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ABSTRACT

This paper demonstrates how to design an instructional process aimed at teaching general methods of thinking, using the Landamatics theory and methodology. Landamatics is not a collection of lesson plans, but rather a general method of approaching the design of any effective course of instruction or any lesson plan. The method formulates general procedures to apply to teaching any specific knowledge and any cognitive process. Analysis of the problems many students have in being able to solve problems similar to those they were taught is that they have not been taught a general method of reasoning as a system of general instructions. In contrast to the empirical generalizations formed in the minds of student who have had conventional instruction, the Landamatics approach forms reliable, scientific, concept-congruous generalizations. This is illustrated through the example of teaching students to recognize right triangles. Several strategies are available to the teacher. One is to lead the students to make independent discoveries of the concept and the method of applying it. Another is to give the students all the information possible about the concept, and a third is to combine these two approaches. The teacher's strategy is chosen according to the objectives desired, but the first strategy appears to be the most valuable. Central to the Landamatics method are getting students to discover and realize the system of mental operations involved in the application of the concept and its definition, and then getting them to formulate a corresponding system of instructions. Providing practice and opportunities for the internalization of the method also follow in the Landamatics approach. This will bring about automatization of the mental operations of the method. Generalizations of this approach through several forms result in a method that can be applied to concepts with different logical structures of their characteristic features. Advantages of this general method are discussed. (Contains 4 tables, 3 figures, and 11 references.) (SLD)

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Preface

The approach to designing instruction for teaching and learning general methods of thinking, described in this chapter, was developed within the framework of the Algorithmico-Heuristic Theory (AHT) of performance, learning, and instruction. Since systems of algorithmic and heuristic instructions, and their corresponding systems of mental operations, represent general methods of thinking, the AHT was, in essence, a theory and methodology of teaching and learning general methods of thinking.

The first studies of the author and his associates were focused on thinking processes and methods involved in knowledge application, i.e., were studies of methods of applying knowledge. Three things, however, soon became clear. First, that methods of thinking are a particular case of a more general methods of cognitive activity which include methods of perception, methods of memorization and some others. Second, that methods of thinking are not limited to the methods of applying knowledge but include methods of acquiring knowledge as well or, stated more generally, methods of learning. Third, that learning methods of knowledge application enormously affects the process of knowledge acquisition making it vastly more effective. The reason for this is simple: people don't learn knowledge just by listening to or reading the explanations (unless, of course, their aim is just mere familiarization with some knowledge). They learn it by applying it to solving problems, which is one of the main purposes of the process of practicing. If this is so, then it becomes apparent why effective methods of knowledge application make the process of knowledge acquisition much more effective: with properly designed instruction, the knowledge application process becomes an important component of the process of knowledge acquisition.

After the first studies had been conducted, it also became clear that teaching methods of cognitive activity affects not only the *processes of learning and thinking* but leads to the formation of certain *qualities of mind* and *personality traits* – such, for example, as intelligence, intuition, self-management, self-regulation and self-control, good organization of mind, a higher level of confidence in the ability to learn and solve problems, and such personality traits as systematicity in approaching problems, thinking of possible strategies for attacking problems and analyzing them before trying to actually solve them, and some others.

In short, the subject of the AHT turned out to be much broader than the term "algo-heuristic" theory and methodology suggested. The AHT became, in

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*The proper understanding of this chapter presupposes knowledge of the major concepts of the Algo-Heuristic Theory of Performance, Learning and Instruction as described, in particular, in Landa 1983, 1997.

fact, a rather general and comprehensive theory of performance, learning, and instruction. Seeing the discrepancy between the actual broader subject of the theory and the narrower subject that the term "algo-heuristic" suggested, Prof. Berkowitz of CUNY coined the name "Landamatics" which we, initially, were hesitant to accept and use. Because, however, this name is beginning to be used on an increasingly wider scale (even on the Internet), we will employ it here as well.

Landamatics is not a theory of learning and instruction that indicates how to teach one or another specific topic, concept, or skill. It is not a collection of effective lesson plans. Rather, it is a *general method (or methodology) of approaching* the *design* of any effective course of instruction or any lesson plan, whether the task is to teach knowledge of certain phenomena or a process of visual analysis of an object or a strategy of thinking or anything else. The method formulates general but, at the same time, sufficiently detailed procedures – algorithmic or nonalgorithmic – which can be applied to designing and teaching *any* specific knowledge and *any* cognitive process.

In this chapter, we will demonstrate how to design an instructional process aimed at teaching general methods of thinking, using the Landamatics theory and methodology.

Among different kinds of methods of cognitive activity, for the purpose of illustration we chose, for this chapter, methods of thinking. Among different methods of thinking (such as methods of explanation, methods of proof, methods of drawing inferences from certain premises, etc.) we chose the method of identification of objects – as belonging to or not belonging to a certain class – on the basis of concepts of those classes and their respective definitions. Later in the chapter, the method will be extended to the method for drawing conclusions not only about objects' belonging to or not belonging to a certain class but also about their attributes and their relationships to other objects. Such conclusions require the application of a broader class of theoretical propositions, such as laws of nature, axioms, theorems, rules, and others.

To summarize, we can say that the intent of this chapter is to formulate and describe, by the chosen example, a general (Landamatics) method of teaching general methods of thinking, i.e., to show not only *what* to teach but *how* to teach it as well. To achieve the challenging learning results specified in the chapter, the what to teach and the how to teach is equally important.

A note on the terminology that will be used. Any process of thinking is a process of applying knowledge. The differences between the thought processes are determined, in the first place, by the purpose of knowledge application: whether it is to identify things, or to explain things, or to prove things (statements), etc. The purpose, along with problem conditions, specify how the learned knowledge should be used (applied) for achieving the goal – what should be mentally done with it. Although very often one can encounter expressions like "visual thinking", the term "thinking" is used here more in a figurative rather than precise sense of the word. Thinking, in contrast, for example, to perception and imagination, deals with concepts and propositions rather than images, although images are always engaged in the processes of thinking. The notion of applying knowledge is broader than the notion of applying concepts and propositions, as the former also includes the application of images. When, throughout this chapter, we use, for brevity, the phrase "a method of applying knowledge" we will have in mind, mainly, a method of applying concepts and/or propositions.

Let us now consider the following two expressions: "a method of applying knowledge for the purpose of identification" and "a method of identification". These expressions convey the same meaning, for the process of identification is carried out through the application of knowledge for the aim of identifying things. We will use these expressions interchangeably. Also, because in this chapter the process of identification, and its corresponding method of identification, are used only to illustrate by example how to teach any methods of applying knowledge, we will often use a broader term "a methods of knowledge application" rather than a more narrow term "a method of knowledge application for the purpose of identification". This will be done to underscore that what was being said with regard to a method of identification is true for all other methods of thinking, and often, even all methods of cognitive activity.

Teaching General Cognitive Processes And Methods Of Thinking As One Of The Most Important Goals Of Education

The fact that recurrently pops up in discussions about the goals and objectives of education is the immense speed of developing new knowledge in a modern, information-based industrial society. Knowledge is changing so rapidly that what we learn today may become outdated and obsolete a decade, or perhaps even a few years, from now.[1]

The following question arises: If knowledge constantly changes in the course of scientific and technological development, do the cognitive mechanisms of acquiring and applying knowledge, in the process of such development, change as well? Or, to be more precise, do they change as rapidly as the knowledge being acquired by mankind? The answer is no.

Experts in any field of scientific, technological or practical activity, who have already learned how to effectively acquire and apply knowledge, use essentially the *same* cognitive operations and processes (out of some repertoire) to learn and manipulate *various* knowledges. These processes may be different with regard to different *kinds* of knowledge (for example, knowledge about facts versus knowledge about laws of nature) and/or with regard to different *kinds* of problems to be solved, but these processes are the same with regard to the *same* kinds of knowledge and problems. Thus, while the knowledge acquired and handled may be *variable*, the ways – *methods* – of its acquisition and handling represent a *constant*. Because ways (mechanisms) used in acquiring and handling varying knowledge are constant, we can say that, in this sense, these mechanisms are *content-independent* and therefore *general*.

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[1] One has, of course, to have in mind that not all knowledge is changing with time and gets obsolete. For example, the fundamental knowledge like the knowledge about basic laws of mathematics or mechanics, about historical facts and events, about many geographical phenomena and some others are very stable and, in fact, "eternal".

