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Information and Communication Technologies (ICT) in Biology Teaching in Slovenian Secondary Schools

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About two-thirds of Slovene secondary schools received computers equipped with data-loggers and sensors to be used in teaching Physics, Chemistry and Biology. Later it was recognized that only a couple of Biology teachers were using the donated equipment in their classrooms or laboratories. The questionnaire, intended to investigate the situation, was posted to schools which had received a donation. Based on the answers, it was possible to assign computer applications from one of the three groups. In the first group were these applications (word processing, e-mail and internet use) towards which teachers have positive attitudes and that they do use for school work. The common element is that teachers can work at home and then use the materials in the classroom. In the second group were applications (presentations, use of data loggers, computer programmes and virtual laboratory) towards which attitudes are positive, but which teachers do not use because of the overloaded curriculum, lack of equipment, and inappropriate training. In the third group are applications (computer games and programming), about which attitudes are negative and which teachers do not use. The Introduction of such applications into teaching is at the moment far from realistic.

Keywords: Biology; Information and communication technologies; ICT; Secondary schools.

INTRODUCTION

Ability to work with information and communication technologies (ICT) is recognized as one of the key competencies necessary for success in life and competition in the labour market (Levy and Murmane, 2001; Salganik, 2001; Eurydice, 2002) which every citizen should possess (Recommendation of the European Parliament and of the Council, 2006), and term 'computer literacy' was introduced to distinguish between users and non-users of ICT (Bawden, 2001). Concerning ICT, two important roles are assigned to schools. The first is to fulfil the expectations of society for demanding ICT skills, and the second is to raise the quality of education in the schools with the support of ICT. Many scholars, teachers and teacher-trainers have recognized the potential of ICT to enhance teaching and learning, and as a side effect the number of published articles about the use of ICT in school work is enormous (Bell and Bell, 2003). However, despite significant investment in training and resources, in reality schools are still far below the level of ICT use in science, transport, communication, industry, and many other fields (Hawkins 2002; Hepp, Hinostroza, Laval and Rehbein 2004; Machin, McNally and Silva, 2007; Eteokleous, 2008).

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State of the literature

- Description of new hardware and innovative software applications designed to be used in schools are reported on daily basis;
- In most cases benefits and positive impacts of ICT on educational outcomes are reported;
- Use of computers in schools, even if available, is mosaic, and underpinned with attitudes and opinions of teachers;

Contribution of this paper to the literature

- This study suggests that perceived importance and usage of software by teachers correlate;
- Developing of new teaching tools is almost meaningless if teachers do not recognize their added value for teaching practice.
- An application will be easier transferred into a classroom if teachers can use it, test it, and prepare teaching materials beforehand at home computers.

Usage of ICT in schools is so diverse that it is almost impossible to list all possible applications. Taylor (1980, 2003) recognized three roles of computers in a classroom: as tutor, tool, and tutee. Introduction of ICT in biology lessons can raise not only level of knowledge but students attitudes toward biology as well (Haunsel and Hill, 1989; Kubiatko and Halakova, 2009). As biology (science) teachers we additionally have to distinguish between two groups of applications. In the first group are generic applications used in all subjects, like word-processing, searching for information, communication using e-mails, and multimedia presentations. In this case if a science teacher does not use ICT in a classroom damage to the students is limited because they can achieve missing skills with their work in other subjects, or at home (Kuhlemeier and Hemker, 2007). In the second group are applications adapted or developed to be used in science teaching (McFarlane and Sakellariou, 2002), like imaging systems in microscopy (McLean, 2000; Fiche, Bonvin, and Bosman, 2006), virtual dissections (O'Byrne, Patry, and Carnegie, 2008), simulations (Ramasundaram, Grunwald, Mangeot, Camerford and Bliss, 2005), virtual laboratory (Jenkins, 2004), and real laboratory exercises with data acquisition systems (Šorgo, Hajdinjak and Briški, 2008). The most important difference among these two groups of applications is that if a science teacher does not use such applications in teaching students in most cases they would not be able to compensate loss with work in other subjects or at home.

The introduction of computers into the teaching and learning in Slovenian secondary schools has followed two general tracks. The first one was the introduction of the compulsory subjects, Computer Science and/or Informatics, into the curriculum. The second one involved the use of computers in a rainbow of different subjects. The introduction of computers into student work in other subjects is encouraged by the authorities, but the final decision about their use in teaching is left to the discretion of the teachers. The difference between these two paths is that teachers from the first group are trained professionals in Computer Science and Informatics, while teachers from the second group are more or less enlightened 'computer amateurs'. Occasionally cooperation between a teacher of Informatics and a teacher from some other subject occurs and enhances student work (Šorgo and Logar, 2006).

