

An Expert Module of an Intelligent Tutoring System

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Abstract

Intelligent Tutoring Systems (ITSs) are complex computer programs that manage various heterogeneous types of knowledge ranging from domain to pedagogical knowledge. ITS aims to overcome some educational problems concerning individual differences, capabilities and skills. So, the recognized leadership in the learning process is centered on the student himself. This research is adopting on the Natural Language processing and intelligent agents in this Intelligent Tutoring Systems.

The resources needed to build an ITS come from multiple research fields, including artificial intelligence, the cognitive sciences, education, human-computer interaction and software engineering. With the aid of Natural Language Processing, we can deal with the student in analyzing his answers and solving the questions, especially that this research concentrates on the basics of the grammar of the Arabic language as a domain knowledge.

The global structure of ITS consists of mainly four modules: a tutor module, a question selector, an expert module and a student module in addition to a user interface module. This research concentrates on the Expert Module (EM) that aims to get the correct answer of a specific question from the domain. EM receives a question that is selected randomly by the question selector from a question bank. Such a question is represented to the student using Arabic language. EM analyzes that question by consulting a dictionary which contains a lot of Arabic words with related features. EM generates the appropriate answer by matching the relating features of that question words.

Keywords Terms—Expert Module, Analysis of a question, solving a question

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1. Introduction

An intelligent tutoring system (ITS) is any computer system that provides direct customized instruction or feedback to students, i.e. without the intervention of human beings. ITS typically consist of four modules: the Tutoring Module, which designs and regulates instructional interactions with the students; the Question Selector Module, which selects a question from a question bank; the Expert Module, which comprises of facts and rules of the particular domain to be conveyed to the student; the Student Module, which is a dynamic representation of the students current state of knowledge; in addition to the User Interface, which controls interaction between the student and the system [Vyshnavi Malathi Ramesh & N. J. Rao (2010)]. Fig.(1) illustrates the structure of an ITS.

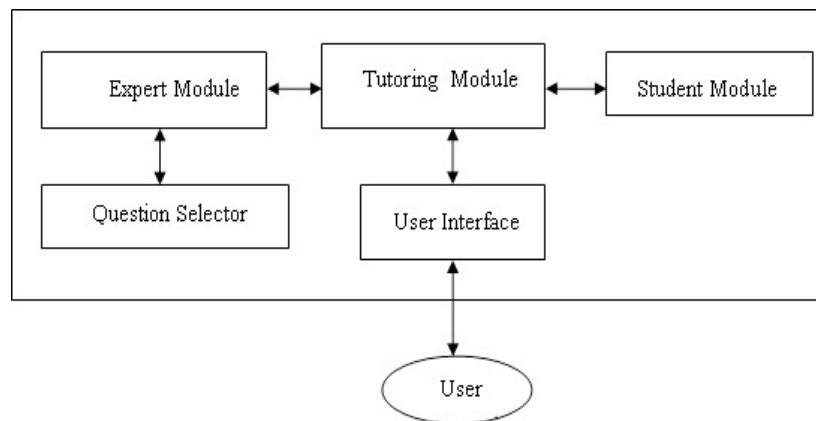


Fig. (1) The global structure of ITS

This research concentrates on the Expert Module. To understand this module we have to talk briefly about the domain knowledge, knowledge base and the Question Selector which its output is the input to EM.

2. Domain Knowledge

Domain knowledge in artificial intelligence is the knowledge about the environment in which the target system operates. Also a domain model is created in order to represent the vocabulary and key concepts of the problem domain. The domain model also identifies the relationships among all the entities within the scope of the problem domain, and commonly identifies their attributes. An important advantage of a domain model is that it describes and constrains the scope of the problem domain. The domain model can be effectively used to verify and validate the understanding of the problem domain among various stakeholders [Peter Brusilovsky & David W. Cooper (2010)]. The adopted domain is the curriculum of the grammar of Arabic language of the elementary stage in Egypt.

2.1. Representing the Domain knowledge in AG_TUTOR

To design a structure for the domain, we use the technology of adaptive hypermedia system. The information structure of a typical adaptive hypermedia system can be considered as two interconnected networks or “spaces” as shown in Fig. (2)

- A network of concepts (knowledge space)
- A network of hypertext pages with educational material [Peter Brusilovsky (2002)].

