Journal of Cases on Information Technology
Volume 25 • Issue 1

Knowledge Management for Information Querying System in Education via the Combination of Rela-Ops Model and Knowledge Graph

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ABSTRACT

E-learning is an online educational system that uses electronic and technology tools and the internet. To facilitate the acquisition of knowledge, students can consult materials and interact directly with lecturers via e-learning educational systems. The method for developing an intelligent querying system for e-learning is suggested in this research. The knowledge base of the system is structured using the knowledge model combining an ontology and the two-layer knowledge graph, called Rela-KG model. The searching problems for knowledge content are studied and solved. The technique is applied to create an intelligent querying system on the course of Database Foundation in Information Technology (IT) at the university. This technique attempts to assist students in reviewing lectures and better comprehending course material through independent study. The experimental results indicate that it would be anticipated to support student access to online learning resources.

KEYWORDS

E-Learning, Fundamentals of Database Systems, Information System, Intelligent Searching, Knowledge Graph, Knowledge Management, Knowledge-Based System, Ontology

DOI: 10.4018/JCIT.324113

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INTRODUCTION

E-learning is a method of distance education. The querying system is a crucial tool for students to use to find the information they need for the learning process for e-learning to be effective (Noy & McGuinness, 2013; Shipunova et al., 2021). According to the learner's search, the search engine acts as a method to search the knowledge of the courses.

An innovative method for creating knowledge bases for intelligent querying systems in education is ontology (Zavyalova, 2020; Nguyen et al., 2021; Ma & Molnár, 2020). One of the main characteristics of ontology is its capacity to enable communication between people and other heterogeneous distributed application systems (Zavyalova, 2020); as a result, an ontology may be used to effectively convey the knowledge of intelligent querying systems (Nguyen et al., 2021; Ma & Molnár, 2020). It is possible to create knowledge bases for intelligent educational systems using the Rela-Ops model, which is an ontology for the intellectuality of relations and operators (Nguyen et al., 2021; Nguyen et al., 2020a). By defining all relevant concepts, relationships between concepts with their attributes and conditions, operators between concepts, and knowledge domain-specific inference procedures, this model enables the expression of knowledge domains (Nguyen et al., 2020a).

The knowledge graph is a knowledge base that integrates data using a graph-structured model (Tran et al., 2022; Chen et al., 2020). This approach is used to store interconnected descriptions of entities that are objects and abstract concepts. In addition, the semantics behind the terminology employed can also be encoded by using a knowledge graph (Chen et al., 2020).

In this paper, we present a method for integrating the ontology Rela-Ops model and the knowledge graph structure as a database, called the *Rela-KG* model, to organize the knowledge of a course. The constructed ontology is used to represent the knowledge components in a course, and the knowledge graph serves as a tool to store the content and relations between entities (concepts, objects, relationships, and rules) of that course. Through the Rela-KG model, the method for building an intelligent querying system based on the knowledge base is also studied. This system can query the content of the knowledge components and make a comparison between their contents. To support the learning process better, the system can recommend the knowledge related to current results.

One of the foundational courses in the information technology (IT) curriculum at universities is Fundamentals of Database Systems (Gillenson, 2023). For this course, a querying system is designed using the Rela-KG model. This knowledge area can be thoroughly organized using this model. It can carry out clever querying and search for the information required for the learning of students. The findings of the trial indicate that it should enhance student access to online learning resources.

In this paper we present the related research about ontology-based methods for creating querying systems in education. We propose the Rela-KG model, a solution to combine the ontology Rela-Ops model and the knowledge graph, and cover the use of the Rela-KG model to structure the course material for Fundamentals of Database Systems. We also describe how to design the querying problems and their algorithms, and we discuss implementation and experimentation of the querying system for the Fundamentals of Database Systems course. In addition, we present the results of surveying about this system on students who have used this system and then conclude with the results of this paper and suggestions for future work.

RELATED WORK

Information search design can be done in a variety of ways (Do et al., 2020; Liu et al., 2018; Hagedorn et al., 2020). Ontology-based techniques are emerging in educational systems to organize course content and knowledge (Almeida et al., 2019; Nguyen et al., 2020b).

A data searching method called index-based search speedily extracts all pertinent results from a database in accordance with entered keywords (Guemmat & Ouahabi, 2018). Elastic search provides index-based search with great search performance (Xu et al., 2022). Elastic search offers a scalable search solution, including parameter addition, modification, deletion, and change via HTTP and JavaScript Object Notation (JSON), as well as indexing in a wide variety of languages (Sun et al., 2022). Its distributed architecture and multi-tenancy features allow for the rapid exploration and analysis of enormous data volumes.

With the help of the educational search engine, students may easily access information they need for their learning process. However, because students did not provide the proper keywords or phrases, the best results may remain buried. Because it strives to comprehend what learners mean, the semantic search engine is the answer to the inaccuracies of index-based search engines.