Purpose of the study

The impetus behind our research was the knowledge that between years 2001 and 2004 about two-thirds (N = 88) of Slovene secondary schools (N = 143) received from the Ministry of Education and Sport a total of 269 computers equipped with data-loggers and a set of probes and sensors to be used in teaching Physics, Chemistry and Biology. Because the community of secondary school Biology teachers in Slovenia is small (about 150 teachers) in subsequent years it was easy to recognize that only few were using the donated equipment in their classrooms or laboratories. Because we have successfully implemented computers in our teaching and laboratory work with equipment also available to other biology teachers (Šorgo and Kocijančič 2004, 2006; Šorgo et. al., 2008) we posed the following questions: How are computers used by our colleagues at other schools and what are the obstacles to their use?' Is non-use of data loggers a special case, or does it only represent collateral damage in the general rejection of computers in school work?

MATERIAL AND METHODS

Our research concerning ICT use was part of the thesis entitled 'The influence of a Computerised Laboratory on the Quality of Biology Teaching, and the Development of Competency in High School Students' (Šorgo, 2007). Research based on the idea that besides equipment availability, which is the most often reported reason for not using computers in the SITES 2 study (Pelgrum, 2001), there must be some other underlying factors which function as barriers. Our predictions were that we should investigate the domains of teacher knowledge, experience, and opportunities. To find answers to our research questions, we prepared an extended questionnaire to be addressed to our colleagues.

Structure of the questionnaire

The questionnaire was based, in some parts, on previously used questionnaires (Computer Attitude Questionnaire; Lavonen, Aksela, Juuti and Meisalo, 2003; Paris, 2004; Nickell and Pinto, 1986; Swain, Monk and Johnson, 2000; Selwyn, 1997; Ediger, 2002). Research questions concerning ICT were addressed to the teachers. These research questions were as follows:

1) Where do teachers have access to computers when these are needed for school work?

2) How many computers and school computer sites are available to teachers for Biology teaching?

3) How often did they use computers at different school sites for Biology teaching over the last year?

4) How important to the teachers were different approaches to acquiring knowledge about computer work?

5) How often had they used different computer applications over the last three years in preparation for school work, classroom work and work with students?

6) From a teacher perspective, how important are different computer applications for teaching Biology?

7) How proficient are the teachers in the use of various computer applications.

There were different methods of answering, what depend on a research question. In first three cases teachers have to circle provided answers or fill in the numbers in blank fields. Last four tables were of the Likert type, with eighteen items each, and teachers have to answer with circling the option on five or six-point scales. In all cases we used the same list of eighteen applications and an option of "other", the difference was recorded on a scales.

First version of the questionnaire was reviewed by five secondary school teachers and according to their comments final version was assembled.

Data collection

A letter of intent was sent out in the 2005/06 school year to the principals at those secondary schools that had received computers with data loggers. After receiving permission from the principals, we sent 317 questionnaires to 56 schools. We received responses from 207 teachers, mostly these from Physics, Chemistry and Biology working at 52 schools. 70 questionnaires were answered by Biology teachers, and these responses are analyzed in our present text. The questionnaires of the Physics and Chemistry teachers are designated for later analysis.

Description of the sample

We received completed questionnaires from 70 Biology teachers. Because we received responses from about 40% of Slovenian secondary school biology teachers, our results can be recognized as representative. 37 of the respondents (52.9 %) taught at grammar schools and 28 (40%) at vocational colleges. Because of anonymity, 5 (7.1 %) teachers did not respond about the type of school. The majority of the teachers taught Biology as a single subject (N = 56; 80 %), but at vocational schools a number of teachers taught Biology in combination with other subjects like Microbiology or Chemistry. In biology teaching female teachers are in the majority (88.6 %). Teachers are, on average, 42 years old, the oldest being 60 and the youngest 24. They had, on average, 15 years of work experience and 15 teachers (21.4 %) had work experience outside schools.

Statistical analysis of the results

Because we were interested in general patterns of ICT usage in schools, we conducted our analyses with our sample as a single group, and we did not break down our group into subgroups to search for differences, for example, between genders. Results are presented as tables. Frequencies are presented as absolute numbers [N] and as percentages [%]. Results of answers measured by scales are presented as mean [M] and standard deviations [SD]. The analyses were performed with the statistical package SPSS 12.0.

RESULTS

Access to computers

All of the biology teachers who responded to the questionnaire (N = 70) have access to computers when they need this for a work: at their homes and schools (N= 61; 87.1%), at home (N = 4; 5.7%), at school (N = 4; 5.7%), and one of them (1, 4%) reported having a portable computer.

