

A Study on Optimization Paths for Digital Deep Learning in Specialized English Education in Higher Vocational Colleges from the Perspective of Cognitive Load Theory

Xiang Huang

Department of Navigation, Jiangsu Maritime Institute, Nanjing 21170, China

Abstract: This study focuses on the optimization paths for digital deep learning in specialized English education in higher vocational colleges from the perspective of Cognitive Load Theory. Based on expounding the core concepts and classifications of Cognitive Load Theory, and by reviewing the current status of relevant domestic and international research, it deeply analyzes the current situation and existing problems of digitalization in specialized English education in higher vocational colleges. Furthermore, starting from Cognitive Load Theory, it proposes targeted optimization paths, including reducing extraneous cognitive load, enhancing germane cognitive load, and reasonably addressing intrinsic cognitive load. The aim is to provide theoretical support and practical guidance for improving the effectiveness of digital deep learning in specialized English education in higher vocational colleges and to promote the effective enhancement of students' specialized English proficiency.

Keywords: Cognitive Load Theory; specialized English in higher vocational colleges; educational digitalization; deep learning.

1. Introduction

1.1. Research Background

Against the backdrop of the rapid development of educational digitalization, specialized English education in higher vocational colleges is facing numerous opportunities and challenges. China's Education Modernization 2035 clearly proposes to accelerate educational modernization, build a strong education country, and promote the digital transformation of education, which points out the direction for the reform and development of specialized English education in higher vocational colleges. Digital technologies provide rich resources and diverse means for teaching, such as online courses, virtual learning environments, and intelligent teaching software, creating more flexible and personalized learning conditions for students (Zhang Liguang et al., 2022) [1]. However, how to effectively utilize these digital resources to achieve students' deep learning has become an urgent problem for educators.

Deep learning emphasizes students' in-depth understanding of knowledge, cultivation of critical thinking, and ability to transfer and apply knowledge, which is highly consistent with the goal of specialized English education in higher vocational colleges to cultivate professionals with practical application capabilities. However, in the actual digital teaching process, students often face various cognitive challenges, resulting in unsatisfactory learning effects. Cognitive Load Theory provides a new perspective and theoretical basis for solving this problem. The Cognitive Load Theory proposed by Sweller (1988) reveals the finiteness of human cognitive resources and their impact on learning. By reasonably controlling and optimizing students' cognitive load in the learning process, learning efficiency can be improved and deep learning can be promoted. Therefore, in-depth research on the optimization paths for digital deep learning in specialized English education in higher vocational colleges

from the perspective of Cognitive Load Theory is of great practical significance.

1.2. Literature Review

1.2.1. Research on Cognitive Load Theory

Since its proposal by Sweller in the 1980s, Cognitive Load Theory has become an important theoretical foundation in the fields of educational psychology and instructional design. In recent years, scholars at home and abroad have conducted in-depth research on Cognitive Load Theory. In foreign studies, Paas et al. (2003) further improved the measurement methods of cognitive load, proposing various measurement means such as subjective evaluation and task performance, which provide effective tools for empirical research on cognitive load [2]. Van Merriënboer and Sweller (2010) proposed a four-component instructional design model based on Cognitive Load Theory, emphasizing that the influence of cognitive load should be fully considered in instructional design, providing a specific guiding framework for teaching practice [3].

In domestic research, Chen Qi and Liu Rude (2020) systematically introduced the basic concepts and application principles of Cognitive Load Theory in Educational Psychology, promoting the dissemination and application of this theory in the domestic education field [4]. Lai Risheng et al. (2005) explored the application of Cognitive Load Theory in multimedia learning, pointing out that reasonable multimedia design can reduce extraneous cognitive load and improve learning effects [5]. These studies have laid a solid foundation for the application of Cognitive Load Theory in the education field.

1.2.2. Research on Digitalization of Specialized English Education in Higher Vocational Colleges

With the advancement of educational digitalization, the digitalization of specialized English education in higher vocational colleges has become a research hotspot. Foreign

scholars such as Bax (2011) explored the application of technology in language teaching, believing that digital technologies can provide a more authentic and interactive environment for language learning, which is beneficial to improving students' language application ability [6]. Among domestic scholars, Wang Haixiao (2021) analyzed the current situation and trends of digitalization in higher vocational English education, pointing out that the richness of digital resources and the innovation of teaching models are the keys to improving the quality of higher vocational English teaching [7].

