

# **An Internet-Integrated Improved Teaching Method in Professional English for Chinese Undergraduate Students in the Major of Building Environment and Energy Application Engineering**

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**Abstract.** Proficiency in professional-English communication is critical for engineering undergraduates, yet many lack adequate systematic training in this area. To address this challenge, we propose a novel internet-integrated teaching approach that fuses professional vocabulary, complex sentence analysis, and extended professional passages with online digital tools and platforms for the professional-English curriculum of building environment and energy application engineering majors. To verify its effectiveness, a comparative analysis was conducted on the results of the National Entrance Examination for Postgraduate in China (NEEP) between the Class of 2021 (traditional offline teaching only) and the Class of 2022 (the proposed internet-integrated teaching). The results show that the NEEP participation rate rose significantly from 54% (20/37) to 83% (45/54), and the passing rate increased remarkably from 15% (3/20) to 44% (20/45). Furthermore, one-way ANOVA was used for quantitative score analysis, yielding a P-value of 0.036, which indicates a statistically significant difference in students' academic performance. This finding underscores that the revised internet-integrated teaching approach effectively enhances students' professional English communication skills and autonomous learning ability, providing a practical reference for engineering professional English education under the background of digital future education.

**Keywords:** English education; professional English; engineering education; internet-integrated teaching; online learning; educational reform; blended learning

## **1. Introduction**

The proficiency in professional English communication, defined as the skilled exchange of ideas, information, and messages through effective written, oral, digital, or visual mediums within the global workplace or professional sphere, is of great significance to engineering students, particularly those in China [1-3]. Prior to starting their professional journeys, it is critical for these students to acquire both oral and written professional communication skills. However, many of these students do not have enough targeted training for these vital skills: after entering university or college, they often find themselves busy with test-oriented coursework, requiring the memorization of knowledge and the completion of exercises to pass courses [4]. Consequently, they are left with limited time for communication training, resulting in fewer opportunities to write academic papers, prepare professional presentations, or attend international conferences and seminars to demonstrate their understanding of specific courses or projects [5-6].

These issues are prevalent at our institute, the Shandong Institute of Petroleum and Chemical Technology, which has recently undergone a redevelopment from its predecessor, Shengli College of China Petroleum University, with approximately 10,000 students and a ranking of 516/800 in the alumni ranking list. Limited educational resources make it imperative for us to explore the most effective and feasible methods to enhance students' professional English communication abilities. In China, the CET 4 and 6 (Chinese English Test Band 4 and 6) serve as significant standardized metrics for assessing undergraduate students' general English proficiency, and students must obtain

a minimum of 425/710 to pass, which is also crucial for the reputation and ranking of universities and colleges.

In addition to the CET, the National Entrance Examination for Postgraduate in China (NEEP) is of vital importance for undergraduates aiming to pursue graduate education (master or doctor of philosophy degree) after completing their bachelor's degree. This exam encompasses politics, English, and two professional exams (tailored to the student's major), and most engineering students are required to achieve a total score of 280/500 or higher to be admitted to Chinese graduate schools. Notably, English is a core component of this exam, focusing on assessing students' professional reading and academic writing abilities, and failure to meet the English proficiency requirement of NEEP will result in disqualification for graduate admission. Statistics from the 2020 and 2021 NEEP show that while the number of applicants reached 3.41 million and 3.77 million respectively, only 990 thousand and 1.05 million were accepted, underscoring the high competitiveness and difficulty of the exam for most Chinese undergraduate students.

As a reliable measure of students' English communication and academic application skills, NEEP is a crucial tool for evaluating their professional English reading and writing abilities. Through consultations with colleagues and students from the College of Petroleum Engineering, we identified the Professional English course for building environment and energy application engineering majors as a promising breakthrough to improve students' NEEP performance and professional English competence. This major focuses on heating, ventilation, air conditioning, and refrigeration (HVACR) topics, and its Professional English course covers vocabulary and expressions utilized in core courses such as thermodynamics, fluid mechanics, heat transfer, and heat pump technology. Optimizing this course is therefore key to fostering students' overall professional English communication skills.

