THE INFLUENCE OF ICT TOOLS ON BIOLOGICAL COMPETENCE OF STUDENTS IN THE AREA OF GENETIC KNOWLEDGE: PRELIMINARY REPORT

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ABSTRACT
The main aim of the research is an attempt to find the answer to the question regarding the influence of ICT tools prepared by authors on high school students' competence in the are of genetics knowledge and skills. In the research 300 students of high school took part. The result points to the fact that in all the studied cases student achievements are significantly higher than in control classes.

KEY WORDS
Genetics education, ICT tools, students' competence

INTRODUCTION

The ability to search for information quickly and use it in problem solving is essential in everyday life and makes ICT tools popular.

Present genetics education points to the importance of this knowledge in citizens, personal, professional and social life. The introduction of genetic issues at lower and lower stages of education is accounted for by the following items: the problems of contemporary civilization, moral and ethics dilemmas, the effects of man's interference in genetics material. Basing on the examples in different countries we can say about the tendency towards "citizen genetics knowledge". But we can observe "biological illiteracy" in all the societies, which is connected with neglecting scientific facts and basing one's own opinion on the information provided by the media (Potyrala, Wolek, 2004).
Learning genetics is connected with the development of knowledge and some brain processes for example perception and cognitive thinking. It is very important for basic competence in biology and genetics education. If we want the students to think in a scientific way, they should: consider natural phenomena and ask about them, gather data, hints and information, create, checked consider their own concepts (Fisher, 1999). In our opinion ICT tools can support the improvement of these skills.

We carried out the comparative analysis of the lists of sets of scientific skills presented by various authors (e.g. Cross, 1999, Jenkins, 1999). They include the following skills among others: mastering the principles of rational scientific thinking, independent and rational acquiring of scientific knowledge (from various sources of information), using scientific knowledge in solving everyday life, professional and social problems, formulating rational explanations for scientific processes and phenomena, identifying the issues requiring to be solved in the course of scientific research, carrying out critical evaluation of conclusions arising from the result analysis of scientific research.

Previous research regarding the application of ICT in genetics education were connected with:

- Specify of the degree of teachers' preparation to undertake the problems of ICT-aided science teaching: teachers' skills, conditions of teaching with ICT methods and aids use (Potyrala, 2000),
- Analysis of the curriculum issues and the scope of the curriculum issues requires ICT use (Potyrala, 2002, 2003),
- Application of ICT tools in genetics teaching at junior high school level (Potyrala, 2003).

In the school year 2003/2004 the authors carried out preliminary research at high school level. The results presented in this paper constitute a part of proper research carried out in the school year 2004/2005.

KEY OBJECTIVES

1. Preparing the interactive tasks with ICT tools use for students at high school level and their application in didactics of genetic.
2. Checking whether or not the application of strategies and methods using ICT tools increases scientific competence of students in genetics at high school level.

RESEARCH DESIGN AND METHODOLOGY

The research aims and problems

The main aim of the undertaken research: Checking if the application of strategies and methods using ICT tools influences the increase in scientific competence of students in genetics at high school level. In particular, using a didactic experiment we resolved to check a research hypothesis that computerized teaching environment significantly influences the increase in scientific competence in students.
The subject of verification was the following null hypothese:
The number of solved problems in control and experimental classes is the same in relation to the alternative that in the experimental class this number is higher. The result of this verification was to supply the answer to the question if the applied method of education in the experimental class really influences the increase in scientific competence of students or not.

The research procedure

In order to verify null hypothese we applied a didactic experiment supported by ICT, which we carried out using two classes – control class (C) and experimental one (E).

In the research will take part the biology teachers and students at high school level (Table 1).

Table1. Number of persons who took part in the research.

Stages of research	Biology teachers	High school students
2003/2004 (first stage of research)	1	60 (30 in experimental classes and 30 in control classes)
2004/2005 (second stage of research)	3	240 (4 experimental classes; 30 students in each one and 4 control classes; 30 students in each one)

The conditions of school's participation in the research were connected with the standards of schools' equipment (e. g. communication and information from the Internet, exploration and application of the ICT tools at the didactic process).

