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Application of CiteSpace Knowledge Graphs in the Teaching of Oil and Gas Storage and Transportation Technology

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Abstract

As a key discipline in the petroleum industry, oil and gas storage and transportation technology shoulders the crucial task of ensuring national energy security and serves as a source of high-quality technical talent for oil and gas companies. In the talent development process, classroom instruction is a crucial way for students to master the basic concepts, principles, methods, and techniques of oil and gas storage and transportation. Traditional teaching models have placed excessive emphasis on textbook knowledge, but in the "Internet+" era, learners should transcend time and space to understand advanced theoretical knowledge both domestically and internationally. Therefore, to diversify the course content, this paper utilizes the internet software CiteSpace to apply knowledge graphs to the teaching of the oil and gas storage and transportation technology course. Taking the course "Basic Knowledge of Oil and Gas Storage and Transportation" as an example, this paper integrates knowledge graphs with classroom tests, classroom themes, and case studies. This integrates internet technology and course resources, breaking the spatial and temporal limitations of learning, promoting the construction of a professional knowledge system, and significantly improving students' comprehensive problem-solving skills, injecting strong momentum into the development of the oil and gas storage and transportation industry.

Keywords

Knowledge Graph; Oil and Gas Storage and Transportation; Basic Knowledge of Oil and Gas Storage and Transportation; Teaching Application.

1. Introduction

The Oil and Gas Storage and Transportation Technology major is primarily aimed at those working on the front lines of production, service, and management [1] in the oil and gas storage, transportation, and supply industries. It cultivates high-quality technical and skilled personnel for roles in oil and gas gathering and transportation, oil and gas pipeline transportation, oil and gas storage, and gas transmission and distribution. These professionals require a solid scientific and cultural foundation and knowledge of oil and gas transportation equipment, oil and gas metering, and oil analysis, as well as certain capabilities in storage and transportation process control and oil and gas transportation operations. Oil and Gas Storage and Transportation Technology courses should emphasize the development of students' thinking and analytical skills. However, some universities have outdated teaching models, focusing too much on textbook knowledge. Teaching content is limited to the existing textbook knowledge level, while neglecting the expansion and extension of extracurricular knowledge. Under these circumstances, it is difficult for students to form a complete knowledge framework and achieve teaching objectives.

Integrating internet technology with course resources can break the spatial and temporal limitations of learning, meet the personalized learning needs of teachers and students, and truly realize the "Internet +" Transformation of traditional teaching models. Knowledge graphs serve as a bridge to this path. Knowledge graphs combine scientific theories and methods such as applied mathematics and information visualization with relevant metrology methods to visually display the core content, development progress, latest technologies, and macro-architecture of a discipline through visual graphs [2] . Applying knowledge graphs to the teaching of oil and gas storage and transportation technology can fully leverage the guiding role of internet technology in professional teaching. For example, "Basic Knowledge of Oil and Gas Storage and Transportation" is the first foundational course in the major and serves as the foundation for the theoretical framework of the oil and gas storage and transportation discipline. By taking this course, freshmen can systematically grasp the basic concepts, principles, and techniques of oil and gas storage and transportation, laying a solid foundation for studying the core courses in the major. A review of the literature indexed by CNKI reveals that current research on similar course teaching focuses primarily on theoretical explanation [3] and practical application [4-5] . Few studies integrate classroom teaching in oil and gas storage and transportation technology with internet technologies to develop a diversified knowledge system. This study will use the "Main Performance Requirements of Gasoline" knowledge point in the course "Basic Knowledge of Oil and Gas Storage and Transportation" as an example to illustrate the application of the CiteSpace knowledge graph in the teaching of oil and gas storage and transportation technology.

2. Theoretical Design of Integrating Knowledge Graphs with Classroom Instruction

Classroom instruction for professional foundation courses is a theoretical and contextualized modern classroom teaching method designed and developed for specific knowledge points or teaching links, with teachers teaching and students learning theoretically as the primary carriers.

Classroom teaching consists of three phases: pre-class, in-class, and post-class. Before class, learners log in to the learning app on their mobile phone or PC to review course information, learn about the upcoming unit, preview relevant materials such as courseware and textbooks, and clarify the teaching objectives, key points, and difficult content. During class, teachers complete the course through a series of steps: introduction, clarifying learning requirements, pre-class testing, interactive learning, post-class testing, and lesson summary. After mastering the key content of the lesson, students engage in advanced learning. Throughout each classroom session, learners utilize CNKI and CiteSpace software, focusing on the current lesson's core knowledge points and branching out to related knowledge in other disciplines. They learn about the latest research developments in these areas, then select appropriate topics based on their situation and engage in targeted reading of high-quality articles to continuously improve their knowledge base, thereby achieving the scientific application of internet technology in classroom instruction.