However, in existing studies, there are relatively few studies that combine Cognitive Load Theory with digital deep learning in specialized English education in higher vocational colleges. Although some scholars such as Li Mang et al. (2020) have explored the application of Cognitive Load Theory in digital learning, research targeting the specific field of specialized English in higher vocational colleges is not in-depth enough, lacking systematic research on optimization paths [8]. Therefore, this study aims to fill this research gap and provide new ideas and methods for digital deep learning in specialized English education in higher vocational colleges.

2. Cognitive Load Theory

2.1. Theoretical Overview

Cognitive Load Theory was proposed by Australian educational psychologist John Sweller in the 1980s. This theory mainly examines the process of learning and problem-solving from the perspective of resource allocation. Its core viewpoint is based on the finiteness of human cognitive resources. When individuals engage in multiple cognitive activities simultaneously, there is a problem of cognitive resource allocation, and the allocation follows the principle of "more here, less there, total amount unchanged"[9]. In the process of learning or problem-solving, various cognitive activities consume cognitive resources. If the total amount of resources required by all activities exceeds the total amount of resources owned by the individual, resource allocation insufficiency will occur, leading to excessive cognitive load, which in turn affects the efficiency of learning or problem-solving.

2.2. Classification of Cognitive Load

2.2.1. Intrinsic Cognitive Load

Intrinsic cognitive load is determined by the nature of the learning material itself, specifically including the complexity of the learning material and the learner's prior knowledge level. The complexity of learning materials is reflected in the number of information elements they contain and the degree of association between these elements. For example, complex professional terms, long and difficult sentences in specialized English, and professional knowledge in specific fields have many information elements and close interconnections, which will bring high intrinsic cognitive load to students. The learner's prior knowledge level also has an important impact on intrinsic cognitive load. If students have rich prior knowledge in a certain professional field, the intrinsic cognitive load of learning materials related to it will be relatively low; conversely, if students lack relevant prior knowledge, the intrinsic cognitive load will increase significantly when facing the same learning materials. Intrinsic cognitive load is inherent in the learning process and cannot be eliminated by changing teaching methods, but some

strategies can be used to reduce its negative impact on learning.

2.2.2. Extraneous Cognitive Load

Extraneous cognitive load mainly stems from the presentation mode of teaching materials and the activities that individuals are required to engage in externally. Unreasonable teaching presentation modes, such as disorganized information presentation, lack of logical order, or simultaneous presentation of too much irrelevant information, will cause students to consume too many cognitive resources when processing information, thereby increasing extraneous cognitive load. For example, in the digital teaching of specialized English, if the interface design of the online course is confusing and the navigation is unclear, students will spend a lot of energy looking for learning content, which undoubtedly increases their extraneous cognitive load. In addition, unnecessary activities that individuals are required to engage in externally, such as frequent switching of learning platforms and cumbersome operation steps, will also increase extraneous cognitive load. Extraneous cognitive load is not necessary for learning. By optimizing instructional design and the presentation mode of teaching materials, this kind of cognitive load can be effectively reduced or even eliminated, thereby releasing more cognitive resources for students' learning.

2.2.3. Germane Cognitive Load

Germane cognitive load refers to the cognitive resources invested by individuals in constructing knowledge structures and establishing connections between new knowledge and existing knowledge. When learners have sufficient cognitive resources available, they can invest additional resources to promote schema construction. This kind of cognitive load that contributes to knowledge construction is germane cognitive load. In specialized English learning, when students can integrate newly learned professional vocabulary and grammatical structures with their existing professional knowledge system, or establish connections with actual professional application scenarios through the analysis of specialized English texts, germane cognitive load is generated. Different from extraneous cognitive load, germane cognitive load has a positive promoting effect on learning. Good instructional design should strive to moderately increase students' germane cognitive load, guide students to conduct in-depth thinking and knowledge integration, thereby improving learning quality.