Biological education in experimental classes was carried out with searching methods such as work with various sources of information, modeling, laboratory method, all of them in problem strategy with ICT tools application. In control classes we used traditional methods, giving methods of teaching, such as the lecture, a speech or description, using student textbook (Table 2).

Table 2. Examples of didactic solutions in experimental (E) and control (C) classes.

No.	Topics of lessons (E &C)	Teaching contents (E & C)	Teaching methods (E)	Teaching methods (C)	Didactic aids (E)	Didactic aids (C)
1.	Heredity and changeability of organisms	Genetic. Hereditary and non-hereditary changeability. Genes, genotype, phenotype.	Problem's discussion, Work with various sources of information	Discussion	Computer programs (e.g. decision tree), Internet	Charts and foil, textbook
2.	Biosynthesis of nucleic acids	Nucleic acids. Replication of DNA and significance of this process. Biosynthesis of proteins (introduction).	Problem's discussion, work with various sources of information. Work with text and over – text's sources of information, modeling method	Discussion	Computer programs (e.g. simulation, animations), Internet	Charts and foil, textbook
3.	Genetic code and biosynthesis of protein process	Biosynthesis of protein process as a genetic expression.	Seminary, work with various sources of information. Work with text and over – text's sources of information, modeling method	Lecture	Computer programs (e.g. interactive tasks, Internet	Charts and foil, textbook
4.	Mendel's laws	Mendel's laws. Genetic crosswords – problem solving.	Method of didactic games – simulation, brainstorming, decision games, work with various sources of information, laboratory method connected with organization of observing and experiments	Lecture	Computer programs (e.g. interactive tasks and some part encyclopedic in nature), Internet	Charts and foil, textbook

During the research we used the computer programs by Potyrala and Chorazki (2001) including a set of interactive tasks in genetics together with instructions, work charts and information – encyclopedic part.

After completing the experiment simultaneously in both kinds of classes an achievement test was carried out (Table 3).

Table 3. Problems performed by students at lessons in the experimental group and appearing in student achievement test. * Student's activities mentioned in parentheses according to typology of extended answer problems according to Szaran (2000).

Student's activities	Type of situation problems (according to Dlugowiejska and Hluszyk, 1999)	Number of problem (in student achievement test)
1. **collecting information** (*analyzing [a], classifying [b], summarizing [c])	• theoretical problem, aiming at control and evaluation of the ability of integrating knowledge in various scientific areas and systematizing it in adequate structures	1a, 1b, 1c
2. **interpreting** (*justifying [a], creating [b])		2a, 2b
3. **communicating** (* synthesizing [a], comparing [b], generalizing [c], applying [d])	• problem controlling and evaluating the ability to communicate in various situations	3a, 3b, 3c, 3d
4. **hypothesis posing** (*associating reasons [a], drawing conclusions [b])	• decision-making problem, requiring the students to solve a problem situation on the basis of the possessed scientific knowledge	4a, 4b
5. **creating concepts and theory checking** (*analyzing [a], comparing [b])	• corrective problem, aiming at control and correction of problem situation	5
6. **controlling** (*generalizing [a], evaluating [b], drawing conclusions, justifying [c])	• problem aiming at control and evaluation of the degree of mastering the knowledge and skills regarding planning and predicting results of undertaken theoretical and practical activities	6a, 6b, 6c

RESEARCH RESULTS

First stage of research

Distribution of number of students according to the number of solved tasks in control and experimental class have been presented in Figures 1 & 2. As can be seen in comparison with the control class in experimental class the number of students who could solve 11 to 15 tasks has clearly increased. In class C, average number of solved tasks per student amounted to 7.2, in class E 11.1. Fraction of tasks solved in class E ($w_E = 0.740$) was considerably higher than in class C ($w_C = 0.478$) (one-tailed test comparing two proportions: $z = -8.05$, $z_{0.05}$ -1.64). This result obviously supports the conclusion that the applied educational method has significant influence on the increase in students' scientific competence (Potyrala, Wolek, 2004).