In the process of teaching design using internet technology, to ensure the quality of professional and technical teaching, at the knowledge level, teachers can set the number of articles learners read to 3-5. After mastering the basic knowledge required by the course, learners can expand their learning scope according to their own knowledge thinking, understand the latest developments in the industry and the urgent problems that need to be solved, and build their own knowledge system, while also providing guidance for future learning and research. Regardless of the knowledge learning link, as university teachers, our goal is to cultivate petrochemical talents with strong professional skills and outstanding comprehensive qualities.

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Therefore, at the ideological level, teachers can set the number of case studies of figures and deeds to 3. By studying the heroic deeds of the long history of petroleum development and taking selfless petroleum workers as role models, learners' thoughts and behaviors can be subtly shaped, completing the most important part of course teaching-the inculcation of ideological and political literacy.

3. Application of the CiteSpace Knowledge Graph in the Teaching of "Basic Knowledge of Oil and Gas Storage and Transportation"

During the classroom teaching and learning process of "Basic Knowledge of Oil and Gas Storage and Transportation," each knowledge unit must be carefully considered and completed: classroom assessment, classroom theme, and classroom case studies. These three components constitute a connected knowledge system. Failure to complete these components prevents progression to the next knowledge unit, making them crucial indicators for evaluating the high-quality and high-quantity completion of each knowledge unit. The course setup is shown in Figure 1.