The knowledge of relations and operators can be successfully represented using the Rela-Ops model (Nguyen et al., 2018; Nguyen et al., 2022a). This model incorporates intellectual elements, such as concepts, relationships, and operators, between concepts and knowledge-related inference procedures. Additionally, it has been used to create intelligent tutoring programs for students (Nguyen et al., 2021; Nguyen et al., 2022a) and intelligent problem-solving tools (Nguyen et al., 2020a; Nguyen et al., 2018). To grasp intellectual contents, however, learners need to be educated because the formulation of this model is not yet natural.

Query-Onto is an ontology used to create intelligent search engines (Pham et al., 2022). Lesson- and keyword-based searches were both designed using this ontology. In courses on data structure and algorithms (Pham et al., 2022) and high school mathematics (Do et al., 2020), it was used to build an intelligent search engine. However, the outcomes of those systems do not match the formal contents of their textbooks.

This study proposes a combination model of the extension ontology Rela-Ops model and the structure of knowledge graph to represent the course content. This method is used to develop an intelligent querying system in the university course Fundamentals of Database Systems. This system was designed to provide better assistance for students in their quests for course content than previous systems offered.

THE COMBINATION OF ONTOLOGY RELA-OPS MODEL AND KNOWLEDGE GRAPH

Rela-Ops Model

The Rela-Ops model has strong points for organizing the knowledge base of intelligent systems in education (Nguyen et al., 2020a; Nguyen et al., 2018). It can represent many kinds of knowledge components. The structure of this model has been presented in . An extension of this model has been developed to design intelligent searching systems in education (Do et al., 2020).

Definition 1: Nguyen et al. (2020a) define the Rela-Ops model as a tube that includes four components: C, R, Ops, and Rules.

The C set is a set of concepts, each of which is an object class. A set of relations between concepts, objects, and their qualities is called the R set. These relations include various binary relations as well as some unique ones like "*is-a*" and "*has-a.*" A set of operators is called an Ops set. The knowledge domain's deductive rules are represented by the Rules set. The rules in the Rules set serve as representations for assertions, theorems, guiding principles, formulas, and other notions. Nguyen et al. (2020a) describe each component's detailed structure.

Each concept is a tube that consists of five components: *Attrs*, *Ops*, *RulObj*, *Content*, and *Key*. *Attrs* is a set of properties of the object, *Ops* is a set of operators on the object, *RulObj* is a set of rules on an object, *Content* is the content of the concept represented as text, and *Key* is a set of keywords to define the concept.

In the real world, the knowledge of the course also includes the knowledge of exercises and their methods to solve the exercises. Thus, the intellectual model needs to represent that knowledge (Do et al., 2020; Nguyen et al., 2018).

Definition 2: According to Pham et al. (2022), the extension ontology of the Rela-Ops model for representing the knowledge of a course is a tube:

(C, R, Ops, Rules) ⊕ (Problems, Methods)

(C, R, Ops, Rules) is an ontology as the Rela-Ops model. The Problems set is a collection of all the fundamental exercises that define a course. It is a set of problems or exercises. The Methods set is a collection of approaches to problem-solving.

Knowledge Graph for Rela-Ops Model

A knowledge graph is a collection of interlinked descriptions of concepts, entities, and relations in a knowledge domain (Hogan, et al., 2021). It uses graph structure to organize the knowledge base, which consists of two main components (Chen et al., 2022; Tran et al., 2021). The knowledge graph for the Rela-Ops model is a two-layer graph. The first layer represents relations between attributes of an object, which are the foundation for establishing the corresponding object. The second layer performs relations between objects; those relations are defined in the R set of the Rela-Ops model.

Definition 3: Given the knowledge domain K = (C, R, Ops, Rules) ⊕ (Problems, Methods) as an extension of the Rela-Ops model, the knowledge graph for this domain is a tube:

KG= (V, E)

In this tube, V is a set of vertices expressing the knowledge of concepts, rules, operators, problems, and methods, as well as the relations between knowledge attributes, according to the structure of the knowledge graph. Each vertex has a structure similar to the structures for each kind of element in the Rela-Ops model in definition 1.