If we accept the point that learning how to acquire and apply knowledge – *any* knowledge, *variable* knowledge – is as important as learning the fundamental knowledge (and perhaps more important than learning specific knowledges that can soon become obsolete), then teaching students *general* cognitive processes and their corresponding methods – becomes one of the critical goals of education.

Obviously, teaching general cognitive processes applicable to variable knowledges can be carried out only through and within teaching specific knowledges. At issue is, however, whether teaching knowledge represents an objective in itself or, also, a means of teaching general cognitive processes.

An Odd Situation In Education

An odd situation takes place in schools: students are requested to identify objects, explain things, draw conclusions, proof statements, and so on but are not taught – and don't know – what is an identification, what is an explanation, what it means to draw a conclusion, to proof a statement, etc. At issue is not a lack of formal definitions of those processes (a definition would not teach much) but knowledge of the mental operations, and their systems, engaged in those processes. An explanation given by one teacher that "to explain means to make something clear" does not teach anything, as the questions arises what one should mentally *do* with something to be explained to make it clear.

Numerous interviews we conducted with teachers showed that in the overwhelming majority of cases they, themselves, didn't know on an *operational level* what is involved in the processes they try to teach students and request them to perform. In other words, they don't know appropriate *methods*, as nobody taught those methods to them.

Not surprising, therefore, are the recent findings of the National Assessment of Educational Progress which were summarized by the New York Times as follows: "American students have some understanding of basic scientific facts and principles, but their ability to apply scientific knowledge, design an experiment or clearly explain their reasoning is "disappointing", according to the latest national test of science education" (The New York Times, May 4, 1997).

Two Meanings Of The Term "Method" In Science And Everyday Language

There exist many definitions of the term "method" in philosophical and scientific literature which often create confusion and hamper communication among scientists. To clarify the issue, let's look at the use of the term "method" in everyday language.

The semantic analysis of the linguistic uses of the word "method" shows that it has two meanings: (a) *actions* leading to solving problems or performing tasks (as in the phrase "A scientist *discovered* a method of diagnosing a disease"), and (b) *instructions* (prescriptions) pointing out the actions to be performed (as in the phrase "A mathematician *formulated* a method for solving a certain class of problems").

To distinguish the two meanings of the term "method" which signifies two different, although connected, phenomena we will designate a method as a system of *a*ctions as M_a, and a method as a system of instructions – a *p*rescription – as M_p. These designations will be used when it may not be clear from the context in which sense a method is meant. We will, however, not use these designations when the meaning is clear from the context or when what is said about a method refers both to M_a and M_p.

Normally, in searching for ways to solve new problems or perform new tasks people first discover (find) actions that lead to the solution, then designate or describe them verbally, and then, subsequently, convert descriptions into prescriptions as to what everyone should do in order to achieve a specified goal (solve a problem, perform a task, etc.). In other words, people first discover M_a's and then convert them into M_p's.

What A "Method" Precisely Is

We define "method" as a structured system of instructions and/or actions for achieving some goal.

This definition delineates the following essential characteristics of a method:

1. A method is always a *system* of instructions and/or actions, not just a single one. Only in extreme cases does the system consists of just one single instruction or action.

2. A method is always a *structured* entity which consists of basic elements (instructions and/or actions) connected in a certain manner (for example, organized in a certain sequence or hierarchy).

3. A method is always a *goal-oriented* phenomenon which is geared to achieving some goal (to perform a task, to solve a problem, etc.). It is not by accident that when people speak about methods they often use the preposition *for* ("a method for..."), although in certain contexts it may be more accurate to use the preposition *of* ("a method of...").

In everyday language and science the notion of a method is often conveyed by a number of full or partial synonyms, such as "process", "procedure", "guide", "technique", "strategy" and some others. The problem is that some of them (like "strategy") are much more polysemantic and ambiguous than the term "method".

Methods As Objective Social And Subjective Psychological Phenomena

Once concepts and propositions are developed in social practice and science, they are objectivized (materialized) in language. Objectivized, they become a social phenomenon which objectively exist in printed or electronic form accessible to people for learning and using. Once learned, they become subjective psychological phenomena which represent subjective *counterparts* to the objectivized societal phenomena.

Subjective methods may or may not conform to the objectivized methods. For example, explanations given by many people are often faulty (incorrect, superficial, inconsistent, etc.). Their subjective methods of explanation do not conform to the effective objectivized methods of explanation developed in science.

Hence, one of the important objectives of education consists in teaching methods in such a way that the subjective methods formed in students' minds conform to the effective objectivized methods developed in social practice and science.

The Relationships Between The Notion Of A Method And The Notion Of A Skill

Although partially related, these notions are not the same, for they reflect different psychological phenomena.

As far as M_p's are concerned, it is obvious that the knowledge of actions to be performed in order to achieve some goal is not the same as the actual execution of actions. One can know, for example, how to swim (i.e., what actions to perform in order to swim) but not be able to swim (i.e., not be able to actually perform those actions). In this respect the notion of a method (M_p) is quite different from the notion of a skill.

A clear distinction must also be made between the notion of M_a as a system of actions and the notion of skills. Skills are *not* systems of actions, they are physiological processes in the brain which represent a *potential* for performing systems of actions, i.e., a potential for executing a method (M_a). This distinction becomes clear from the following simple example: When someone says about a surgeon that he is very skillful, the speaker does not mean that he is performing actions involved in surgery at this very moment. The meaning of this statement is that he *can* perform, he has the *potential* for executing those actions when the task of performance arises. Thus the notion of a method as a system of *actions* (M_a), not only as a system of *instructions* (M_p), is also different from the notions of skills.

Obviously, there is a direct connection between the systems of actions making up M_a's and skills: the performance of actions leads to the formation of physiological processes and associations in the brain which leave "traces" after the actions cease to be executed. These "traces" *are* skills. On the one hand, they are the *results* of the performed actions and, on the other hand, they represent a *potential* for their performance in the future, *once actuated*

Another way to characterize skills is to say that they are actions (or systems of actions) in their *latent* form.

The fact that skills are formed only through performance of certain actions and their systems, makes it clear that in order to develop good, effective skills in students it is necessary to teach them good, effective methods. Teaching methods is a *means* for developing skills.

The Difference Between Knowledge Of And Command Of A Method

A clear distinction must be made between the knowledge of and the command of a method. To *know* a method means to know its instructions which manifests itself in the ability to *verbally formulate* them. To *have command* of a method means to be able to *perform operations* (physical and/or mental). The following situations may – and do – take place in schools and real life:

1. A person knows a method and has command of it.

2. A person knows a method but does not have command of it.

   Example: a person knows how to swim (has knowledge of the actions to be performed) but is unable to swim.

3. A person doesn't know a method but has command of it.

   Example: a person is able to solve problems of a certain class by effectively performing a system of pertinent operations (making up M_a), but is unable to describe them or formulate a system of corresponding instructions.

4. A person neither knows a method nor has command of it.

Failure To Teach General Methods Of Thinking In Conventional Instruction And Its Negative Consequences

One of the problems encountered by practically all teachers is this: many students are able to solve problems *similar* to those they were taught to solve but are unable to solve problems of the same class or type which don't have enough outward similarity to the taught ones. Or they make errors in solving such problems. Why?

Our analysis has shown that it is because they were taught solution processes which, in the demonstrations provided, were applied to some selected content–specific problems only – *without teaching the general method of reasoning as a system of general enough instructions (M_p)* as to what mental operations are to be used and applied to *any* content.

This kind of instruction is typical and widespread. As a result of such instruction, a system of actions (M_a) is associated in the students' minds only with the contents that were used in the demonstration. *And only by such – and similar - contents the operations can be actuated in the process of solving other problems.* That is why when confronted with problems, whose contents are dissimilar to those used in demonstrations, the students are either stuck (they don't know "what to do") or come to wrong solutions.

An Example of One of the Typical Methods Used in Conventional Instruction

Our former colleagues at the Institute of General and Educational Psychology in Moscow, Dr. Zykova, was present at a geometry lesson in one of the Moscow schools. The topic was "right triangles". This is what the teacher and the students were doing at the lesson:

Pedagogical action 1. The teacher explained that there are several types of triangles and that each type has specific characteristics. She said that today they would be studying right triangles and gave a definition ("a right triangle is a triangle which has a 90° angle").