2.3. Significance of the Theory in Education

Cognitive Load Theory provides a series of important guiding principles for education and teaching. By analyzing different types of cognitive load, educators can better understand students' cognitive states in the learning process, thereby optimizing instructional design in a targeted manner. For example, in the organization and presentation of teaching content, teachers can reasonably arrange the teaching sequence according to the characteristics of the intrinsic cognitive load of learning materials, decompose complex knowledge into simple modules, and guide students to learn step by step to reduce the impact of intrinsic cognitive load. At the same time, by optimizing the presentation mode of teaching materials, such as using clear and concise language and reasonably applying multimedia resources, extraneous cognitive load can be reduced, creating a more favorable cognitive environment for students' learning. In addition, teachers can design various teaching activities to guide

students to actively construct knowledge systems, increase germane cognitive load, and promote the occurrence of deep learning. In specialized English education in higher vocational colleges, the application of Cognitive Load Theory can help teachers make better use of digital teaching resources, improve teaching effects, and cultivate students' specialized English ability and practical application ability.

3. Current Situation of Digitalization in Specialized English Education in Higher Vocational Colleges

3.1. Application of Digital Resources

In current specialized English education in higher vocational colleges, the application of digital resources is becoming increasingly widespread. Various online learning platforms provide students with rich specialized English course resources, covering various aspects from basic professional vocabulary to professional literature reading and specialized English listening and speaking. For example, some higher vocational colleges cooperate with well-known online education platforms to introduce specialized English courses with industry pertinence, and students can carry out independent learning according to their own learning progress and needs. At the same time, digital teaching materials such as electronic textbooks and multimedia courseware have also been widely used. Teachers present specialized English knowledge in a way that combines pictures, texts, audio, and video through carefully produced multimedia courseware, enhancing the intuitiveness and attractiveness of teaching content. In addition, the application of intelligent teaching software in specialized English teaching is gradually increasing, such as some software that can automatically correct homework and provide personalized learning suggestions, providing timely feedback and guidance for students' learning.

3.2. Digital Transformation of Teaching Modes

With the development of digital technologies, the teaching mode of specialized English in higher vocational colleges has also undergone significant changes. The traditional teaching mode dominated by teachers' lectures has gradually transformed into a blended teaching mode, and the combination of online and offline teaching has become the mainstream. In classroom teaching, teachers use multimedia equipment and network resources for teaching, stimulate students' learning interest and improve students' classroom participation by playing videos related to specialized English and organizing online discussions. After class, students can complete homework, take tests, and communicate with teachers and classmates through online learning platforms. For example, some higher vocational colleges have adopted the "flipped classroom" teaching mode. Students learn basic knowledge independently by watching online course videos before class, and during class, they mainly carry out group discussions, case analyses and other activities. Teachers answer questions and provide guidance on the problems encountered by students in the process of independent learning. This transformation of teaching mode aims to give full play to the advantages of digital technologies and cultivate students' independent learning ability and cooperative learning ability.

3.3. Students' Learning Experience and Effects

From the perspective of students' learning experience, most students hold a positive attitude towards the digitalization of specialized English education. The richness of digital resources and the flexibility of learning methods provide them with more learning choices and meet the learning needs of different students. For example, some students believe that online courses allow them to watch repeatedly, which helps them understand and master specialized English knowledge; the personalized learning suggestions of intelligent teaching software are also very helpful for their learning. However, in the actual learning process, there are still some problems affecting students' learning effects. On the one hand, some students lack effective screening and management capabilities when facing a large number of digital learning resources, resulting in low learning efficiency. For example, some students blindly choose courses on online learning platforms without formulating a reasonable learning plan, and finally fail to complete learning tasks. On the other hand, there are many interfering factors in the digital learning environment, such as online socializing and entertainment information, which easily distract students' attention, increase students' cognitive load, and affect the concentration and depth of learning. In addition, some students lack real-time supervision and guidance from teachers in the process of digital learning, and cannot solve problems in a timely manner, which also affects learning effects to a certain extent.