E is a set of edges of this graph representing relations between vertices in V. There are two kinds of edges in E:

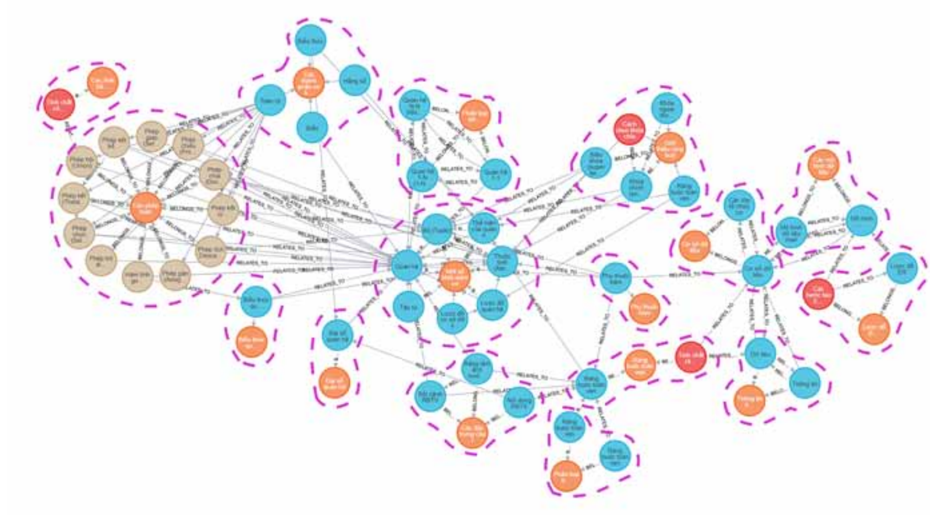
$$E = E_{attrs} \cup E_{objs}$$

E_{attrs} is the set of edges representing relations between attributes in an object. Those attributes and their relations are the foundation of the corresponding object. E_{objs} is the set of edges performing relations between objects.

Each edge in E is a tube (*Attrs, Properties, Start, End*), in which, *Attrs* is a set of attributes of a relation, *Properties* is a set of properties of the corresponding relation, *Key* is a set of key phrases related to the corresponding relation, *Start* is a start vertex of the corresponding relation, and *End* is an end vertex of the corresponding relation. Each edge represents a relation that impacts directly from the *Start* vertex to the *End* vertex arbitrary.

Figure 1 shows a part of the graph-based structure for the knowledge domain about the course of Fundamentals of Database Systems. This two-layer graph can represent almost all concepts and relations of knowledge. It overcomes the flexibility limitations of relational databases, allowing data points to be encoded as richly connected entities. Therefore, it is helpful to organize unstructured data in a way that the knowledge can easily be extracted and recommended by its related knowledge in this domain.

Figure 1. The knowledge graph of the fundamentals of database systems course



The Combination of the Ontology Rela-Ops Model and the Structure of the Knowledge Graph

Truong et al. (2022) presented a method for integrating the Rela-Ops model with the structure of a database. However, this method is not effective when applied to a question-answering system. The structure of the database is difficult to reason through their relations. For application in a practical querying system, the graph-structure is useful to represent data by its connections between nodes. It can be used to deduce hidden relations. Thus, the combining of the ontology Rela-Ops model and the knowledge graph is very helpful to build an intelligent querying system via the knowledge base.

Definition 4: The combination of the extension ontology Rela-Ops model and the structure of knowledge graph, called the Rela-KG model, includes:

$$K = (C, R, Ops, Rules) \oplus (Problems, Methods) \rightarrow K_{KG}$$

(C, R, Ops, Rules) ⊕ (Problems, Methods) is an extension ontology from definition 2.

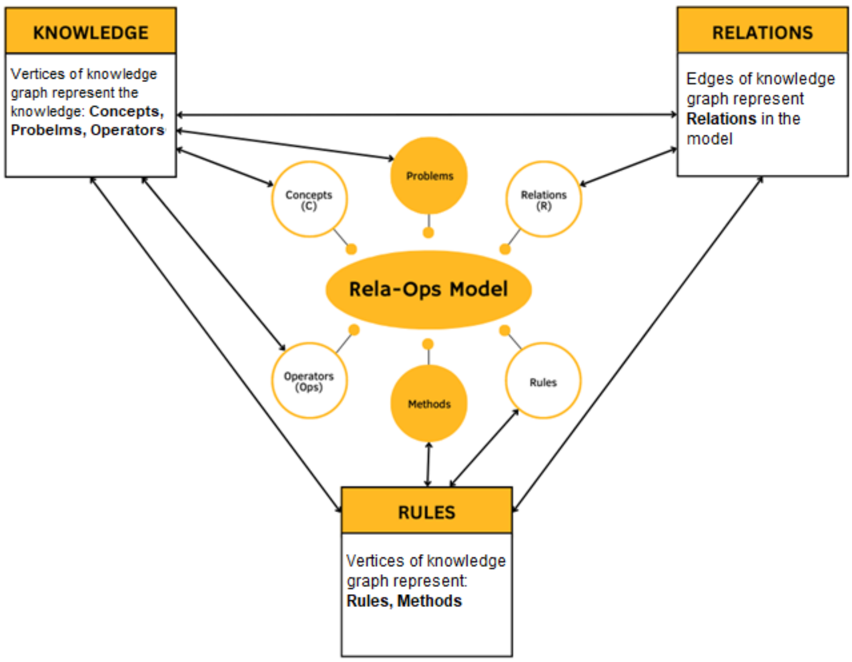
K_{KG} is a two-layer knowledge graph from definition 3 that performs the intellectual content in the Rela-Ops model. Each vertex in the graph K_{KG} is classified into two types: Knowledge and Rules.

