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Nama	: **Dr. Dra. Sulis Janu Hartati, MT**
NPP	: 15.01.1.452
NIDN	: 0722016401
Status	: Dosen Tetap
Tugas	: Pemakalah Seminar Internasional " A Study of Knowledge and Reasoning Mathematics in Algorithms Computing
Tanggal	: 10 Nopember 2016
Tempat	: Universitas Dr. Soetomo

Demikian surat tugas ini dibuat untuk dilaksanakan sebaik-baiknya dan penuh tanggung jawab dan hasilnya di laporkan kepada Dekan.

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A STUDY OF KNOWLEDGE AND REASONING MATHEMATICS IN ALGORITHMS COMPUTING

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Abstract. In this paper, we intend to show, the links between mathematical reasoning and the algorithms computing. The question in this paper are how to categorize knowledge in logic and algorithms and what kind of mathematical reasoning which is used in algorithms computing. Method used in this is literature based research methodology. The study objective are to categorize knowledge learned in Algorithms and kind of mathematical reasoning which is used in algorithms computing. The result of the study is the categorization of the knowledge that can be done by using deductive and analogy logic. All knowledge which is learned in Algorithms computing must be categorized into conceptual and metacognitive knowledge. Reasoning mathematics in algorithms are deductive reasoning. The deductive reasoning used to compuse the algorithms and to investigate the truth of an algorithms have been made. Learning question design directing to conceptual and metacognitive knowledge is proven to be able to create meaningful learning process. 85% of students can identify inter-correlation between one concept to others, and 81% of students can evaluate their own works.

Keywords**:** Reasoning Mathematics, Algorithms, Deductive Reasoning, inductive Reasoning, Conceptual Knowledge

I. INTRODUCTION

According to Burner, a teachers must be able to create a meaningful learning process. This affirmation has been proved by Hartati [9a]. The affirmation confirms that meaningful learning influences students' comprehension of division operation.

Other opinions, which are similar to Burners, come from Maher & Davis [11] and Steffe [16]. According to Steffe [16], the fundamental duty of mathematics teacher is to accelerate mathematical meaning development of theirs students. If a teacher fails to do this, then the learning process will be meaningless. Students cannot remember, transfer or apply information which is meaningless to them. According to Maher & Davis [11], one of the teachers' duties in learning process is to construct their own intellectual so that they can present a mental representation that suits well to their students' mental representation.

Burner [4] said that learning incorporates three processes, consisting: (1) gaining new information, (2) transforming information, and (3) testing the relevance of transformation result. The definition of information the previous sentence is the adaptation process, or transformation of prior knowledge which has been already acquired based on the new information. Therefore, the approach used in learning can use 2 assumptions [4]. First assumption is someone's knowledge can be acquired interactively. This means that, in learning, active interaction process between the learner and his environment must take place, in order to transform existing behavior into the expected forms. Second assumption states that someone's knowledge is constructed by connecting new knowledge to the prior knowledge which has been already acquired. Someone's comprehension of something, either in the form of procedural or conceptual knowledge, depends on the cognitive structure of mental aspect or mind.

Knowledge is classified into four groups, consisting of factual, conceptual, procedural, and metacognitive [1]. In this paper, we intend to show, the links between mathematical reasoning and the algorithms computing. It is important to be assessed because more than 70% students of STMIK Surabaya have found difficulties in learning Logic and Algorithms [9b]. This condition is also identified in some other Higher Education institutions in Indonesia [2][12][14].

Based on the explanation, The question in this paper are how to categorize knowledge in logic and algorithms and what kind of mathematical reasoning which is used in algorithms computing. The objective in respect to this question is to find the characteristics the knowledge being learned in Algorithms categorize and to know kind of mathematical reasoning which is used in algorithms computing. The finding is used for establishing the learning question is each topic. In the end, it is expected that the finding can be applied as a guide for designing the meaningful learning.

