# Abstract

Homeostasis is a biological core concept that represents, in fact, the biological essence of living organisms: the dynamic stability, existing in the concentration of materials, rate of normal processes and the occurrence of body reactions under special conditions. Homeostasis constitutes a biological core-concept that is a common feature of many subjects and various fields of biology. Furthermore, the concept crosses organization hierarchy levels, namely that it exists in the micro and macro levels, starting from the molecule and bacteria, through the eukaryotes, the tissue, the limb, the physiological system up to the multi-system whole body. There are difficulties in comprehending the resulting concept. The difficulties can arise from the need to join the concrete - sensory aspects of the homeostasis, as it is actually "felt" in the whole body with the scientific aspects that are abstract and complex and require formal mental processes to understand them. Comprehension of these abstract aspects involves cognitive skilled operations of conceptual knowledge, as an example of system mental processes and micro-macro integration.

The question of teaching the core concept in biology, the homeostasis, represents the dualism that exists regarding the teaching of a core concept in the field of knowledge. The dilemma is focused in two approaches:

- Learning the general concept and applying it in detail from the general to the particular
- An opposite approach: learning the specifics and from them to infer the general concept - from the specific to the general.

The present investigation, from the viewpoint of the contribution of each approach, dealt with conveying information and scientific perception of the concept. The first approach was applied by explicit instruction, expressed in the declared and specific learning of the homeostasis concept. The second approach was applied by implicit instruction that relies on revealing the concept, appearing as a mechanism, a state and a process and inferring of the various aspects of homeostasis from examples. The two instruction paths were accompanied by a computerized learning environment, in which both the general and the specifics are displayed. It means that the computerized environment presents the homeostasis concept according to the common characteristics of all the factors and processes and also through examples.

The computerized environment focused on the lactose operon, that constitutes a system of homeostasis in the molecular - prokaryotes level.
The goal of the research was to examine the combined effect of explicit instruction with learning by means of computerized tools on the general knowledge and types of knowledge of the students, regarding the homeostasis core concept. A further goal was to investigate the combined effect of explicit instruction with learning by means of computerized tools on the comprehension of the homeostasis concept's features expressed by the students. Through this, the goal of the research was to identify types of conceptions and misconceptions of homeostasis that exists within them.

The research was conducted among 465 $11^{th}$ and $12^{th}$ grade students, specializing in biology and learning molecular heredity and gene control within the framework of the field of genetics and other biology domains. The lactose operon, present in bacteria was studied as an example of homeostasis in the molecular level and served as a bridge to the homeostasis in the level of whole body of organism. The classes, participating in the research, were divided into four research groups. The students of each group learned the homeostasis concept in one of the combined manners through explicit or implicit instruction with or without computer assisted learning. The four research groups were: explicit instruction + computer learning (EXPCOM); implicit instruction + computer learning (IMPCOM); explicit instruction + classic learning without computer (EXP); implicit instruction + classic learning without computer (IMP).

The research hypotheses related to the differences in knowledge and comprehension of the homeostasis characteristics prior to and after the learning process and also to the differences among the four research groups, in knowledge and comprehension of the homeostasis characteristics.

Hypothesis A: improvement will be found in the overall knowledge and in the types of knowledge after learning, in comparison with the knowledge prior to learning. The greatest improvement will be found in EXPCOM group.
Hypothesis B: differences will be found in the knowledge of the homeostasis concept after learning, between the explicit and implicit instruction and between learning with and without a computer. The interaction between explicit instruction and learning with a computer will be found to be favorable, regarding the overall

knowledge of homeostasis, types of knowledge and conceptual knowledge skills of the students.

Hypothesis C: improvement will be found in the comprehension of the homeostasis core concept characteristics after learning, in comparison with the comprehension prior to learning. The greatest improvement will be found in the EXPCOM group.

Hypothesis D: differences will be found in the homeostasis comprehension after learning, between the explicit and implicit instruction and between learning with computer and without a computer. The interaction between explicit instruction and learning with a computer will be found to be favorable, regarding the comprehension of the homeostasis core concept characteristics found among the students.