3.4. Existing Problems and Challenges

Although progress has been made in the digitalization of specialized English education in higher vocational colleges, there are still many problems and challenges in the practice process. In terms of teaching resources, although digital resources are rich, there are cases of uneven quality. Some online courses have outdated content, which is disconnected from actual industry applications and cannot meet students' needs for the latest professional knowledge; some multimedia courseware are crudely produced, with unclear information presentation, which instead increases students' cognitive burden. In terms of teaching modes, although the blended teaching mode has been widely applied, in actual operation, the connection between online and offline teaching is not smooth enough. For example, some teachers fail to make full use of the results of students' online learning in classroom teaching, leading to repeated teaching content; some students lack effective supervision and evaluation mechanisms in online learning, making it difficult to guarantee learning quality. In terms of students, in addition to the above-mentioned problems of insufficient learning management ability and vulnerability to interference, there are large differences in digital learning ability among different students. Some students are not proficient in operating digital learning tools, which affects the smooth progress of learning. In addition, in the process of educational digitalization, teachers' digital teaching ability is also facing challenges. Some teachers lack in-depth understanding and application ability of digital teaching tools and teaching methods, making it difficult to give full play to the advantages of digital teaching.

4. Optimization Paths for Digital Deep Learning in Specialized English Education in Higher Vocational Colleges

4.1. Optimization of Instructional Design Based on Cognitive Load Theory

4.1.1. Strategies to Reduce Extraneous Cognitive Load

In the digital instructional design of specialized English education in higher vocational colleges, reducing extraneous cognitive load is an important link to improve teaching effects. Firstly, it is necessary to ensure that the presentation of teaching materials is concise and clear. For complex content in specialized English, teachers should sort out and simplify it reasonably to avoid information redundancy and confusion. For example, when making multimedia courseware, concise language should be used to express professional concepts, and excessive decorative words should be avoided; for long and difficult sentences in specialized English, students can be helped to understand them through grammatical analysis and sentence structure decomposition instead of directly presenting complex sentences. Secondly, optimize the organization and navigation of teaching resources. Online learning platforms should have clear interface design and convenient navigation systems to facilitate students to quickly find the required learning resources. Teachers can classify and organize teaching content according to chapters and knowledge points, and set clear catalogs and indexes so that students can clearly understand the structure and level of learning content. In addition, reasonably control the teaching rhythm to avoid presenting too much information in a short time. In classroom teaching, teachers should reasonably arrange the teaching progress according to students' cognitive characteristics and acceptance ability, and leave enough time for students to think and digest. For example, when explaining specialized English texts, analysis can be carried out paragraph by paragraph. After explaining each paragraph, some questions can be set to guide students to think and discuss, helping students understand and master the content of the paragraph.

4.1.2. Methods to Enhance Germane Cognitive Load

Enhancing germane cognitive load is helpful to promote students' deep learning, and various methods can be adopted in specialized English teaching in higher vocational colleges. One is to design challenging learning tasks. Teachers can design some tasks that require students to think in depth and integrate knowledge according to the teaching objectives of specialized English and students' actual level, such as specialized English case analysis and project-based learning. For example, when learning business English courses, teachers can provide some real business cases and require students to analyze and formulate solutions using the learned specialized English knowledge. In this process, students need to comprehensively apply professional vocabulary, grammar, business knowledge, etc., thereby increasing germane cognitive load and improving their ability to understand and apply knowledge. The second is to promote students' active learning. Encourage students to actively participate in the learning process and actively construct knowledge systems through group cooperative learning, classroom discussions, role-playing and other activities. In group cooperative learning, students can communicate with each other, share views, and complete learning tasks together, which can not

only improve students' learning enthusiasm, but also enable students to think about problems from different angles and deepen their understanding of knowledge. For example, in specialized English listening and speaking courses, group dialogue exercises can be organized to simulate real work scenarios, allowing students to improve their language expression and application ability in communication. The third is to give students timely feedback. Teachers should provide timely and effective feedback on students' learning process and results, help students understand their learning situation, find problems and adjust learning strategies in a timely manner. Feedback can include evaluations of students' homework and tests, as well as immediate feedback on students' performance in classroom teaching. For example, when correcting students' specialized English compositions, teachers should not only point out grammatical errors and improper use of vocabulary, but also put forward specific improvement suggestions on the structure and content expression of students' articles, guiding students to continuously improve their knowledge system.

