EXERCISES AS A TOOL FOR UNDERSTANDING THE TERMINOLOGY IN THE LEARNING PROCESS OF DATA STRUCTURES

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ABSTRACT

Methodological aspects of the study of new terms in the Data Structures course are considered. Some ideas about forming these terms are proposed in the context of the abstract-deductive method. A system of exercises for its understanding is discussed. The article is suitable for Data Structures teachers.

I. INTRODUCTION

The learning of every school subject includes the studying of its terminology as a first step. Consequently, every term appears to be a part of a whole system, particularly created regarding the pattern of learning. The method of learning a term involves forming the term and its understanding. The following article offers an idea of forming the terms in the abstract-deductive method of the Data Structures learning process and a system of exercises for its understanding.

II. THE LEARNING PROCESS OF THE TERMS IN STUDYING DATA STRUCTURES

Forming of the terms in the learning process of Data Structures

Each term has volume (a multitude of objects or relations, which are included in the term) and contents (the common and typical attributes, same for all the elements of that multitude). "The forming of the term is a logical process, which describes and/or explains the idea of that term or the volume and contents of it, which is named with the term, using known, already entered terms only. The result of the process is a sentence called description or definition of that term" [2].

In the learning process of Data Structures, the following definitions are used:

- Genetic – in those types of definitions, the current object is defined by the way of forming. Given that, the structures of linear list, graph, etc. are defined.
- Recursive – in those types of definitions, a basic (start) object is entered and the rules for forming of new objects from the already existing ones are formulated. An example of a recursive definition is the tree one.
- Definitions based on the closest type and origin quality – in those definitions the term is defined using a character attribute (typical indication) of a term with a higher volume (origin term). This is the way to define stack, queue, deck with origin term linear list, a binary tree with origin term tree and so on.

Considering those definitions contain the way of forming the object or use already established terms, they do not require special preparation. Hence, in the forming of Data Structures terms, using abstract-deductive method is goal-oriented.

Understanding of the terms and their definitions

This is a process which cannot be isolated from the process of forming terms. In particular, it includes the creation of a clear and exact idea of the volume, as well as the contents of the term, to the learner. This is why it is necessary, using the appropriate specific exercises, to create models of the object viewed, which despite the differences among them, have similar structure and attributes. The purpose of this process of accumulation of empirical material is to put the emphasis on the character attributes of the term viewed, to clear the private characteristics of the specific examples and by way of abstracting, extract the contents of the defined term, its connection with other terms in the system and the opportunities for application and development (of the contents). The applicable character requires also a corresponding program realization of the structure viewed. In this idea of understanding the terms and their definitions in the Data Structures learning process, a system of exercises, including the following three (3) modules, can be suggested:

1. Organization of the empirical material – an accumulation of facts on the basis of observation, experimentation, induction, analogy, summary.

The basic goal of the organization of an empirical material is the creation of situations in the form of exercises, using which, the character qualities forming the contents of the term viewed, are differentiated. In this module, the following stages can be distinguished:

1. 1. Observation and Experimentation

The exercises at this stage have the purpose of creating special situations which offer the learners an opportunity to extract knowledge about the structure and possible operations using the term, as well as its introduction in already known systems of objects. This offers deeper and longer understanding of the new knowledge.

1. 2. Induction.

A main rule of the recognition process is the unique-to-universe relationship; from facts established on the basis of observation and trial to the summary.

Induction is a logical form of a similar method of reasoning. This stage is based on the exercises from the previous one and has the following requirements toward them: to select a sufficient amount of unique cases, guaranteeing diversity; the contents of each one of the unique cases should not vary, change its type, in order to be able to help the students find the common, i.e. the contents of the conclusion.

1. 3. Analogy.

In the organization of the empirical material, along with the induction, analogy is also applied – the disbursement of the similarity of the objects on the basis of certain qualities. The basic purpose of the exercises at this stage is a development of the logical thinking and creative application of knowledge accumulated about the object through finding a similarity among objects of a different nature.

1.4. Summary and Abstract

These two methods are used mostly in the process of forming the terms and are inextricably bound up with each other. The summary is separation of important, for a certain class, objects or processes qualities, and the abstract – ignorance of the unimportant for the certain consideration qualities.

As an example for this module, in the learning of stack, the following exercise can be suggested:

Exercise (Basic quality of the organization of elements in the stack)

a) (1.1) The symbols H, E, L, L, O, are entered trough the keyboard, which accumulate consequently in a stack. Draw a scheme to show the accumulation of the symbols in the stack (draw the stack and its contents). Define the word which is shown trough the consequent exclusion of the symbols from the stack.

b) (1.2) Applying the scheme from sub-problem a), define the word that would be shown after the exclusion of its symbols from the stack as soon as they are entered through the keyboard, from the words “TEXTBOOK”, “DOG”, “HOUSE”.

c) (1.2) What would be the word, which is created on the basis of the method described, regardless of what input symbols enter the stack.

d) (1.3) Verbally describe the algorithm, which given a whole number and using a stack, brings up a number, comprised of the same numbers, but in the opposite direction.

e) (1.3) Verbally describe an algorithm, which, using a stack, defines the binary presentation of one real number *n*.

f) (1.4) Summarize the results, drawing a conclusion about the structure connections among the elements of the stack, their basic operations and the character application of stack structure derived from them.

g) (1.4) Create an exercise which requires the use of a stack. Is it possible that it can be solved with the use of a different structure? What are the advantages and disadvantages in the use of a stack?

