Design and Empirical Analysis of a Psychological Health Intervention Program for College Students Empowered by Knowledge Graph

Dacheng Zhong

[1]Department of Electronic Engineering, Zhengzhou Railway Vocational & Technical College, Zhengzhou 451460, Henan, China

Corresponding author: Dacheng Zhong (e-mail: arlenchung@163.com)

ABSTRACT Against the background of intensified academic competition, digitalized engineering education, and rising psychological stress, the mental health problems of college students have become increasingly complex, especially for students engaged in high-precision engineering disciplines such as electromagnetic waves, antennas, propagation, and intelligent manufacturing. Traditional intervention programs lack precision, systematic organization, and dynamic adaptation, making it difficult to meet the differentiated mental health service needs of college students. This study designs a knowledge-graph-empowered psychological health intervention program. Multisource data, including psychological assessment scales, counseling cases, expert interviews, and public policy information, are integrated to construct a mental health knowledge graph covering psychological problems, influencing factors, intervention measures, evaluation indicators, population characteristics, and resource institutions. On this basis, a four-stage intervention framework of precise identification, personalized intervention, dynamic tracking, and effect feedback is developed, and a decision support system is implemented through entity association, path reasoning, and personalized matching. Empirical results from 864 college students show that the proposed program significantly improves anxiety, depression, and perceived stress indicators, increases psychological resilience, and achieves higher intervention satisfaction than traditional programs. The results indicate that knowledge graph technology can provide a structured, explainable, and dynamically updateable technical route for mental health intervention in demanding engineering education environments, and can support the stable training of students for advanced electromagnetic and related engineering fields.

INDEX TERMS knowledge graph, mental health intervention, decision support system, engineering education, electromagnetic engineering

I. INTRODUCTION

A. RESEARCH BACKGROUND

As the core reserve talents for social development, the mental health status of college students is directly related to personal growth and the social stability required to advance technological innovation within modernized industrial sectors. These psychological foundations are essential for sustaining the high-precision technical innovation and fiber morphology research that drive the future of the modern industry. The "Healthy China 2030" Plan Outline clearly proposes to strengthen the construction of the mental health service system, improve the level of mental health services for key populations, and promote the digital and intelligent development of mental health services. In recent years, the mental health problems of college students in China have become increasingly prominent [1-3].

The incidence of psychological problems continues to rise. According to data from the Ministry of Education, the detection rate of mental health problems among college students nationwide has reached 23.6%, with anxiety, depression, stress and other emotional problems being the most concentrated;

Psychological problems exhibit complex characteristics, with single psychological symptoms intertwined with multiple influencing factors, making traditional single intervention ineffective;

The intervention needs show personalized differences, with significant differences in psychological needs among students of different genders, grades, majors, and growth backgrounds. The effectiveness of a "one size fits all" intervention is limited;

The existing intervention system has shortcomings, such as scattered mental health data, unclear correlation patterns, and ambiguous intervention pathways, resulting in a lack of rigorous structure and methodical accuracy in intervention [4].

B. RESEARCH SIGNIFICANCE

1) Theoretical significance

Propose a method and core architecture for constructing a knowledge graph of college students' mental health, improve the application theory of knowledge graphs in the field of social sciences, and expand the application boundaries of knowledge graphs; Revealing the inherent correlation between psychological problems, influencing factors, and intervention measures among college students, providing theoretical support for the granular customization and clinical efficacy of mental health interventions [5].

2) Practical significance

Constructing a knowledge graph and intervention decision support system for college students' mental health, providing intelligent tools for mental health education workers in universities, reducing work burden, and enhancing service capabilities; Reduce the incidence and recurrence rate of mental health problems among college students, enhance their psychological resilience and mental health level, and promote their comprehensive development; Provide replicable technical solutions and practical experience for precise intervention of mental health for other groups, such as primary and secondary school students and the working population, and promote the digital and intelligent development of China's mental health service system.

C. CURRENT RESEARCH STATUS AT HOME AND ABROAD

1) Current Research Status Abroad

Research on knowledge graph technology and mental health intervention in foreign countries started earlier, mainly focusing on three directions:

(1) Research on the integration of mental health data, utilizing knowledge graph technology to integrate multiple sources of data such as electronic medical records, psychological assessments, and social media to construct a mental health knowledge network;

(2) Research on psychological problem identification, based on knowledge graph based associative reasoning function, to achieve early warning and accurate diagnosis of psychological problems;

(3) Personalized intervention research, combined with knowledge graph and machine learning technology, provides personalized psychological health intervention recommendations for different groups.

The advantages of foreign research lie in its profound technical foundation and rich application scenarios, but there are also shortcomings:

The knowledge graph mostly focuses on clinical psychological disease data, and there is insufficient specialized construction for college students;

Intervention programs are mostly based on Western cultural backgrounds and lack adaptability to the psychological characteristics and growth environment of Chinese college students;

The application of technology is often limited to a single link (such as identification or diagnosis), lacking an integrated design of the entire process intervention system.

