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Exploration of the Application of Knowledge Graphs in University Medical Education Under the Background of Artificial Intelligence

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Abstract: The integration of artificial intelligence (AI) technology and the digitalization of higher education has provided new development directions for the optimization and upgrading of university medical education. Relying on structured semantic networks and visual presentation forms, knowledge graphs can adapt to the characteristics of medical education featuring a complex knowledge system, close internal correlations and strong practicality, and they demonstrate unique values in medical knowledge integration, expansion of teaching scenarios and optimization of learning modes. Based on the background of educational digitalization, this paper elaborates on the enabling effects of AI and knowledge graphs on university medical education, sorts out the standardized construction procedures of medical knowledge graphs, and discusses the practical application paths of knowledge graphs combined with teaching scenarios of basic medicine, clinical medicine and other courses. It is expected to provide useful references for the digital transformation of university medical education.

Keywords: Artificial intelligence; Knowledge graphs; University medical education; Educational digitalization

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1. Introduction

China Education Modernization 2035 proposes to promote the digital transformation of education and boost the in-depth integration of information technology and education and teaching. The construction of New Medical Disciplines requires universities to strengthen interdisciplinary integration of medicine and cultivate medical talents with systematic thinking and practical capabilities. AI has advantages in optimizing teaching management and adaptive planning of personalized learning paths, providing technology support for the innovation of educational models. The popularization of AI technology has gradually broken the limitations of traditional medical teaching. As an important branch of AI, knowledge graphs are the main manifestation of knowledge engineering and possess very broad development prospects. With the characteristics of visualization, strong correlation and expandability, knowledge graphs have become an important carrier connecting medical knowledge and intelligent teaching [1]. In university medical teaching, knowledge is presented independently based on single disciplines and chapters, which makes it difficult for students to sort out knowledge correlations on their own. Besides, the distribution of teaching resources and teaching guidance cannot match the learning rhythm of each student. Integrating knowledge graphs into university medical education can reorganize the presentation form of medical knowledge with the help of AI's data analysis and knowledge integration capabilities, and satisfy the dual demands of teaching and learning. Combined with the development background of AI and the practical characteristics of medical education, this paper explores the application logic and practical paths of knowledge graphs in university medical education.

2. Core values of AI and knowledge graphs empowering university medical education

2.1. Reshape the presentation and organization forms of medical knowledge

The absorption and migration of medical knowledge require the establishment of a complete logical system; memorizing scattered knowledge points alone cannot form clinical thinking. AI technology can conduct semantic analysis on massive medical texts, textbooks and diagnosis and treatment guidelines, and knowledge graphs can convert analyzed knowledge into network structures consisting of nodes and correlations [2]. This organizational form changes the discipline-based knowledge division mode of traditional textbooks, and reorganizes scattered medical contents from different disciplines in accordance with physiological logic and diagnosis & treatment processes. Taking ophthalmology as an example, knowledge graphs can connect eye anatomical structures, visual physiological functions and abnormal pathological changes to form the knowledge system of 'structure—function—pathology' interconnection and help students build complete cognitive frameworks with internal logic.

2.2. Conform to the cognitive development rules of medical students

The learning paths of medical students follows the cognitive sequence from basic courses to clinical applications and from theoretical knowledge to practical operation. Different students have varying learning progress and comprehension abilities. AI can record students' behavioral data such as learning operations and knowledge absorption status, and knowledge graphs can match corresponding learning contents and resources based on such data. When students learn basic knowledge points, they can extend to related clinical contents step by step via graphs; when encountering confusing knowledge points, they can trace back pre-requisite knowledge and view auxiliary materials relying on graphs. Such adaptive mode conforms to the gradual rules of medical learning, and the learning process can be carried out in line with students' cognitive rhythms.