Availability of ICT for Biology teaching in schools

Teachers were asked about school sites and number of computers available for their work with students.

From the results presented in Table 1, we can recognize that a sufficient number of computers for using computer applications with a class of students (working individually or in small groups) is, for the majority of teachers, available only in Computer Science or Informatics and Multimedia classrooms. A well recognized problem is that Computer classrooms are not available for teaching Biology at optimal times.

Limitations on the use of data-loggers in such classrooms are safety (use of water, aggressive chemicals, etc.), lack of available space on the desks for experiment assembly, and the near almost impossibility

of assembling laboratory equipment for long term experiments because of computer sharing between classes.

Only five teachers reported that they had access to more than four computers in classes/laboratories that can be used for laboratory work or group work. About three-quarters of the teachers have access to a single computer (N = 51; 72.8 %) in their preparatory room. This computer is in most cases shared among all the Biology teachers at the school. Because its main purpose is teachers' work in lesson preparation and administration, student access to this computer is rarely allowed. A little more than half the teachers (N = 36; 51.4 %) have access to a computer on a trolley. This computer most often occupies a staff room and must be shared with all other teachers at the school, a factor which could definitely be a limitation on its use. Less than two-fifths (N = 27; 38.6 %) have computers with a permanent place in a Biology classroom, and only four teachers (5 %) reported having a portable computer. Only the last two groups could use ICT on demand.

Number of lessons with ICT in the last school year teachers were asked, how many lessons they had performed with the support of ICT in the last school year.

Table 1. Number of computers and school locations, where computers are available for biology teaching when required.

	Number of computers					
Location	1	2-3	4-8	9-16	16+	Total
A specialized classroom for teaching biology.	26	1				27
A specialized laboratory for teaching biology.	14		2			16
A preparatory room (office) for biology teachers.	47	2	2			51
A classroom dedicated to teaching Science subjects.	2		1			3
A Science laboratory.	5	1	2			8
Computer on a trolley or portable computer.	30	3	3			36
A Computer Science/Informatics classroom.	1		1	27	12	41
A Multimedia classroom.	9	2	4	8	1	24
Portable computer.	1	2	1			4

Table 2. Location and number of lessons carried out using computers during the last school year.

	Number of lessons				
Location	1-3	4-6	7-9	10+	Total
A specialized classroom for teaching biology.	8	5	1	11	25
A specialized laboratory for teaching biology.			2	3	5
In a preparatory room (office) for biology teachers.	1	1		1	3
In a classroom dedicated to teaching Science subjects.	1	2		2	5
In a Science laboratory.	1				1
Computer on a trolley or portable computer.	7	6	2	1	16
In a Computer Science/Informatics classroom	6	1	1	3	11
In a Multimedia classroom	1			3	4
Other classrooms	3				

Table 3. Importance of different approaches to knowledge gained from their work with computers. The mean and standard deviation on a six-point (0-6) Likert scale are reported.

Approaches to knowledge	M	SD
Self-education	4,5	0.7
At home from children, partners, or friends	3,6	1.3
Through courses offered as in-service training	3,5	1.5
From colleagues at school	2,9	1.6
Through courses offered by institutions outside school system	1,7	1.9
As a subject at university	1,3	1.5
As a subject at high school	0,8	1.2

It is clear from the results presented in Table 2 that teachers most often used ICT in their classrooms. The correlation between computer use and location in a classroom is positive r (49) = 0.44, p = 0.01. We can predict that the use of computers, at least for demonstrations and multimedia presentations, would increase if every Biology classroom were equipped with at least one computer and a projector. Our conclusion is strengthened by the lack of correlation between availability of computer in a preparatory room and their use in the classroom (r (45) = 0.07, p = 0.64) or the availability of a computer on a trolley for all teachers in the school and the number of biology lessons carried out with such computers (r(36) = 0.06, p = 0.72).

Importance of different approaches to knowledge gained from their work with computers

Teachers answered on a six-point scale about the importance of different approaches gained from their work with computers. The scale was: 0 – did not receive; 1 – very unimportant; 2 – unimportant; 3 – partly important; 4 – important; 5 – very important

We can draw conclusions about the importance of each approach from the calculated means [M].

The most important route to the computer proficiency (Table 3) was self education. (M = 4.5). Only two teachers assessed self-education as being unimportant and 42 saw it as very important. Then follows learning from partners and in the family (M = 3.5). We can connect our findings with the knowledge that the majority of the teachers prefer to fulfil obligations that do not require direct contact with students, colleagues or parents (preparation or assessment of students work, etc.) at home, so they can fix a problem with ICT without delay, in most cases by themselves or with family help. School-supported in-service training offered by the Board of Education was

Table 4. Frequency of use (F), perceived importance (I) of and proficiency (P) in computer use for school work.