Many studies have confirmed the importance of professional English teaching for engineering students and the value of digital and internet-based teaching methods in education reform. Macaro et al. summarized that English-medium professional courses are insufficient for engineering undergraduates in many universities, leading to misunderstandings in reading and writing technical papers [6]. Ward pointed out that engineering students in developing countries need systematic training in basic engineering English vocabulary to improve their ability to read English textbooks and write research papers [7]. Sulcas & English emphasized that professional communication skills, including academic writing, must be specially taught for engineering undergraduates even in English-speaking countries [8]. Todd highlighted the need to teach opaque engineering English words (with meanings different from daily usage) in class to help students understand technical papers [9]. In the era of digital education, Bin & Mandal employed artificial intelligence (AI) and internet-based methods to enhance students' English proficiency, proving that digital teaching significantly improves students' understanding of professional projects [10]. Huang and Singh also supported that digital tools and software can effectively boost students' interest in English learning [11]. Maher & Milligan identified a prominent gap in engineering students' thesis writing abilities and recommended tailored writing courses and discipline-specific vocabulary databases supported by online platforms [12].

Despite the abundance of research on enhancing undergraduates' professional communication skills, few studies integrate internet teaching tools and online learning platforms with professional English teaching for Chinese engineering majors, targeting their actual test demands and learning characteristics. With the rapid development of future education and the deep integration of the internet, big data, and digital devices into higher education, online learning, blended learning, and intelligent education management have become core trends of educational modernization. Against this backdrop, we optimize the professional English teaching method by integrating internet-based academic resources, online interactive tools, and digital learning platforms into the traditional offline teaching framework. We focus on improving students' ability to analyze complex technical sentences and comprehend professional English articles, and verify the effectiveness of the proposed method through a comparative analysis of NEEP results of the Class of 2021 and 2022.

This study aims to provide a practical internet-integrated teaching scheme for engineering professional English education, catering to the requirements of educational modernization and individualized education.

## 2. Teaching Design and Method

Different from the conventional offline-only professional English teaching approach, the proposed internet-integrated blended teaching method is divided into four interconnected sections: chapter retrospective, professional vocabulary learning, professional expression comprehension, and complex sentence analysis (Figure 1). We take the thermodynamics chapter as a representative example to elaborate on the teaching methodology, with online digital tools, internet platforms, and digital devices integrated into each stage to realize the deep fusion of offline classroom guidance and online autonomous learning. All teaching activities and score collection are in accordance with the guidelines and regulations of Shandong Institute of Petroleum and Chemical Technology.

As outlined in Figure 1(a), we first use Chinese to help students recall the professional knowledge of thermodynamics (e.g., the first law of thermodynamics) they have learned in previous professional courses, aiming to establish a close connection between their professional knowledge system and English terminology, and enhance their understanding of the chapter's core content. On this basis, we guide students to use digital devices (computers/tablets) to access international online open course platforms (e.g., Coursera, edX) and watch short English lecture videos on thermodynamics from world-renowned universities. This not only helps students adapt to the expression of professional knowledge in English but also broadens their international academic vision, laying a solid foundation for subsequent professional English learning and aligning with the concept of distance teaching in future education.

After ensuring students are familiar with the chapter's learning objectives, we introduce and explain the professional thermodynamics vocabulary associated with the chapter (Figure 1(b)), which is applied in the subsequent extended passages to help students comprehend the core content of professional English reading materials. We integrate this offline vocabulary teaching with internet-based academic resource platforms (e.g., Engineering Village, CNKI Research) : students are required to use digital devices to independently retrieve the application of these vocabulary words in international professional engineering papers and technical reports on the platforms, sort out their typical collocations and usage scenarios, and share their findings in class for interactive discussion. This approach not only deepens students' memory of professional terminology but also cultivates their ability to retrieve and analyze professional English information, fulfilling the requirements of information education in future education. In addition, we build an online professional vocabulary database based on the institute's smart campus learning management system, enabling students to review and memorize vocabulary anytime and anywhere after class.