II. THEORITICAL FRAMEWORK

A. Classification of Knowledge

According to Anderson & Kartwoth [1], classification of knowledge consist of: factual, conceptual, procedural, and metacognitive knowledge.

Factual knowledge is separated between one another, one fact to others are not connected, as in the information

bits [1]. Knowledge is grouped into two, which are terminology and detail of certain element. The example of terminology in Logic and Algorithms is symbol, such as the convention in writing variable names, flowchart symbols, mathematical expressions, logical operations, and logical relations. Detail of certain element in Logic and Algorithms can be represented by input design, output design, and standard form of sequential, branching and looping processes.

Conceptual process is a more complex knowledge. It consists of factual and conceptual knowledge which are organized to be more complex conceptual knowledge [1]. Conceptual knowledge is the knowledge that is constructed of inter-correlation between basic elements with wider structure so that a specific function is created [15]. This knowledge covers: classifications and categorizations, principles and generalizations, theories, models, and structures. Examples of classifications and categorizations are data, constants, parameters, variables, various types of data processing, as well as modularity. Principle to form, algorithms design principles as well as passing parameters principles represent the member of principles and generalizations. Finally, the examples of theories, models and structures are represented by branching as well as various types of looping flowcharts.

Procedural knowledge is knowledge about how to do something [1][15]. This knowledge includes certain skills, algorithms, techniques, and certain criteria in applying the right methods. Some examples of the procedural knowledge are sorting procedure and data searching from various algorithms and certain algorithm tracings.

Metacognitive knowledge is the knowledge about general cognition, as illustrated that awareness of knowing an idea or not is confirmed as the cognition itself [1]. Metacognitive knowledge incorporates strategies and is proved to be able to improve awareness of reasoning process and existing learning process [5]. As an illustration, students can design flowcharts to solve a problem, and later they can evaluate their constructed flowcharts and determine the flowcharts' correctness values.

Algorithms computing has the purpose of providing the students with the capability to design algorithms which are presented in flowchart and pseudocode in solving computation problems. The topics algorithms computing are emphasized in the creation of logical automation processes, presented in flowchart and pseudocode [7]. In this research, computation problems are limited to the problems of the basic of data processing, those are branching, looping process and combination of each other.

B. Mathematical Reasoning.

There are two main rival psychological theories of reasoning. They are deductive and inductive reasoning. Deductive reasoning is the kind of reasoning in which, roughly, the truth of the input propositions (the premises) logically guarantees the truth of the output proposition (the conclusion), provided that no mistake has been made in the reasoning.

In Mathematics, a reasoning is the basic ideas of mathematical proof and to develop skills in writing mathematical statements [19], like proposition. A proposition is a sentence which is either true or false, but not both.

Therefor, mathematical reasoning covering of the capability to think logically, that develops in studying mathematics and carrying out to other discipline [20][21] . The components is a mathematical statement, called a proposition, that can be worth true or false, but not both [22]. To study mathematical statement fields, it's necessary to gasp simultaneously syntactic, semantic and pragmatic aspects.

The syntax is the study of the rules and constraints of well-formedness of the sentences or the formulae of a given language. For example, the following formula " $A \cap (B \subset C) = A \cap B$" (actually proposed by students) violates a syntax rule of set theory. Indeed, "$\cap$" is an operator that accepts two terms and provides a term, while "$B \subset C$" is a binary relation (a predicate) that accepts terms and provides a proposition, or a "open sentence".

The semantic is the study of interpretations and models of formal theories. It concerns truth values and hence references. According with Tarski [18] the basic notions are : "open sentences", "designation", and "satisfaction for an open sentence by an assignment in a structure". A structure Σ consists in a domain for objects (for example the integer numbers set *N*), function (for example *successor*, *addition*) properties (one place predicate, for example *to be primary*) and relations (two or more places predicate, for example *to be less than*) ; the syntax of the language provides sentences ; some of them are open (*see note number 3*). An open sentence F with *n* free variables *x1, x2, ..xn* is satisfied by *n* objects *a1, a2, …an* if the proposition obtained while assigning the object *a*i to the variable *xi* for every *i* from *1* to *n* is true in the considered structure. If every *n*-uplet satisfies the open sentence in a structure Σ, then Σ is a model for F.