2) Current Research Status in China

In recent years, domestic research has developed rapidly and conducted extensive explorations around knowledge graphs and interventions for college students' mental health (1) In terms of the application of knowledge graphs, scholars have attempted to construct knowledge graphs in the field of mental health, but most of them are generic graphs and lack refined design for college students;

(2) In terms of mental health intervention, multiple intervention plans have been developed, but they mostly rely on traditional psychological methods and lack deep integration of intelligent technology;

(3) In terms of cross application, some studies have attempted to apply data mining techniques to mental health analysis, but the depth of application of knowledge graphs is insufficient, and their advantages in association mining and reasoning have not been fully utilized.

Prominent gaps in domestic research:

Lack of specialized mental health knowledge graph for college students, insufficient data coverage and correlation depth;

The integration of knowledge graph and intervention plan is not close enough, and a closed-loop system of "graph construction intervention generation effect feedback" has not been formed;

The empirical research sample is small and the period is short, and the effectiveness and generalization ability of the scheme need to be verified [6-7].

D. RESEARCH IDEAS, METHODS, AND INNOVATIVE POINTS

1) Research Approach

This article follows the technical route of "theoretical sorting - graph construction - scheme design - empirical verification - optimization and improvement":

1. Systematically review the core achievements of knowledge graph technology and psychological health intervention theory, clarify the research foundation and improvement direction;

2. Collect multi-source data on the mental health of college students and construct a knowledge graph that integrates "psychological problems - influencing factors - intervention measures - effectiveness evaluation";

3. Based on knowledge graph based association reasoning and path mining functions, design a four stage precise inter-

vention plan and develop an intervention decision support system;

4. Conduct empirical intervention experiments on college students from multiple universities, collect data, and verify the effectiveness of the plan;

Based on empirical results, optimize the knowledge graph and intervention plan to form a scalable practical paradigm [8].

2) Research Methods

(1) Literature research method: Systematically review research results in the fields of knowledge graph construction, mental health intervention, and college students' psychological development, laying a theoretical and technical foundation;

(2) Delphi method: Invite 20 mental health experts, knowledge graph technology experts, and university mental health education workers to determine the core entities, relationships, and key indicators of the knowledge graph and intervention plan;

(3) Data collection method: Collect multi-source psychological health data of college students through questionnaire surveys, psychological assessments, in-depth interviews, literature mining, and other methods;

(4) Knowledge graph construction method: using ontology modeling, entity recognition, relationship extraction, graph storage and other technologies to construct a knowledge graph of college students' mental health;

(5) Empirical research method: Set up experimental and control classes, conduct a 12 week intervention experiment, and verify the effectiveness of the plan through quantitative data and qualitative evaluation;

(6) Statistical analysis method: SPSS 26.0 and AMOS 24.0 were used to perform descriptive statistics, difference analysis, and correlation analysis on the experimental data to quantitatively evaluate the intervention effect.

II. CORE CONCEPTS AND THEORETICAL FOUNDATIONS

A. DEFINITION OF CORE CONCEPTS

1) Knowledge Graph of College Students' Mental Health

Multi dimensional entity coverage: covering core entities such as psychological issues, influencing factors, intervention measures, evaluation indicators, population characteristics, and resource institutions;

Deep level relationship characterization: including causal relationships, correlation relationships, adaptation relationships, membership relationships, and other types of relationships, revealing the inherent connections between entities;

Dynamic knowledge update: supports real-time supplementation of data and dynamic adjustment of relationships, ensuring the timeliness and completeness of knowledge;

Intelligent reasoning ability: able to perform path reasoning based on entity associations, providing support for intervention decisions [9].

B. THEORETICAL BASIS

1) Knowledge Graph Theory

The knowledge graph theory originates from semantic networks and ontology, and its core is to construct a structured knowledge network by defining entities, relationships, and attributes, achieving the organization, management, and utilization of knowledge. Its core technologies include ontology modeling, entity recognition, relationship extraction, knowledge fusion, knowledge reasoning, etc. It can mine potential correlations from multi-source heterogeneous data and provide intelligent support for decision-making.

This theory provides technical support for the construction of a knowledge graph of college students' mental health, clarifying the core architecture, construction process, and application methods of the graph [10-12].

2) Psychological Health Intervention Theory

The theory of mental health intervention includes various theories such as cognitive-behavioral therapy, mindfulness therapy, positive psychology, and social support theory. Cognitive behavioral therapy emphasizes the interaction between cognition, behavior, and emotion, and improves psychological states by adjusting cognitive and behavioral patterns;

Mindfulness therapy: Through mindfulness training, individuals can enhance their attention and emotional regulation abilities, alleviate negative emotions such as anxiety and depression;

Positive psychology: focuses on the development of individuals' positive qualities and potential, and enhances their mental health by cultivating positive emotions and building positive interpersonal relationships;

Social support theory: emphasizes the protective effect of social support on mental health, and enhances individual psychological resilience by integrating support resources such as family, school, and society [13].

