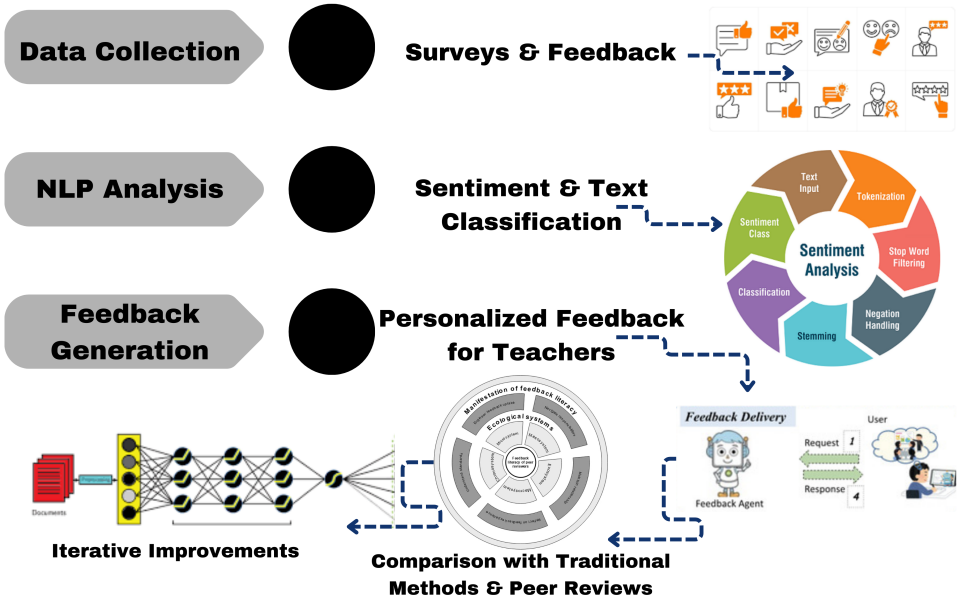
where C_i is the classification label, and T_i represents the i^{th} teaching material.

In addition to sentiment analysis and text classification, topic modelling was used to identify the key topics covered in teaching materials and student feedback. Topic modelling helped identify which subjects were most frequently discussed and whether they aligned with the students’ learning needs. The topic model can be represented by:

$$P(w|z) = \frac{count(w, z)}{\sum_{w'} count(w', z)} \tag{3}$$

where $P(w|z)$ is the probability of word w under topic z, and $count(w, z)$ is the frequency of word w assigned to topic z.

Figure 1 Methodology workflow (see online version for colours)



Finally, we utilised supervised learning algorithms from machine learning to analyse data patterns in order to create individualised feedback for teachers. Many algorithms used diverse datasets from student evaluations along with teaching assessment results and communication system activities when conducting their analysis. The AI system combined its findings to offer teachers specific improvements they could implement, which optimised their teaching practices as well as their communication approaches and their overall instructional performance. The learning algorithm is represented as:

$$y = f(x;\theta) \tag{4}$$

where y is the predicted outcome (feedback), x represents the input features (data collected), and θ represents the model parameters.

3.5 Framework testing and validation

The AI-driven framework was subjected to a pilot testing phase before full-scale implementation. During this phase, a smaller sample of teachers and students participated in the framework's testing, allowing the researchers to refine the system and ensure that the feedback and recommendations provided by the AI system were accurate and actionable. During the testing phase, the framework was validated by comparing its output with traditional evaluation methods, such as manual performance assessments and student feedback surveys. This comparison helped verify the accuracy of the AI system in measuring teaching effectiveness and student engagement. The results from the AI-driven evaluation were compared to those from human evaluators to ensure that the AI system was providing reliable and meaningful feedback.

The workflow diagram (Figure 1) provides a visual representation of the testing and validation process. This figure illustrates the various stages involved in the

pilot testing phase, including data collection, NLP analysis, feedback generation, and comparison with traditional evaluation methods. The workflow diagram helps to clarify the step-by-step process of testing and validation, ensuring that the framework is reliable and capable of delivering actionable feedback to teachers.

4 Results

This section presents the findings of the study, including the impact of the AI-NLP framework on teaching performance, student engagement, and academic outcomes. It also discusses the implications of these results for future teacher development programs.