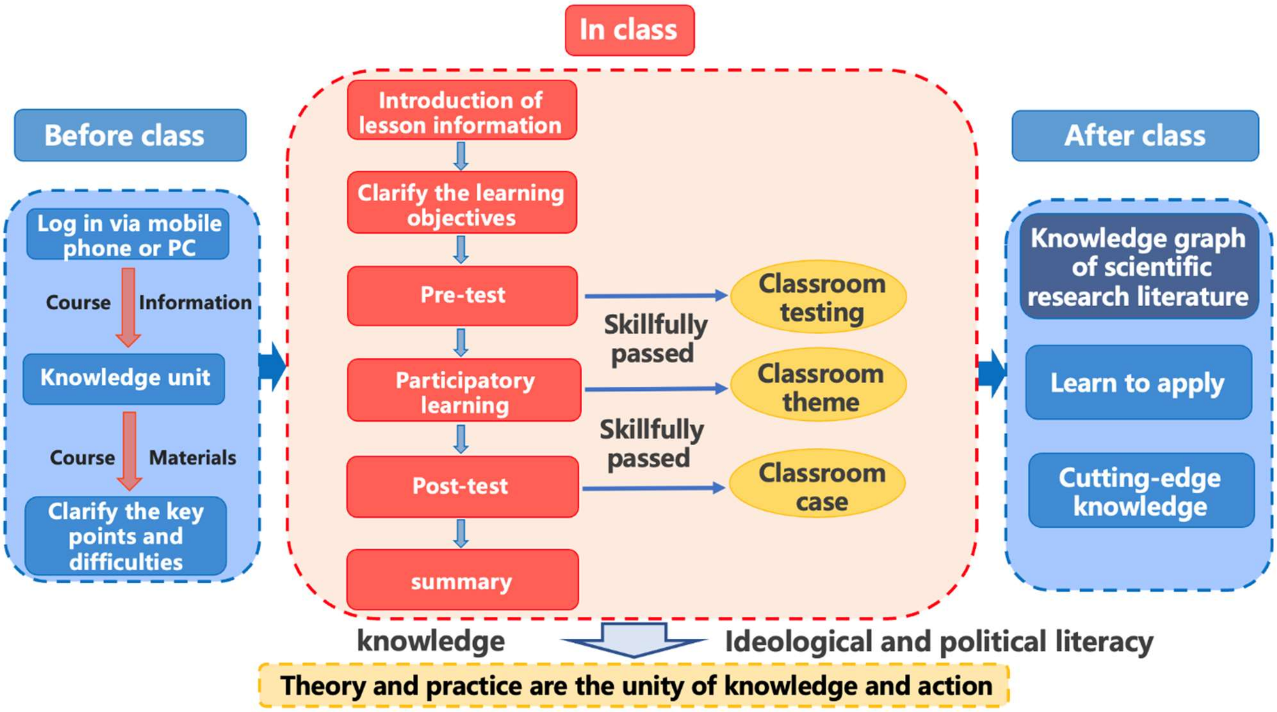

Figure 1. Application of Knowledge Graphs in Teaching

Integrating the knowledge graph with classroom tests, classroom themes, and case studies, linking CiteSpace software to each knowledge graph segment, teachers can pre-enter selected keywords, and learners select the top 10 points based on the content to read. This allows them to explore the latest fields and themes with the most research participants, understand the latest developments in these fields or issues, and continuously improve their knowledge base. The following details the specific applications of the CiteSpace knowledge graph in these three segments.

3.1. Classroom Assessment

After the classroom introduction, clarifying the knowledge objectives of "Main Performance Requirements of Gasoline," and highlighting key points and difficulties, teachers can use keyword cluster analysis to determine the class theme and key areas. Incorporating current hot

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topics, they can design pre-assessment content to truly reflect students' theoretical foundation and understanding of a key point. This helps teachers understand students' cognitive level and interests, providing a reference for selecting subsequent teaching strategies based on their basic learning situation. This can also serve as a basis for evaluating students' previous learning outcomes and providing targeted supplementary instruction to address their shortcomings. Figure 2 shows the clustering of keywords centered around "gasoline performance." This allows learners to effectively identify topics, predict trends, and analyze knowledge structures.

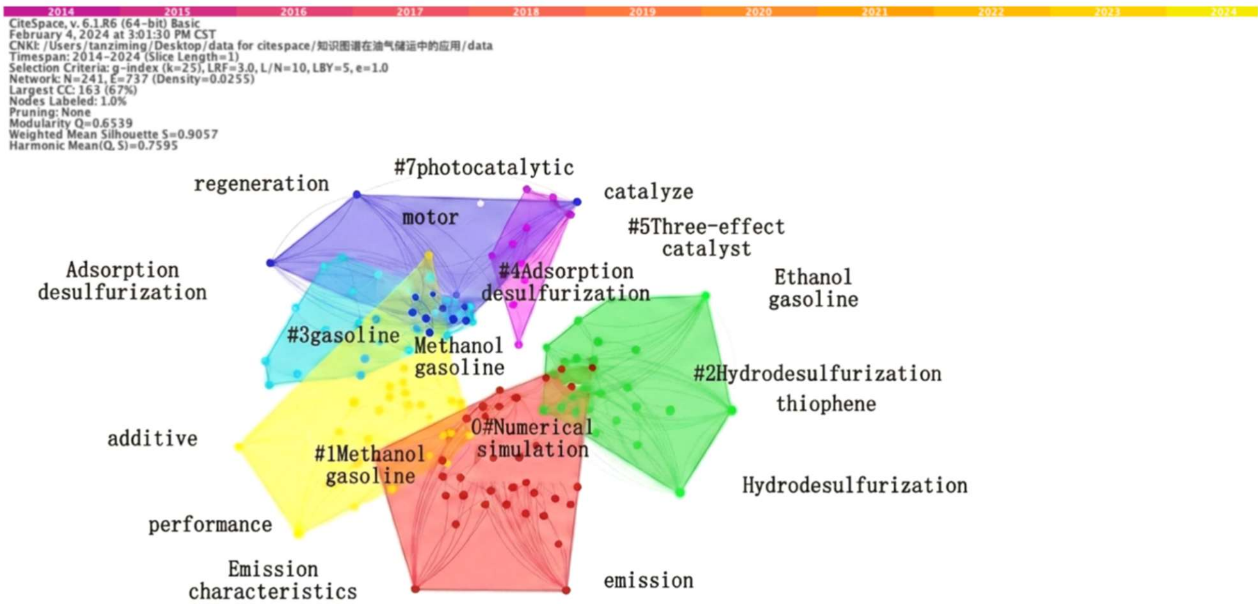

Figure 2. Keyword Clustering for Gasoline Performance

3.2. Class Topics

As a key component of the CiteSpace knowledge graph in professional teaching, it integrates the fragmented knowledge within each knowledge unit into a cohesive whole, combining it with classroom teaching objectives and key points. The following uses the teaching of "Main Performance Requirements of Gasoline" as an example to introduce the types of knowledge graphs and their applications in classroom topics.