The details for these two types of vertices are as follows:

- Knowledge vertices store contents of the course as natural language. This information will be shown to users when the results are extracted.
- Rules vertices include rules with relations, functions, and operators related to inference rules in the knowledge domain.

Figure 2 is the combination of the extension ontology Rela-Ops model and the knowledge graph K_{KG}.

Figure 2. The structure of the Rela-KG model



Application to Design the Knowledge Base of the Fundamentals of Database Systems Course

This section contains a portion of the Fundamentals of Database Systems course from the university's IT curriculum. The intellectual foundation of this course is drawn from Elmasri and Navathe (2016) and Silberschatz et al. (2019). The extension ontology Rela-Ops model and the knowledge graph combine to organize the knowledge base about this course for an intelligent querying system. We present six examples of the knowledge from the Fundamentals of Data Systems course represented in the system.

1. **C Set of Concepts of Database Systems Knowledge:** The set C consists of concepts such as Closure, Tuple, Database, Feature, Primary Key, Foreign Key, Functional Dependency, Relational Schema, Instance, etc.
2. **R Set of Relations Between Concept*s*:** The set R includes two kinds of relations:
    a. The relations "*is-a*" and "*has-a*" between concepts.
    b. Other binary relations—for example:
        i. **+ Relations *Intersect* (∩):** Relations about intersection between two attribute sets, relations, etc.
        ii. **+ Relations *Union* (∪):** Relations about union between two attribute sets, relations, etc.
3. **Ops Set of Operators:** In knowledge of relational algebra, some operators are represented as follows:

Ops: = {*Selection, Assignment, Cartesian product*}

- ***Selection*** **(σ_p(R)):** This operator is used to extract tuples (rows) from the relation R, which satisfies the selection condition *p*, then returns a relation with *k* attributes in the same order as the original list. The selection is commutative.
- ***Assignment*** **(A←B):** This operator is used to describe complex queries; the result on the right of assignment is assigned to the relational variable on the left.
- ***Cartesian Product*** **($S \times P$):** If *S* has *n* tuples and *P* has *m* tuples, the result is a set including $n \times m$ tuples. Cartesian product is often used in conjunction with selections to combine related tuples from two relations.

4. **Rules Set of Inference Rules:** Some rules in the Fundamentals of Database Systems course can be represented by structures of rules in the Onto-Data model. Some particular rules are:
r_1: *symmetric rules*

{*T*: relation, *U*: relation, *V*: relation},
$\{T \cup U = V\} \rightarrow \{U \cup T = V\}$
$\{T \cap U = V\} \rightarrow \{U \cap T = V\}$

r_2: *associate rules*

{*T*: relation, *U*: relation, *V*: relation, *R*: relation},
$\{T \cup (U \cup V) = R\} \rightarrow \{(T \cup U) \cup V = R\}$
$\{ T \cap (U \cap V) = R\} \rightarrow \{(T \cap U) \cap V = R\}$

r_3: *implication rules*

{*O*: set of objects, *A*: attribute set, *B*: attribute set, *C*: attribute set, *D*: attribute set, | $A, B, C, D \subseteq O$},
$\{B \subseteq A\} \models \{A \rightarrow B\}$
$\{A \rightarrow B\} \models \{AC \rightarrow BC\}$
$\{A \rightarrow B, B \rightarrow C\} \models \{A \rightarrow C\}$
$\{A \rightarrow B, A \rightarrow C\} \models \{A \rightarrow BC\}$
$\{A \rightarrow BC, A \rightarrow B\} \models \{A \rightarrow C\}$
$\{A \rightarrow B, BC \rightarrow D\} \models \{AC \rightarrow D\}$

5. **Problems Set of Exercises:** There are some common exercises about keys of relation schema, functional dependencies, the closure of an attribute set, etc., such as:
   a. Identifying a relation schema's keys.
   b. Solving the issue with locating the initial/intermediate attribute set using the functional dependency network.
   c. Determining an attribute set's closure.
6. **Methods Set of Methods for Solving Some Problems:** There are some methods for solving problems, such as:
   a. Finding the closure of an attribute set.
   b. Finding a key of a relation schema.
   c. Finding all keys of a relation schema.
   d. Using the functional dependency graph to find the original/intermediate attribute set.

Table 1 presents the topics for the relational algebra chapter in this system.