4.1.3. Methods to Enhance Germane Cognitive Load

Enhancing germane cognitive load is helpful to promote students' deep learning, and various methods can be adopted in specialized English teaching in higher vocational colleges. One is to design challenging learning tasks. Teachers can design some tasks that require students to think in depth and integrate knowledge according to the teaching objectives of specialized English and students' actual level, such as specialized English case analysis and project-based learning. For example, when learning business English courses, teachers can provide some real business cases and require students to analyze and formulate solutions using the learned specialized English knowledge. In this process, students need to comprehensively apply professional vocabulary, grammar, business knowledge, etc., thereby increasing germane cognitive load and improving their ability to understand and apply knowledge. The second is to promote students' active learning. Encourage students to actively participate in the learning process and actively construct knowledge systems through group cooperative learning, classroom discussions, role-playing and other activities. In group cooperative learning, students can communicate with each other, share views, and complete learning tasks together, which can not only improve students' learning enthusiasm, but also enable students to think about problems from different angles and deepen their understanding of knowledge. For example, in specialized English listening and speaking courses, group dialogue exercises can be organized to simulate real work scenarios, allowing students to improve their language expression and application ability in communication. The third is to give students timely feedback. Teachers should provide timely and effective feedback on students' learning process and results, help students understand their learning situation, find problems and adjust learning strategies in a timely manner. Feedback can include evaluations of students' homework and tests, as well as immediate feedback on students' performance in classroom teaching. For example, when correcting students' specialized English compositions, teachers should not only point out grammatical errors and improper use of vocabulary, but also put forward specific improvement suggestions on the structure and content expression of students' articles, guiding students to continuously improve their knowledge system.

4.1.4. Measures to Reasonably Address Intrinsic Cognitive Load

Although intrinsic cognitive load is difficult to reduce directly, some measures can be taken to help students better cope with it. On the one hand, teachers can carry out hierarchical teaching according to students' prior knowledge level. Before teaching, understand students' specialized English foundation and prior knowledge reserve through tests, questionnaires, etc., then divide students into teaching groups at different levels, and formulate differentiated teaching objectives and teaching contents according to the characteristics of different groups. For students with less prior knowledge and weak foundation, the teaching content should focus on explaining and consolidating basic knowledge, and gradually improve their learning ability; for students with better foundation and rich prior knowledge, some extended learning tasks, such as translation and interpretation of specialized English literature, can be provided to meet their learning needs. On the other hand, use knowledge visualization tools to assist teaching. Some abstract concepts and complex knowledge in specialized English can be presented through knowledge visualization tools such as charts, mind maps, and concept maps to help students better understand and remember. For example, when explaining the knowledge system in a certain professional field in specialized English, a mind map can be drawn to clearly show the relationship between various knowledge points, enabling students to intuitively grasp the overall structure of knowledge and reduce intrinsic cognitive load. In addition, teachers can guide students to establish their own knowledge framework, systematically sort out the learned specialized English knowledge, and continuously improve and enrich this framework with the deepening of learning, thereby improving students' ability to organize and manage knowledge and better cope with intrinsic cognitive load.

4.2. Optimization and Integration of Digital Resources

4.2.1. Screening and Updating High-Quality Resources

Screening high-quality resources from numerous digital resources is the key to improving teaching quality. Schools and teachers should establish strict resource screening mechanisms to evaluate and screen online courses, electronic textbooks, teaching software and other resources. The evaluation criteria can include the accuracy and timeliness of resource content, the degree of 契合 with the specialized English teaching syllabus, and the rationality of teaching methods. For example, for online courses, it is necessary to check whether the course content covers the latest professional knowledge and industry trends, whether the production quality of teaching videos is good, and whether the teacher's explanation is clear and easy to understand. At the same time, the selected digital resources should be updated regularly to ensure their timeliness. With the continuous development and changes in the professional field, the teaching content of specialized English also needs to keep pace with the times. Schools and teachers should pay attention to industry development trends, timely replace resources with outdated content that does not meet the needs of practical applications, and provide students with the latest and most practical specialized English learning resources.