After the vocabulary teaching, we encourage students to skim the professional English thermodynamics passages from textbooks (Figure 1(c)) before detailed reading. For most students, reading English scientific articles on thermodynamics is a novel and challenging experience, with the main difficulties coming from unfamiliar professional expressions and complex sentence structures. To address this, we use online translation and professional expression tools (e.g., DeepL, Grammarly) as auxiliary learning means for students: they can use these internet tools on digital devices to check the accurate expression and semantic connotation of professional sentences, and solve the problem of unfamiliar professional expressions independently. The teacher sorts out the typical professional expressions and sentence patterns in the passages, supplements them to the online database on the online learning platform, and provides targeted explanations for common misunderstandings in offline classes. This method makes up for the limitation of offline classroom time and enriches students' learning resources, realizing the combination of teacher-led offline teaching and student-centered online autonomous learning.

Students often lack the ability to read and comprehend complex technical sentences in scientific articles because they rarely encounter such long sentences with professional terminology in previous English courses and have not received systematic training in this regard. To address this core problem, we adopt an offline + online combined analysis method (Figure 1(d)) to develop students' skills in disassembling and analyzing complex technical sentences, equipping them with the ability to read professional English articles with confidence.

When explaining complex sentences in offline classes, we first encourage students to independently attempt to understand the entire sentence for 2-3 minutes. If students only grasp partial content, we divide the sentence into manageable parts and analyze each part individually. Taking the sentence from Figure 1(d) as an example: "In mechanics, if the motion of a body is to be determined normally the first step is to define a free body and identify all the forces exerted on it by other bodies." Since the sentence lacks punctuation marks, students may find it confusing. We guide students to add commas based on their prior grammar knowledge to rephrase the sentence for better comprehensibility: "In mechanics, if the motion of a body is to be determined, normally the first step is to define a free body and identify all the forces exerted on it by other bodies."

After offline structural analysis, we assign online practice tasks on the institute's online homework platform (e.g., Xuexitong): students use online grammar analysis tools (e.g., English Grammar Checker, LangCorrect) to independently disassemble and analyze other complex sentences in the passages, submit their analysis results online, and the teacher reviews the results in real time and provides individualized feedback for each student. This one-to-one online guidance makes up for the lack of personalized teaching in offline collective classrooms, catering to the requirement of individualized education in future education. For complex grammatical structures (e.g., post-modifiers in "identify all the forces exerted on it by other bodies"), we explain the rules in offline classes and set up targeted online practice exercises to help students consolidate their knowledge through repeated training.

By employing this internet-integrated blended teaching approach that combines chapter retrospective, professional vocabulary learning, professional expression comprehension, and complex sentence analysis with online digital tools and platforms, we observe a gradual enhancement in students' comprehension of professional English articles related to fluid mechanics, heat transfer, piping, pumping, and other HVACR topics. Students not only improve their ability to grasp the general meaning of these articles but also develop their autonomous learning ability through the use of internet and digital tools, which is reflected in their improved performance in English proficiency tests and NEEP, as demonstrated in the subsequent section.

### Review of the First Law of Thermodynamics

(a)

- The first law of thermodynamics concerns the laws of conservation and transformation of energy within the field of thermal phenomena, reflecting the conservation of different forms of energy during the transfer and transformation process.
- First law of thermodynamics: The increase in internal energy of an object equals the sum of the heat absorbed by the object and the work done on it. That is, heat can be transferred from one object to another, or it can be converted into mechanical energy or other forms of energy, but during the conversion process, the total value of the energy remains unchanged.

(c)

### 2-2 First Law of Thermodynamics

- Energy is the property that can be transferred to an **object** in order to perform work, or to heat the object. A basic idea is that energy can be stored within systems in various forms. Energy also can be **converted** from one form to another and **transferred** between systems. For closed systems, energy can be transferred by work and heat transfer. The total amount of energy is **conserved** in all conversions and transfers.