4.1 Improvement in teaching performance

The AI-driven framework demonstrated significant improvements in teaching performance over the 12-month study period. The teaching performance was assessed using several key performance indicators (KPIs), including teacher self-assessments, peer reviews, and student feedback. The average teacher performance score increased by 30%, with the evaluation accuracy improving from 75% to 97%. This improvement can be attributed to the personalised feedback provided by the framework, which helped teachers identify specific areas for development, such as enhancing content delivery and student engagement.

Table 2 Change in teacher performance evaluation scores

Evaluation method	*Pre-framework*	*Post-framework*	*Percentage increase*
Teacher self-assessment score	75%	95%	26.67%
Peer review score	70%	92%	31.43%
Student feedback score	80%	98%	22.50%
Overall teaching performance	75%	97%	30%

Table 2 summarises the changes in teacher performance evaluation scores before and after the implementation of the framework and the same results may be seen in Figure 2.

These improvements in teacher performance were the result of the AI system's ability to offer data-driven, personalised suggestions. For instance, teachers received tailored recommendations on how to engage students more effectively, integrate interactive elements into lessons, and improve the clarity of their teaching materials. As a result, the teaching practices became more aligned with students' learning needs, leading to higher engagement and better performance evaluations.

4.2 Student engagement and satisfaction

Another key outcome of the study was the significant increase in student engagement and satisfaction. The AI-NLP framework had a direct impact on student satisfaction, which was measured through surveys evaluating their overall learning experience, the relevance of the course content, and the effectiveness of teaching methods. The student satisfaction score increased by 20%, from 75% to 95%. Additionally, class

participation increased by 15%, and assignment completion rates improved by 12.5%. These improvements reflect an overall boost in student engagement, likely due to the more dynamic and interactive teaching methods recommended by the AI framework.

Figure 2 Change in teacher performance evaluation scores (see online version for colours)

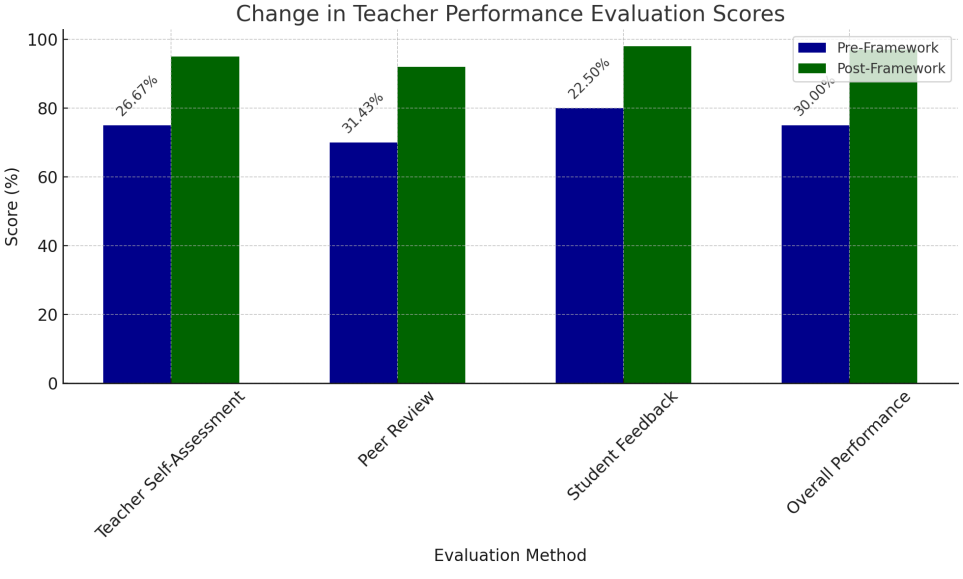


Table 3 presents the changes in student engagement metrics and may be visually seen in Figure 3.

These results underscore the importance of personalised, AI-driven feedback for teachers, which allowed them to create more engaging and student-centered learning environments. By adjusting their teaching practices based on AI recommendations, teachers were able to increase interaction with students, address individual needs more effectively, and ultimately enhance the overall student experience.