In AG_TUTOR, we had transferred all the domain knowledge into concepts and fragments. So, we can easily design our networks of concepts (knowledge space) and hyperspaces (hypertext pages) as the sample of the network that is shown in Fig. (2). The sample of the Arabic Grammar of Fig.(2) was designed as concepts and fragments like that:

Concept name: speech الكلام

Its fragments: noun الإسم, verb الفعل, particle الحرف

Concept name: the nominal sentence الجملة الإسمية

Its fragments: مبتدأ, خبر

Concept name: verbal sentence الجملة الفعلية

Its fragments: فاعل, فعل, verb, subject

And a network of concepts (knowledge space) comes through:

- مبتدأ, خبر and فاعل are connected to the names
- The verb of the verbal sentence is connected to فعل

But the network of hypertext pages comes through:

- The speech, the names and the nominal sentence pages are connected together.
- The verbal sentence and the verb pages are connected together.

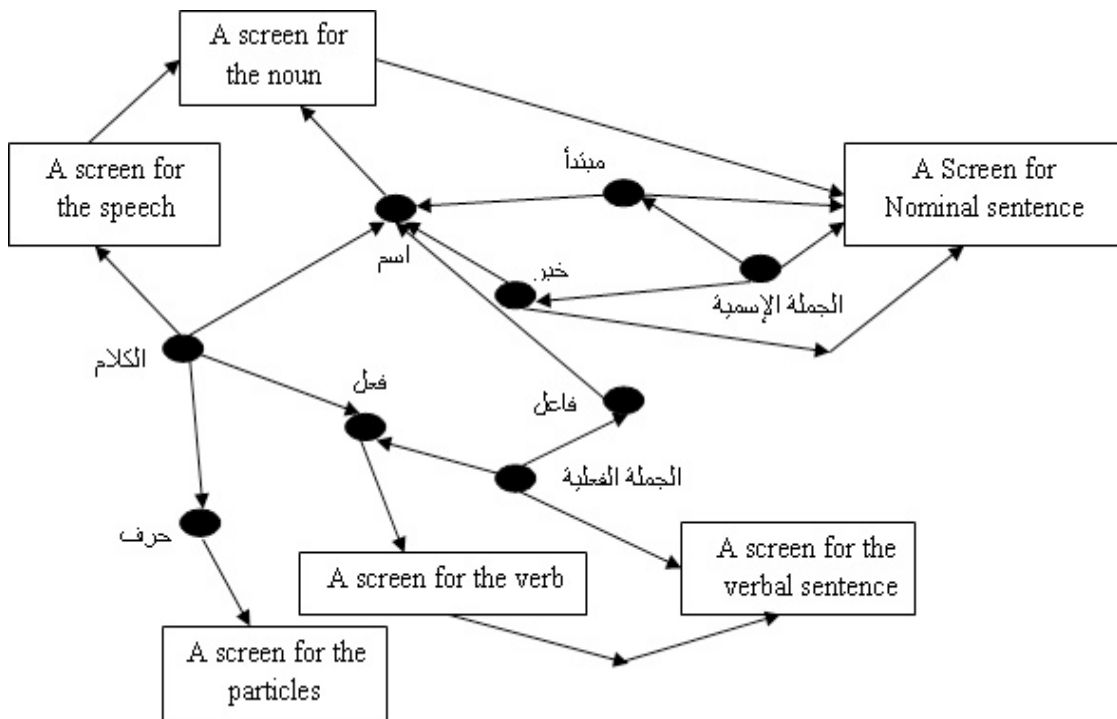


Fig. (2): A sample of network of a part of Arabic Grammar

And so on all the grammar that will be taught will be transferred to this form and then to database tables on the computer. Through this analysis, we can obtain a big network like the one in Fig. (2). This network includes a network for all the concepts and the relations between them and another network for the hyperspaces (pages) for

each concept and the relations between them, then how each network related with the other one.