The intervention program was applied to verify the hypotheses. The intervention in learning was applied in four variations, according to the research groups: explicit and implicit instruction together with learning with or without a computer, namely, classic learning. The explicit instruction included three stages, starting from the general and progressing to the specific - from the concept to the application:

A. Overview of homeostasis - learning the characteristics common to the general homeostasis phenomena and processes that are expressed at the macro level

B. Learning the operon model in a detailed and declared manner, emphasizing the view of the operon system as a homeostatic system in the bacteria cell and the molecular level

C. Declared and explicit integration of the homeostasis concept (by the teacher) through the macro and micro level.

The implicit instruction included three stages in the direction opposite to that of the explicit instruction: from the specific to the general - revelation and inference from examples:

A. Introduction to the theme of control and regulation

B. Study of the operon model as a DNA sequence, functioning in control and regulation: elucidation of the components of operon and the operating mechanism

C. Revealing and identification of the connection between the operon model and the principles of the homeostasis concept by the students. The integration between the macro and micro levels of the homeostasis concept was conducted by the students through analysis and synthesis, without explicit statements of the teacher. The learning process, aided by a computer, was conducted by means of four learning tools: two types of simulation: scientific animation and analog (humoristic) animation, an interactive game and virtual laboratory. The learning tools were part of an interactive site*, that deals in depth with the various aspects of the homeostasis concept at all levels.

The study took on both a quantitative and qualitative methodology. The following questionnaires were used to investigate the variables in the study:

A. Questionnaire of knowledge and comprehension of the homeostasis concept - prior to learning

B. Questionnaire of knowledge and comprehension of the homeostasis concept - after learning

C. Conceptual questionnaire - after learning

D. Interviews

E. Repertory Grid.

The answers to the questions in questionnaires A, B, C were analyzed both quantitatively (ANOVA and MANOVA) and qualitatively (content analysis). Overall knowledge and types of knowledge: declarative, procedural, analog and conceptual, were tested in these questionnaires. The conceptual knowledge was specifically tested by the following cognitive skills: induction, deduction, system thinking and micro-macro integration. The comprehension of the students concerning homeostasis characteristics: dynamics, feedback, multi-systems, environments, physiological equilibrium, control and regulation, dependence among events and hierarchic levels of organization were also tested by the questionnaires. The responses of the students in the interviews were analyzed according to the abovementioned types of knowledge, from which their comprehension were exposed. Also, the students' responses were analyzed regarding their attitudes towards studying by means of computerized learning tools. System perception of physiological systems and identification of their homeostasis characteristics were tested by the Repertory Grids.

A clear trend is apparent from the research findings to the preference of explicit instruction, mainly with a computer. These findings are compatible with conclusions

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of other investigations that dealt with this question, concerning other themes, as an example of comprehending complex systems. The research hypotheses were sustained by most of the variables in the study. Hypothesis A was sustained, concerning the following variables: general knowledge and types of knowledge: declarative, procedural, analog (partly) and conceptual (partly). It means that there was an improvement of the grades in the measures of knowledge of the homeostasis concept in most of the research groups after the learning process. Hypothesis B was sustained, concerning the following variables: general knowledge, analog knowledge, conceptual knowledge, skills of conceptual knowledge - induction, deduction, system thinking and micro-macro integration. Specifically, explicit instruction combined with the computer (EXPCOM) and explicit instruction by itself (EXP) were found to be most effective concerning the measures of knowledge of the homeostasis concept. Hypothesis C was partially sustained: after learning through intervention, there was improvement in the comprehension of two of the homeostasis features: dynamics and environment in comparison with the comprehension of these features after learning. Hypothesis D was sustained, concerning the following variables: dynamics, environment, physiological equilibrium, control and regulation, dependence among events and hierarchic levels of organization.