4.2.2. Integrating Multimodal Resources

The integration of multimodal resources can provide students with a richer and more comprehensive learning

experience, help reduce students' cognitive load, and promote deep learning. In specialized English teaching in higher vocational colleges, various modal resources such as text, pictures, audio, and video can be organically integrated. For example, when explaining specialized English texts, the text version of the text, relevant pictures and charts can be provided to help students understand the professional concepts in the text, the audio of the text can be played for students to conduct listening training, and some video materials related to the text content, such as explanations by industry experts and display of actual work scenarios, can also be found to deepen students' understanding of knowledge from multiple angles. In addition, virtual reality (VR) and augmented reality (AR) technologies are used to create an immersive learning environment for students. In the practical teaching of specialized English, real work scenarios are simulated through VR or AR technologies, allowing students to communicate and apply specialized English in a virtual environment, improving students' learning interest and participation, and at the same time enhancing students' understanding and application ability of professional knowledge. For example, in tourism English teaching, VR technology can be used to allow students to virtually visit famous scenic spots and conduct tour guide explanations in English, enabling students to exercise their specialized English expression ability in real situations.

4.2.3. Establishing a Personalized Resource Recommendation System

Each student has different learning abilities, interests, and learning needs. Establishing a personalized resource recommendation system can better meet students' personalized learning needs. Schools and teachers can use learning analytics technology to collect data in students' learning process, such as learning time, learning progress, homework completion, test scores, etc., and understand students' learning characteristics and needs through data analysis. Then, according to these analysis results, recommend suitable digital learning resources for students. For example, for students who have a faster learning progress and have higher pursuit of professional knowledge, some difficult specialized English literature and academic lecture videos can be recommended; for students who have difficulties in a certain knowledge point, relevant tutoring materials and practice questions can be recommended. The personalized resource recommendation system can not only improve students' learning efficiency, but also stimulate students' learning enthusiasm, enabling students to conduct deep learning in their areas of expertise and interest.

4.3. Cultivating Students' Digital Learning Ability

4.3.1. Guidance on Learning Strategies

In the digital environment of specialized English education in higher vocational colleges, cultivating students' learning strategies is crucial. Teachers should teach students effective learning strategies to help them better manage and utilize digital learning resources. The first is time management strategy. Teachers should guide students to formulate reasonable learning plans, arrange online learning time reasonably, and avoid procrastination and fatigue caused by too long learning time. For example, teachers can help students formulate a weekly specialized English learning plan, clarify the learning tasks and learning time to be completed each day, so that students can develop good learning habits.

The second is information screening and management strategy. Facing massive digital information, students need to learn to screen useful information and manage this information effectively. Teachers can teach students how to use keyword search, evaluate the reliability of information sources and other methods to screen information through teaching activities; at the same time, guide students to use note-taking software, literature management software and other tools to classify and organize learning materials for easy reference and review in the future. In addition, there is problem-solving strategy. In the process of digital learning, students will inevitably encounter various problems. Teachers should cultivate students' problem-solving ability and guide students to learn to use online resources, consult teachers and classmates, etc. to solve problems. For example, teachers can organize students to conduct group discussions, let students share the problems they encounter in the learning process and how to solve them, and cultivate students' ability to solve problems independently. When students encounter difficulties in specialized English translation, teachers can guide students to use online translation tools for preliminary translation, then compare with reference translations, analyze the problems in their own translations, and try to find solutions to the problems.

4.3.2. Training on the Use of Digital Tools

To enable students to make better use of digital learning tools and improve learning efficiency, schools and teachers should carry out systematic training on the use of digital tools. The training content can include the use of common online learning platforms, learning management software, specialized English learning tools, etc. For example, for online learning platforms, students should be trained on how to register accounts, log in to the platform, find courses, and participate in course learning activities (such as watching videos, submitting homework, participating in discussions, etc.); for learning management software, students should be taught how to use the software to formulate learning plans, record study notes, manage learning materials, etc. In addition, according to the characteristics of specialized English learning, some use skills of specialized English learning tools, such as professional term dictionaries and literature retrieval tools, can also be introduced. For example, teach students how to use professional term dictionaries to accurately find the meanings and usages of professional vocabulary, and how to use literature retrieval tools to obtain relevant specialized English literature and conduct effective reading and analysis. Through systematic training, students can master the use of digital learning tools proficiently, reduce the cognitive load caused by unskilled operation, and improve the effect of digital learning.