3. Knowledge Base

Knowledge base (KB) is a technology used to store complex structured and unstructured information used by a computer system. The initial use of the term was in connection with expert systems which were the first knowledge-based systems [Roger Nkambou¹&Jacqueline Bourdeau²&Valéry Psyché² (2010)].

3.1. Knowledge acquisition

Knowledge acquisition is the process of extracting, structuring and organizing knowledge from one source or more, mostly from human experts, so it can be used in software such as an Expert System (E.S.) or any other applications in Artificial Intelligence (AI). This is often the major obstacle in building any application of Artificial Intelligence [Ioannis Hatzilygeroudis& Jim Prentzas (2009)]. The source of the domain knowledge in this research is the transcripts that the Arabic Expert made them from the curriculum of the Arabic grammar of the fourth grade of primary school.

3.2. Knowledge type

In order to progress through the levels of integrations in the curriculum, teachers must become proficient in articulating learning objectives based on conceptual knowledge, as well as being explicit in their teaching of the procedural knowledge. In this research, the domain knowledge (as said before) is the curriculum of Arabic Grammar of the fourth grade of elementary schools. This domain is considered Conceptual knowledge. The domain consists of many concepts and relations between each one and others. Each concept represents a lesson

3.3. Knowledge representation

Knowledge representation is a term that is used in the artificial intelligence (AI) fields dedicated to representing information about the world in a form that a computer system can utilize to solve complex tasks such as diagnosing a medical condition or having a dialog in a natural language. Knowledge representation incorporates findings from psychology about how humans solve problems and represent knowledge in order to design formalisms that will make complex systems easier to design and build. Knowledge representation and reasoning also incorporates findings from logic to automate various kinds of *reasoning*, such as the application of rules or the relations of sets and subsets [Judith Masthoff Bamshad Mobasher& Michel C. Desmarais Roger Nkambou (2012)] .

EM knowledge is represented using production rules method. The production rule method consists of: facts and rules. Fig.(3) shows the production rule system of EM.

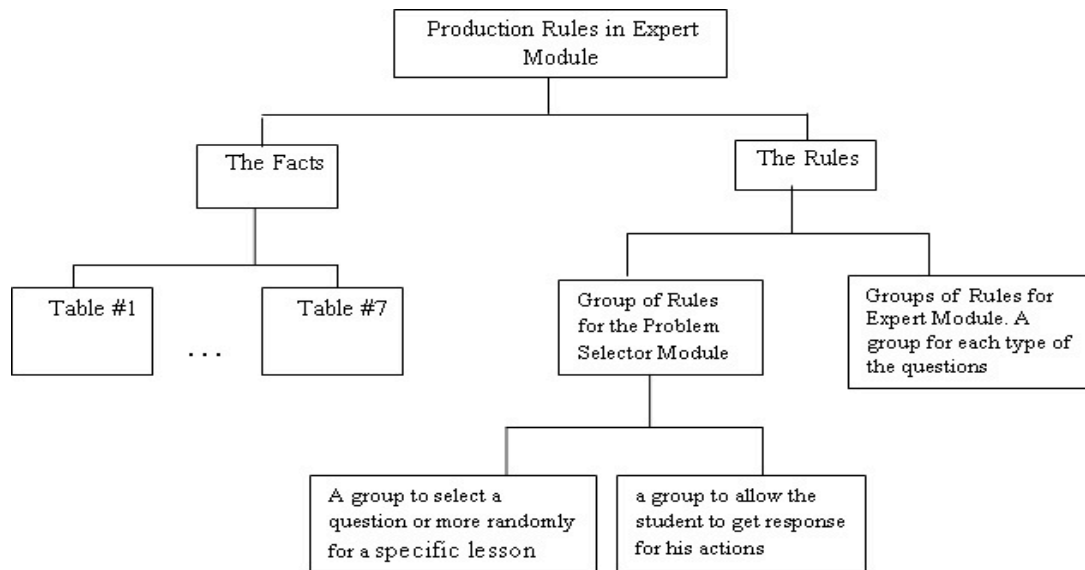


Fig. (3) the production rule system of EM

Rule-based cognitive models serve many roles in intelligent tutoring systems (ITS) development. They help to understand student thinking and problem solving, help to guide many aspects of the design of a tutor, and can function as the “smarts” of a system. Cognitive Tutors using rule-based cognitive models have been proven to be successful in improving student learning in a range of learning domain. [Vincent Aleven (2010)].