Let us consider the following structure $\Sigma : <N, +, \times, 0; 1; s, \alpha, \beta >$ with + for addition, × for multiplication, *s* for function, successor, α for even number, and β for primary number, and the open sentence *F*: "if *x* is an even number, then its successor is a primary number." *4* satisfies *F* ; indeed *4* is even, and *5* is primary ; *8* doesn't satisfy *F*, for *8* is even, and *9* is not primary ; notice that, although this might not be obvious for most of us, every odd number satisfies *F* ; indeed, the antecedent of the conditional is false.5 Then, we can close *F* in order to get a proposition in two manners : (1) "$\forall x Fx$" (for every *x* , *Fx*) ; (2) "$\exists x Fx$" (for at least one *x Fx*). In Σ (1) is false and (2) is true. In $\Sigma 1$ with only integers from 1 to 7, (1) and (2) are both true ; in $\Sigma 2$ as {8 ; 14 ; 20 }, (1) and (2) are both false. So the semantic as developed in model-theoretical point of view takes care of the objects you are working with, and the domain you consider.

The pragmatic concerns the context, which are involved in the situation, and hence their knowledge about the situation. Consequently, the pragmatic aspect is more than referential function. It involves not only the "real world", but also what is possible and exploration of possibilities' field. So, the pragmatic doesn't concern mathematics at all, but on mathematical reasoning in algorithms.

In this paper, the mathematical reasoning is predicate calculus, specially the elementary model theory with Tarski's semantic conception of truth [18]. The semantic is the study of interpretations and models of formal theories. it

concerns truth values and hence references. According with Tarski (1944) the basic notions are : "open sentences", "designation", and "satisfaction for an open sentence by an assignment in a structure". A structure consists in a domain for objects (for example the integer numbers set *N*), function (for example *successor*, *addition*) properties (one place predicate, for example *to be primary*) and relations (two or more places predicate, for example *to be less than*).

III. RESEARCH METHOD

The method used in this research is literature based research methodology. The theory that will be assessed are classification of knowledge according to Anderson & Kartwoth [1], and mathematical reasoning from Tarski's semantic conception of truth [18].

The sample consists of 120 students. They are a part of the participants in Logic and Algorithms class in odd semester of year 2013/2014. Data collection is done by using tests. Period of data collection is September – October 2013. Data analysis is conducted by using the proposition. Conclusion is drawn by applying the following methods: (1) for literature review, deductive reasoning and inductive reasoning from analogy type are used, and (2) for evaluating the test result, descriptive statistics is applied.

IV. RESULTS AND ANALYSIS

The knowledge being learned in algorithms computing consists of: (1) data processing, including modular approach, (2) variables, parameters, data, constants, arithmetical and logical operators, as well as mathematical logic relations, (3) varied automation processes, covering sequential, branching, looping, as well as combination of these three, (4) algorithm development by using flowchart and pseudocode, (5) array, and (6) various searching and sorting algorithms [7][6][10][17].

A. Data Processing and Modular Approach

This topic describes the concept of data processing automatically, by using the main device which is computer. The description starts from the explanation of the components of data processing devices, including: computer systems, simple logical program, procedure of making program, algorithm presentation by using pseudocode and flowchart [7].

Basic knowledge required to understand the topic includes: variables, parameters, data, constants, mathematical expressions, arithmetic and logic operators, and various data processing activities. Data processing means to transform input data into a specific output. This makes data processing become a complex activity. In order to simplify a technique which is known as modular is required. The purpose of this technique is to make the complex and complicated process can be transformed into some smaller and more specific processes, so that the complexity of each smaller process is lower than the complexity of the entire process.