Pedagogical action 2. She then demonstrated right triangles by giving several illustrations of this concept.

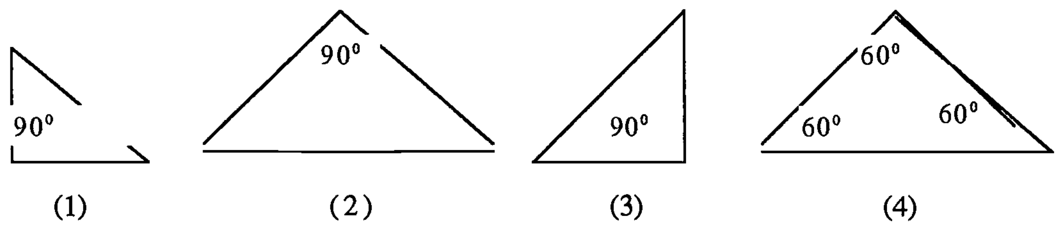
Pedagogical action 3. She then provided (conducted?) practice for the students to learn both the concept (definition) of a right triangle and how to apply it:

> *Action 3a.* She asked students to formulate the definition of a right triangle.
> *A few students did it correctly.*
>
> *Action 3b.* She then asked students to give examples of right triangles by drawing them on the blackboard.
> *Two students did it correctly.*
>
> *Action 3c.* Afterwards, she displayed several geometric figures on the blackboard, among which were right and non-right triangles, and asked students to point out (identify) the right triangles.
> *Several students did it correctly.*
>
> *Action 3d.* She then asked students if they had any questions or if everything was clear.
> *The students enthusiastically responded – in chorus – that everything was clear.*

Everything went very well and both the teacher and the students were sure that they had perfectly mastered the concept and learned how to apply it.

After the classes, Dr. Zykova asked one of the students, who was very active during the lesson and had correctly answered the teacher's questions, to participate in a small experiment. In it, she asked the student to give the definition of a right triangle. The student gave the correct definition saying that a right triangle is a triangle which has a 90° angle.

Then she offered him four triangles and asked him to indicate which of them were right triangles:



He chose (1) and (3).

Experimenter: What about triangle (2)? It also has a right angle! Isn't it a right triangle?

Student: No, for a triangle to be right, the right angle should be at the bottom of the triangle either on the left or right hand side.

Despite the fact that the student gave the correct definition of a right triangle, this verbal definition was no more than a purely mechanical reproduction of the words spoken by the teacher when she formulated the definition. His *actual* concept of the right triangle was different from the *correct* concept of a right triangle contained in the teacher's definition and accurately verbally stated by the student. The correct concept *did not* include such irrelevant characteristic as the position of the right angle in a triangle. However, the student's concept *included* this irrelevant characteristic and, therefore, was incorrect (narrow).

How did the student's erroneous concept form in his mind when the instruction was seemingly well conducted (examples and counterexamples of the concepts were given, practice provided, etc.)? Despite the correct definition the student knew and gave, his *actual* concept reflected an *empirical generalization* of the objects (geometric figures) he encountered in the course of instruction – the spatial positions of the right angles in the triangles which were given as illustrations of the concept.

Zykova says that the major cause of the student's error was the limited variations of the spatial position of the right triangles provided in the illustrations. The students were shown triangles only in the "standard" positions (positions (1) and (3)). The pedagogical cure offered by Zykova (Zykova, 1963) and other representatives of the school of pedagogical thought advocating, consciously or unconsciously, empirical generalizations as the basis of learning and concept formation is: a teacher who introduces a new concept should vary - as widely as possible – the irrelevant features of the objects which illustrate the concept. This would prevent students from making limited generalizations and forming narrow concepts based on them.

Sure, limited variations of objects' irrelevant features is one of the causes of students' wrong concepts and errors in their decisions and solutions. But the major deep-rooted cause of the problem is, in our view, different.

Why It Is Impossible To Provide High Quality Instruction And Learning On The Basis Of Empirical Generalizations

Empirical generalizations, by varying irrelevant objects' characteristics, are good when the number of irrelevant variables and their related attributes is very small. But when it is greater than "very small", then the number of necessary variations gets so large that it becomes practically impossible to provide all of them in the course of instruction. (For example, if the number of irrelevant variables for a class of objects is only three (color, size, and spatial orientation), and each of them has only a few attributes, then the number of combinations of irrelevant characteristics will reach several dozen. No teacher is able to provide, in the course of instruction, several dozen variations of the same object, if only for the lack of time.)

If, however, the number of variations provided is less than objectively needed, there will always be the potential possibility that the generalizations in the students' minds will be incongruous with the scientific contents of the concepts. The discrepancy between the contents of the students' concepts and the contents of the scientific concepts is rather typical when learning any discipline in today's schools.

The greater the discrepancy between the objectively required number of variations and those actually provided, the greater the probability that (a) the generalizations formed in the students' minds will be inadequate and, as a result, (b) the rate of inaccurate concepts based on those generalizations will be very high.

The true cause of the problem of faulty concept formation and faulty concept application is, according to Landamatics, that students are not taught general methods of concept acquisition and application which does not require the impractical exhaustive variation of irrelevant features of objects. And if this is the true cause, then the preventive medicine and cure would be not the exhaustive variation of objects' irrelevant features but the teaching and learning of general methods of thinking. Only this can overcome the limitations of the empirical generalizations and form such very broad generalizations which are fully congruous with the scientific contents of the scientific concepts.

Landamatics Approach To Overcoming – Via Teaching Methods Of Thinking – The Limitations In Generalizations And In The Transfer Of Concepts And Mental Operations

Landamatics has developed and advocates a radically different approach to forming generalizations, concepts, and thought processes via purposeful and explicit teaching methods of thinking (both M_p's and M_a's).

This approach:

- Makes a great number of variations unnecessary
- Guarantees the formation of proper, adequate generalizations

- Guarantees the formation, on the basis of adequate generalizations, of accurate concepts and propositions

- Guarantees the formation, within students, of effective methods of acquisition and application of knowledge (images, concepts and propositions)

- Guarantees the broadest and most accurate transfer, not limited by experience, of both knowledge and mental operations to new situations and problems

- Guarantees a dramatic reduction in errors and difficulties of learning

- Guarantees the development of the ability to self-manage, self-regulate, and self-control of one's own mental operations

- Makes it possible to achieve all of the above – reliably and relatively fast.

In contrast to the empirical generalizations formed in the minds of students who have had conventional instruction, the Landamatics approach forms ***r*eliable, *s*cientific *c*oncept-*c*ongruous (RSCC)** generalizations.

Design Of Instruction Based On The Landamatics Principle Of Teaching Methods Of Thinking
(an illustration)

To show, in a simple and contrasting way, the difference between the formation of a concept on the basis of an empirical generalization, on the one hand, and of the RSCC's generalization, on the other hand, we will use the same example of teaching students the concept of a right triangle, which would include teaching them a method of applying it to the task of recognizing (identifying) right triangles among (from?)other triangles.

As in teaching everything, two basic approaches (strategies, methods) can be used in teaching right triangles: (1) have students (get students to?) make an independent discovery of what is to be learned by properly guiding them, and (2) teach them ready-made knowledge and methods.

We will start with the first strategy (method). Here are the instructional objectives and activities which it involves:

1. The students' independent discovery of the concept of a right triangle.

2. Figuring out the triangle's name (the term used in science to designate the concept).

3. Framing the concept's logically correct definition.

4. The independent discovery of a system of mental operations (M_a) for applying the concept.

5. Formulation of the discovered method (M_p).

6. Learning, through practicing, how to apply the method.

7. Internalization of the method's instructions (M_p).

8. Automatization of the method's operations (M_a) and, thus, insuring its complete mastery and command.

Strategy (Method) 1

(Guiding students towards making independent discoveries of a concept, its designation, its definition, and the method of applying it)

Out of eight instructional objectives and activities listed above we will describe here the last five which are specific for the Landamatics method.

Instructional objective 4: *Get students to discover and consciously realize the system of mental operations (M_a) involved in the application of the learned concept, and its definition, to the task of identifying objects as belonging or not belonging to the defined class* (in this case, to the class of right triangles).

Pedagogical actions:

1. Ask the students what they should do in their heads in order to determine, on the basis of the definition, whether a triangle is a right triangle.

The students say that they have to check whether a triangle has a right angle.