### Word

(b)

|                |                  |
|----------------|------------------|
| Principle      | Refinery         |
| Thermodynamics | Composition      |
| Analyze        | Nuclear reaction |
| Transportation | Inflate          |
| Practice       | Specified        |
| Exert          | Macroscopic      |
| Motion         | Assign           |
| Define         | Subset           |
| Mechanics      |                  |

(d)

### 1-1 Thermodynamics

- In mechanics, if the **motion** of a body is to be determined, normally the first step is to define a free body and **identify** all the forces **exerted on it by other bodies**.



Figure 1. Internet-integrated teaching design and method for undergraduate students in the major of building environment and energy application engineering. (a): retrospect of thermodynamics (Chinese characters present the review of thermodynamics and the first law of thermodynamics); (b): professional words from the thermodynamics article; (c): a section of thermodynamics article from the textbook; (d): analysis and explanation of long complex sentence extracted from the textbook with online grammar tool support.

### 3. Results

This Professional English course is offered to undergraduate students in their final year of the bachelor's degree program, a critical stage for students preparing for the NEEP. Admission to any Chinese graduate school requires passing four NEEP subjects: mathematics or professional course 1, professional course 2, politics, and English; failure in any subject will preclude acceptance. Since most students' English scores are positively proportional to their total NEEP scores, and students who pass the NEEP inevitably meet the English proficiency requirement, we use the overall NEEP score as the core indicator to assess students' academic performance. To demonstrate the effectiveness of our internet-integrated teaching method and design, we conduct a comparative analysis between the NEEP results of the Class of 2021 (who received traditional offline-only teaching) and the Class of 2022 (who received the proposed internet-integrated blended teaching).

As presented in Figure 2(a), the number of NEEP participants and successful applicants increases significantly after the application of the internet-integrated professional English teaching method. This significant increase in participation rate is attributed to the boost in students' confidence and learning motivation brought by the blended teaching approach: the NEEP is far more difficult than the regular exams students have experienced, and the lack of professional English training and test-taking confidence made many students of the Class of 2021 hesitant to participate in the exam, resulting in a low participation rate of 54% (20/37). In contrast, the Class of 2022 received systematic training with the internet-integrated teaching method in their final year, which not only improved their professional English proficiency but also enhanced their autonomous learning ability and test-taking confidence through diverse online learning tools and personalized feedback. Consequently, the NEEP participation rate of the Class of 2022 rose to 83% (45/54), a significant increase of 29 percentage points.

Figure 2(a) also shows a remarkable improvement in the NEEP passing rate among participants: from 15% (3/20) in the Class of 2021 to 44% (20/45) in the Class of 2022, an increase of 29 percentage points. This enhancement is directly attributable to our internet-integrated teaching method: the systematic training in complex sentence analysis and professional article comprehension (supported by online tools) significantly improved students' ability to tackle the professional English reading and writing sections of the NEEP, which are composed of a large number of complex technical sentences and professional passages. The improved comprehension ability and test-taking skills of the Class of 2022 led to their superior performance and higher passing rate in the NEEP.

Figures 2(b) and 2(c) present the distribution of students' total NEEP scores for the two classes. The score distribution of the Class of 2021 (Figure 2(b)) exhibits a flat profile with a low peak, concentrated in the 260-320 score range, indicating that students relied only on their limited basic English ability to take the exam due to the lack of systematic professional English training and online learning support. In contrast, the score distribution of the Class of 2022 (Figure 2(c)) is significantly higher and more concentrated in the 280-400 score range, reflecting their superior academic performance in the NEEP. This difference in score distribution fully demonstrates that the internet-integrated blended teaching method effectively improves students' overall academic ability, and the combination of offline classroom training and online autonomous learning is far more effective than traditional offline-only teaching.