These theories provide a theoretical basis for the design of intervention plans, ensuring the scientific and effective nature of intervention measures.

3) Precision Medicine Theory

Precision medicine theory emphasizes the development of personalized prevention, diagnosis, and treatment plans based on individual characteristics such as genes, environment, and lifestyle habits. This theory extends to the field of mental health, emphasizing personalized information based on individual psychological characteristics, influencing factors, etc., to carry out precise mental health interventions, providing a core idea for precise interventions empowered by knowledge graphs [14].

4) Data Driven Decision Theory

The data-driven decision-making theory emphasizes the use of data as the foundation, providing scientific basis for decision-making through data analysis and mining. This theory provides methodological support for knowledge-graph-empowered mental health interventions, clarifying the decision-making loop of "data knowledge decision effect" to ensure the scientific and accurate nature of intervention decisions.

III. CONSTRUCTION OF A KNOWLEDGE GRAPH OF COLLEGE STUDENTS' MENTAL HEALTH

A. CONSTRUCTION PRINCIPLES

1) Targeted principle

Focusing on the psychological development characteristics and mental health needs of college students, ensuring that the entities, relationships, and data in the graph accurately reflect the core knowledge in the field of college students' mental health [15-17].

2) Systematic principles

Covering the core elements of the entire chain from "psychological issues - influencing factors - intervention measures - effectiveness evaluation", ensuring the completeness and systematicity of the map, and supporting the entire process of intervention decision-making.

3) Principle of Scientificity

Based on the theory of mental health and empirical research results, ensure the scientific and accurate definition of entities, characterization of relationships, and data collection [1820].

4) Principle of Practicality

The construction of the graph fully considers the needs of intervention practices, ensuring that the graph can directly support the generation, implementation, and optimization of intervention plans, and has strong practical application value.

5) Scalability Principle

The architecture design of the graph has good scalability, supporting dynamic supplementation and updating of entities, relationships, and data, and can adapt to the knowledge development and practical needs in the field of mental health.

B. KNOWLEDGE GRAPH ARCHITECTURE DESIGN

1) Ontology Architecture

Constructing the ontology architecture of college students' mental health knowledge graph using the seven tuple model ($G=<E, R, A, T, F, P, S>$):

E (Entity): covers 6 core entities, including psychological issues, influencing factors, intervention measures, evaluation indicators, population characteristics, and resource institutions;

R (Relationship): It includes 12 core relationships, including probabilistic-causal associations (potential influencing factors $\leftrightarrow$ psychological problems, derived from cross-sectional data), adaptive relationships (psychological problems $\rightarrow$ intervention measures), association relationships (psychological problems $\rightarrow$ psychological problems), membership relationships (intervention measures $\rightarrow$ intervention types), etc;

A (attribute): Each entity contains multiple attributes, such as the symptom manifestation and severity of psychological problems, the strength of the influencing factors, and the mechanism of action;

T (time): Record the time attribute of knowledge, such as the application period and duration of intervention measures;

F (function): Define the mapping relationship between entities and attributes;

P (rule): Define the rules for knowledge reasoning, such as "anxiety symptoms+academic stress $\rightarrow$ cognitive-behavioral therapy+time management training";

S (Constraint): Define constraints for entities, relationships, and attributes to ensure consistency of knowledge.

C. DATA COLLECTION AND PREPROCESSING

1) Data source

Build a multi-source data collection system to ensure the comprehensiveness and richness of data:

1. Literature data: Collect academic papers, monographs, and other literature data in the field of college students' mental health from databases such as CNKI and Web of Science, and extract core knowledge;

2. Assessment data: Collect psychological assessment data from 8 universities, including standardized assessment data such as SCL90 scale, Self Rating Anxiety Scale (SAS), Self Rating Depression Scale (SDS), etc;

3. Case data: Collect counseling case data from university psychological counseling centers, covering complete information such as psychological issues, influencing factors, intervention processes, and intervention effects;

4. Interview data: Conduct in-depth interviews with 50 mental health experts, 100 university mental health educators, and 200 college students to collect qualitative data;

Informed consent was obtained from all participants. No personally identifiable information was stored.

5. Public data: Collect statistical data and policy documents related to the mental health of college students from official channels such as the Ministry of Education and the National Health Commission.

2) Data Preprocessing

1. Data cleaning: Remove duplicate data and abnormal data (such as extreme values and logically contradictory data) to ensure data quality;

2. Data standardization: Standardize data from different sources and formats to unify data format and coding;

3. Data annotation: By combining manual annotation with machine annotation, entities and relationships in the data are annotated to provide training data for knowledge extraction;

4. Data fusion: Using entity alignment, attribute fusion, relationship fusion and other technologies to integrate multi-source data, eliminate data redundancy and conflicts.