Instructional objective 5: *Get students to explicitly formulate the corresponding system of instructions (M_p);*

Pedagogical actions:

1. Ask the students to formulate a detailed set of instructions, or commands – i.e., *a method* – of what a person, who does not know how to use the definition of a right triangle, should do in his mind in order to determine whether some given triangle is a right triangle or not.

2. If the students formulate the method correctly, proceed to the next instructional objective; if not, then explain to them (the explanation is not given here for lack of space) how to formulate the method (M_p) of actions in order to recognize whether a triangle is right or not right.

Students formulate, with the teacher's help if needed, the following method:

1. Refer to the definition of a right triangle and isolate its characteristic feature – the presence of a 90 degree angle.

2. Mentally superimpose this feature on a given triangle and check to see if it has a 90⁰ angle.

3. Draw a conclusion according to the following rules:

(a) If a triangle has a 90⁰ angle, then it is a right triangle.

(b) If it does not have a 90⁰ angle, it is not a right triangle.

4. Write down the formulated method (algorithm) on the blackboard or display it by any other medium (if prepared beforehand).

Instructional objective 6: *Provide practice in the application of the formulated method* (M_p).

Pedagogical actions:

1. Tell the students that the task now is to practice applying the formulated method for recognizing right triangles among other triangles.

2. Show them various triangles and have them determine, following the method, which of them are right triangles and which are not.

3. Explain that they should use the method in a step-by-step manner: look at the first instruction and do what it says, then look at the second instruction and do what it says, etc.

Following the method, the students easily identify right triangles regardless of the position of the right angle.

Instructional objective 7: *Provide for the method's internalization, through special exercises, and thus insure its full mastery.*

Pedagogical actions:

1. Tell the students that they seem to no longer need any more the instructions on the blackboard and seem to be able to replace them by *self-instructions (self-commands).*

2. Tell them that you will now erase the instructions on the blackboard and show a few more triangles. They should determine which of them are right triangles by giving themselves self-instructions as to what to do – instead of following the instructions on the blackboard.

The students easily perform all the necessary mental actions (M_a) *by giving themselves self-instructions.*

Instructional objective 8: *Effect automatization of the mental operations of the method (M_a).*

Pedagogical actions:

1. Tell the students that they don't seem to further need even self-instructions, for they now know what to do in order to recognize a right triangle.

2. Show them the last set of triangles among which they have to find the right triangles. Ask them to find them as quickly as possible without giving themselves any self-instructions.

The students easily perform the assignment – find the right triangles instantaneously.

This completes the full circle of Landamatics-designed instruction based on Strategy 1.

Although the description of the Landamatics methodology of teaching and learning the concept of a right triangle and the method of its application was pretty long, in reality the entire lesson takes no more than 15-20 minutes.

Notes On The Psychological Mechanisms Of A Method's Internalization And Automatization Effected Via The Landamatics Instructional Methodology

What does it mean to internalize the *instructions* of the method (M_p) and automatize the *operations* of the method (M_a)? What happens in the mind during the processes of internalization and automatization?

According to the Landamatics theory, gradual internalization and automatization of a method is nothing more than a *gradual shift,* in the process of learning and practicing, *from one kind of an operations' actuator to another.*

1. *At the first stage* of learning a method, operations are actuated *externally* (from the outside) by the tangible method's instructions which exist in some tangible, material form (printed or electronic).

2. *At the second stage*, operations become actuated *internally* (from the inside) by the self-instructions. This is the stage of the method's (M_p's) internalization.

3. *At the third stage*, a need in any instructions (external or internal) disappears and the operations start to get actuated by the goals and problem conditions themselves. This stage is the stage of the operations' (M_as') automatization.

In the course of moving from stage to stage, internal psychological mechanisms of mental processes undergo, according to Landamatics, one critical change: executed *successively* (in a step-by-step manner) at stages 1 and 2, mental operations start to be performed *simultaneously* (or partially simultaneously) at stage 3.

Simultanization of mental operations makes possible the following:

- *Parallel* processing of information instead of initial sequential (successive?) processing
- Recognition of objects as *patterns*, as *gestalts*
- Carrying out mental operations (processes) very *fast*, *instantaneously* or almost instantaneously
- Carrying out mental operations (processes) *without effort* (they proceed as if by themselves).

These characteristics of mental processes are signs of their mastery and automatization.

In conventional instruction, these characteristics are formed (if formed) in a spontaneous, haphazard and often ineffective way. The Landamatics makes their formation a well planned and instructionally well managed process, thus guaranteeing the high quality of mental abilities developed as a result of simultanization.

Strategy (Method) 2
(Teaching concepts, terms, definitions, and methods in ready-made form)

With Strategy 2, instead of having the students discover the concept of a right triangle, figure out its term and frame its definition (as was the case with strategy 1), the teacher simply teaches all this knowledge to the students in ready-made form (with appropriate illustrations and exercises).

Conditions for Choosing Between Strategies 1 and 2

It is obvious that Strategy 1 is educationally more valuable, advantageous and beneficial than Strategy 2. But Strategy 1 takes more time.

It seems that the only condition for choosing one or another strategy is the amount of available time. Not infrequently, however, there is not enough time for using full-fledged discovery strategy 1 but more time available than needed for using Strategy 2. For this situation Landamatics suggests to use both strategies in a certain proportion. We call this a mixed, or *combination*, strategy.

Strategy (Method) 3
(combination strategy)

With this strategy, certain things within a topic are taught using the discovery strategy, and certain other things are taught by providing knowledge in ready-made form. Which topics should be taught by one or by the other strategy is determined by the teacher's objectives at the given moment and by the relative benefits that each of the method would provide with regard to each particular topic to be taught.

The Substantial Drawback Of The Method Of Thinking Taught In The Geometry Lesson Described Above

The method of thinking formulated for identifying right triangles was *general* in the sense that it could be applied to identification of any right triangle, but it was, at the same time, *very specific*, for it could be applied to identification of *only* the right triangles.

Is it possible to modify this method so that it will be applicable to other contents as well? In other words, is it possible to make it more general? The answer is yes.

Increasing The Degree Of Generality Of A Method

As an example and a departure point, we will use the method of identifying a right triangle formulated earlier. Let us designate the lowest *d*egree of generality as d_1, the next (higher) degree of generality as d_2, and so on. Because the degree of generality of the method for identifying a right triangle is the lowest, this method will have index d_1. Each method with a lower degree of generality will be placed in the left column of a (the?) table. It will be juxtaposed side by side with a method having the next higher degree of generality which will be placed in the right column of the table. Those juxtapositions will make the comparison of the methods' degrees of generality easier. The differing elements in the contrasting methods will be delineated by using italics.

Generalization 1: from d_1 to d_2

Table 1

Method 1 (d_1)	**Method 2** (d_2)
In order to identify a *right triangle*: 1. Refer to the definition of the *right triangle* and isolate its characteristic feature – *the presence of a 90 degree angle.* 2. Mentally superimpose this feature on any given *triangle* and check to see if it has *a 90^0 angle.* 3. Draw a conclusion according to the following rules: (a) If a *triangle* has *a 90^0 angle*, then it is a *right triangle.* (b) If it does not have a *90^0 angle*, it is *not a right triangle.*	In order to identify an *object* as belonging or not belonging to a certain class: 1. Refer to the definition of the *class* and isolate its characteristic feature(s). 2. Mentally superimpose this feature(s) on any given *object* and check to see if it has *all of the features.* 3. Draw a conclusion according to the following rules: (a) If an *object* has *all of the features*, indicated in the definition, then it *belongs to the class of objects defined in the definition.* (b) If it does not have *at least one* of the features, it *does not belong to this class of objects.*

We suggest that the reader apply Method 2 – following its instructions in a step-by-step manner - to each of a number of geometric figures given below. The task is to determine (identify) which of them is a rhombus. Here is a definition of a rhombus which can be used: "A rhombus is a parallelogram whose 4 sides have the same length".

Here are a few figures, and we want to determine which one is a rhombus (if, of course, it is present here):

(1) (2) (3) (4)

Now please apply this method to the task of identifying a right triangle (using examples of triangles given on p. 9). The reader will see that Method 2 is applicable to the identification of both a right triangle and a rhombus.

This means that it is more general than Method 1 which is applicable to identifying only a right triangle.