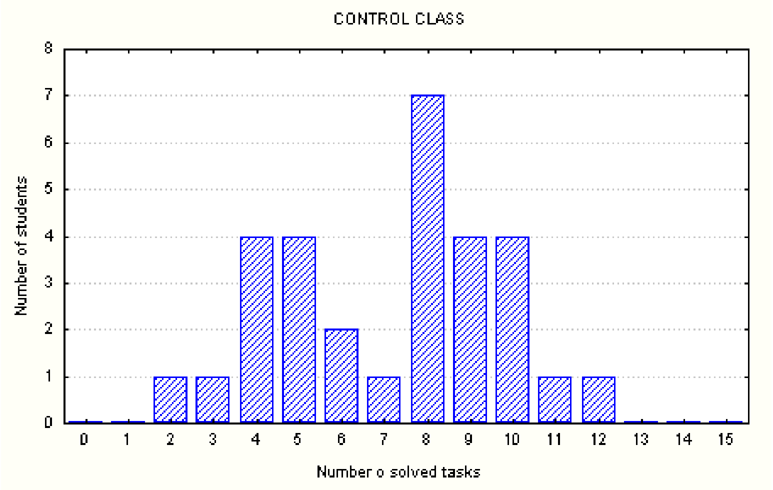


Figure 1. Distribution of number of students according to the number of solved tasks: control class, $n = 30$.