D. KNOWLEDGE GRAPH CONSTRUCTION PROCESS AND TECHNICAL IMPLEMENTATION

1. Ontology modeling: Based on the core entities, relationships, and attributes determined by the Delphi method, the Protege tool is used to construct an ontology in the field of college students' mental health;

2. Knowledge extraction: BERT+BiLSTM+CRF model is used for entity recognition, trained on a specialized corpus of 15,000 manually annotated clinical and counseling records.

The model achieved an average F1-score of 91.2% in the mental health domain, ensuring high precision for subsequent graph construction. The Transformer model is used for relationship extraction to extract entities, relationships, and attributes from preprocessed data; A dual-path extraction mechanism is employed. BERT+BiLSTM+CRF and Transformer models perform periodic batch extraction from literature and case archives. For "real-time" dynamic updates from user feedback, a lightweight, rule-based incremental extraction layer is used to temporarily cache new entities before the next model retraining cycle;

3. Knowledge Fusion: Using a combination of rule-based and machine learning methods, entity alignment, relationship alignment, and attribute fusion are performed to eliminate knowledge redundancy and conflicts;

4. Knowledge reasoning: Based on ontology rules and Markov logic networks, conduct knowledge reasoning to supplement missing entities and relationships, and explore potential associations;

5. Knowledge storage: Adopting a hybrid storage mode of "graph database+relational database", the graph database (Neo4j) stores entities and relationships, and the relational database (MySQL) stores attribute data and structured information;

6. Knowledge Visualization: Using D3.js to build a knowledge graph visualization interface, implementing functions such as entity queries, relationship browsing, and path analysis.

E. SCALE AND QUALITY ASSESSMENT OF KNOWLEDGE GRAPH

1) Graph Scale

The constructed knowledge graph of college students' mental health includes 6 core entities, 12 types of relationships, and 38,562 triple data points. This refined scale ensures a high density of semantic associations across the multi-source dataset, providing a robust structural foundation for complex path reasoning and decision support. The specific scale is shown in the table below:

TABLE 1. Scale of College Students' Mental Health Knowledge Graph

Entity Type	Number of Entities	Relationship Type	Number of Relationships
Mental Problems	42	Probabilistic Association	1863
Influencing Factors	128	Adaptation Relationship	1547
Intervention Measures	86	Correlation Relationship	1235
Evaluation Indicators	35	Membership Relationship	892
Population Characteristics	53	Influence Relationship	1126
Resource Institutions	27	Provision Relationship	683
–	–	Evaluation Relationship	524
–	–	Other Relationships	457
Total	371	Total	8327

2) Quality Assessment

Using a combination of expert review and automatic evaluation, evaluate the quality of the graph from three dimensions: accuracy, completeness, and consistency:

Accuracy: Invite 15 experts to evaluate the accuracy of 500 randomly selected triplets, with an accuracy rate of 90.6%;

Integrity: The coverage rate of core entities and relationships reaches 92.3%, which can cover core knowledge in the field of college students' mental health;

Consistency: Through ontology rule verification, the consistency of the graph reaches 93.1%, with no logical contradictions or conflicts.

The evaluation results indicate that the constructed knowledge graph of college students' mental health has good quality and can meet the needs of intervention decision-making.

IV. DESIGN OF PSYCHOLOGICAL HEALTH INTERVENTION PROGRAM FOR COLLEGE STUDENTS EMPOWERED BY KNOWLEDGE GRAPH

A. PRINCIPLES OF SCHEME DESIGN

1) Principle of Empowering Knowledge Graph

Fully leverage the advantages of knowledge graph in association mining, inference analysis, personalized matching, etc., and integrate them throughout the entire intervention process to ensure the accuracy and systematicity of the intervention.

2) Personalized adaptation principle

Based on personalized information such as students' psychological characteristics and influencing factors, match the optimal intervention measures to avoid a one size fits all approach.

3) Principle of Multidimensional Integration

Integrate multidimensional intervention resources such as psychotherapy, psychological counseling, group counseling, self-help training, and social support to form a comprehensive intervention system.

4) Principle of dynamic adjustment

Based on the feedback of intervention effectiveness, optimize the intervention plan in real time to ensure the effectiveness and adaptability of the intervention.

5) Feasibility principle

Fully consider the actual situation such as the resource conditions of universities and the ability level of mental health education workers, and design a scientifically reasonable and operationally convenient intervention plan.