To appreciate the degree of generality of Method 2, we suggest that the reader apply it to solving a grammatical task of identifying a clause among (within?) the following groups of words: (a) "My God!"; (b)"Please, forgive me"; (c) "When Peter entered the room", and (d) "I really like this book". The following definition of a clause can be used:): "A clause is a group of words with a subject and a predicate" (Hirsch, 1993).

How General Is Method 2?

Browsing through a math course, we stumble upon the following rule: "A number is divisible by five if it ends in 5 or 0". In order to test Method 2 for its degree of generality, let us select a few test numbers (for example, 15, 17, 20 and 23) and determine - following method 2 - whether they are divisible by 5. We suggest you go through this exercise. If you did, you should have come to a few erroneous conclusions.

Why? Obviously, it is because Method 2 is not general enough.

How do you find a more general method? In order to do so, it is necessary to find out why Method 2 worked successfully when applied to some concepts and definitions and didn't work on some others.

Why Didn't Method 2 Always Work?

To diagnose the problem, let us compare the definitions of those concepts for which the method worked and the rule for which it didn't. How do they differ from each other? The difference is almost obvious: the characteristic features of both a rhombus and a clause are connected by the logical conjunction *and* (i.e., conjunctively), whereas the characteristic features of divisibility by 5 are connected by the logical conjunction *or* (disjunctively). Apparently, Method 2 works only for conjunctive concepts and propositions and does not work for disjunctive ones. The task now is to devise a method – Method 3 - for disjunctive structures of characteristics features.

Here is Method 3 as compared to Method 2:

Table 2

Method 2 (for conjunctive concepts) d_2	**Method 3** (for disjunctive concepts) d_2
In order to identify an object as belonging or not belonging to a certain class: 1. Refer to the definition of the class and isolate its characteristic feature(s). 2. Mentally superimpose this feature(s) on any given object and check to see if it has *all of the features*. 3. Draw a conclusion according to the following rules: (a) If an object has *all* of the features, indicated in the definition, then it belongs to the class of objects defined in the definition. (b) If it does not have *at least one* of the features, it does not belong to this class of objects	In order to identify an object as belonging or not belonging to a certain class: 1. Refer to the definition of the object and isolate its characteristic features. 2. Mentally superimpose this feature(s) on any given object and check to see if it has *at least one of the features*. 3. Draw a conclusion according to the following rules: (a) If an object has *at least one* of the features, indicated in the definition, then it belongs to the class of objects defined in the definition. (b) If it does not have *all* of the features (i.e., it has none of the features), it does not belong to that class of objects.

The reader can easily test Method 3 by finding definitions whose characteristic features are connected by the logical conjunction *or*. Here are some of them from various textbooks: "A change in the size or shape of something is a physical change"; "The indirect object answers the question, "To whom?' or "To what?"; "Adjectives are the words we use to describe *how* something looks or feels or tastes or sounds".

Is Method 3 more general than Method 2? The answer is no. If Method 3 had subsumed Method 2, then it would have been more general than Method 2. But it does not, it just *complements* Method 2. This means that it has the same degree of generality.

A Graphic Representation Of General Methods

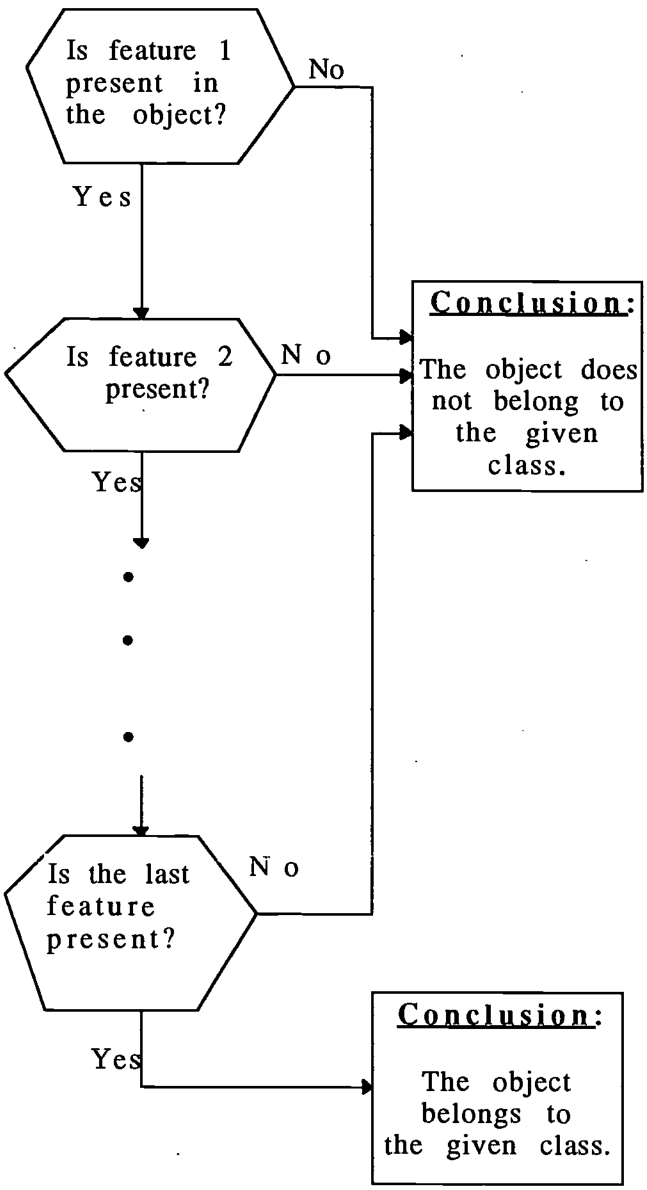
An effective way of describing, in detail, the system of actions involved in executing a method is to represent it graphically in flowchart form (see next page).[2]

[2] Graphic representations organizing mental and other processes have been recently labeled "graphic organizers" (see, for example, S. Parks & Black, 1990,1992).

Table 3

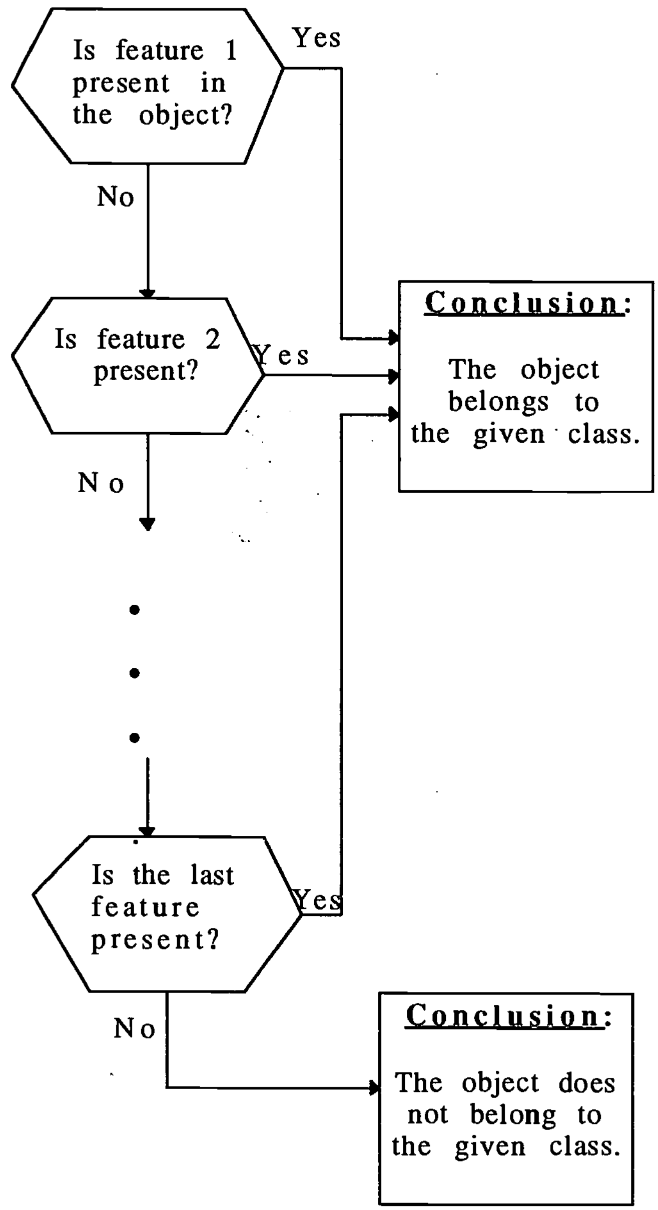
General method 2
for applying conjunctive concepts and identifying objects whose features are connected by the logical conjunction AND

In order to identify whether some object belongs or does not belong to a certain class, refer to the class's definition, isolate its characteristic features and then check to see:



General method 3
for applying disjunctive concepts an identifying objects whose features are connected by the logical conjunction OR

In order to identify whether some object belongs or does not belong to a certain class, refer to the class's definition, isolate its characteristic features and then check to see:



Is A Combination Of Methods 2 And 3 General Enough To Handle Any Logical Structure Of Characteristic Features?