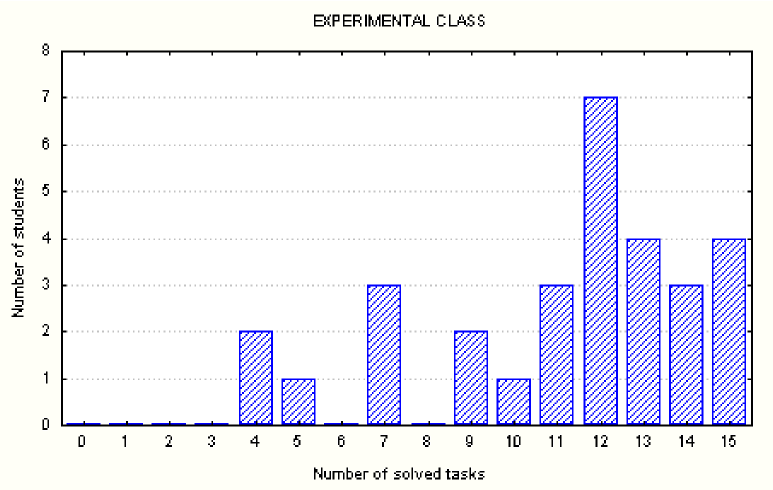
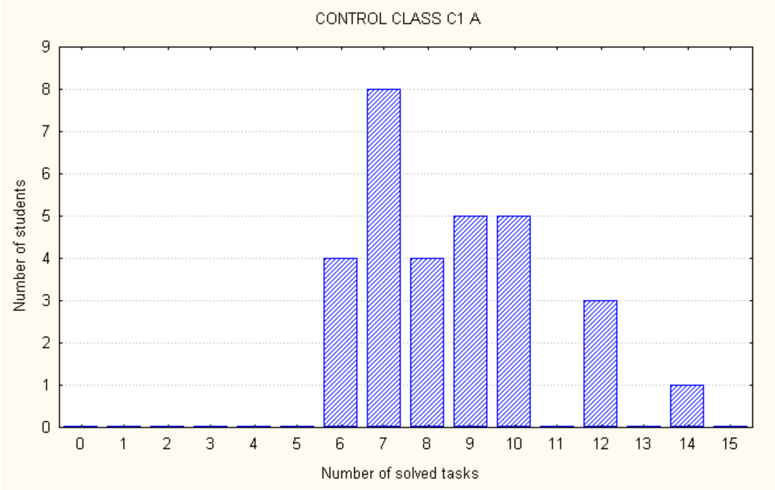
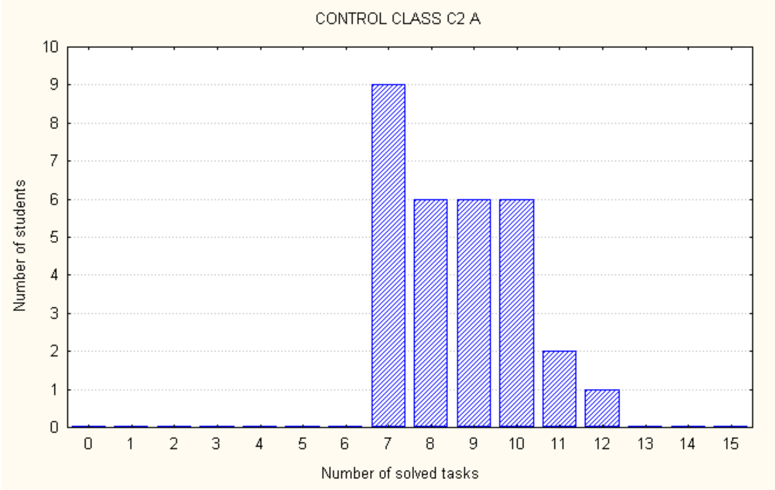
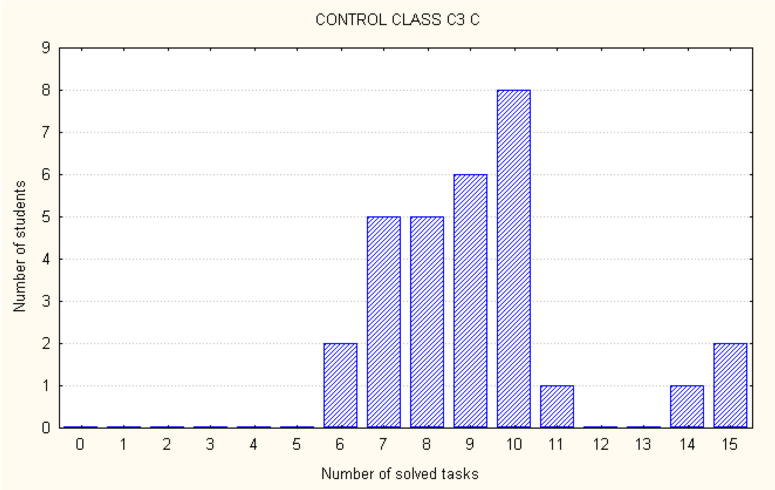