3.3.1. The facts: The facts are represented through a big database. This database was implemented using Microsoft Access including eleven tables for all ITS. But in EM and Question Selector, 7 tables of this database are used. These tables represent the question bank and the dictionary of this module. Samples of these tables are shown below:

1. Problem table: contains question heads and three codes; concept number, concept type, and question head number such as: اسحب اسم الإشارة المناسب وضعه في مكانه المناسب فيما يأتي: (press on the correct answer between brackets)

problems			
c code	type code	P no	question head
4	1	1	أعرب الجملة التالية:
1	1	1	اسحب اسم الإشارة المناسب وضعه في مكانه المناسب فيما يأتي:

Table (1) problems table

2. Questions table: contains the sentences needed to be solved beneath each question head and four codes; concept number, concept type, and question head number, and number of the sentence such as: تلميذ (هذا هذان هؤلاء)
(----- is a pupil (this – these))

questions				
c_code	type_code	P_no	q_no	question
4	1	1	1	العصفور جميل
4	1	1	2	العلم نور
1	1	1	1 تلميذ (هذا هذان هؤلاء)
1	1	1	2 طفلة صغيرة (هذه هذان هؤلاء)

Table (2) question table

The tables (1,2) and the relations between them and some other tables are the data base of the question selector and EM.

3. Word table: contains all the words that are included in all exercises that will be presented to the student and its feature codes.

Words					
w_code	word	type	gender	count	anatomy
148	العصفور	1	1	1	2
149	جميل	1	1	1	5
150	العلم	1	1	1	4
151	نور	1	1	1	4
152	تلميذ	1	1	1	1
153	طفلة	1	2	1	1
154	صغيرة	1	2	1	5

Table (3) words table

4 . Classify table: contains word type such as: (noun) حرف , (opposition) فعل , (verb) اسم and a code for each.

5. Gender table: contains the gender of the word and a code for each such as: مؤنث , مذکر (male, female)

6. Count table: contains the count of the word and code for each such as: مفرد , مثنى , جمع (singular, double, plural)

7. Anatomy table: contains the kind of the word and a code for each such as: إنسان , حيوان , نبات , جماد , صفة (human, animal, plant, adjective)

Classify	
Type	Type Code
اسم	1
فعل	2
حرف	3

Table (4) Classification Table

Gender	
Gender	Gender Code
مذكر	1
مؤنث	2

Table (5) Gender Table

Count	
Count	Count Code
مفرد	1
مثنى	2
جمع	3

Table (6) Count Table

Anatomy	
Anatomy	Code
انسان	1
حيوان	2
نبات	3
جماد	4
صفة	5

Table (7) Anatomy Table

The tables (3-7) and their relationships are the database of the Expert system module (we'll talk about it latter).

3.3.2. The Production Rules

A production system (or production rule system) is a computer program which consists primarily of a set of rules about behavior. These rules, termed **productions**, are a basic representation found useful in automated planning, expert systems and action selection [Budi Hartanto, Jim Reye (2013)].

Productions consist of two parts: a sensory precondition (or "IF" statement) and an action (or "THEN"). If a production's precondition matches the current state of the world, then the production is said to be *triggered*. If a production's action is executed, it is said to have *fired*. A production system also contains a database, sometimes called working memory, which maintains data about current state or knowledge, and a rule interpreter [Budi Hartanto, Jim Reye (2013)].