Based on the knowledge base performed by the extension of Rela-Ops model, we used the knowledge graph K_{KG} from definition 3 to organize the content of this knowledge base. The structure of the graph K_{KG} is shown in Figure 1. In the next section we present problems for querying the

Table 1. Topics of relational algebra chapter

Order	Group of Topics
1	variable, operator, constant, expression
2	selection, projection, assignment, union, set-difference, set-intersection, Cartesian product, theta-join, outer join, inner join, division, grouping function
3	commutation, combination

intellectual content in the combination model of ontology Rela-Ops model and the structure of the knowledge graph, and algorithms for solving them.

PROBLEMS AND ALGORITHMS

Finding the information for an inputted query is the main challenge for an intelligent querying system. When a user enters a query, the knowledge base of the system is used to extract suitable results. The work begins by extracting and analyzing key phrases from the query along with their relationships. The system then searches its knowledge base by looking for relations between key phrases and knowledge components. It will then extract the results' content from the knowledge base. There are three problems with extracting the knowledge:

Problem 1: Classifying the Inputted Query

This issue will aid in categorizing the different types of entered queries. This activity helps to extract the content that is appropriate for the query. The issue is extracting the query's primary keywords from the entered query. These phrases are employed to select pertinent knowledge outcomes from its knowledge base.

Problem 2: Extracting and Matching the Key Phrases to Retrieve Knowledge Content

This method compares the similarity between the meaning of the keywords and the knowledge base material by using the set of keywords that were retrieved from the query. The required knowledge for the inputted query is determined. Additionally, this issue resolves the determination of the knowledge that is pertinent.

Problem 3: Searching the Related Knowledge With the Extracting Results

The system will retrieve the knowledge needed to respond to the inquiry and communicate with the user from the results of an inputted query. The system also recognizes some knowledge associated with the discovered solutions.

Query Classification Technique

In this study, the inputted query is classified into two types: Searching and Comparing. Through a survey of students, these types are main issues that students usually have to meet in their learning. Details of these query types are as follows:

- **The Kind of Searching:** After the system extracts key phrases from the inputted query, they will be recognized and classified to the knowledge base of the system.
- **The Kind of Comparing:** This is an extension of the search functionality. After retrieving two corresponding knowledge content attributes from the input query, the system compares attribute to attribute and shows the differences between each component of the compared objects.

Extracting and Matching the Keywords to Retrieve Knowledge Content

We compared the meaning of keywords and matched them to the material in the knowledge base by collecting the keywords extracted from the queries. For the supplied query, this technique will identify the key phrases and retrieve the necessary knowledge by comparing those key phrases with the key phrases in the database.

Given a knowledge domain K = (C, R, Ops, Rules) ⊕ (Problems, Methods) → K_{KG} as the Rela-KG model and an input query *q*, the following algorithm retrieves intellectual content that is suitable for query *q*. This algorithm works via the relation between knowledge represented in K; in addition, using the structure of knowledge graph K_{KG}, we can deduce the hidden knowledge to increase the content of the extracted results using these input and output attributes:

Input: The knowledge domain K as the Rela-KG model;
Query *q*.
Output: Knowledge content from K is suitable for query *q*.
Algorithm 1: Here are the components and steps for algorithm 1:

```
Key:= {}  // Set of key phrases of q;
Comp:= {} // Set of component results from K.
Known:= {} // Set of results
Results: = {} // Knowledge Content of results.
Step 1. Step 1 consists of these tasks:
• Update Key by using the technique in (Nguyen et al., 2021) to
extract key phrases from query q.
• Construct relations between key phrases in Key through relations
in K.R.
Comp: = Set of components of K based on constructed relations
Step 2. Step 2 consists of these tasks:
  • Retrieve knowledge from components in Comb that are related to
key phrases in Key.
  • Update Known.
Step 3. Mapping the content from K_KG to elements in Known consists
of these tasks:
  TempKnowledge: ={}
  for k in Known do
     d:= type(k);
     Search the content in the K_KG.V has type d to receive content
for element k.
     Update TempKnowledge;
  end for
  for k in TempKnowledge do
     Deduce the relations between the vertex k and other content
in the K_KG through relations in R-set and rules Rules-set
          Known_k:= {k} ∪ {k' | ∃ r ∈ K.R, r(k, k')}
     Update Result by Known_k;
  end for
Step 4. Step 4 consists of this task:
 Return Results.
```

Searching for Related Knowledge

Students require some background information on the subject they are researching. The relevant information helps students fully comprehend the subject matter of their searches. In this section we present an algorithm for searching a set of relevant knowledge.

Given a knowledge domain K = (C, R, Ops, Rules) ⊕ (Problems, Methods) → K_{KG} as the Rela-KG model, a query *q* and its results received through algorithm 4.1. This algorithm determines a set of knowledge related to results of query *q*.