When preparing lessons, teachers need to build upon their knowledge beyond the textbook and design rich and substantial content to ensure the content is more advanced. After completing the in-class learning, learners need to update and expand their knowledge based on remaining questions or interests to complete their professional knowledge. Therefore, it is necessary to understand the recent developments in gasoline performance. Taking the past 10 years as an example, a search using CNKI with the following criteria: Topic: Gasoline Performance; Time Range: January 1, 2014 - January 1, 2024, retrieved 322 articles. Based on the retrieved articles, the following results are obtained:

Figure 3 shows that research on gasoline performance continued from 2014 to 2024, with publications reaching a peak in 2016 and subsequently showing an overall downward trend. This reminds learners that gasoline performance research is currently less frequent and its status as a hot topic has declined. It also encourages learners to consider the reasons for this phenomenon, allowing them to be problem-oriented, actively engage in practical research, explore the causes, and discover new ideas.

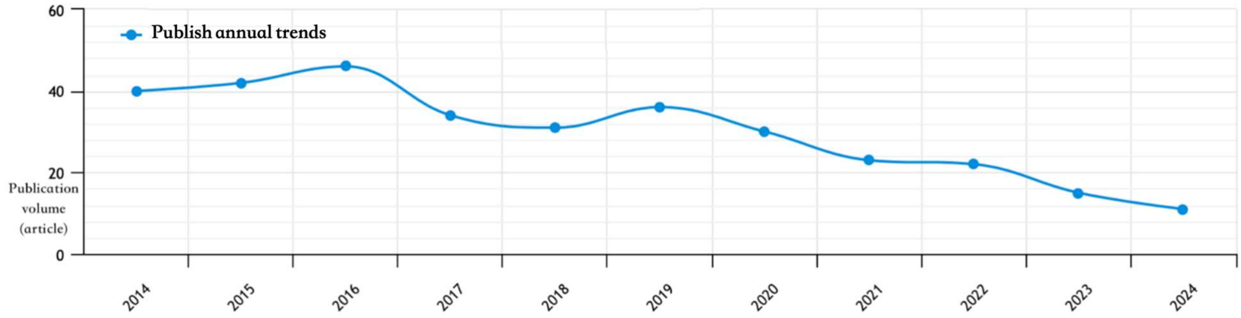

Figure 3. Trends in the Number of Published Articles on Gasoline Performance Over the Past 10 Years

Figure 4 shows that gasoline performance has been extensively researched in the fields of "fuel chemical engineering," "petroleum and natural gas industry," and "automotive industry," demonstrating that gasoline performance remains a key research issue in the petrochemical industry.

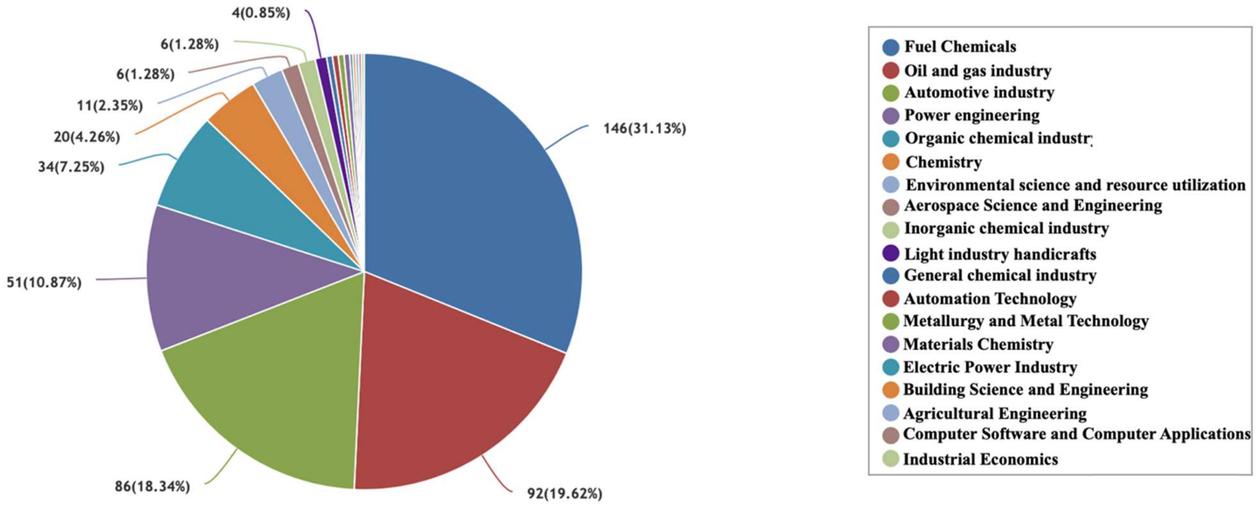

Figure 4. Distribution of Major Research Disciplines in Gasoline Performance Over the Past 10 Years