In this research the rules are represented through a big group of rules appeared in the implementation (the code) of the module. Fig. (3) shows the production rules of EM. A group for each type of the questions. Here is a sample from EM rules:

Rule #1: to solve a question like the one mentioned before:

اسحب اسم الإشارة المناسب وضعه في مكانه المناسب فيما يأتي: تلميذ (هذا- هذان هؤلاء)

(press on the correct answer between brackets: (this – these) ----- is a pupil)

```
if((second_word[2].equals(first_word[2]))&&(second_word[3].equals(first_word[3]
))) then {answer[0]= choices[i];break;}
```

4. Question Selector Module

The main goal of question selector module is to select a random question from a question bank (table #1 & #2) and represent it to the student according to the lesson that he selects and give him the chance to answer. The input of the question selector module is the data base bank. This bank of questions is represented mainly through the table #1, table #2 and their relationships with other tables in the database. The question bank consists of a huge number of questions. The bank is divided to many groups of questions as a group for each lesson. In this research, there are many types of questions, these types are:

1. Multiple Choices questions (MCQ)
2. Match to the correct sentence
3. Press on something (like: signal names,)
4. Fill in the space with the correct answer from the brackets
5. Get out a verb, a noun, or a particle or
6. Parse a sentence
7. Arrange a nominal sentence to be a verb sentence and vice versa (reordering).
8. Give the Plural, double or of a noun

5. The Expert Module

Cognitive modeling is the activity of producing a detailed description of the knowledge involved in student performance in a given domain, including strategies, problem-solving principles, and knowledge of how to apply problem solving principles in the context of specific problems [Vyshnavi Malathi Ramesh& N. J. Rao (2010)]. In this research EM is used the production rules method for representation of the knowledge base (rules and facts) that used for solving the question that is represented to the student. EM uses this knowledge to guide other parts of the system. EM depends on the technology of Natural Language Processing and uses available rules of our course to get solutions of the problems. It simulates human experts in decision making or the instructor in the Education [David Ngi Chin (1987)]. This module contains the rules of the domain knowledge that help to get the correct answer of the question. As shown in Fig. (4), the input to the Expert Module is the code of the question that is represented to the student which is the output of the Question Selector. And the output of this module is the correct answer.



Fig.(4) input and output of the Expert Module

5.1. Design of the Expert Module

The methodology of this module is established on the idea of defining some features for the words that are used in the exercises that will be shown to the student. These words are put in a dictionary with the features of each one of these words as mentioned before (table #3-7). For each word in the question, we put specific codes for a group of features for the word as shown in the word table #3 (the dictionary):

As an example: the word شجرة (a tree) has the features: اسم - نبات - مؤنث - مفرد (means: noun, plant, female and single) so, it will take a code: "1 2 1 3" and so on for all words of all exercises.

The idea of defining the features of each word has many advantages:

- This module can deal with singular, double and plural nouns, male and female, and word types (اسم حرف فعل).
- By this method we can add any additional questions without changing the program, so the program can be used for any question except if it has a semantic problem.
- This idea will help us in evaluating the student answer and medicate his problems.

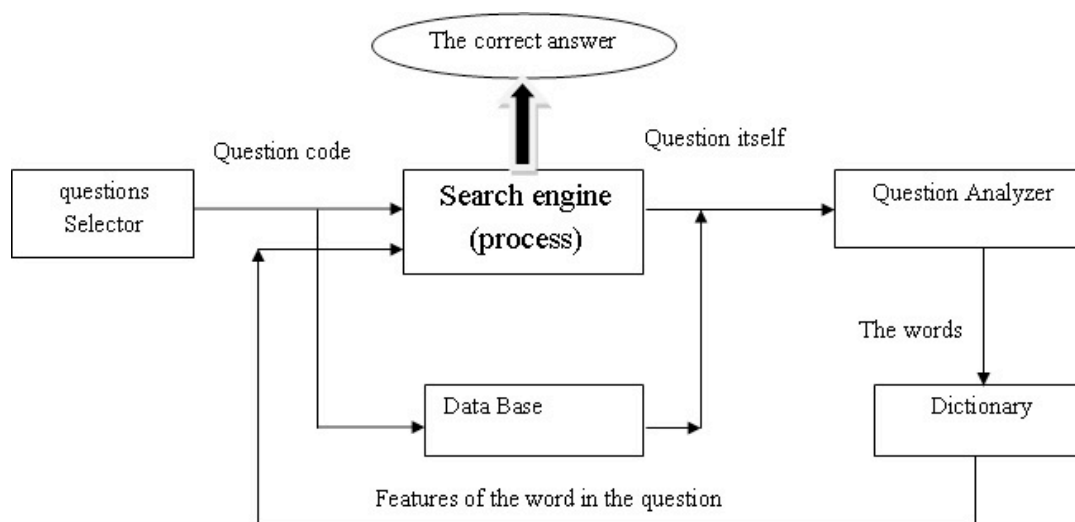


Fig. (5) the Expert Module

As shown in Fig. (5), the Expert Module consists of many components. These components are:

- **Database:** is a group of tables that contain the table of question head (problem table #1) and questions tables (questions table #2) and their relationships with some other tables.
- **The dictionary:** it has a huge number of words with the codes for each word. These codes are a type code, a gender code, count code and anatomy code. The dictionary mainly exists in the word table # 3 that mentioned before. Also the (tables #4-7) have relationships with table #3. Up to now the dictionary contains about 600 words for the first part of the curriculum.
- **The type code:** is a code for each type of the words such as the noun has code 1, the verb has a code 2 and so on. (shown in classify table #4)
- **The gender code:** appeared in the gender table such as male has a code 1 and female has a code 2. (gender table #5)
- **The count code:** is a code for the count of the word such as مفرد (single) has a code 1, مثنى (double) has a code 2 and so on. (shown in table count table #6)
- **The anatomy code:** it has the codes of the types of the noun such as انسان, حيوان, نبات, جماد, صفة. (shown in anatomy table #7)
- **Question analyzer:** it takes the question, analyzes it and gets the features of the words of that question.
- **Search engine:** it has two tasks of searching:

- ✓ Taking the question code as the output of the Question Selector to get the question itself by searching in the database tables.
- ✓ Searching in the dictionary after analyzing the question by the question analyzer to get the features of each word in the question. So the system can get the correct answer that matches to these features.