Input: The knowledge domain K as the Rela-KG model;
Query *q*.
Output: A collection of information regarding to results of query *q*.
Algorithm 2: Here are the attributes and steps for algorithm 2:

Step 1. Step 1 consists of these tasks:
Known: = Set of knowledge results for query *q* extracted by algorithm 1.
Step 2. Step 2 consists of these tasks:
For each *k* in *Known* **do**
Determine the set of knowledge related to *k*
Related(*k*):= {*k'*| ∃ *r* ∈ K.**R**, *r*(*k*, *k'*) ∨ *r*(*k'*, *k*)}
Step 3. Step 3 consists of these tasks:
Determine the set of knowledge related to set *Known*:

$$Relate(Known) := \bigcup_{k \in Known} Related(k)$$

Classify the knowledge in Relate(*Known*) based on types of knowledge components in K
Step 4. Mapping the content from $\mathbf{K}_{KG}$ to elements in *Relate(Known)* requires these tasks:

```
  Results:= {};
  for k in Relate(Known) do
     d:= type(k);
     Search the content in the table has type d to receive content for element k.
     Update Results.
  End for
```

Step 5. Step 5 consists of this task:
Return *Results.*

INTELLIGENT QUERYING SYSTEM FOR THE COURSE OF FUNDAMENTALS OF DATABASE SYSTEMS

For students majoring in computer science, Fundamentals of Database Systems is a crucial general education course. The purpose of this course is to help students learn the relational database model, the ER (Entity Relation) diagram, data standardization and preservation, and relational algebra by introducing them to the ideas and significance of database management systems. The Fourth Industrial Revolution, where numerous processes, stages, or management systems are coded and run by devices and software to effectuate business performance, emphasizes the role of this course and its applications. As one of the foundational courses in the IT curriculum, there is a very high demand from students for help with this topic. The designed program will be applied to close knowledge gaps among the students. In the next two sections we outline the design of the intelligent querying engine used in the Fundamentals of Database Systems course and present the system's experimental findings.

The Architecture of Intelligent Querying System

Books serve as a source of information for the Fundamentals of Database Systems course (Elmasri and Navathe, 2016, Silberschatz et al., 2019). This knowledge collection can be categorized into chapters, modules, subjects, exercises, and techniques for solving them. The combination of the extension Rela-Ops model and the knowledge graph is used to store the course's materials. The knowledge base of the intelligent querying system was designed to solve the problems with intellectual searching. The results for the entered query will be retrieved by the search engine. The architecture of this system is depicted in Figure 3 and was developed in accordance with the framework of intelligent educational systems (Nguyen et al., 2022b).

Testing and Experimental Results

The intelligent querying system for the Fundamentals of Database Systems course can support students in searching the contents of this course through inputted query. The program also recommends some knowledge related to current search results for users. Figure 4 shows the user interface of the built intelligent querying system. Users can input a query into the system in Vietnamese. Besides the content of the search results, the system also provides other knowledge related to those results as intellectual tags.

Figure 5 shows the interface of results for a comparison query. Through the inputted query in Vietnamese, the system extracts two main objects. From these objects, the system makes the comparison via their attributes, contents, and internal rules. Similarly, with search results, the system will also recommend other knowledge related to the compared objects as intellectual tags.

Figure 3. The architecture of intelligent querying engine based on integrating ontology onto data model