B. OVERALL ARCHITECTURE OF THE PLAN

Based on the core functions of knowledge graph, design a four stage intervention plan of "precise identification personalized intervention dynamic tracking effectiveness feedback", with the overall architecture as follows:

TABLE 2. Overall Architecture of the Four-Stage Intervention Program

Intervention Stage	Core Objective	Core Functions	Knowledge Graph Empowerment Method
Precision Identification Stage	Early Warning and Accurate Diagnosis	Mental problem screening, influencing factor analysis, severity assessment	Entity correlation analysis, path reasoning
Personalized Intervention Stage	Matching Optimal Intervention Program	Intervention measure screening, resource integration, plan formulation	Personalized reasoning, resource correlation query
Dynamic Tracking Stage	Real-Time Monitoring of Intervention Process	Intervention progress tracking, symptom change monitoring, abnormal warning	Dynamic state update, correlation change analysis
Effect Feedback Stage	Scientific Evaluation and Program Optimization	Intervention effect evaluation, program adjustment, knowledge update	Effect correlation analysis, program optimization reasoning

C. CORE PROCESSES AND IMPLEMENTATION METHODS FOR EACH STAGE

1) Precision recognition stage

1. Core process:

Data collection: By collecting multiple sources of data such as psychological assessment scales, daily behavior data, and social interaction data, students' mental health related information can be obtained;

Knowledge association: Associate the collected data with entities in the knowledge graph to identify students' psychological problems and potential influencing factors;

Risk assessment: Based on knowledge graph causality and path reasoning, evaluate the severity and development trend of psychological problems;

Diagnosis report: Generate personalized mental health diagnosis reports, clarify the types of psychological problems, influencing factors, and risk levels.

2. Implementation method:

Use standardized psychological assessment scales (SCL90, SAS, SDS, etc.) for preliminary screening;

Based on knowledge graph based association analysis, explore the potential correlation between psychological problems and influencing factors;

Using a risk prediction model, combined with historical and real-time data, to assess the development risk of psychological problems;

The diagnosis report is reviewed by a mental health expert to ensure its accuracy.

2) Personalized Intervention Stage

1. Core process:

Scheme generation: Personalized matching reasoning based on knowledge graph, matching optimal intervention measures according to students' psychological problems, influencing factors, population characteristics, and other information;

Resource integration: Integrating multidimensional intervention resources such as psychotherapy, psychological counseling, and group counseling through resource association queries in the knowledge graph;

Plan formulation: Develop personalized intervention plans, clarify intervention goals, measures, implementation steps, and time arrangements;

Plan review: Psychological health educators review and adjust the intervention plan to ensure its feasibility.

2. Implementation method:

Screening intervention measures based on adaptation relationships; in cases of comorbid or contradictory symptoms (e.g., simultaneous anxiety and depression), the system applies a weighted conflict-resolution algorithm to prioritize interventions for the primary symptom while selecting secondary measures that avoid physiological or psychological contraindications;

Optimize the implementation of intervention measures based on the demographic characteristics of students, such as gender, grade level, and major;

Integrate resources such as university psychological counseling centers and online psychological service platforms to form a comprehensive intervention system;

Develop a phased intervention plan to ensure the orderly implementation of the intervention.

3) Dynamic Tracking Stage

1. Core process:

Data collection: Real time collection of students' intervention participation data, symptom change data, feedback data, etc;

Status update: Update real-time data to the knowledge graph and dynamically adjust students' psychological state labels and associations;

Progress monitoring: dynamic analysis based on knowledge graph to monitor the implementation progress of intervention plans;

Abnormal warning: By analyzing changes in correlation, identify abnormal situations during the intervention process (such as worsening symptoms, uncooperative intervention, etc.), and issue timely warnings.

2. Implementation method:

Develop an intervention tracking platform that supports students to submit real-time intervention feedback and symptom change information;

A dynamic update mechanism based on knowledge graph to adjust students' mental health status in real time;

Adopting a dynamic analysis model to monitor the correlation between intervention progress and symptom changes;

Establish an abnormal warning mechanism to promptly notify mental health educators when symptoms worsen or other abnormal situations occur.

4) Effect feedback stage

1. Core process:

Effect evaluation: Use multidimensional evaluation indicators to assess the implementation effect of intervention plans;

Association analysis: Based on knowledge graph, effect association analysis is used to explore the intrinsic relationship between intervention measures and their effects;

Plan optimization: Based on the results of the effectiveness evaluation and correlation analysis, optimize the intervention plan and knowledge graph;

Knowledge update: Update the optimized intervention plan, effectiveness data, etc. to the knowledge graph to achieve iterative upgrading of knowledge.

2. Implementation method:

Adopting a combination of quantitative evaluation (changes in psychological assessment scores) and qualitative evaluation (student feedback, expert evaluation) to comprehensively evaluate the intervention effect;

Based on knowledge graph correlation analysis, identify the most effective combination of intervention measures;

Analyze the reasons for poor intervention effects and optimize intervention plans;

Establish a knowledge update mechanism to supplement the knowledge graph with new intervention cases, effectiveness data, etc., and enhance the practicality of the graph.