5.2. Implementation of the Expert Module:

EM is implemented using Java netBeans and Microsoft Access for the database

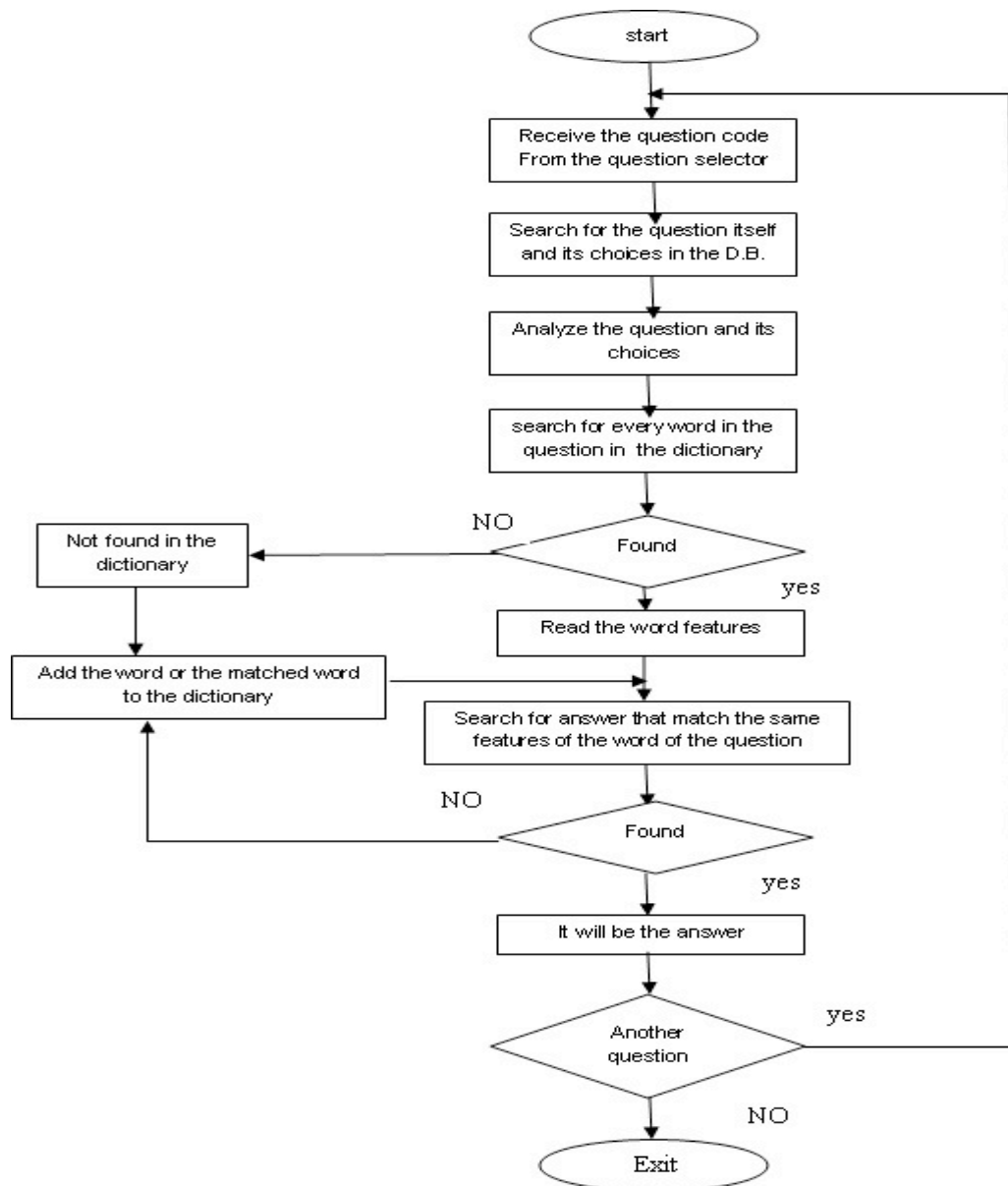


Fig. (6) the flow chart of the Expert Module

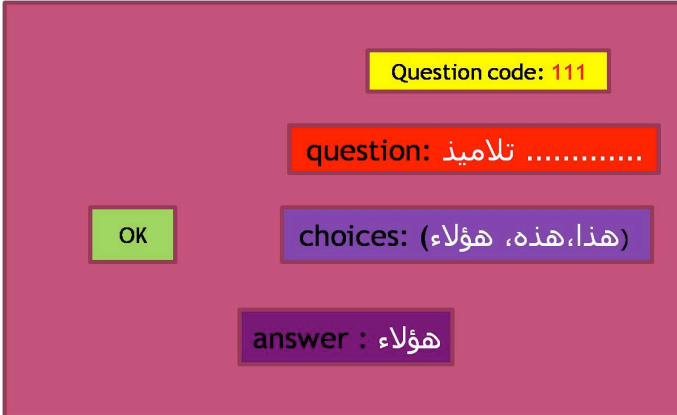
Fig. (6) shows the flow chart of the expert module. Here are the steps to get the correct answer:

1. The Expert Module receives the question code from the Question Selector as input.

2. Search for the question itself in the database tables (tables #1, #2 and their relationships)
3. Analyze the question and its choices (if exists) and search for its words in the dictionary
4. If found, read question features code and search for the matched answer (that match the same features)
5. If not, then it is not in the dictionary, so the word can be added and repeat
6. If there is another question repeat, if not Exit

6. The output of the Expert Module:

Fig. (7) shows the output form of the Expert module for a specific question.



The screenshot displays the output of the Expert Module for a specific question. It features a dark red background with several colored boxes containing text. At the top, a yellow box displays "Question code: 111". Below it, a red box shows "question: تلاميذ". To the left of the question box is a green "OK" button. Below the question box, a purple box displays "choices: (هذا، هذه، هؤلاء)". At the bottom, another purple box displays "answer : هؤلاء".

Fig. (7) The output form of the Expert Module

7. Conclusion

The research problem is to design and implement a module that takes a question of the domain as input and gives a solution for this question as output. This domain is the Grammar of the Arabic language for the elementary schools in Egypt. In this research, an Expert Module was designed and implemented to solve the question on the same time that it is represented to the student. The module is tested and worked for all types of questions that are mentioned before. But the only constraint for EM is being that the question has a semantic problem such as an essay question.

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