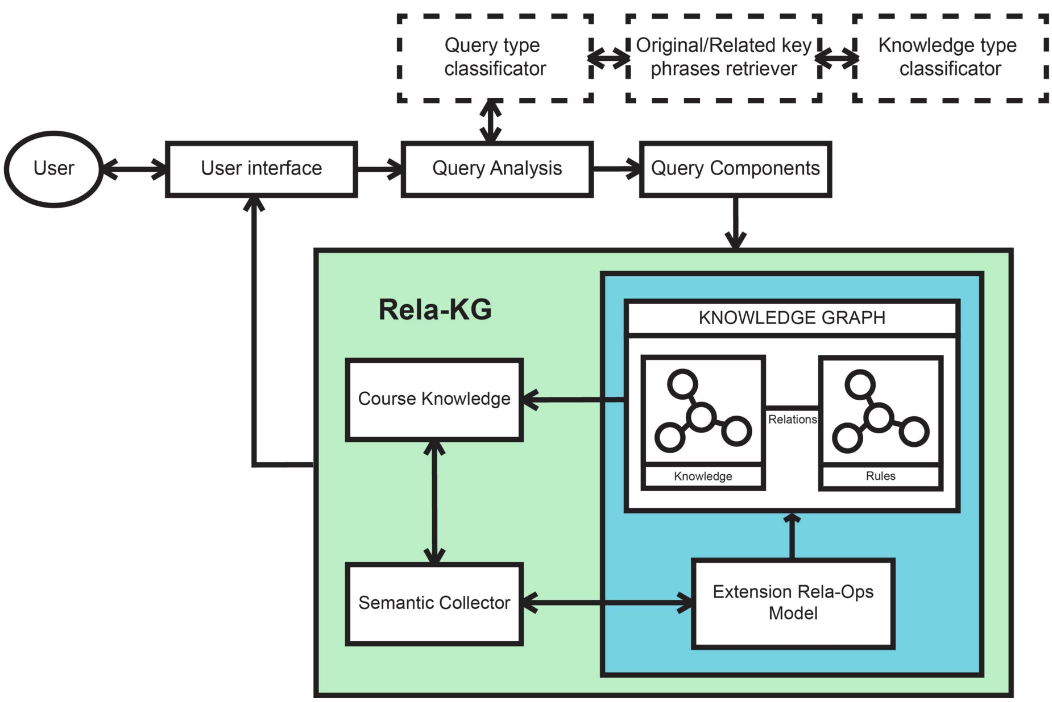
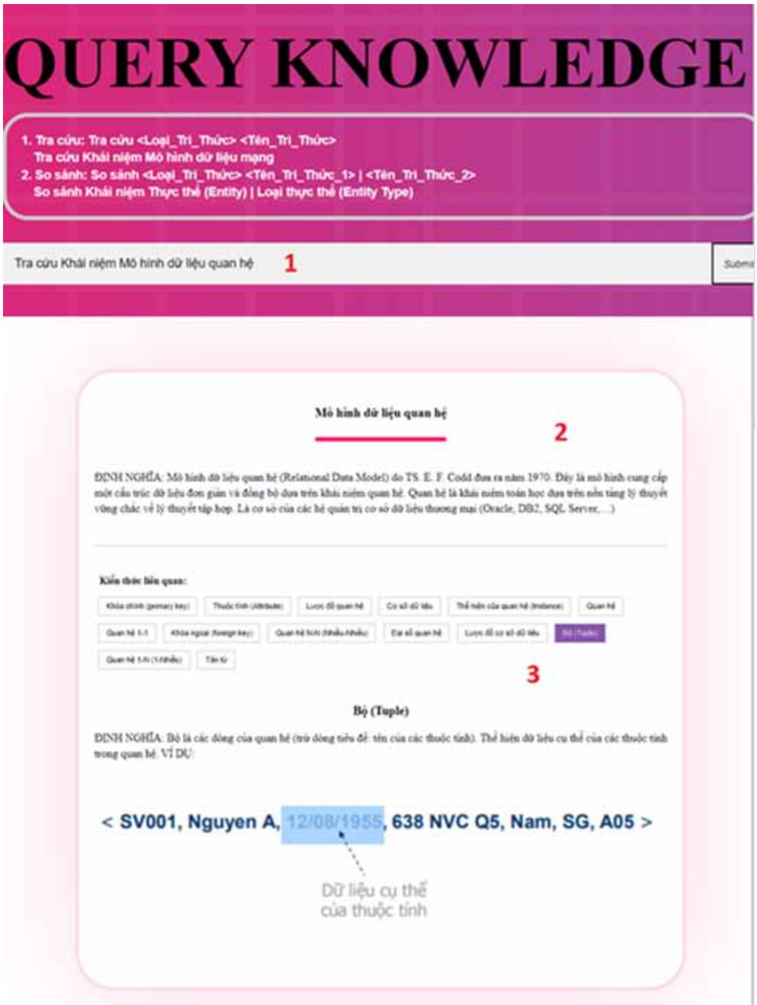


Figure 4. Interface of the intelligent querying system for fundamentals of database systems course



Students at the university tested the system for searching based on the knowledge of Fundamentals of Database Systems course. Students entered content related to the course. The system then provided a list of results matching the inputted contents. Those results were classified into intellectual types—definitions, rules, operators, exercises—and their solving methods. In addition to retrieving results, this querying engine automatically recommended other knowledge related to the current searching knowledge.

Two stages of evaluation were used to assess the testing results. They system initially logged user confirmations of proper outcomes in comparison to the content they provided. The lecturers in charge of the relevant courses then double-checked the findings that were recorded at stage 1. The testing results could be accepted as accurate only if they were verified simultaneously by lecturers and users. Stage 2 is a survey of students' opinions for evaluating the system in practice.

When students tested the system, each student inputted 03 queries for searching or comparing the knowledge of Fundamentals of Database Systems. The queries might belong to searching/comparing concepts from the Fundamentals of Database Systems course, searching for rules (theorems, properties), or searching for kinds of problems and their solving methods. Afterward, students took a

Figure 5. Interface for query of comparing of the system

survey to evaluate the effectiveness of this system. The survey was interested in sufficient knowledge about usefulness of the main functions in learning: for example, searching the knowledge, comparing two objects in the course's content, and recommending related knowledge.