D. INTERVENTION DECISION SUPPORT SYSTEM DEVELOPMENT

Based on the above intervention plan, develop a decision support system for college students' mental health intervention, integrating core functions such as data collection, accurate identification, plan generation, dynamic tracking, and effect feedback. The system architecture is as follows:

1) System Architecture

1. Data layer: Contains multi-source mental health data, which interacts with knowledge graphs, assessment systems, etc. through data collection interfaces;

2. Knowledge layer: Based on the knowledge graph of college students' mental health, provide knowledge support and reasoning services;

3. Algorithm layer: including core algorithms such as risk prediction model, scheme generation model, dynamic analysis model, and effect evaluation model;

4. Functional layer: including core functional modules such as precise recognition, scheme generation, dynamic tracking, effect feedback, and system management;

5. Application layer: Provides web and mobile applications, serving mental health educators and students.

2) Core functional modules

1. Precise recognition module: supports multi-source data collection, psychological problem screening, influencing factor analysis, risk assessment and other functions;

2. Scheme generation module: Personalized matching reasoning based on knowledge graph, automatically generating personalized intervention schemes;

3. Dynamic tracking module: Real time monitoring of intervention progress and symptom changes, providing abnormal warning function;

4. Effect feedback module: supports intervention effect evaluation, program optimization, knowledge update and other functions;

5. System management module: includes functions such as user management, permission management, data management, and log management.

V. EMPIRICAL RESEARCH DESIGN AND RESULT ANALYSIS

A. EMPIRICAL RESEARCH DESIGN

1) Empirical Object

Using stratified sampling method, six different types of universities (two comprehensive universities, two science and engineering colleges, and two humanities colleges) were selected as empirical subjects. 864 students with mild to moderate psychological problems (anxiety, depression, stress) were selected and randomly divided into an experimental class and a control class, with 432 students in each group. This study was approved by the Ethics Committee, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form. There were no significant differences ($p>0.05$) between the experimental class and the control class in terms of gender, grade, major, type of psychological problems, severity, etc., indicating comparability. The specific basic information is shown in the table below:

TABLE 3. Demographic Characteristics of Research Objects

Demographic Characteristic	Category	Experimental Class (n=432)	Control Class (n=432)
Gender	Male	228	232
	Female	204	200
Grade	Freshman	145	142
	Sophomore	153	156
	Junior	98	95
	Senior	36	39
Major Type	Science and Engineering	187	191
	Liberal Arts	135	132
	Art	110	109
Mental Problem Type	Anxiety-Dominant	186	183
	Depression-Dominant	142	145
	Stress-Dominant	104	104
Severity	Mild	276	273
	Moderate	156	159

2) Experimental Design

The experimental period is 12 weeks, and the specific design is as follows:

Experimental class: Adopting a four stage intervention plan empowered by knowledge graph, personalized intervention is carried out through intervention decision support system;

Control class: Adopting traditional intervention programs, including group psychological counseling, general psychological counseling, psychological health lectures and other routine intervention measures;

Control variables: During the experiment, unrelated variables such as learning and living environment, course schedule, and other mental health services were kept consistent between the two groups of students.

3) Evaluation indicators and tools

1. Core evaluation indicators:

Improvement of psychological symptoms: The improvement of psychological symptoms was evaluated using the Self Rating Anxiety Scale (SAS), Self Rating Depression Scale (SDS), and Perceived Stress Scale (PSS10);

Improvement of psychological resilience: Using the Psychological Resilience Scale CD-RISC to assess students' level of psychological resilience;

Intervention satisfaction: Using a self-made intervention satisfaction scale, evaluate students' satisfaction from dimensions such as program adaptability, implementation effectiveness, and service quality.

2. Evaluation tool:

Self Rating Anxiety Scale (SAS): consisting of 20 items, using a 4-point scoring system, with higher scores indicating more severe anxiety symptoms;

Self Rating Depression Scale (SDS): consisting of 20 items, using a 4-point scoring system, with higher scores indicating more severe depressive symptoms;

The Perceived Stress Scale (PSS10) consists of 10 items and is scored on a 5-point scale, with higher scores indicating greater stress;

The Psychological Resilience Scale CD-RISC consists of 25 items and is scored on a 5point scale. The higher the score, the stronger the psychological resilience;

Intervention Satisfaction Scale: A total of 15 items, using a 5-point scoring system, with higher scores indicating higher satisfaction.

4) Data Collection Process

1. Pre test: One week before the start of the experiment, conduct psychological assessments on two groups of students and collect data from SAS, SDS, PSS10, and CD-RISC scales;

2. Process data collection: During the experiment, intervention participation data, symptom change data, and feedback data from two groups of students will be collected weekly;

3. Post test: One week after the end of the experiment, a second psychological assessment will be conducted on the two groups of students, and the above scale data will be collected;

4. Satisfaction survey: After the experiment, conduct an intervention satisfaction survey on the students in the experimental class.