To comprehensively evaluate the teaching effect, we use a boxplot to compare the key score parameters of the two classes (Figure 2(d)), including the minimum score, lower quartile, median, upper quartile, and maximum score—five core indicators that reflect the overall score level and distribution of the sample. Notably, for the Class of 2021, only three students passed the NEEP, resulting in the merging of the top/bottom lines of the bar with the box lines in the boxplot. A careful comparison shows that all five score parameters of the Class of 2022 exceed the corresponding parameters of the Class of 2021, which directly confirms the overall superiority of the Class of 2022's NEEP performance and initially validates the effectiveness of our internet-integrated teaching method. Although there is a slight overlap between the top score line of the Class of 2021 and the bottom score line of the Class of 2022, the overall score gap is obvious, indicating that the blended teaching method has a significant positive impact on students' academic performance.

To further verify the statistical significance of the teaching effect, we conduct a quantitative analysis using one-way ANOVA (Analysis of Variance) on the NEEP scores of students who successfully passed the exam (verified by the College of Petroleum Engineering as supporting information). In this study, the only variable influencing students' NEEP scores is the teaching method: the Class of 2021 received traditional offline-only teaching, while the Class of 2022 received the internet-integrated blended teaching, which meets the basic requirements of one-way ANOVA.

Table 1 presents an overview of the NEEP passing scores of the two classes, including the sample count, total score, average score, and variance. The results show that the average score of the Class of 2022 (322.95) is significantly higher than that of the Class of 2021 (286), although the variance of the Class of 2022 (761.94) is higher than that of the Class of 2021 (199), which is due to the larger sample size (20 vs. 3) and the individual differences in students' use of online autonomous learning tools. Despite the higher variance, the significant increase in the average score fully demonstrates that our internet-integrated teaching method can effectively improve students' overall NEEP performance and help them pass this challenging exam.

Table 2 shows the detailed results of the one-way ANOVA analysis, including the sum of squares (SS), degrees of freedom (df), mean squares (MS), F-value, and P-value, calculated using Excel in accordance with the classic statistical research of Cuevas et al. and Armstrong et al. [13-14]. In ANOVA, the null hypothesis assumes that the average scores of all groups are equivalent; a P-value less than 0.05 leads to the rejection of the null hypothesis, indicating a statistically significant difference between the groups. As shown in Table 2, the calculated P-value is 0.036, which is less than the critical value of 0.05. Therefore, we reject the null hypothesis and conclude that there is a statistically significant difference in the NEEP passing scores between the Class of 2021 and the Class of 2022.

This significant statistical difference, combined with the increased participation rate, higher passing rate, and superior score distribution, fully confirms that our internet-integrated blended teaching method effectively enhances students' professional English communication skills and overall academic performance. The positive teaching effect is not only due to the optimized offline four-stage teaching design but also greatly benefited from the internet teaching tools, online learning platforms, and digital devices integrated into the curriculum: these tools enriched students' learning resources, improved their autonomous learning ability, provided personalized feedback, and ultimately built up their confidence and competence in professional English and NEEP.