Figure 2. Distribution of number of students according to the number of solved tasks: experimental class, $n = 30$.

Second stage of research
Distribution of number of students according to the number of solved tasks in control and experimental class have been presented in Figures 3 & 4.


CONTROL CLASS C1 A
Number of students
Number of solved tasks
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


CONTROL CLASS C2 A
Number of students
Number of solved tasks
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


CONTROL CLASS C3 C
Number of students
Number of solved tasks
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

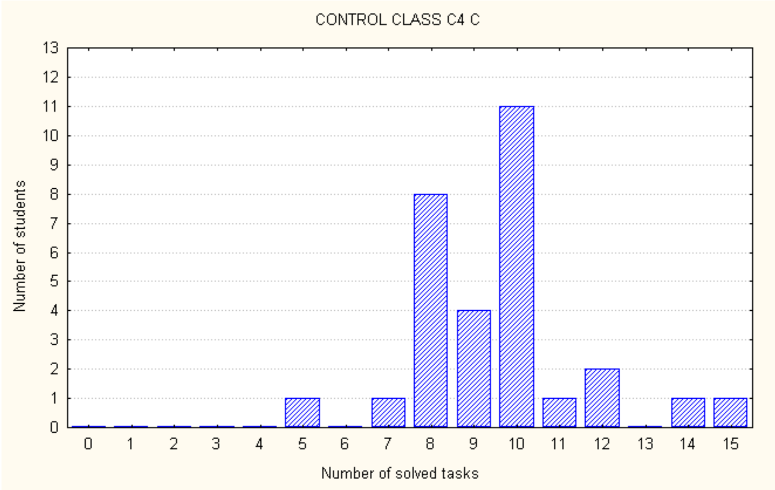
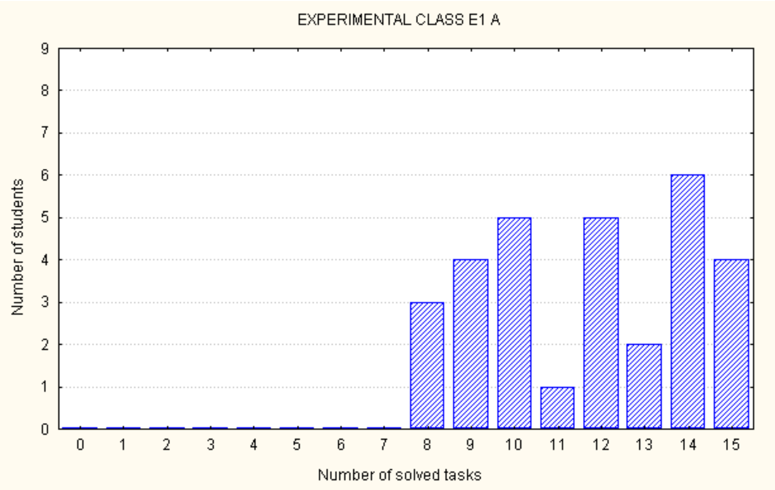
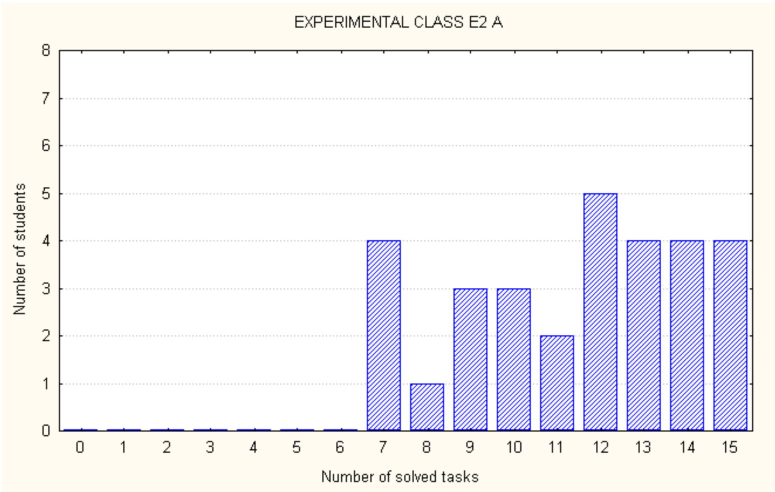


Figure 3. Distribution of number of students according to the number of solved tasks: control classes.
C1– C4 – control classes 1–4; A, B, C – teachers participating in the experiment