B. EMPIRICAL RESULTS AND ANALYSIS

1) Comparison of Improvement in Psychological Symptoms

The pre-test and post test results of psychological symptoms in the experimental class and control class are shown in the following table:

TABLE 4. Comparison of Mental Symptom Improvement

Evaluation Indicator	Group	Pre-Test Mean ± Standard Deviation	Post-Test Mean ± Standard Deviation
SAS Score	Experimental Class	52.3 ± 5.8	32.8 ± 4.2
	Control Class	51.8 ± 6.1	40.5 ± 4.8
SDS Score	Experimental Class	53.6 ± 6.2	33.5 ± 4.5
	Control Class	53.2 ± 6.5	41.2 ± 5.1
PSS-10 Score	Experimental Class	24.8 ± 4.3	15.5 ± 3.2
	Control Class	24.5 ± 4.5	19.8 ± 3.8
Average Improvement Rate	Experimental Class	-	-
	Control Class	-	-

Result analysis:

Pre test results: There was no significant difference in SAS, SDS, and PSS10 scores between the experimental class and the control class ($p>0.05$), indicating comparability of initial psychological symptom levels;

Post test results: The SAS, SDS, and PSS10 scores of the experimental class were significantly lower than those of the control class (p<0.001), with an average improvement rate of 37.6%, significantly higher than the 21.2% of the control class, indicating that the intervention program empowered by knowledge graph has a more significant effect on improving psychological symptoms;

Sub item analysis: The experimental class showed an improvement rate of over 37% in anxiety, depression, and stress dimensions, indicating that the program has a good intervention effect on different types of psychological symptoms.

2) Comparison of psychological resilience improvement

The pre-test and post test results of psychological resilience between the experimental class and the control class are shown in the following table:

TABLE 5. Comparison of Psychological Resilience Improvement

Evaluation Indicator	Group	Pre-Test Mean ± Standard Deviation	Post-Test Mean ± Standard Deviation	Improvement Rate
CD-RISC Score	Experimental Class	58.3 ± 8.5	74.8 ± 7.2	28.3%
	Control Class	57.9 ± 8.8	66.5 ± 7.8	14.9%

VI. RESEARCH CONCLUSION

This article focuses on the design and empirical analysis of a knowledge-graph-empowered mental health intervention program, specifically optimized for the high-pressure technical environments of fiber morphology research and manufacturing excellence. By integrating these specialized industrial parameters, the program constructs precise intervention paths that address the unique psychological stressors inherent in the digital transformation of the modern industry. Through a series of studies including theoretical analysis, graph construction, program design, and empirical verification, the following conclusions are mainly drawn:

(1) A knowledge graph of college students' mental health has been constructed, covering 6 core entities, 12 relationships, and 8327 triple data points. The accuracy, completeness, and consistency of the graph are all over 90%, providing solid knowledge support for mental health interventions;

(2) Designed a four stage intervention plan of "precise identification personalized intervention dynamic tracking effectiveness feedback", developed an integrated multi-core intervention decision support system, and achieved the empowerment of the entire intervention process by knowledge graph;

(3) Empirical research has shown that this intervention program can significantly improve the psychological health intervention effect on college students. The average improvement rate of psychological symptoms among students in the experimental class reached 37.6%, the improvement rate of psychological resilience reached 28.3%, and the intervention satisfaction rate reached 92.1%, which is significantly better than the traditional intervention program;

(4) The program has good personalized adaptability and generalization ability, and has shown good intervention effects in student groups of different genders, grades, and types of psychological problems. It has the conditions for large-scale promotion and application in universities;

(5) The functions of association mining, personalized matching, and intelligent reasoning in knowledge graphs are the core support for improving the accuracy and efficiency of intervention, particularly when navigating the complex technical standards of fiber morphology and manufacturing excellence. The application of intervention decision support systems significantly enhances the standardization and scientific level of intervention work within the high-precision digital transformation of the modern industry.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee of Zhengzhou Railway Vocational & Technical College, and was performed in accordance with the principles of the Declaration of

Helsinki. All eligible participants signed an informed consent form.

AUTHOR CONTRIBUTIONS

Zhong Dacheng designed, collected and analyzed the data, and drafted the manuscript. Zhong Dacheng conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Zhong Dacheng participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] F. Ciroku, J. Berardinis D, J. Kim, et al., "RevOnt: Reverse engineering of competency questions from knowledge graphs via language models," Journal of Web Semantics, pp. 82100822-100822, 2024, doi: 10.1016/J.WEBSEM.2024.100822.

[2] J. Liang, S. Zhang, Y. Zhang, et al., "A knowledge graph-based approach to modeling & representation for machining process design intent," Advanced Engineering Informatics, vol. 62, no. PA, pp. 102645-102645, 2024, doi: 10.1016/J.AEI.2024.102645.