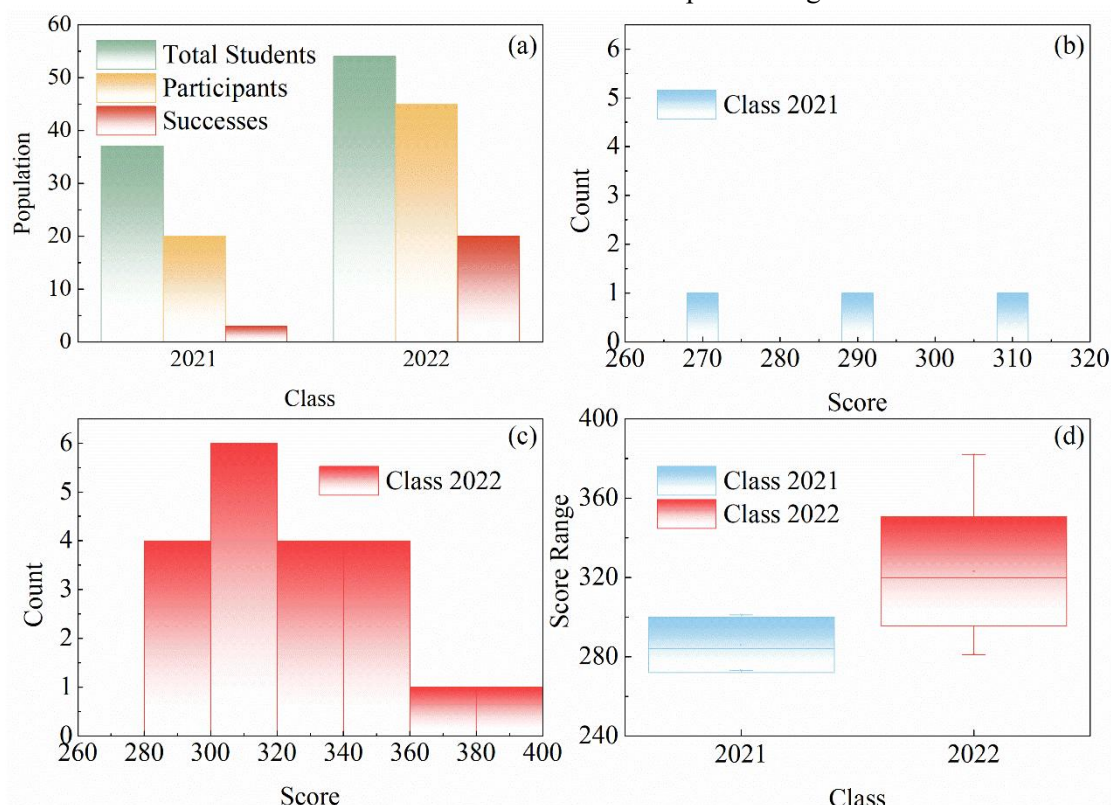


Figure 2. Comparison of students' NEEP results in Class 2021 (traditional offline teaching) and Class 2022 (internet-integrated blended teaching). (a): statistics of total students in the major, NEEP participants, and students admitted to graduate schools; (b) NEEP score distribution profile of Class 2021; (c) NEEP score distribution profile of Class 2022; (d) boxplot comparison of NEEP scores between the two classes (five core parameters: minimum, lower quartile, median, upper quartile, maximum).

Table 1. Summary of data

| Group      | Count | Sum  | Average | Variance |
|------------|-------|------|---------|----------|
| Class 2021 | 3     | 858  | 286     | 199      |
| Class 2022 | 20    | 6459 | 322.95  | 761.94   |

Table 2. Results by ANOVA

| Source of variation | SS       | df | MS      | F    | P-value |
|---------------------|----------|----|---------|------|---------|
| Between groups      | 3561.66  | 1  | 3561.66 | 5.03 | 0.036   |
| Within groups       | 14874.95 | 21 | 708.33  |      |         |

## 4. Summary

In this study, we introduce an enhanced teaching methodology to improve the English proficiency of undergraduate engineering students in the professional-English course. Unlike traditional approaches, our method not only equips students with professional terminology but also focuses on facilitating their comprehension of complex English articles through the integration of long and challenging sentences and passages. To assess the effectiveness of our approach, we conduct a comprehensive evaluation comparing the NEEP scores of the Class of 2021 and the Class of 2022, who received traditional and the proposed internet-integrated teaching methods, respectively. Our qualitative and quantitative analysis reveals that our method significantly enhances students' professional English skills, which proves that our improved teaching method is practical and effective for undergraduate engineering students majoring in building environment and energy application engineering. This study has a minor limitation that the research sample is

limited to students from our institute, and the current teaching method has not yet involved the training of oral professional English communication skills. In the future, we will expand the research sample and integrate online oral communication tools to optimize the teaching system, and further explore the integration of artificial intelligence (AI) technology with professional English teaching to better adapt to the development of digital future education.

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