When testing Methods 2 and 3 for their generality, we have encountered the following two propositions:

1. A provision of the Social Security Administration: "Only unmarried mothers who have one dependent child and whose income does not exceed $12,000, or married mothers who have two dependent children and whose household income does not exceed $16,500 are eligible for this benefit".

2. A grammatical definition: "A verb is a word that is characteristically the grammatical center of a predicate and expresses an act, occurrence, or mode of being" (Webster's guide to business correspondence, 1988, p. 217).

How do you determine whether a specific woman is eligible for the benefit in question or not? How do you make the determination? How should you reason? Similarly, how do you determine whether a specific word is a verb or not? How should you reason?

Neither method 2, nor Method 3 is applicable to those propositions, for each of them contains both the conjunction *and* and the disjunction *or*. In other words, the logical structures of conditions of "eligibility for this benefit" and characteristic features of a verb are neither purely conjunctive nor purely disjunctive. It is a *mixed* structure. But Method 2 and Method 3 are designed, each, for purely conjunctive or purely disjunctive logical structures and do not say anything about how to handle mixed structures. Therefore, they are not general enough and a more general method or methods are needed.

A Method For Discerning The Inner Logical Design Of Mixed Logical Structures Of Complex Concepts And Propositions

Let's demonstrate the method offered by Landamatics by example of the Social Security Administration provision cited in the previous section:

Operation 1. Convert a proposition stated in the categorical form into the conditional if,...then form.

"If an unmarried mother has one dependent child and her income does not exceed $12,000 or a married mother has two dependent children and her household income does not exceed $17,500, ***then****, and only then, is she eligible for the benefit in question."*

Operation 2: To reveal the coverted proposition's inner logical structure, describe it using the parentheses.

"If (an unmarried mother has one dependent child and her income does not exceed $12,000) OR (a married mother has two dependent children and her

*"**If** (an unmarried mother has one dependent child and her income does not exceed $12,000) OR (a married mother has two dependent children and her household income does not exceed $16,500), **then**, and only then, she is eligible for the benefit in question."*

Operation 3. Present the revealed logical structure in the graphic "logic diagram" form which makes the structure more transparent and distinct.

Logic diagram

IF

I.

(a) an unmarried mother has one dependent child

and

(b) her income does not exceed $12,000

OR

II.

(a) a married mother has two dependent children

and

(b) her household income does not exceed $17,500,

THEN, and only then, is she eligible for the benefit in question.

Operation 4. Express the proposition (in its sentential or in logic diagram form) in a formula of propositional logic which describes its logical structure succinctly in the most generalized form.

Let us designate condition I(a) by letter *a*, condition I(b) by *b*, condition II(a) by *c*, condition II(b) by *d*, and the conclusion "she is eligible for the benefits in question" by E. We will further designate the logical conjunction *and* by &, the logical conjunction *or* by v, the *if..., then* connection in one direction as →, and the if..., then connection in both directions as ↔.

Then in the language of propositional logic our formula will look like this:

$$(a \ \& \ b) \ v \ (c \ \& \ d) \leftrightarrow E.$$

The formula reads as follows: **If** there are conditions *a* and *b* OR conditions *c* and *d*, **then**, and only then, draw conclusion *E*.

We suggest that the reader apply the just described method to the definition of a verb and then compare the logical structures of both propositions.

Once done, it will become obvious that while the first proposition is a **disjunction of conjunctions**, the second proposition is a **conjunction of disjunctions**.

Now we suggest that the reader on his or her own figure out a method for applying the disjunctive-conjunctive concepts and propositions (Method 4) and a method for applying conjunctive-disjunctive propositions (Method

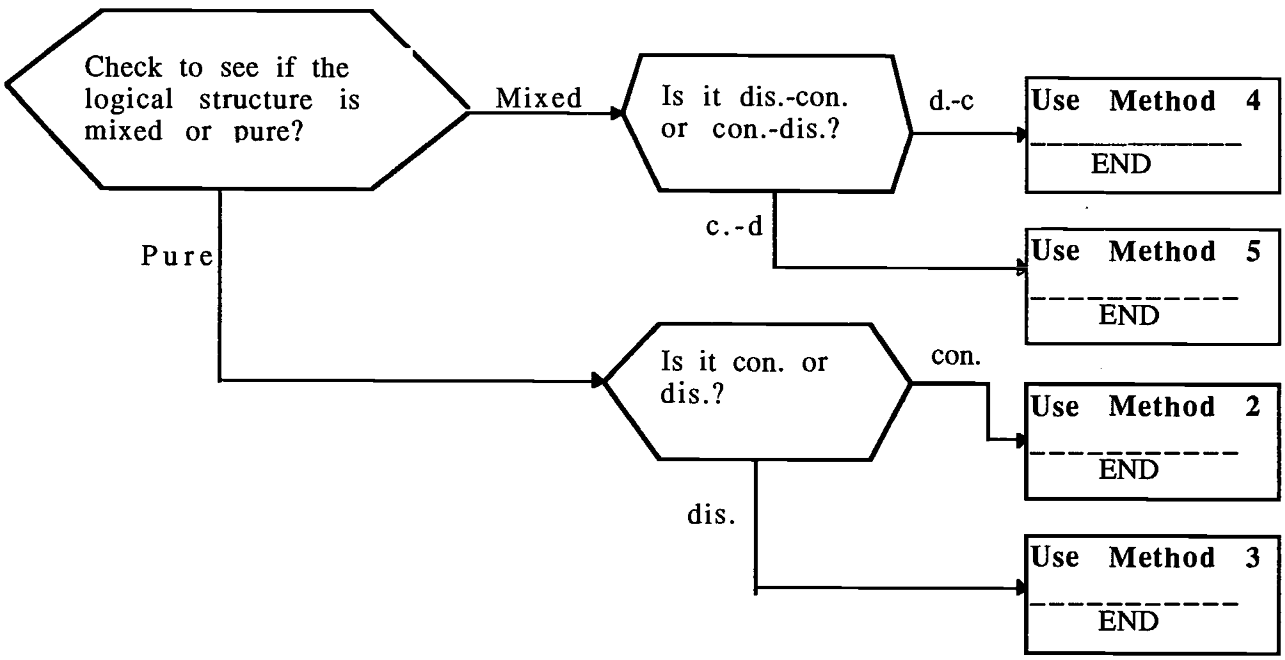
5). These methods will have a greater degree of generality (d_3) than methods 2 and 3 whose level of generality was d_2

A Still More General Method Is Needed

Now we need a unifying more general method (d_4) which will subsume and bring together in a single system all the methods developed so far.

Here is how it can look:

Method 6
(d_4)



Is Method 6, Finally, the Most General Method? Let Us See...

The methods formulated above were developed for the application of concepts with different logical structures of their characteristic features which were reflected in the concepts' definitions. But definitions are just one kind of propositions. Other kinds of propositions are rules, axioms. theorems, laws of nature (of physics, chemistry, biology, etc.), statements about attributes of objects and their relationships, and some others. Students encounter all of them in the studies at school and they are supposed to learn and know how to apply them.

In order for the formulated Method 6 to be the *most general* method for applying knowledge, it must work on *any* knowledge, including rules, laws and other kinds of propositions. Such a method must be applicable to all of them. Does method 6, and the less general methods on which it draws, work on all kinds of propositions? Let's test it.

Let's consider a simple geometric proposition (theorem) about one of the attributes of squares: "The diagonals of a square are perpendicular".

In the conditional if...,then form: "If a geometric figure is a square (S), then its *d*iagonals are *p*erpendicular (dp)".

In the language of propositional logic: $S \rightarrow dp$.