Figure 5 shows the main research topics in gasoline performance over the past decade. Among them, research on engines, methanol gasoline, and ethanol gasoline has been prevalent, further demonstrating the importance of gasoline performance to engine function. A thorough review of the research literature reveals that most of the articles are case studies. Learners can combine the basic knowledge learned in class with understanding the analytical process in the literature to consolidate their learning through practice.

Figure 6 shows the main keywords currently used in gasoline performance research. This provides students with a clear direction for further study and allows them to further read relevant literature based on their interests and hot topics.

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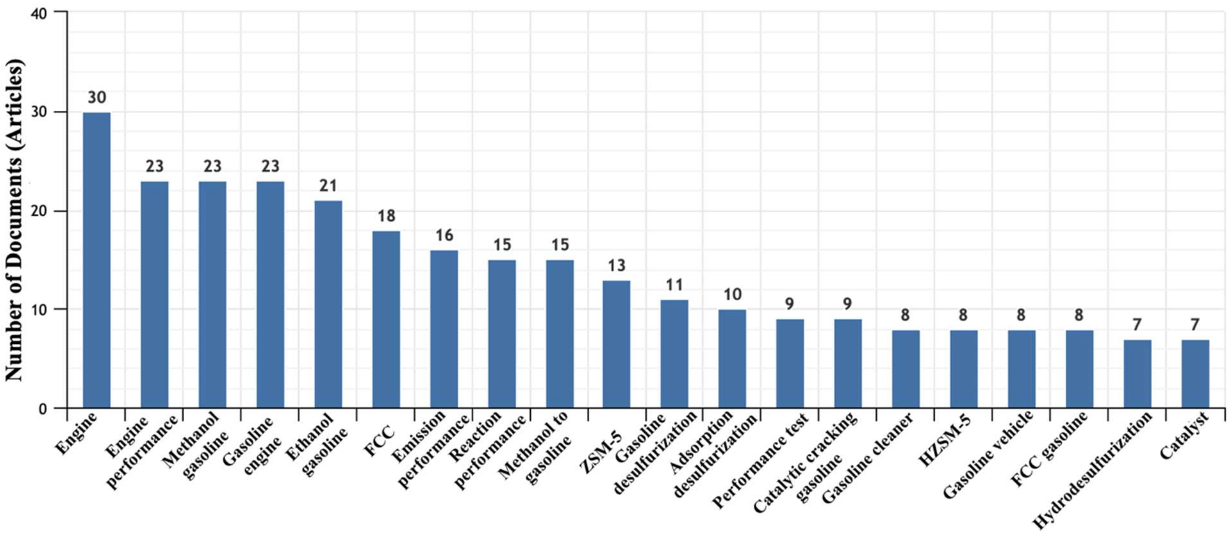

