ICT TOOLS IN BIOLOGY EDUCATION

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Author's interests are connected with the application of the new technologies in biology education. The main aim of author's concept of learning and teaching biology is improving the creativity level in students at different stages of education during problem solving process at the lessons with ICT tools use. On the other hand, the research problem is concerned with application of information transforming models in practice, especially behavioral and cybernetic models connected with ICT tools use. The results of the research will be used for preparation of theoretical basis for formulating the main assumptions for multimedia in biology education and specifying theoretical premises of conceptualism in computer-aided biology didactics. The author prepared the practical models and patterns connected with improving student's cognitive skills at various stages of education.

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INTRODUCTION
Computer science education, information and communication technology (ICT) are at present becoming one of the most important elements defining the basic competences of students. Information technology integrates medial, informative and computer science education, but also all the educational subjects mentioned in the curriculum basis of general education. In science and biology education there increasingly appear concepts of integrated teaching, showing the student the world in a holistic manner. The principle of universal activity of students in cognitive, emotional and motivation, as well as in practical sphere is preferred. More and more often attention is paid to the fact that the contemporary problem is not so much lack of information as its surplus, and the crowd of information as well as its unnecessary excess of details may be an effective tool of disinformation. Hence forming in students such skills as selection, evaluation and organizing of information (forming its structure) seems justified, so that they can serve drawing conclusions.

In this article the author’s part of concept of ICT-aided Biology teaching has been briefly outlined, taking into account various manners of didactic transformation of biological teaching contents. Selected ICT tools have been presented in the light of teaching principles and cognitive activities model.
I. MAIN PRINCIPLES OF TEACHING AND THEIR COMPUTER-AIDED REALIZATION

The computer programs as a didactic aid are often described in didactic literature all over the world. It is not enough that they play, for instance, motivational, exercising, synthesizing or supervising function, they are to be made an independent source of reliable, easily comprehensible information, given in a way that activates students. It is also important not to replace various functions and tasks of didactic aids applied in the process of teaching-learning Biology with each other, but only to interfere skillfully. It is underlined that school practice requires methodically grounded application of these aids in the processes of teaching and educating.

Learning is usually defined as acquiring knowledge and skills. Cognitive skills signify considerable increase in skillful performance of cognitive tasks as a result of practice (Ericsson & Oliver, 2002). Cognitive analysis of tasks is a preliminary condition for effective teaching as it precisely identifies the skills that are to undergo teaching, and allows introducing effective computer-aided teaching curriculums, which may quicken the pace of learning even three times (Anderson 1998, Potyrala 2003a).

In **Tab.1** there are examples of student’s activities at Biology lessons carried out on the basis of software use in view of the realization of basic teaching principles. The definition of didactic principles as general norms of teacher’s proceedings while preparing and carrying out lessons that make it possible to take into account the information from many sources simultaneously and maintaining the direction of students’ learning activities seems to be most proper here.

It is worth underlining that not all the computer programs can be called cognitive tools. Only those that have been adapted or invented considering learning according to didactic principles qualify here.

**Tab. 1.** The examples of students’ activity at computer-aided lessons in connection with the realization of main principles of teaching (Potyrala, 2003b).

<table>
<thead>
<tr>
<th>PRINCIPLES OF TEACHING</th>
<th>Computer-aided realization of the main principles of teaching</th>
<th>Levels of cognitive activities (according to Kwiatkowski, 1994)</th>
<th>STUDENTS ACTIVITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINCIPLE OF COMPLIANCE WITH SCIENCE</td>
<td>Specifies the main criteria of teaching contents selection and the way of their assimilation</td>
<td>Teaching contents adequate to the level of modern knowledge. Logical arrangement of headings and curriculum contents. Considering specific and non-specific transfer.</td>
<td>Level of theoretical structures and sensual cognition Level of imaginative models</td>
</tr>
<tr>
<td>PRINCIPLE OF GRADUAL BUILDING UP OF KNOWLEDGE</td>
<td>Points to the necessity of gradual build-up of knowledge and specifies structure of knowledge</td>
<td></td>
<td>Completing the existing structure of knowledge and forming new structures, forming imaginative models of biological phenomena</td>
</tr>
</tbody>
</table>
PRINCIPLE OF ILLUSTRATING KNOWLEDGE

Says that we must help our students to learn the facts immediately through the realization of the activity. Specifies the criteria of choice of the best kind of students’ activity

Information which is shown through words or drawing (illustration) or animations.