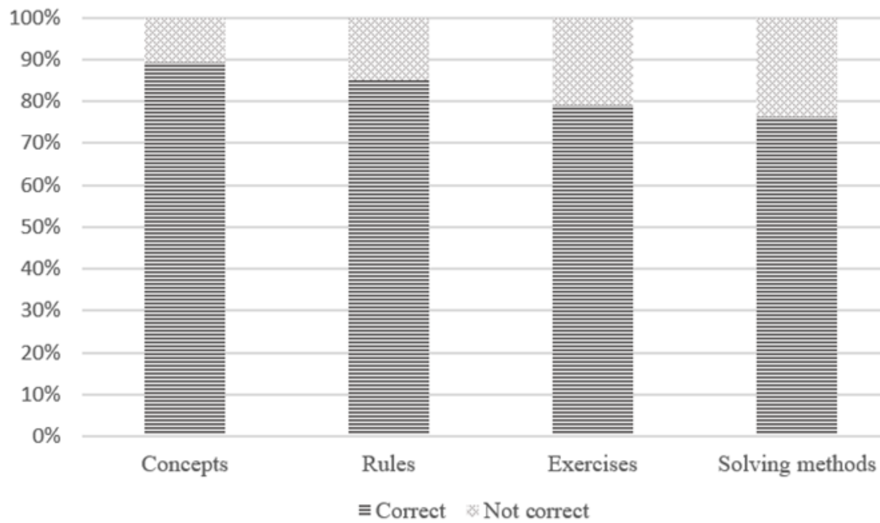
There were 171 students who joined this survey with 513 queries. Table 2 and Figure 6 show the test results of those queries in stage 1 of the testing.

At stage 2 of the testing, the surveyed students, 171 students, were from universities in Ho Chi Minh city. Those students included first-year students (32%), second-year students (15%), third-year students (28%), and last-year students (25%). All of them studied the course of Fundamentals of

Table 2. Experimental results on tested queries

Query Content	Number of Queries	Correct	Rate
Concepts	166	148	89.1%
Theorems/properties/rules	127	108	85.0%
Problems (exercises)	114	90	78.9%
Solving methods	109	83	76.1%
Total	**513**	**429**	**83.6%**

Figure 6. Experimental results on tested queries



Database Systems. Based on the results received from the system, the students evaluated this program by answering the survey questions, which are organized on a Likert scale of 1 to 5, which means very bad to very good. The results of this survey are presented in Table 3.

The results of the survey show that this intelligent querying system is very effective for students' learning in the Fundamentals of Database Systems course. Most students evaluated the abilities of the system well, especially the function of recommending related knowledge. From these results, the intelligent querying system is emerging to develop and become an assistant tool for learning in the real word.

CONCLUSION AND FUTURE WORK

In this paper, we presented the combination model of the extension ontology Rela-Ops model and the structure of two-layer knowledge graph, called the Rela-KG model. The knowledge base of an intelligent querying system in e-learning can be organized using this approach, which is referred to as the Rela-KG model. It shows the connections between various knowledge domain components and increases adaptability. Additionally, the problems of querying on a knowledge base, such as searching and comparing information and recommending related knowledge, are researched and resolved.

Table 3. Results of survey

Criterion	Level (Very Bad to Very Good)				
	1	2	3	4	5
The knowledge base is sufficient.	21%			79%	
Searching function is useful in learning.	23%			77%	
Comparing function is useful in learning.	22%			78%	
Recommendation of related knowledge is useful.	20%			80%	

The advantage of this study is that the substance of the search results is completely displayed, and similarly, the performance in the relevant course's textbooks.

We applied the Rela-KG model to build an intelligent querying system for the Fundamentals of Database Systems course in the IT curriculum. This program supports the learning of this course. It separates the results into intellectual components of the course in addition to the results extracted for an inputted query. Additionally, it suggests additional information in search results. This feature helps students comprehend the information they are looking for better than with other systems.

In the future, the intelligent querying system can develop more functions to support many kinds of queries. Through the Rela-KG model, the knowledge base can combine several knowledge domains (Nguyen et al., 2020a; Nguyen et al., 2022a) to enable the querying engine to facilitate the study of foundational IT courses at the university. Additionally, chatbot tutoring environments offer a focused learning environment (Okonkwo & Ade-Ibijola, 2022; Weber et al., 2021). The chatbot environment's querying system will be a more capable and engaging online tutoring platform to promote students' learning (Nguyen et al., 2020c; Jiang et al., 2022). Moreover, the intelligent supporting system for multiple-choice training tests will eventually be combined with the intelligent querying system in e-learning (Mai et al., 2018; Kusairi, 2020). The integrated system will assist students in reviewing and assessing their level of course understanding.

COMPETING INTERESTS

The authors of this publication declare there are no competing interests.

FUNDING

This research was supported by the VNUHCM-University of Information Technology's Scientifc Research Support Fund.

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