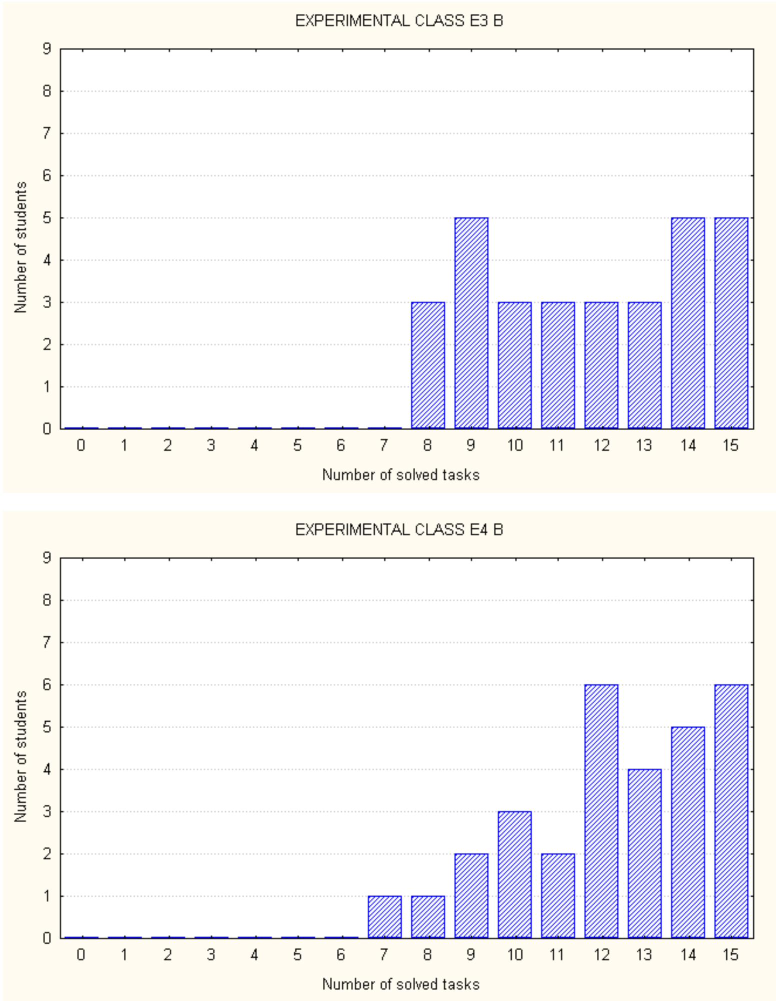


Figure 4. Distribution of number of students according to the number of solved tasks: experimental classes. E1–E4 – experimental classes 1–4; A, B, C – teachers participating in the experiment.

Similarly as in previous research (first stage) we find out that in experimental classes the number of students who could solve 11 to 15 tasks has clearly increased. The performed research confirmed previous observation that average number of solved tasks per student is always lower in control classes than in experimental classes. In all the studied cases student achievements are significantly higher than in control classes (Tables 4 & 5). Consequently, the fraction of solved tasks in control classes was lower than in experimental classes (Table 4). It is necessary to put an attention for this pattern because it is always the same independently of the teachers participating in the experiment. Obviously this result point to the fact that the applied educational method has significant influence on the didactical process (Wolek, Potyrala, in prep.).

Table 4. List of results. C1- C4 –control classes 1 - 4 ; E 1 - E4– experimental classes 1- 4; A, B, C – teachers participating in the experiment; n – number of students; k – number of the tasks in the series; $\bar{x}$ – average number of solved tasks; f – number of tasks solved in a given class; $f_{\max}$ – total number of tasks to be solved, $f_{\max} = 30 * k$; w – fraction of solved tasks, $w = \frac{f}{f_{\max}}$.

Statistics	Classes							
	C1 A	C2 A	C3 C	C4 C	E1 A	E2 A	E3 B	E4 B
n	30							
k	15							
$\bar{x}$	8,6	8,6	9,2	9,5	11,7	11,4	11,7	12,3
f	257	259	276	286	351	343	352	369
$f_{\max}$	450							
w	0,571	0,576	0,613	0,636	0,780	0,762	0,782	0,820

Table 5. Results of t-test for two independent samples. df – degrees of freedom; p – probability under H_0. The level of significance $\alpha = 0,05$ (one-tailed test). C – control classes; E – experimental classes.

$\bar{x}_C$ vs $\bar{x}_E$ ($n_C = n_E = 30$)	t	df	p
C1 vs E2	-5,449	58	0,000001
C2 vs E2	-5,080	58	0,000004
C3 vs E3	-4,147	58	0,000111
C4 vs E4	-5,044	58	0,000005

CONCLUSIONS

The interactive tasks with computer use made genetics contents easier for the students and let them identify the problems and make plans for solving them. It is important that task structure should take into account among others:

- possibility to choose the way, from experiment to theory or the other way round,
- using instruction and interactive dictionaries,
- possibility of self-control.

The criteria of evaluation of the Biology teaching computer programs have to be created in connection with the conception of these programs and the scope of teaching contents in genetics at different levels of education. It is indispensable to adapt the teaching contents in computer programs or Internet sources of information to student's age and abilities. The teaching contents should function together with other teaching contents or with some interactive tasks.

The performed research confirmed previous opinions that various means of communication applied in Biology teaching, while using ICT tools affect increasing scientific competence of students (Čipera *et al*., 1996, Unterbruner, 1999, Potyrala, 2003). During our experiment it was expressed through improving such scientific skills as for instance: gathering information and its interpretation and communication. Increase in competence makes students become capable of forming a 'scientific' problem and suggest the proper research hypothesis, and thus makes them capable of solving biological tasks.

At school what is above all taken into consideration are student achievement standards. The grade, however, is based on requirement standards, which should be comparable in the educational system. The so-called 'equality of opportunities' is one of the educational standards in the European Union countries. Its principle is among others creating such educational conditions for students that their needs can be fulfilled within a standard curriculum.

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