Level of symbolic models

Analysis of extra-textual sources of information and realization of practical activities

PRINCIPLE OF STUDENTS’ ACTIVITY

Indicates the criteria of choice of the best kind of students’ activity

Interactive character of the programs extends the ability to perceive

Level of sensual cognition and theoretical structures

Problem solving, verifying imaginings regarding phenomena and processes

PRINCIPLE OF INDIVIDUALIZATION OF TEACHING

Specifies a system of individualized ways of cooperation between teacher and student.

Individual pace of learning

Level of sensual cognition and theoretical structures

Choice of the way of working with the program (from experiment to theory or the other way round), developing individual plans for complex activities

II. THE WAYS OF DIDACTIC TRANSFORMATION OF TEACHING CONTENTS IN BIOLOGY WITH COMPUTER USE

The tendency to introduce some biology problems (e.g. genetics) at lower and lower stages of education involves the necessity to perform didactic transformation of teaching contents.

The ways of didactic transformation process realization are among others:

✓ reduction of teaching contents,
✓ reduction of structure (e.g. reduction of details, charts and models use),
✓ reorganization and reconstruction biological knowledge through e.g. build-up the new structures.

ICT tools may support the different ways of didactic transformation if the teaching material has an ordered structure, in which some elements are basic due to their number and importance of relations with other elements. It is connected with a proper choice and range of curriculum contents – simplifying structures of building and processes, eliminating names, formulas, detailed notions disturbing biology knowledge structure in students. It is very important taking into consideration the relations between teaching contents and teaching aims formulated as aimed students’ achievements.

The author’s concept of didactic transformation of genetics teaching contents at the junior high school level was to develop a spiral structure of genetics contents, i.e. grouping the teaching material in consecutive cycles. The first cycle (first part of curriculum) contains the whole teaching material in its basic form, understood as general interdependencies between the structure and function of genetic material, the second cycle (second part of curriculum) develops the information from the first cycle in order to make the students aware of the relationships between a genotype and a phenotype of organisms, the next cycle (third part of curriculum) extends the range of information and required skills, moving within the same curriculum notions. In such a type of curriculum it is not essential to master the previous cycle fully as the next cycle will revise and complete the information in the same range of contents anyway. Within each cycle material is presented in a linear way; spiral structure regards only the repeatability of contents in consecutive cycles (Potyrala, 2003a).
Meanwhile the computer programs, which are available and Internet sources of information are mainly informative or encyclopedic in nature, that’s why they only slightly influence cognitive activity of the subject. Hence the need for developing the author’s own computer programs.

While talking about cognitive activity of the subject we mean various forms of his or her activities in learning. That is (according to Wlodarski, 1998):

- activity expressing itself in arriving at new statements (1),
- activity on the acquired material, when the individual encountered it in a ready form, not participating in its creation (2),
- activities of the subject regarding arranging the contents (3),
- verbalization – naming what is given from outside, what is happening or is going to happen (also in the subject’s activities) in image (performance) form (4),
- repetitions, usually not serving cognition, but revision (5).

Classification of computer software used in Biology teaching is presented in scheme 1. Cognitive activity of a software user has been taken as the basis for this classification.

Scheme 1. Types of computer programs used at Biology lessons. Digits given in brackets match the digits attributed above to various forms of activities in learning (Potyrala, 2003b).