2.3. Expand implementation scenarios and dimensions of medical teaching

Traditional medical teaching mainly adopts classroom lectures and courseware display with relatively single forms. Nowadays, combined with online teaching platforms and virtual teaching tools, knowledge graphs can expand teaching scenarios. Before class, students can preview knowledge points independently through graphs; during class, teachers can carry out interactive teaching with graphs; after class, students can consolidate learned knowledge and expand their horizons relying on graphs. Meanwhile, knowledge graphs can be connected with clinical cases, teaching videos, scientific research literature, and multiple types of resources, linking theoretical teaching, clinical practice, and scientific research exploration, and enriching teaching contents and forms [3,4].

3. Construction procedures of knowledge graphs in university medical education

3.1. Integration and screening of core teaching data sources

The primary link of constructing medical knowledge graphs is integrating teaching data sources. Constructors take university medical teaching syllabuses, national planned textbooks and clinical diagnosis & treatment guidelines as core data sources, and incorporate the latest medical research literatures, teaching courseware, virtual simulation resources and other contents. Data sources vary for different medical courses: biochemistry focuses on interdisciplinary materials of biology, chemistry and molecular science, while immunology centers on data covering immune cells and immune responses [5].

3.2. Extraction of medical knowledge entities and correlations

After integrating data sources, natural language processing models of AI are adopted to extract medical knowledge and entity correlations from texts and materials. Knowledge entities refer to specific medical concepts such as diseases, symptoms, pathological features and medicines, while correlations cover logical relations including diagnosis and analysis as well as treatment. Professional medical teachers shall review contents extracted by AI during extraction, correcting errors and supplement missing information [6]. Hundreds of core knowledge entities can be extracted for some courses through this procedure, forming basic data covering core course knowledge domains.

3.3. Construction and optimization of hierarchical knowledge frameworks

After extracting knowledge entities and correlations, hierarchical knowledge frameworks are built in accordance with medical teaching cognitive logic and curriculum systems. Taking general course overviews as first-level nodes, the framework subdivides secondary and tertiary nodes such as organ systems, disease types and regulatory mechanisms downward, gradually extending to specific knowledge points to form vertically connected knowledge veins. Horizontal knowledge correlations are constructed based on clinical diagnosis & treatment and physiological regulation logics, forming networked connections between knowledge points of different levels and modules.

3.4. Matching and mounting of multi-modal teaching resources

After building hierarchical frameworks, multi-modal teaching resources are matched to knowledge nodes. Matched resources include anatomical diagrams, tissue morphology images, clinical cases, exercise banks, research literature, and curriculum ideological & political materials. Resource screening follows the principles of teaching applicability, medical authority, and content frontier. When students click any knowledge node, they can view corresponding explanation materials, exercises and clinical cases, forming a resource system integrating learning, practice and expansion, and transforming knowledge graphs into interactive and applicable teaching tools.

4. Specific applications of knowledge graphs in university medical education under the background of AI

4.1. Reconstruct course contents and sort out logical veins of knowledge

Basic medicine courses such as anatomy, physiology and pathology are taught separately in traditional teaching, with knowledge of different disciplines isolated, making it hard for students to build coherent knowledge systems. With the help of AI's knowledge integration and semantic correlation capabilities, knowledge graphs conduct structural reconstruction of traditional course contents, and integrate scattered medical knowledge points across different courses and chapters based on logics including anatomical structures, tissue morphology, physiological functions and pathological changes for visual network presentation [7].

For example, learning age-related macular degeneration requires knowledge of multiple basic medicine disciplines. Under traditional teaching modes, teachers teach knowledge of ocular anatomy, retinal tissue morphology, physiological functions of visual cells and macular pathological changes separately. Knowledge graphs take the logic of 'macro structure—micro morphology—physiological function—pathological change—clinical manifestation' as the core, integrating interdisciplinary knowledge into a complete system and demonstrating correlations between knowledge points. For instance, the layered structure of macular retina and cell types in histology, visual transmission and metabolic & immune defense mechanisms in physiology, dry and wet pathological classifications of macular degeneration, deposition of drusen and formation of neovascularization in pathology, as well as clinical manifestations of vision loss and metamorphopsia. Meanwhile, teachers can match animation demonstrations to assist students' comprehension, helping them establish systematic interdisciplinary medical cognition.