This is obviously a true statement. Now let us inverse it: "If the diagonals in a geometric figure are perpendicular, then this figure is a square: $dp \rightarrow S$. This statement is not true, for a figure that has perpendicular diagonals may also be a rhombus, not just a square.

Thus, statement $S \rightarrow dp$ in our example is true, but the inverse statement $dp \rightarrow S$ is not true.

There exist only one kind of propositions which are always true in both directions - the definitions. Other propositions that are true in one direction may or may not be true in the other direction. Their truth or falsity in the other direction must be determined in each particular instance.

The methods described so far were general only with regard to definitions and those other two-directional propositions which are true in both directions. But these methods are not applicable - or not completely applicable - to one-directional propositions which are true only in one direction. This means that the described methods are still not most general.

The methods for applying one-directional propositions are partially different from the methods of applying two-directional propositions. In the following table we will describe methods for the pure conjunctive (Method 2a) and the pure disjunctive (Method 3a) structures within the one-directional propositions. We suggest that you compare them with their corresponding methods 2 and 3 (p. 19) designed for two-directional propositions to see the difference. Obviously, the need for Methods 2a and 3a creates a need for Methods 4a and 5a which the reader can easily create by modifying Methods 4 and 5.

Methods For Pure Conjunctive And Disjunctive Structures Within One-Directional Propositional Knowledge

Here are the methods:

Table 4

Method 2a (for conjunctive concepts and conditions expressed in one-directional propositions (d_2)	**Method 3a** (for disjunctive concepts and conditions expressed in one-directional propositions) (d_2)
In order to identify an object as belonging or not belonging to a certain class or to determine whether to perform an action indicated in the right part of an if..., then proposition: 1. Refer to the proposition and isolate the characteristic feature(s) or conditions indicated in its left part. 2. Mentally superimpose the feature(s) or condition(s) on any given object or situation and check to see if it has the feature(s) or the condition(s). 3. Draw a conclusion according to the following rules: (a) If an object or situation has all the features or conditions, indicated in the left part of the proposition, then it belongs to the class of objects specified in the proposition's right part. If the proposition's right part indicates an action to be performed, this is the action to execute. (b) If an object or situation does not have at least one of the features or conditions, then **no conclusion can be drawn. If an action is indicated in the right part of the proposition, it is not known whether this is the action to be performed.**	In order to identify an object as belonging or not belonging to a certain class or to determine whether to perform an action indicated in the right part of an if..., then proposition: 1. Refer to the proposition and isolate the characteristic feature(s) or conditions indicated in its left part. 2. Mentally superimpose the feature(s) or condition(s) on any given object or situation, and check to see if it has the feature(s) or the condition(s). 3. Draw a conclusion according to the following rules: (a) If the object or situation has at least one of the features or conditions, indicated in the left part of the proposition, then it belongs to the class of objects specified in the proposition's right part. If the proposition's right part indicates an action to be performed, this is the action to execute. (b) If the object or situation does not have all of the features or conditions, then **no conclusion can be drawn. If an action is indicated in the right part of the proposition, it is not known whether this is the action to be performed.**

An example to instruction 3b of Method 2a. Let us suppose that someone has formulated the following if...,then rule with an action indicated in its right part: "If it is raining, take an umbrella when leaving the home". Now suppose that it is *not* raining. Must I *not* perform the action, i.e., *not* take an umbrella? Not necessarily. I still may take the umbrella if I *expect* rain later in the day. The rule says what to do if the condition is present but does not say what to do if it is *not* present. The rule offers no conclusion about what to do if it is *not* raining. It leaves the decision open.

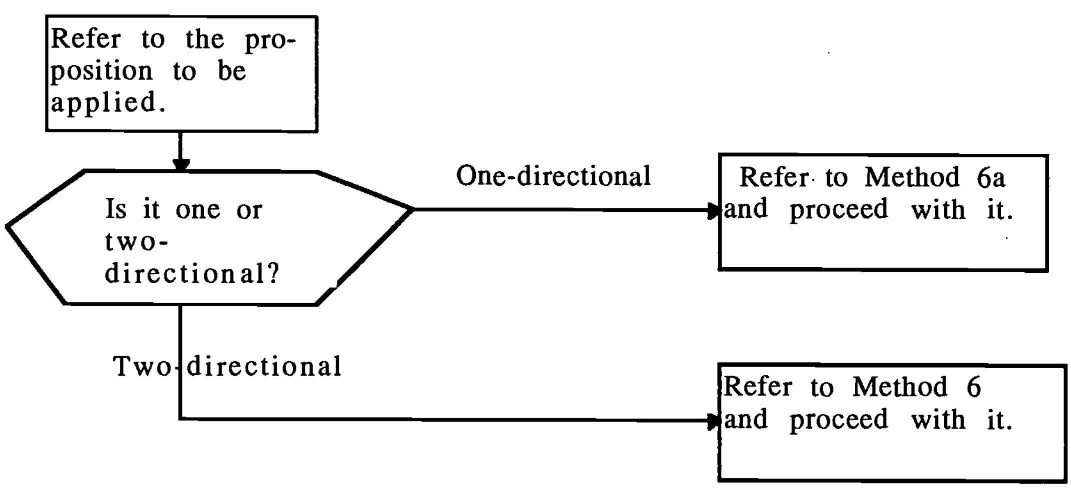
An example to instruction 3b of Method 3a. Let us suppose that someone has formulated the following if...,then rule with an action indicated in its right part: "If it is raining or you expect it to rain later in the day, take an umbrella when leaving home". Now suppose that it is not raining nor is expected to rain. Must I *not* perform the action, i.e., *not* take an umbrella with me? Not necessarily. I still may take the umbrella for some other reason. The rule says what to do if at least one of the conditions is present but it does not say what to do if neither of them is present. It leaves the decision open.

It is obvious that the modifications which were made in Methods 2 and 3 to turn them into Methods 2a and 3a (to fit one-directional propositions) should be made in all the other methods (4 through 6) because they are also based on Methods 2a and 3a. We suggest that the readers make these modifications and develop Methods 4a through 6a on their own.

Method 7
(the most general)
(d_5)

Now we have arrived – at last! – at the most general method for learning and applying *any* conceptual knowledge expressed in *any* kind of propositions (definitions, rules, theorems, laws, etc.). These propositions may have *any* logical structure of characteristic features or conditions in the left part of the if...,then statement and they may have *any* of the two kinds of connections between the left and the right parts (two-directional or one-directional).

Here are the instructions which should precede methods 6 and 6a in order to make method 7 the most general:



Note. In propositions covered by the methods described in this chapter, the connection between the antecedent and the consequent is deterministic. There are also propositions which have a probabilistic connection – where the consequent follows from the antecedent with some probability rather than certainty. That is why Method 7 is the most general with respect to deterministic propositions only.

How Difficult Is It To Teach Students The Most General Method Of Applying Conceptual And Propositional Knowledge?

From the description of the most general Method 7, and the way we have arrived at it, an impression may have arisen that teaching and learning it is a difficult and lengthy process. In fact, it is an easy and relatively fast process which students greatly enjoy. Moreover, it is possible to teach even junior high school students how to independently *discover* both the basic logical structures of concepts and propositions and the methods of handling them. In chapter 15 of (Landa, 1974), a detailed lesson is described. We strongly suggest that the readers familiarize themselves with that lesson, as it almost gives a script on how to conduct it. The methodology for conducting the lesson is so precise and well structured that it almost represents a teaching (instructional) algorithm which any teacher can follow and use.

After the original Russian 1966 edition of the book (Landa, 1974) was published, some preliminary experiments were conducted with primary school students. They showed that younger children, too, can be taught the basic logical structures of concepts and proposition, and methods of handling them.

It takes more time to teach students some auxiliary methods which are discussed in the next section.

The Explicit And Implicit Logical Structures Of Propositions. Why Auxiliary Methods Need To Be Taught And Learned To Make The General Method Work

In the majority of examples which we used to build the most general method of applying knowledge, the logical conjunctions *and*, *or*, *not* and *if...,then* were present in the propositions, and, thus, were explicit. This made discerning the logical structures – and their representation in the logic diagram form – relatively easy. However, in many propositions, both in science and everyday language, the logical conjunctions are expressed by grammatical conjunctions or are not present at all, which makes them – and their related logical structures – hidden or implicit.

Landamatics has developed methods for "explicitating" hidden or implicit logical structures which cannot be discussed here for lack of space. We will limit ourselves to a few examples just to give an idea of the nature of the problem.