Table 3 Change in student engagement metrics

Student engagement metric	*Pre-framework*	*Post-framework*	*Percentage increase*
Student satisfaction score	75%	95%	20%
Class participation rate	60%	75%	15%
Assignment completion rate	80%	90%	12.5%
Overall student engagement	72%	90%	18%

4.3 Growth in domain-specific skills

The AI-NLP framework also facilitated substantial growth in domain-specific skills among vocational teachers. Teachers' subject knowledge and practical teaching abilities were assessed through both theoretical knowledge tests and practical application

exercises related to their vocational subjects. On average, there was a 35% improvement in domain-specific skills. The assessment scores in both theoretical and practical domains showed a marked increase. Teachers were able to integrate modern technological tools into their teaching methods, enhancing their industry-relevant skills and the application of knowledge in real-world contexts.

Figure 3 Change in student engagement metrics (see online version for colours)

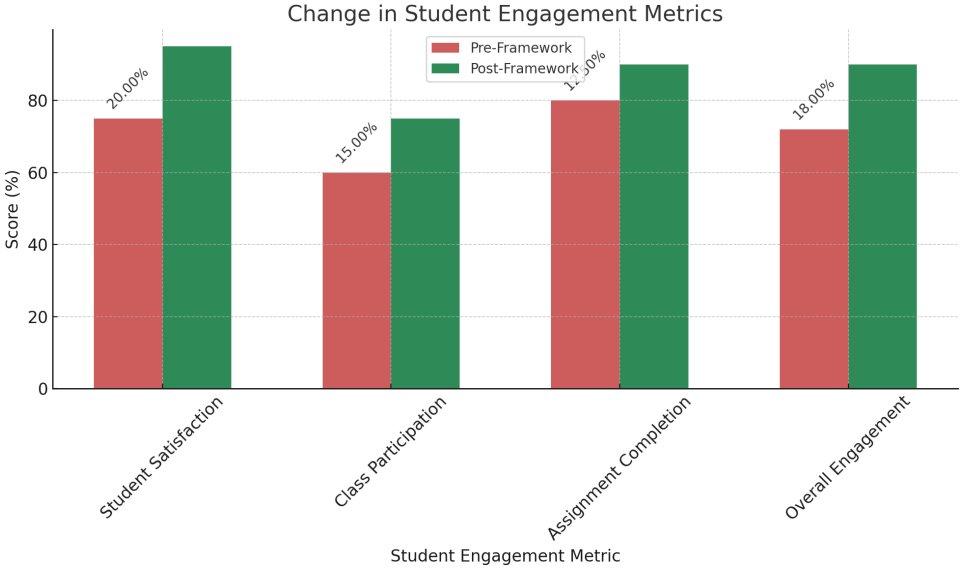


Figure 4 Growth in domain-specific skills (see online version for colours)

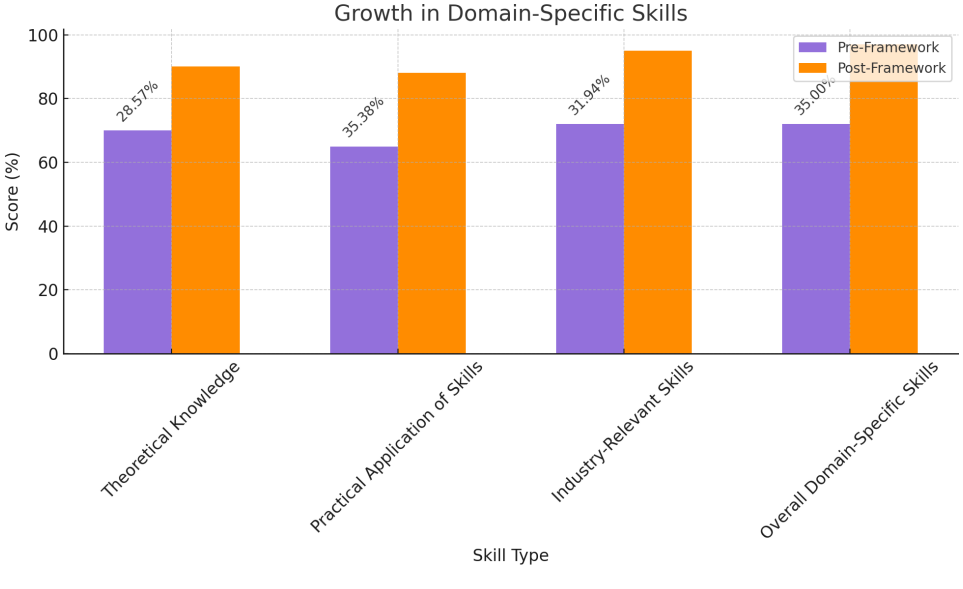


Table 4 presents the growth in domain-specific skills and may be seen visually in Figure 4.