III. SELECTED ICT TOOLS PREPARED BY AUTHOR

Within the research on the problems of didactic transformation of the biology contents (especially in genetics) at the level of junior high school the author developed computer programs (Potyrala & Chorazki, 2002) topic-wise associated with the teaching biology issues at this stage of education – Photo 2. The simplest of them provide only some information through a drawing, animation or written word, and sometimes they supervise the degree of
their learning. Slightly more difficult programs allow the students to, for instance, actively participate in the course of an experiment regarding the generations of hybrids, the degree of revealing a given characteristic or the calculation of gains and losses resulting from specific activities.

These programs can also provide the teacher with auxiliary elements in preparation for the lessons – a collection of illustrations and other materials may be used in lesson conceptuses, students’ papers, folies. Charts with tasks can be used for a written revision test in the given issues. It was the author’s aim to make interactive elements of the program support the build-up of knowledge and the process of shaping notions, reinforced research, independent searching and processing of information and increase the intensity of working on particular problems, and thus increase the students’ attention and ability to memorize.

Examples of tasks and operational teaching aims assumed for realization during lessons carried out with computer use are presented in Tables 2a and 2b.

**Tab. 2a**
Examples of formulating teaching aims and tasks predicted for the realization during lessons. ‘Dominance and Recessiveness’ and ‘Blood Group Inheritance’.

<table>
<thead>
<tr>
<th>Teaching Aims</th>
<th>Tasks which should be carried out by students while working with computer program</th>
<th>OPERATIONAL AIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understanding the phenomena of dominance and recessiveness on the example of selected man’s characteristics,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understanding phenomenon of independent inheriting of characteristics,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understanding the phenomenon of recombination as one of the sources of changeability in nature,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General knowledge of Mendel’s work and laws.</td>
<td></td>
</tr>
<tr>
<td>Skills:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Using the foregoing</td>
<td></td>
</tr>
</tbody>
</table>

1. Specifying a genome on the basis of phenotype.  
2. Specifying genotypes and phenotypes of parents and offspring (independent inheriting of 2 or 1 characteristic).  
3. Filling in Punnet’s chessboard  
   - Doing exercises following instruction,  
   - Graphic presentation of exercises results.  

- To define the notion of ‘dominance’ and ‘recessiveness and give 3 examples of such characteristics in man.  
- On the basis of parents’ characteristics specify characteristics of offspring resulting from the phenomenon of recombination  
- Explain why generation F1 is uniform as far as phenotype and genotype are concerned.
notions,
• Interpreting the results of Mendel’s experiments,
• Solving simple genetic crossings over regarding inheriting selected organism characteristics.

‘Dominance and recessiveness’ program construction:
1. Introduction – phenotype and genotype description of Mendel’s experiments – possibility of explaining new notions through entry screen display (vocabulary) and charts.
2. ‘Decision tree’ test and a task of filling in Punnet’s chessboard.
3. Confirming a well - solved task.

‘Man’s Features Inherited in accordance with Mendel’s Laws’ program construction:
1. Student chooses any two pairs of features, establishes phenotypes and genotypes of parents and offspring.
2. Confirming the result of a well-solved problem in case of error; granting a clue allowing for completing information.

The tasks presented in Table 2b aim at controlling and evaluation of the degree of mastering by students the knowledge and skills regarding planning and predicting the results of the undertaken theoretical and practical activities.

Tab. 2b.
Examples of formulating teaching aims and problems for realization in lessons in ‘Importance of Genetics’

<table>
<thead>
<tr>
<th>Teaching aims</th>
<th>Problems which should be solved by students while working with the computer program</th>
<th>OPERATIONAL AIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Knowledge of possibilities to apply the results in experimental genetics in medicine and animal breeding.</td>
<td>1. Analysis of text chart of the computer program.</td>
<td></td>
</tr>
<tr>
<td>• Knowledge of the latest discoveries in developmental genetics,</td>
<td>2. Specifying the essence of procedures used in a given area of genetics as well as advantages and disadvantages of suggested activities.</td>
<td></td>
</tr>
<tr>
<td>• Knowledge of the notions: ‘biotechnology’, ‘genetic engineering’; and the subjects of interest of these areas of knowledge.</td>
<td>3. Establishing possible consequences of man’s intervention in genetic material of plants and animals.</td>
<td></td>
</tr>
<tr>
<td><strong>Skills:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Performing a simple classification of genetic research applied in medicine and animal breeding,</td>
<td>✔ Point to 2 areas of knowledge in which biotechnology is applied.</td>
<td></td>
</tr>
<tr>
<td>• Perceiving relations between activities used in biotechnology and genetic engineering and their</td>
<td>✔ Explain the meaning of the notion ‘transgenic animals’ on the basis of the text chart.</td>
<td></td>
</tr>
</tbody>
</table>
‘Importance of Genetics’ program construction:

1. Text chart – introduction to the subject of research methods and techniques applied in experimental genetics.
2. ‘Activities’ (to be chosen by students)
3. Experiment’s protocol – selection made by students.
4. Assistance – guidelines complementing the knowledge, vocabulary.
5. Consequences of undertaken activities and conclusion regarding the possibilities of their carrying out (ban or permission).
6. Check-up questions – mini-test – possibility of self-checks

All the above mentioned computer programs created by the author are electronic version of problems and tests contained in ‘student work charts’ (Potyrala & Chorazki, 2002). Tasks of this type require revealing the following abilities by students:

- Associating the contents of a specific task and the more general natural problem,
- Formulating hypotheses regarding predicted solutions and research methodology scheme,
- Perceiving practical importance of the performed task.

Other methodical guidelines together with detailed discussion of the procedures of achieving teaching aims at computer-aided Biology lessons containing contents regarding genetics and selected issues concerning structure and functions of man’s body and ecology have been presented in an additional book – Photo 3 (Potyrala & Stawiński, 2001).

IV. THE OTHERS POSSIBILITIES OF APPLYING ICT TOOLS IN BIOLOGY EDUCATION

In theory a biology teacher has numerous possibilities of applying ICT tools at lessons, especially so, that elements of ICT-aided education are taken into consideration in the curriculum basis, curriculums and assumptions of inter-subject educational medial path. To do it, he or she must adapt available computer tools for his or her needs, form biology teaching concept (or its particular parts), prepare the didactic structure in the form of conspectus or screenplays of lessons carried out on the basis of ICT means and tools’ use.

In practice proper use of these tools encounters numerous difficulties. Therefore, the author presented Polish teachers with possibilities of using ICT tools also in teaching taxonomy of organisms and in realization of the project method (Potyrala, 2003c; Potyrala&Kuczek, 2003).
ICT tools’ use in the realization of project method seems fully justified. According to the assumptions of project proceeding the course of lesson, both in the scale of the whole project, as in case of single lessons should be in accordance with the scheme: from involvement, through exploration and transformation of knowledge, to presentation of products and reflections. Ecological education versus media in the light of research and possibilities of ICT tools’ use in realization of projects in ecology and environmental protection at various stages of education are the subject of separate work of the author (Potyrala and others 2002a, 2002b)

V. CONCLUSIONS

It is often noted that effective introduction of computer to school requires on the one hand the change of its organization, and on the other – accepting interdisciplinary and systematic approach to knowledge and introducing problem teaching. It is also noted that one of the reasons why school should teach in an integrated way, should be departure from encyclopedic approach and introducing a different subject structure of integrated teaching, aiming at modernization of didactic aids and measures applied in regard with students.

Tasks that are interactive in nature activate students, fix the acquired knowledge and influence the form of their presentation by students. In case of genetic knowledge also the proper order of acquiring information is essential. It is a misunderstanding to transfer genetic contents from the level of high school to the considerably lower level without considering the principles and stages of didactic transformation of biological knowledge. It contradicts psychological and pedagogical criteria and leads to excessive burdening of students’ minds, and hence to thinking chaos and decreasing of interest in this area of knowledge. Building up the new genetic knowledge should occur gradually, basing on the material basic knowledge (Potyrala, 2003a).

Didactic model is a tool of metalearning: it makes students aware of how to learn, how to make cognitive processes more effective. Information technology facilitates the realization of educational aims through activating students in the cognitive process.

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