Examples of translation of grammatical conjunctions into logical conjunctions

Grammatical conjunctions	Translation into logical conjunctions
1. He is smart **but** lazy.	1 He is smart **and** lazy.
2. I will **not** forgive him **unless** he apologizes.	2. **If** he **does not** apologize, **then** I will **not** forgive him. Also: **If** he apologizes, **then** I will forgive him.
3. The bank robber said to the tellers, "Keep quiet **and** you will be OK"<	3. The bank robber said to the tellers, "**If** you keep quiet, **then** you will be OK".

We call the translation of grammatical conjunctions into the logical conjunctions *and*, *or*, *not*, and *if...,then* the reduction of propositions to their *standard logical form*, or *logical standardization*. Only a reduction of this kind clearly brings to light the logical structures of characteristic features and conditions, and makes it possible for a person to correctly and effectively use the methods of applying knowledge described above.

We suggest that the reader select or make up a number of sentences with various grammatical conjunctions (for example, therefore, rather than, otherwise, neither...nor, provided and others) and translate them into standard logical form.

Example of explicitation of an implicit logical structure

Implicit logical structure	Explicitated logical structure
1. "A participial phrase is a group of related words containing a participle." (Warriner & Griffith, 1957, p. 37)	1 **If**, and only if, the words in a group are (a) related **and** (b) contain a participle, **then** this group of words is a participial phrase.

We suggest that the reader select a number of propositions with implicit logical structures and then explicitate them. An example of such a proposition may be the following definition: "An adverb is a word or a combination of words typically serving as a modifier of a verb, an adjective, another adverb, a preposition, a phrase, a clause, or a sentence and expressing some relation of manner or quality, place, time, degree, number, cause, opposition, affirmation, or denial" (Webster's Guide to Business Correspondence, 1988, p. 197).

The Educational Value Of Discovering, Teaching And Learning General Methods Of Thinking

Teaching and learning general methods of thinking have the following imporftant educational benefits:

- It equips students with uniform and ubiquitous *tools* to acquire, manipulate, and apply knowledge of *any* content across all disciplines
- It requires teaching and learning of each of the methods just *once*, making it unnecessary to teach and learn how to acquire, manipulate and apply each *particular* knowledge
- It *saves enormous amount of time*, and thus vastly increases the *productivity* of both teaching and learning.
- It enormously *increases the quality* of acquired knowledge, skills and abilities.
- It dramatically *reduces difficulties* in teaching and learning.
- It *prevents many errors* or *immensely reduces their rate* .
- It *creates expert-level learners and performers* almost from everyone – and does this reliably and relatively fast.

Some Additional Educational Benefits Derived From Teaching And Learning General Methods Of Thinking

Here are some additional, but extremely important, educational benefits derived from teaching general methods of thinking:

- Students begin to understand the *general makeup* and *structure* of knowledge – *any* knowledge – regardless of its specific domain and contents, which leads to the development of *interdisciplinary thinking*
- Students acquire a powerful tool for *structural analysis* and comparison of knowledge regardless of its contents and domain specificity
- They acquire a tool and develop the ability to *see the common (general)* in the *particular (specific)*
- They begin to easier *transfer* knowledge, mental operations and their systems (general and more specific methods) from one content to another both within the same subject matter and between

different subject matter domains; the range of transfer becomes incomparably broader

- They become *conscious* of their own thinking processes and acquire the tool, and the ability, to *self-manage*, *self-regulate*, and *self-control* these processes. Their thinking becomes truly *self-sufficient* and *independent.*

- They develop *general approaches* to *attacking different problems* within the same or different domains of knowledge.

Why Are General Methods Of Thinking Not Commonly Taught In Schools Today?

There are several reason for it:

1. The insufficient maturity of educational science which has yet to realize the critical importance of teaching students of all ages general methods of thinking.

2. The underdevelopment of general methods of thinking in pedagogy and psychology, which results in a lack of scientific knowledge of the makeup and structure of different methods of thinking.

3. The underdevelopment in pedagogy and psychology of instructional methods for teaching general methods of thinking.

4. The focus, in instruction practice, on teaching and learning specific knowledges and skills rather than general methods of knowledge acquisition, manipulation, and application, on whose basis, from Landamatics' point of view, specific knowledges and skills should be taught and learned.

5. The unawareness or insufficient awareness that most teachers have – and that many professionals and expert performers in all areas of activity have – of their own mental processes and methods of thinking, which makes the communication of these methods and their transfer to students practically impossible.

6. The flaws in teacher preparation and training result in the fact that student teachers and practicing teachers do not learn either general methods of thinking (and other methods of cognitive activity) or general methods of teaching general methods of thinking.

A Brief Summary Of Problems In Learning And Thinking Resulting From Not Teaching Students General Methods Of Thinking

Here is a brief summary of problems in learning and thinking which develop when students are taught neither general methods of thinking nor how to discover them on their own:

1. If general methods of thinking are not taught, students are forced to

try to discover them on their own.

2. If methods for the discovery of general methods of thinking are not taught, then students can use the only method available to them - trial and error.

3. Discovering general methods of thinking by trial and error is a difficult process (hence, the difficulties and problems in learning and thinking).

4. Discovering general methods of thinking by trial and error is a long process (hence, the duration of instruction and learning in each particular topic is too long).

5. Discovering general methods of thinking by trial and error is, as a rule, an unsystematic and haphazard process.

6. The discovered methods are, very often, based on empirical generalizations and are not general enough (they enable only limited transferability and limited areas of application).

7. Very often, not all the component actions are discovered and, as a result, the discovered methods are defective in one or several respects (incomplete, ineffective, etc.).

8. In cases where the discovered methods are correct and general enough, they are often inefficient (not economical).

9. Students who discover the operations of a method (M_a) through trial and error are, as a rule, unaware of them, for the operations don't reach the level of consciousness (M_p). As a result, students are unable to self-manage, self-regulate, and self-control their mental processes.

10. Because of the unawareness of mental operations, students cannot communicate their mental processes and their systems (M_a's) to other people.

Are General Methods Of Thinking Content-Free?

The answer is yes if under content one understands the features that make, for example, a triangle different from a rhombus or a noun. But the answer is no if one includes in the notion of a content also the logical structures of those features. *A logical structure of a content is also a content although of a radically different nature.* Methods are not determined by the contents of the first kind but are determined - and reflect - the contents of the second kind.

The power of general methods of thinking consists in the fact that they allow one to isolate contents of the second kind and mentally separate them from the contents of the first kind. This makes it possible to apply mental operations to *any* content of the first kind, even such which was never encountered in the past experience. Thereby general methods of thinking enable people to overstep the limits of their past experiences and effectively think about things with which they had no prior personal experience.

General Methods Of Thinking And Intelligence

Finally, cognitive psychology in the USA and some other countries came to the thesis that intelligence is teachable and learnable (see, for example, Wimbey & Wimbey, 1975; Sternberg, 1983; Perkins, 1995). (This thesis, incidentally, was put forward in Soviet cognitive and educational psychology several dozen years ago). What, however, is specifically teachable? What kind of processes or mechanisms? Until there is a clear and precise answer to this question, the thesis about teachability and learnability of intelligence hangs in the air. In order to know how to teach – *produce* – intelligence, it is necessary to know what precisely it is.

According to Landamatics, general intelligence is nothing other than a command (not knowledge or not just knowledge!) of a system of the most general methods of thinking applicable to any content-specific knowledge.

What does to teach and learn intelligence mean, then?

It means, according to Landamatics, to teach and learn general methods of thinking which *lead* to the development of general intelligence. One note is necessary here. Intelligence is *not* the performance of operations which make up methods (M_a's). Intelligence is what is *left* in the brain as a *result* of performing the methods' operations. Intelligence is (are?) the "traces" of previously performed systems of operations, their aftereffects.

This can be expressed in another way: intelligence *cannot be taught or learned*, only methods can. Intelligence can only be *formed* as a result of performing and internalizing methods' operations.

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We have been dealing, in this chapter, with only *deterministic* methods of knowledge application which are based on the full information about the objects to which knowledge is applied. There are, however, *probabilistic* general methods of cognitive activity and thinking that lie at the foundation of probabilistic intuitive judgments. The discussion of the probabilistic methods of cognitive activity and the instructional methods of teaching them is a separate topic.

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