4.2. Connect clinical knowledge and cultivate diagnosis & treatment thinking

The core goal of medical education is to cultivate students' clinical diagnosis and treatment capabilities. Clinical knowledge is closely linked with basic theories and related to real pathological and diagnosis & treatment procedures. Knowledge graphs can connect basic theories and clinical content, helping students understand the practical application value of knowledge and gradually develop clinical thinking.

In the study of ophthalmic diseases, knowledge graphs can demonstrate diagnosis and treatment logics. Taking age-related macular degeneration as an example, the graph first presents the pathogenesis, correlating pathological features such as drusen deposition and neovascularization during macular degeneration, then displays typical clinical symptoms and ophthalmic examination indicators of the disease, and finally corresponds to clinical schemes such as antioxidant therapy and anti-vascular endothelial growth factor treatment. Students can form a comprehensive understanding of the complete process from basic pathology to clinical diagnosis & treatment via graphs, and grasp the theoretical basis of each diagnosis and treatment measure. Standardized real clinical cases and virtual simulation diagnosis resources are mounted on graphs, allowing students to analyze diseases combined with cases and sort out diagnosis & treatment ideas, further transforming theoretical knowledge into clinical analytical capabilities [8].

4.3. Empower independent learning and provide intelligent learning navigation

University medical education attaches importance to cultivating students' autonomous learning abilities. Knowledge graphs can assist students in independent study, breaking the restrictions of textbook chapters and courses and meeting personalized learning and exploratory expansion demands.

Students can check complete curriculum knowledge frameworks via graphs to clarify learning priorities and advance at their own learning paces. AI records students' learning tracks on graphs, and automatically pushes supplementary materials and exercises based on data such as knowledge points with long browsing duration and frequent mistakes [9]. For example, during independent study of ophthalmology and imaging courses, after learning basic imaging knowledge, students can extend to view materials of fundus fluorescein angiography and optical coherence tomography angiography via graphs, read cutting-edge literatures and electronic cases, and explore the value of new technologies in ocular disease diagnosis [10]; when learning macular-related knowledge, students can connect contents of anatomy, histology, physiology and pathology through graphs, independently sort out a complete knowledge chain covering normal macular structure, pathological changes, clinical manifestations, medication treatment and prognosis assessment, and conduct in-depth exploration.

4.4. Assist teaching implementation and improve the precision of guidance

Teachers' teaching work shall be based on students' learning status. Knowledge graphs can record students' learning data and analyze the whole process of students' medical knowledge construction and learning & application, providing intuitive learning situation references for teachers and supporting personalized teaching adapted to differentiated students' cognitive levels [11]. Teachers can check the overall learning progress of the whole class through graphs and grasp the completion and mastery degree of each knowledge point. For instance, in ophthalmology teaching, if teachers find that most students get low scores in exercises related to drug therapy for macular degeneration, they can extend teaching hours on this part and add clinical case analysis in class to help students focus on this content. In addition, teachers can view individual students' learning conditions through graphs and provide accurate, efficient personalized tutoring. For students confused about basic prerequisite knowledge, teachers can guide them to review prior content; for students with solid foundations, frontier and extended resources on graphs can be recommended.

5. Conclusion

The development of AI technology has pushed university medical education into a critical stage of digital transformation. With unique multi-data integration, knowledge correlation capabilities and networked systematic presentation forms, knowledge graphs serve as a vital medium linking AI technology and medical teaching. This is not only an inevitable trend, but also a key path to improve the effectiveness of medical education in universities. In the future, along with the upgrading of AI technology and deepening medical education reform, knowledge graphs will integrate more clinical resources and frontier content, optimize interactive modes and adaptive capabilities, and assist universities in cultivating outstanding medical talents who can meet the demands of the new era.

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