4.3.3. Cultivating Independent Learning Ability

Independent learning ability is the key for students to achieve good learning effects in the digital learning environment. In specialized English education in higher vocational colleges, teachers should pay attention to cultivating students' independent learning ability. First of all, stimulate students' learning motivation and interest. Teachers can make students realize the importance and practicality of specialized English learning by introducing actual professional cases and demonstrating the application of specialized English in the industry, thereby stimulating students' learning enthusiasm and initiative. For example, when explaining business English courses, some real business negotiation cases can be introduced to let students see the

application of specialized English in actual business activities, thereby improving students' interest in learning business English. Secondly, guide students to establish the awareness of independent learning. Teachers should make students understand the importance of independent learning and help students realize that they are the main body of learning and should be responsible for their own learning. For example, teachers can organize students to discuss the significance and methods of independent learning in class, encourage students to share their learning experiences and insights, and cultivate students' awareness of independent learning. In addition, teachers can guide students to gradually master independent learning methods by setting independent learning tasks. For example, assign some extracurricular specialized English reading tasks, require students to independently choose reading materials, formulate reading plans, and complete reading reports. In this process, teachers provide students with appropriate guidance and feedback to help students improve their independent learning ability.

4.4. Improving Teachers' Digital Teaching Ability

4.4.1. Training and Professional Development

Schools should attach importance to the improvement of teachers' digital teaching ability and provide teachers with systematic training and professional development opportunities. The training content can cover digital teaching concepts, application of teaching tools, instructional design and implementation, etc. In the training of digital teaching concepts, teachers should be made to understand the development trend and importance of educational digitalization, master the principles and methods of digital instructional design based on Cognitive Load Theory, and update teaching concepts. For example, by organizing teachers to participate in lectures, seminars and other activities related to educational digitalization, teachers can be exposed to the latest educational concepts and research results, and broaden their horizons. In terms of training on the application of teaching tools, detailed operation training should be carried out for digital tools commonly used by teachers in teaching, such as online teaching platforms, multimedia courseware production software, and intelligent teaching software, so that teachers can master the use skills of these tools proficiently and flexibly use various tools for teaching according to teaching needs. For example, hold multimedia courseware production training courses, invite professionals to explain to teachers how to make exquisite multimedia courseware, including how to select appropriate pictures, audio, video materials, and how to design the layout and interactive effects of courseware. In addition, training on instructional design and implementation can also be carried out to guide teachers on how to design reasonable teaching plans using digital resources according to the teaching objectives and student characteristics of specialized English, and effectively implement and adjust teaching plans in the teaching process. For example, organize teachers to conduct case analysis and practical drills of instructional design based on digital teaching, so that teachers can improve their instructional design and implementation capabilities in practice.

4.4.2. Teaching Team Collaboration and Communication

Establishing a teaching team collaboration and communication mechanism is helpful for teachers to jointly improve their digital teaching ability. Teachers can carry out

teaching research and practice through team cooperation, share teaching experience and resources, and solve problems encountered in teaching together. For example, establish a specialized English digital teaching team, which can include English teachers in different professional directions, educational technology experts, etc. The team regularly organizes teaching research activities, where teachers exchange their experiences and confusion in digital teaching and discuss solutions together. At the same time, team members can cooperate in division of labor to jointly develop digital teaching resources, such as online courses, teaching courseware, teaching case libraries, etc. Through team collaboration, teachers can give full play to their respective advantages and improve the quality and applicability of digital teaching resources. In addition, teaching teams can also carry out exchanges and cooperation with other higher vocational colleges or industry enterprises, learn from advanced digital teaching experience and practices. For example, organize teachers to observe and learn in other colleges to understand the successful experience of other colleges in digital teaching of specialized English; invite industry experts to participate in the discussion activities of the teaching team, provide suggestions on the actual needs of the industry for teaching, and make teaching better combined with industry practice.