2. A logical organization of the accumulated material – it is done on the basis of the system of terms and on the basis of the program realization.

The logical organization requires to get familiar with the class, realizing the corresponding structure, and can be divided by the following stages:

2.1. Reading of a program fragment – given a program fragment and input data, the learner is to define the result.

2.2. Finding a program fragment, realizing a given action – among several given program fragments and a given action, the learner is to find those that realize the given action. Among all the program fragments, realizing the action, the learner is to find the ones that have optimum actions.

2.3. The organization of a mixed program fragment – mixed program fragment, input data and a result are given. The task of the learner is to put in right order the commands to the functions, so that when the fragment from the given input data is performed, it brings up the result we are looking for. One complication at this stage is to have built-in redundant managing constructions.

2.4. Finding a previously made mistake in the program fragment, realizing the given action – in the text of the program fragment, realizing the described action, there is a mistake. The learner's task is to find and correct the mistake, following the logic of the algorithm.

2.5. Selection of a step in an incomplete program fragment – the purpose of the learner is to fill in the missing step in the net of operators, given that the conditions have been already provided.

2.6. Forming the program fragment on the basis of a verbally described algorithm – using an algorithm given by the professor, the learner is to write a corresponding program code, realizing this algorithm.

2.7. The individual solution of application problems, using a set library. The purpose of this stage can be announced on two (2) levels:

A) *Typical suggestions of the structure viewed to be given.*

Applications, requiring program realization, should be wisely chosen concerning the topic and difficulty and to put an emphasis on the method of processing the data, specific for the structure viewed. Complicated and volume applications should be avoided. Some of them require the introduction of the learner to additional information which can lead to concentrating of the learner's attention on the new problem. An example of a sample exercise is the conversion of an expression from infix to postfix type, where before the algorithm is given, the terms infix and postfix record of an expression, should be clarified, and appropriate examples and exercises for converting should be given.

At this stage, it is really important to put an emphasis on the usage of the particular structure, and not on the amount of problems solved. In this aspect, self-aiming problems created should be avoided, because of the unreal involvement of the structure viewed, with the purpose of exercising the basic operations with it. Many times these unreal scenarios of exercises make the use of the structure useless and even the learners themselves can find more optimal solution without its application. This leads to the loss of motivation in the understanding of the course material.

B) *Comparative analysis of the possible solutions which do not use the given structure.*

The purpose of the comparative analysis can be summarized in the following directions:

- The inability for solving the particular problem to be shown and its program realization without the use of the given structure.
- The difference in time needed to process the real data to be shown, using the particular structure in time needed for processing without its usage.

3. Application of the theory created during the second stage– the exercises are used as a motive for the following development of the theory and an opportunity for its effective application.

Solving problems on your own is included in the module, requiring expansion of the bank of functions found in the library viewed. The solution of problems of this sort requires the development of individual or group projects. Appropriate for this module are exercises requiring individual research of additional material concerning the topic.

III. CONCLUSIONS

According to the method suggested in the article above, the learner first accumulates knowledge about the object studied (the data structure viewed). The product, received by the student, is compared with an analog and through a series of interrelated exercises, an accent is put on the basic qualities of the object, as well as the possibilities of its application. As a result of this, the learner thinks over, builds on, or specifies his/her solution. All this requires the use of the following methods:

- the method of goal-oriented exercises – each of them should perform a certain function in the system. The exercises should be interrelated. These relationships are called "relations". A relation can be comprised of several exercises. The most common relations in the system are: relation of the common idea, relation of concretization, relation of summarization, relation of analogy, relation of marginal case and so on.;
- a heuristic discussion, which helps the learners draw conclusions with the help of the system of questions;
- summarization of the solution of a problem and regeneration of proposals for the process of looking for a solution, given similar exercises.

The proposed system of exercises satisfies the following conditions [1]:

- comprised of concrete course exercises, whose purpose is to achieve the common goal for every school goal – solution of the practical problems;
- has quality structure completeness, i.e. is created with the idea of the principle for completeness;
- contains scholarly goals for forming of theoretical knowledge and ways of action in the learners;

- the systematization of the problems allows their difficulty to change progressively on the basis of the development of their structure and at every stage of difficulty – on the basis of the power of problematic progress.

The system integrates new contents of ideas and logic organization, which are relative to the goals that the training process has – creative type of learning, possibility for evaluation and choice of optimum solution of the corresponding practical problem. The creative thinking offers a wide range of using the knowledge accumulated, solving the arguments between up-to-date learning and requirements of the problem situation, originality of the solution. In applying that type of thinking, the textbook should be used in a special situation to achieve the goal of discovering something new. In the method suggested in the following article, the learner first accumulates knowledge about the current object and using series of related exercises, puts an accent on the major features of the object and the possibilities for its application. The planned results comprise of the following qualities of the learner: ability to generate ideas; application of the creatively accumulated, through personal activity, knowledge and skills, to the new problem situation; orientation in the key problems; ability to act in situations of infinity.

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