The required knowledge in order to understand input and output design incorporates: (1) knowledge about the output form expected by users, (2) rule and convention in making the output. Therefore, students must be able to find the output form expected by users. Then, they have to be able to predict input form required to produce the expected output. In this stage, they are demanded to have the capability to identify variables and their types. Next, they are supposed to be able to transform the input to output. In the process stage, another capability which has to be acquired by the students is the capability to predict mathematical expressions as well as logical relations required in the transformation process. Finally, by using the prediction, the students must be able to determine the correctness of the constructed prediction.

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B. Data, Constant, Parameters, Variables, Arithmetical Operationsand Logic

After explaining data processing, some books continue the discussion with various data types, constants, parameters, variables, arithmetic operators, logic, and logical relations [7]. If this knowledge is understood separately, it will not bring meaningful learning process. Some capabilities which have to be acquired by students in learning this knowledge are: (1) Students have to be able to identify differences between data, constants, parameters, and variables, (2) Students must be able to write mathematical expression (including: arithmetic operators, logic and logical relations) which are correlated with data processing, and (3) Students are demanded to have the capability to recognize differences between data, constants, parameters and variables as inputs or outputs..

Thus, learning process for this topic cannot be separated from data processing. Knowledge category of data, constants, parameters, variables, arithmetic operators, logic, and logical relations is not properly represented by factual knowledge. Instead, this knowledge category must be directed to conceptual knowledge. As a consequent, learning question has to reach the stage of establishing relation between the knowledge and data processing.

C. Sequential, Branching and Looping Processes

Data processing incorporates four processes: sequential, branching, looping, and recursion. Each process type often includes mathematical expression. Because of the reason, in order to design meaningful learning, the learning process for data processing cannot stand alone. The discussion has to be related to the application of mathematical expressions.

Sequential process is a data processing which is executed sequentially from the beginning step to the final step. This makes the accuracy of placing the commands in the right order has to be noted by the users of the process. These commands includes: inputting data, storing data to variables,

processing data which is presented in mathematical equations, transforming input data into output data, as well as displaying data. Students are required to be put into an awareness of changing these processes' order in general can change the meaning of these processes. Consequently, the produced output can be different.In short, the learning process for sequential process has to place the processes' sequence as the base component.

The sequence of processes can be introduced by: (1) identifying the output models and their variables, (2) predicting input requirements as well as their variables, and (3) constructing transformation process for the input model to become the output model. Some things required to be noted in transformation process construction are determining mathematical expressions and accuracy in determining the sequence for transformation process. To sum up, sequential process learning has to relate mathematical expressions and the accuracy of commands' sequence.

The process to transform input to output is regularly faced with some possibilities, not only to run the commands in sequent from the beginning to the end. Therefore, in data processing, a process to tackle with given possibilities is required. This kind of process is called branching process. It needs logical relations or logic operators. Hence, the learning for branching process topic is supposed to be connected to logic operators and logical relations, besides mathematical expressions.

Data processing is not possible to be done just once. In fact, looping condition is always met. Regarding this condition, looping process is a necessity. In this process, comprehension of logic operators and logical relations are necessary. Thus, learning for looping process must be related to mathematical expressions, logic operators and logical relations, sequential processes, as well as branching processes. Students are also provided with the capability to differentiate looping processes from branching processes.

Briefly, learning process for sequential, branching and looping processes cannot be separated from the whole data processing topic. As a consequent, learning question must reach the stage for building relation of all this knowledge with data processing.

D. Algorithm Development by Using Flowchart and Pseudo code Approaches

Developing algorithms is the heart of discussion in Logic and Algorithms. Some books start the discussion with developing algorithm topic after all data processing components have been explained in detail.

This topic is a continuation of sequential, branching and looping processes. Discussion is started with basic symbols used as well as pseudo code writing structure. Then, flowchart and pseudo code structures will be explained for sequential, branching and looping processes. Next step is to use those structures to solve computation problems, especially in creating business documents without the use of database.

After learning these topics, students are expected to acquire the capability to design flowchart or pseudo code for solving computation problems, especially in creating business documents without the use of database. Therefore, what needs to be the focus of this learning is selection of the right business documents as discussion topics. It is important since business documents being discussed are not recognized by students, bigger and more complex knowledge structures will not be able to be realized.