4.4.3. Teaching Reflection and Improvement

Teachers themselves should pay attention to teaching reflection and improvement, and continuously improve their digital teaching ability. In the teaching process, teachers should pay close attention to students' learning reactions and learning effects, collect students' feedback in a timely manner, and reflect on the teaching process. For example, teachers can understand the problems and difficulties encountered by students in the learning process and the shortcomings in teaching through classroom observation, analysis of students' homework and test scores, and data analysis of online learning platforms. Then, according to the reflection results, adjust and improve the teaching content, teaching methods, and application of teaching resources. For example, if it is found that students have difficulties in learning a certain specialized English knowledge point, teachers can re-examine the presentation mode of the teaching content and consider whether it can be explained in a simpler and easier way; if it is found that students' participation in the online learning platform is not high, teachers can think about how to optimize the design of teaching activities to improve students' learning enthusiasm and participation. In addition, teachers can combine teaching reflection with teaching research, conduct in-depth research on the problems existing in teaching, explore more effective teaching strategies and methods, and continuously improve their teaching level and digital teaching ability.

5. Conclusion

This study deeply explores the optimization paths for digital deep learning in specialized English education in higher vocational colleges from the perspective of Cognitive Load Theory. By analyzing Cognitive Load Theory, it clarifies the concepts of intrinsic cognitive load, extraneous cognitive load, and germane cognitive load and their mechanism of action in teaching. Based on the analysis of the current situation of digitalization in specialized English education in higher vocational colleges, it reveals the existing

problems in current teaching, such as uneven quality of digital resources, unsmooth connection of teaching modes, insufficient digital learning ability of students, and teachers' digital teaching ability to be improved. In response to these problems, a series of optimization paths are proposed based on Cognitive Load Theory, including reducing extraneous cognitive load, enhancing germane cognitive load, and reasonably addressing intrinsic cognitive load from the perspective of instructional design; optimizing and integrating digital resources by screening and updating high-quality resources, integrating multimodal resources, and establishing a personalized resource recommendation system; cultivating students' digital learning ability from the aspects of learning strategy guidance, digital tool use training, and independent learning ability cultivation; and improving teachers' digital teaching ability through training and professional development, teaching team collaboration and communication, and teaching reflection and improvement. These optimization paths aim to provide scientific guidance for digital deep learning in specialized English education in higher vocational colleges, reduce students' cognitive burden, improve learning efficiency, and promote the improvement of students' specialized English ability.

However, this study still has certain limitations. On the one hand, the research is mainly based on theoretical analysis and summary of existing practical experience, lacking large-scale empirical research to further verify the effectiveness of the proposed optimization paths. Future research can design rigorous empirical studies, select specialized English teaching classes in different higher vocational colleges for comparative experiments, and collect more abundant data to evaluate the implementation effect of optimization paths. On the other hand, with the continuous development and update of educational digital technologies, new teaching tools and teaching modes are constantly emerging, and the optimization paths proposed in this study may need to be continuously adjusted and improved according to the development of technologies. Follow-up research should continue to pay attention to the latest developments in the field of educational digitalization, and timely integrate new technologies and concepts into the research on optimization of digital deep learning in specialized English education in higher vocational colleges to better adapt to the development needs of education and teaching.

References

- [1] Zhang Liguang, Liu Xiaolin, Wang Yu. (2022). Theoretical Logic and Practical Path of Educational Digital Transformation. *E-education Research*, (1), 5-13.
- [2] Paas, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, 38(1), 63-71.
- [3] Van Merriënboer, J. J. G., & Sweller, J. (2010). Cognitive load theory in health professional education: Design principles and strategies. *Medical Education*, 44(1), 85-93.
- [4] Chen Qi, Liu Rude. (2020). *Educational Psychology* (3rd ed.). Higher Education Press.
- [5] Lai Risheng, Zeng Xiaoqing, Chen Meirong. (2005). The Application of Cognitive Load Theory in Instructional Design and Its Enlightenment. *Psychological Science*, 28(5), 1115-1119.
- [6] Bax, S. (2011). CALL: past, present and future. *System*, 39(1), 13-24.

- [7] Wang Haixiao. (2021). College English Teaching Reform in the New Era: Problems and Countermeasures. *Foreign Language Teaching*, 42(3), 56-61.
- [8] Li Mang, Li Ziyun, Zheng Tainian. (2020). Cognitive Mechanism and Instructional Design of Digital Learning. *E-education Research*, (1), 5-13.
- [9] Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257-285.