Figure 5. Major Research Topics in Gasoline Performance Over the Past 10 Years

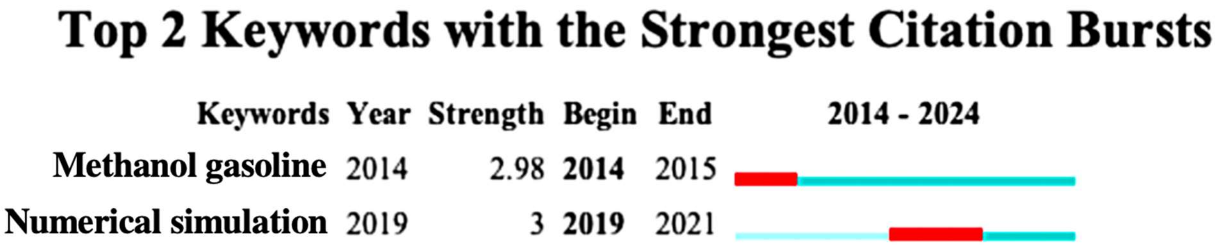

Figure 6. Journal Distribution of Gasoline Performance Research

3.3. Classroom Case

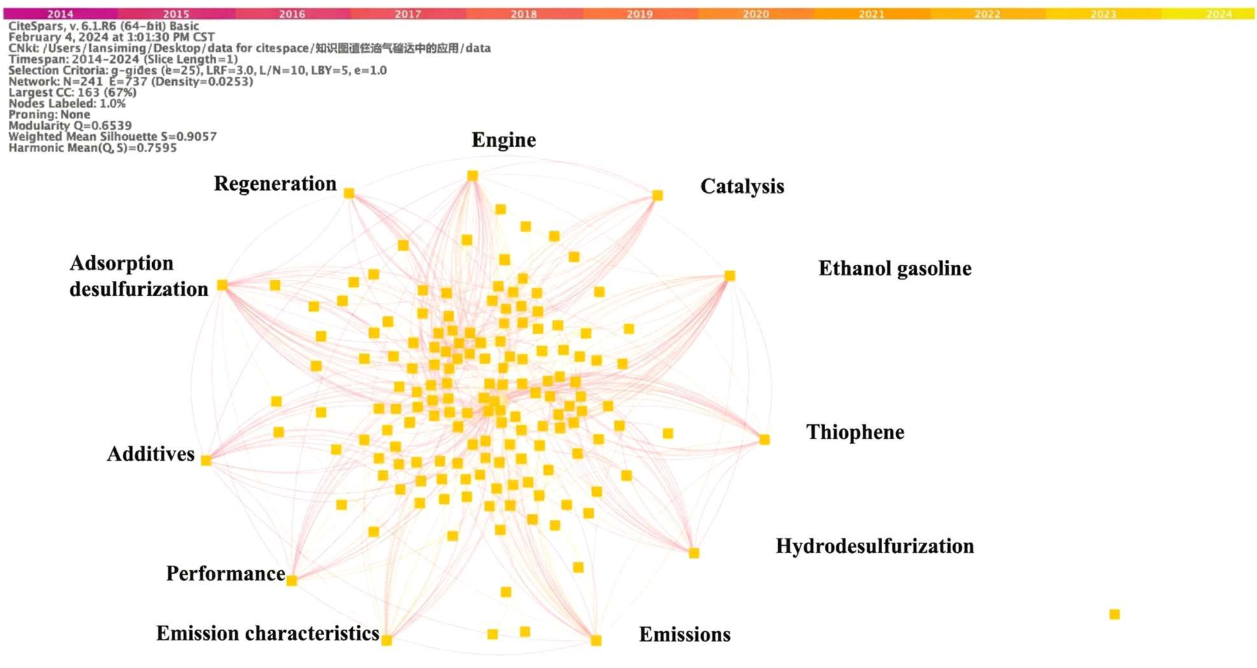

Figure 7. Knowledge Map of Gasoline Performance

To test learning outcomes, after the basics of gasoline performance are explained, teachers design and present comprehensive case studies to learners, requiring them to complete the comprehensive case studies based on the content learned in class. This comprehensive case study helps learners connect knowledge about gasoline performance, its scope of use, and gasoline engine functions, truly integrating theory with practice. Figure 7 shows a knowledge graph on gasoline performance generated using CiteSpace software. The specific content displayed is linked to the knowledge units studied in this lesson, thus completing the knowledge network for gasoline performance.

4. Conclusion

Extending the application of the CiteSpace knowledge graph in the "Basic Knowledge of Oil and Gas Storage and Transportation" course to the specialized course on oil and gas storage and transportation technology not only improves teachers' teaching skills and overcomes professional skill barriers, but also facilitates students' mastery of key course content. It also connects fragmented knowledge into a knowledge system tailored to their specific circumstances, allowing them to develop personalized learning plans and truly achieve mutual improvement.

Using the CiteSpace knowledge graph to assist learning also places higher demands on both teachers and students. Teachers are required to master literature research methods, primarily using CNKI, and the use of CiteSpace software, and to regularly update the knowledge graph to ensure that the information remains current. Students, while mastering the basics, are required to proactively expand their knowledge base based on cutting-edge materials, gradually becoming well-rounded individuals with knowledge across multiple disciplines and fields.

In summary, the teaching of the Oil and Gas Storage and Transportation Technology major still has many shortcomings. In the following teaching practice, we will continue to improve and update the shortcomings of teaching under the background of the "Internet +" era, and explore teaching methods that adapt to the information age.

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