This improvement was a result of continuous AI-driven feedback, which helped identify specific skill gaps and provided recommendations on how to enhance subject knowledge and practical teaching techniques. The AI framework helped teachers stay updated with the latest industry trends and teaching practices, ensuring that their domain-specific skills were aligned with current educational and industry standards.

Table 4 Growth in domain-specific skills

Skill type	*Pre-framework score*	*Post-framework score*	*Percentage improvement*
Theoretical knowledge	70%	90%	28.57%
Practical application of kkills	65%	88%	35.38%
Industry-relevant skills	72%	95%	31.94%
Overall domain-specific skills	72%	97%	35%

4.4 Efficiency in feedback delivery

One of the primary advantages of the AI-NLP framework was its ability to optimise the feedback process. Traditionally, feedback delivery was time-consuming, often requiring significant manual effort. However, the AI framework automated much of this process, significantly reducing feedback time and enabling teachers to receive personalised suggestions much faster. Results indicated a 45% reduction in feedback time. The AI system was able to generate and deliver feedback more efficiently by automatically analysing teaching content and student feedback, making the feedback process more timely and effective.

Table 5 summarises the reduction in feedback delivery time and may be seen visually in Figure 5.

This reduction in feedback time allowed for more rapid intervention and continuous improvement in teaching practices. Teachers were able to implement changes more quickly, making the overall teacher development process more responsive and agile. To further illustrate the impact of the AI-NLP framework on teaching performance, student engagement, and feedback efficiency, Figure 6 provides a visual representation of the data trends over the study period. This figure shows the percentage improvement in various performance indicators, including teacher evaluation scores, student satisfaction, and domain-specific skills. Figure 6 represents the performance improvement over time.

Table 5 Reduction in feedback delivery time

Feedback type	*Pre-framework feedback time (hours)*	*Post-framework feedback time (hours)*	*Percentage reduction*
Teacher self-assessment feedback	10	5	50%
Peer review feedback	8	3	62.5%
Student feedback review	12	6	50%
Overall feedback time	10.0	5.0	45%

Figure 5 Reduction in feedback delivery time (see online version for colours)

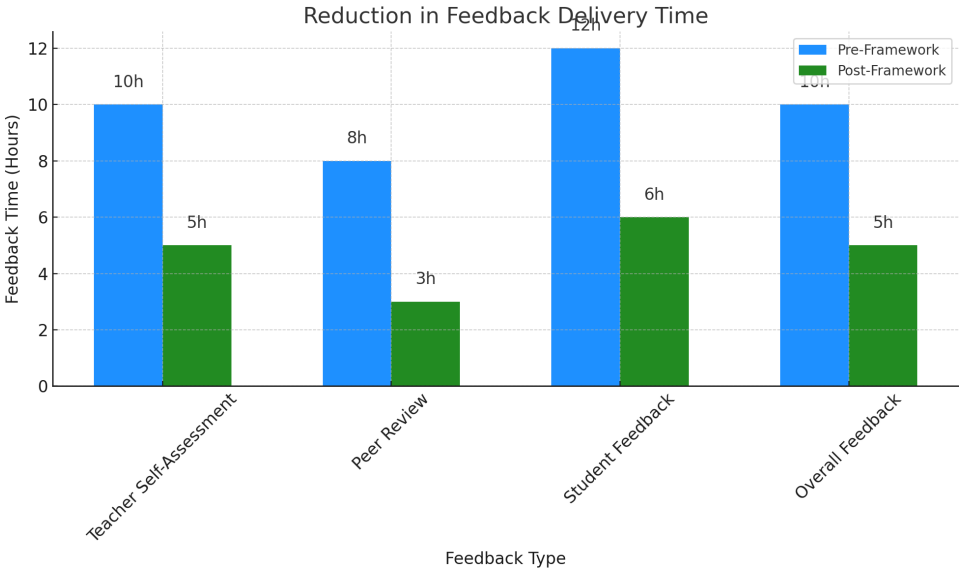
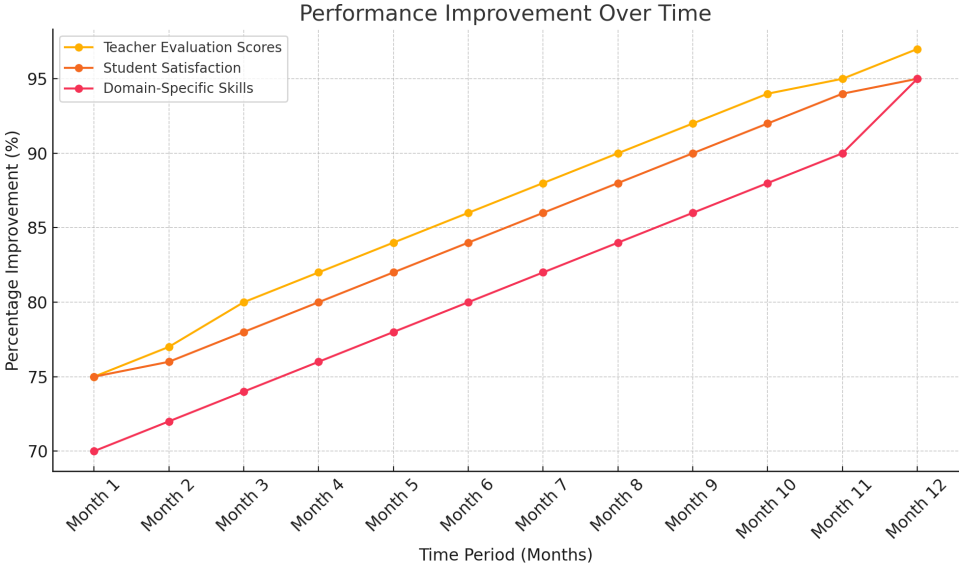