To be brief, in learning algorithms development, knowledge outside the scope of Logic and Algorithms, such as the knowledge about creation of some business documents, has to be noticed. In addition, the learning process can be detached from the whole data processing concept. As a result, learning questions has to get to the stage of making predictions about the relations of each topic in algorithm development with data processing.

E. Array

Array is a variable type that can be used for storing some data. In data processing, some arrays are connected, so that they can be related to form tables and to be used as database. The difference between array and database is the characteristic of the stored data. The data stored in array will only last as long as the computer is on. Once the computers are off, the data will be lost and cannot be found any longer.

Array is a variable type that can be used for storing some data. In data processing, some arrays are connected, so that they can be related to form tables and to be used as database. The difference between array and database is the characteristic of the stored data. The data stored in array will only last as long as the computer is on. Once the computers are off, the data will be lost and cannot be found any longer.

F. Searching and Ordering Algorithms

In processing data, searching and sorting algorithms are frequently required. Purposes of these algorithms are to find and to sort specific data in arrays. Many books present various searching and sorting algorithms in pseudocode form [7][3][6][10][17]. Hence, searching and sorting algorithms can be classified as procedural knowledge. However, if students' capabilities are limited to run the procedure, then the learned algorithms will not be meaningful to the students. As a result, students' capabilities are required to be improved to reach the stage of selecting appropriate searching and sorting algorithms to solve computation problems.

This establishment of the capability level to be reached causes a change in knowledge categories. Initially, searching and sorting algorithms are categorized as procedural knowledge, but then it has to be changed to conceptual and metacognitive one. As a consequence, learning those two algorithms has to be linked to some topics, including: modular technique and parameter passing; accuracy in identify input variables, processes as well as output; and accuracy in selecting searching and sorting algorithms to solve specific computation problems.

Based on the prior discussion, it can be noticed that searching and sorting algorithms are categorized as conceptual and metacognitive knowledge. This means that learning question should include two aspects, conceptual and metacognitive knowledge. First aspect is associated with constructing variable relations by using passing parameter and modular technique.Second aspect is linked to the capability to determine the correctness of relation designs.

G. Application to Learning Process

Evaluation results regarding the learning questions demonstrated: (1) not all learning questions direct to conceptual knowledge, and (2) none of these directs to metacognitive knowledge. Therefore, learning questions are transformed so that they can direct to conceptual and metacognitive knowledge.

The transformations which have been done includes: (1) changing detail objectives in every learning session, (2) preparing media for stimulating learning activities in class, and (3) increasing discussion time allocation to become two times the lecture talk in order to help the students in relating the knowledge which has been learned. Learning media which has been added to this research is software application that can be used for learning the correlation between data processing component, variables, data, constants, operators, logical relations, sequential processes, branching processes, and looping processes.

Based on the questionnaires handed-out to 120 students, it can be demonstrated that: (1) all respondents agree that software application can be very helpful to them in finding the correlation between one concept to others, (2) 102 students or 85% of the respondents can identify the correlation between data processing components, variables, data, constants, operators, logical relations, sequential processes, branching processes, and looping processes, and (3) 98 students or 81% of the respondents can evaluate their own works.

V. CONCLUSIONS

By using deductive and analogy reasoning, the knowledge in Logic and Algorithms can be categorized into factual, conceptual, procedural, and metacognitive. While reasoning mathematics in algorithms are deductive reasoning. The deductive reasoning used to compuse the algorithms and to investigate the truth of an algorithms have been made.

However, in order to design meaningful learning, all knowledge in Algorithms computing has to be categorized as conceptual and metacognitive.

Based on the result test, it is acknowledged that: (1) 85% of the students can relate components of data processing, variables, data, constants, operators, logical relations, sequential processes, branching processes as well as looping processes; also (2) 81%of the students are capable to evaluate their own works.

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