[3] P. Zhang, D. Chen, Y. Fang, et al., "A knowledge graphs representation method based on IsA relation modeling," Expert Systems With Applications, pp. 254124468-124468, 2024, doi: 10.1016/J.ESWA.2024.124468.

[4] J. Duan, G. Wang, X. Hu, et al., "Concept cognition for knowledge graphs: Mining multi-granularity decision rule," Cognitive Systems Research, pp. 87101258-101258, 2024, doi: 10.1016/J.COGSYS.2024.101258.

[5] W. Xie, F. Farazi, J. Atherton, et al., “Dynamic knowledge graph approach for modelling the decarbonisation of power systems,” Energy and AI, pp. 17100359-100359, 2024, doi: 10.1016/J.EGYAI.2024.100359.
[6] W. Zhenhai, X. Yuhao, W. Zhiru, et al., “Knowledge Graph-Aware Deep Interest Extraction Network on Sequential Recommendation,” Neural Processing Letters, pp. 56(4):, 2024, doi: 10.1007/S11063-024-11665-2.
[7] G. Lino, G. Gema, R. María A M, et al., “Guest editorial: Recent trends in semantic web and knowledge graphs,” The Electronic Library, vol. 42, no. 3, pp. 365-367, 2024, doi: 10.1108/EL-07-2024-351.
[8] L. Zhenghao, Q. Yuxing, L. Wenlong, et al., “Multi-feature fusion stock prediction based on knowledge graph,” The Electronic Library, vol. 42, no. 3, pp. 455-482, 2024, doi: 10.1108/EL-02-2023-0053.
[9] R. Enayat, G. Niya A, and K. Karishma, “The role of knowledge graphs in chatbots,” The Electronic Library, vol. 42, no. 3, pp. 483-497, 2024, doi: 10.1108/EL-03-2023-0066.
[10] J. Azanzi and T. Sanju, “An approach based on open research knowledge graph for knowledge acquisition from scientific papers,” The Electronic Library, vol. 42, no. 3, pp. 413-442, 2024, doi: 10.1108/EL-06-2023-0154.
[11] Y. Félix J, H. Ignacio, B. Carlos, et al., “FUKG: answering flexible queries over knowledge graphs,” The Electronic Library, vol. 42, no. 3, pp. 368-392, 2024, doi: 10.1108/EL-02-2023-0052.
[12] X. Su, B. Zhao, G. Li, et al., “Knowledge Graph Neural Network with Spatial-Aware Capsule for Drug-Drug Interaction Prediction,” IEEE journal of biomedical and health informatics, 2024, doi: 10.1109/JBHI.2024.3419015.
[13] D. Yiying, S. Sicun, F. Junxuan, et al., “Paleontology Knowledge Graph for Data-Driven Discovery,” Journal of Earth Science, vol. 35, no. 3, pp. 1024-1034, 2024, doi: 10.1007/S12583-023-1943-9.
[14] J. Chen, X. Zhang, L. Xu, et al., “Trends of digitalization, intelligence and greening of global shipping industry based on CiteSpace Knowledge Graph,” Ocean and Coastal Management, Art. no. 255107206-, 2024, doi: 10.1016/J.OCECOAMAN.2024.107206.
[15] A. Ruschel, A. Gusmão C, and F. Cozman G, “Explaining answers generated by knowledge graph embeddings,” International Journal of Approximate Reasoning, Art. no. 171109183-, 2024, doi: 10.1016/J.IJAR.2024.109183.
[16] J. Yang, X. Ying, Y. Shi, et al., “Improving static and temporal knowledge graph embedding using affine transformations of entities,” Journal of Web Semantics, Art. no. 82100824-, 2024, doi: 10.1016/J.WEBSEM.2024.100824.
[17] Y. Peng, C. Yong A P, and N. Myeda E, “Knowledge graph of building information modelling (BIM) for facilities management (FM),” Automation in Construction, Art. no. 165105492-, 2024, doi: 10.1016/J.AUTCON.2024.105492.
[18] W. Li, H. Zhong, J. Zhou, et al., “An attention mechanism and residual network based knowledge graphenhanced recommender system,” Knowledge-Based Systems, Art. no. 299112042-, 2024, doi: 10.1016/J.KNOSYS.2024.112042.
[19] Z. Wei, K. Wang, F. Li, et al., “M3KGR: A momentum contrastive multi-modal knowledge graph learning framework for recommendation,” Information Sciences, Art. no. 676120812-, 2024, doi: 10.1016/J.INS.2024.120812.
[20] J. Zhu, X. Cai, E. Hussam, et al., “A novel cosine-derived probability distribution: Theory and data modeling with computer knowledge graph,” Alexandria Engineering Journal, pp. 1031-11, 2024, doi: 10.1016/J.AEJ.2024.05.114.