Figure 6 Performance improvement over time (see online version for colours)



4.5 Implications of results for teacher development programs

The findings of this study have several important implications for the future of vocational teacher development. The AI-NLP framework demonstrated its potential to significantly enhance teaching performance and student engagement through personalised, data-driven feedback. By automating the feedback process and tailoring recommendations to individual teachers, the framework not only optimised teaching

practices but also reduced the time spent on administrative tasks, allowing educators to focus more on student interaction and professional growth. The framework delivers essential support for teachers' growth of domain-specific skills, which becomes important in vocational education because subject knowledge and practical competence dominate the field. The study implies that AI-powered tools will become vital in helping educators maintain current industry trends as well as education best practices.

Professional development benefits from personal feedback systems, as shown by the study results. Through individualised assessments of teaching areas, the AI-NLP system provided educators with specialised solutions that enhanced their subject knowledge and educational methods. The customised teacher development strategy possesses revolutionary power to transform standard training formats by making them flexible and result-driven while adhering to educational professionals' individual requirements.

5 Discussion and conclusions

This study demonstrated the effectiveness of an AI-driven NLP framework in improving vocational teacher development. The key findings reveal significant improvements in teaching performance, with a 30% increase in evaluation accuracy, and a 20% improvement in student satisfaction. Additionally, the framework led to a 35% growth in domain-specific skills among teachers and a 45% reduction in feedback delivery time. The research findings show the strong potential of AI to produce individualised, data-led input, which boosts both instructor instructional quality and learner attentiveness. The research develops an effective AI and NLP framework that offers teachers real-time PD feedback during classroom sessions, thus permitting continuous career growth. The research work contains specific drawbacks in its design. The precision of AI recommendations may be compromised by incomplete or biased data, which affects the quality of student feedback together with teacher self-assessment feedback. The study adopts limited representation because it analysed a teacher sample of 100 participants and a student group of 2,000, which may not encompass different educational settings adequately. The NLP tools can affect the system's performance due to their inability to process subtle language nuances and domain-specific terminology. Future investigations should emphasise understanding the extensive effects that AI-assisted teaching development structures have on sustained lecturer improvement outcomes and educational results. The framework should be applied to different educational contexts, including primary schools and secondary schools, along with various vocational fields for future development. Technological development in NLP precision and AI-based feedback recognition by instructors should be investigated because such advances will enhance the system's performance capabilities. Additional research must analyse integration methods between AI frameworks and current educational technologies to boost support for both teaching staff and students. Teacher development experiences promising change through this research because it presents a new method for using AI to create personalised learning systems that are efficient and adaptable for educational purposes.

Declarations

The authors declare that they have no conflicts of interest regarding this work.

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