Implicit instruction, independent of the learning method, with or without a computer, was effective referring to procedural knowledge and the comprehension of homeostasis features: multi-systems and physiological equilibrium. Learning with a computer, irrespective of the instruction method (EXPCOM and IMPCOM) was effective referring to two types of measures: A. knowledge aspects - procedural knowledge, induction and micro-macro integration; B. comprehension aspects of homeostasis, appeared in physiological equilibrium, control and regulation and dependence among events. In general, there was mutual positive effect of explicit instruction on learning with a computer and vice versa. The opposite effect was evident regarding procedural knowledge and comprehension of the multi-system characteristic. There was a correlation between the two types of knowledge: procedural and conceptual as well as between the two types of knowledge: analog and conceptual. That correlation was prominent in the conceptual knowledge skill - deduction. Furthermore, there was a varied correlation between conceptual knowledge skills and comprehension of homeostasis characteristics; A. Micro-macro integration and the theme of hierarchic levels of organization; B. System thinking and the themes of multi-system and dependence among events.

Attitudes of the students towards learning by means of a computer were expressed in two ways: A. Assessment of the contribution of the computer tools to operon learning, in particular and of the homeostasis concept in general. The scientific simulation was found to be the most effective learning tool followed by, in descending order, game, analog simulation and virtual laboratory; B. Aspects emphasized in all the learning tools (according to the students). The methodic element that stood out, was illustration (in simulation and by game), while the content elements that stood out, were dynamics and control.

The present study shed light on the understanding of the core concept in biology: homeostasis. These comprehensions actually represent the overall biological concept gained by students that have specialized in biology in high school. These comprehensions also reflect aspects of perception of complex systems.

The contribution of the research is conveyed in two fields:

A. Theoretical field:

1. Study the effect of explicit instruction in general and explicit instruction of learning with the computer in particular on the meaningful learning of an abstract and complex core concept, e.g. homeostasis
2. Analysis of students' comprehension that developed during the biology studies regarding the homeostasis concept.

B. Applicable field:

1. Proposal of instruction methods of the core concept in the knowledge field
2. Characterization of the contribution of computerized learning tools to the meaningful learning of a multi-field core subject which crosses all levels of organization.

Aspects arose in the research that are eligible for application and in-depth research, regarding knowledge, for the instruction and learning by means of a computer. Regarding knowledge, the connection between procedural knowledge and conceptual knowledge raises the question concerning the order of instruction which is most effective - the mechanism (procedural) followed by the connection to the general concept (conceptual) or the opposite direction. This issue (in biology, for example) can be examined regarding the instruction of physiological systems comprising biochemical processes that depend on the exact anatomic structure and a suitable physiological system. Regarding the clear association between analog knowledge and conceptual knowledge, the connection has to be "harnessed" for developing analog knowledge that constitutes a variety of possibilities of presentation (the configuration) of the learned concept. Regarding explicit instruction, the research findings raised aspects of explicit instruction that are suitable for a broad and in-depth research:

A. The effect of explicit instruction on the thinking "space" of the students: broadening or narrowing the "space"
B. Effect of explicit instruction on the development of system thinking
C. Instruction of a core concept: in an explicit or implicit manner?
D. Factors that determine the effectiveness and efficiency of the manner of instruction - explicit or implicit: "strength" of the instruction with time, potential of transferring the learned subject to the same field or another field; the age of students, which generally reflects the level of knowledge of the students.

The differential effectiveness of the computerized learning tools for developing and upgrading various types of knowledge and comprehension of the homeostasis concept raises the question, concerning instruction of a topic or core concept by means of a computer. It emerges from the findings, that the potential learning of the computerized learning tools should be exhausted. This is due to the fact that each learning tool is directed towards specific - didactic purposes and plans, and is based on a theoretical rational during its scientific and educational development.

The present research has implications regarding instruction of other core concepts that are unique to the knowledge field or that are likely to be even multi-field and interdisciplinary. Methodical implications will be applied from the standpoint of examining the effect of the combination of instruction and learning on knowledge and comprehension of students. Investigation of the content of the students' comprehension may constitute a basis for analysis of comprehension of students in other subjects, and in detecting the roots of faulty understanding. Practical implications will be expressed in the reference to the research findings as a basis of knowledge and patterns of comprehension, for the development of units for instruction of other biological core-concepts. In addition, the research findings can provide leverage for the development of system thinking among the students.