	F		I		P	
Application	M	SD	M	SD	M	SD
Word processing	4,1	1,1	4,3	0,9	3,9	0,9
Searching for information on the internet	3,9	1,1	4,3	0,7	3,6	1,0
e-mail	3,7	1,3	3,8	1,0	3,9	0,9
Participation in forums or in interest groups	1,4	0,8	1,8	1,5	1,5	0,8
Viewing films, or photos; listening to music	2,1	1,2	2,9	1,3	2,9	1,2
Processing of your own films, pictures, etc.	2,0	1,1	3,2	1,1	2,5	1,2
Statistical packages (SPSS, Statistica, etc.)	1,3	0,5	1,9	1,3	1,6	0,9
Multimedia	2,2	1,1	3,5	1,3	2,6	1,2
Spreadsheets (Excel, Access, etc.)	1,7	0,9	3,1	1,4	2,3	1,2
Maintaining a web page (FrontPage, FTP, etc.)	1,3	0,8	2,6	1,4	1,3	0,8
Presentations (PowerPoint, etc.)	2,8	1,4	4,4	0,7	3,1	1,3
International e-projects (Net Days,etc.)	1,2	0,6	2,6	1,6	1,4	1,0
Computer simulations and virtual laboratory	1,4	0,7	3,5	1,2	1,8	1,0
Programming (Basic, Pascal, C,etc.)	1,0	0,2	1,3	1,2	1,1	0,4
Programmes for drawing (Paint, etc.)	1,3	0,5	2,2	1,4	1,6	0,8
Games	1,2	0,7	1,3	1,0	1,8	1,1
Interactive programmes dedicated to school	2,0	0,9	3,8	1,2	2,9	1,2
Computer based laboratory (data-loggers)	1,4	0,8	4,0	1,1	1,8	1,0

F = Frequency; I = Importance; P = Proficiency

Table 5. Correlations between frequency of using a computer application for school work, perceived importance, and teachers' proficiency in use of application. All correlations are significant at p < 0.001 level.

	Frequency	Importance	Proficiency
Frequency	1	0.737	0.949
Importance	0.737	1	0.765
Proficiency	0.949	0.765	1

assessed more important than help from colleagues. The low importance placed on knowledge gained in schools can be seen in the fact that subjects both in high school and university left teachers almost untouched.

Use of computers for school work

We were interested in the frequency of use, perceived importance of and proficiency in the use of various computer applications. In all three cases we used the same list of eighteen applications and an option of "other", the difference was recorded on a scales.

The first question was: How often have you used the computer in last three years in your preparation for school work, work in the classroom and in work with your students (seminars, homework, communication, etc)? Teachers answered on a five-point scale: 1 – never; 2 – a few times in year; 3 –once or twice a month; 4 – once or twice a month a week; 5 – more than twice a week

The second question was: In your opinion, how important the use of computers in your preparation for school work, work in the classroom and in work with your students (seminars, homework, communication, etc)? Teachers answered on a five-point scale: 1 – very unimportant; 2 – unimportant; 3 –neutral; 4 –important; 5 – very important.

The third question was: How would you grade your proficiency in working with computers? Teachers answered on a five-point scale: 1 – no experience; 2 – satisfactory; 3 – good; 4 – very good; 5 – excellent.

The most often used application in school work (Table 4) is a word processor, which is used at least once a week by 74.3 % (N =52), but never used by two teachers (2.9 %), followed by searching for information on the internet, which is performed at least once a week

Table 6. The difference between the importance (I) given to computers and their usage (U) for school work. Means and difference between the means (D) are reported

Application	I	U	D
Presentations (PowerPoint, etc.)	4.4	2.8	1.6
Searching for the information on the internet	4.3	3.9	0.4
Word processing	4.3	4.1	0.2
Computer based laboratory (data-loggers)	4	1.4	2.6
e-mail	3.8	3.7	0.1
Interactive programmes dedicated to school	3.8	2	1.8
Computer simulations and virtual laboratory	3.5	1.4	2.1
Multimedia	3.5	2.2	1.3
Processing of your own films, pictures, etc.	3.2	2	1.2
Spreadsheets (Excel, Access, etc.)	3.1	1.7	1.4
Viewing films, or photos; listening to the music	2.9	2.1	0.8
Maintaining a web page (FrontPage, FTP, etc.)	2.6	1.3	1.3
International e-projects (Net Days, etc.)	2.6	1.2	1.4
Programmes for drawing (Paint, etc.)	2.2	1.3	0.9
Statistical packages (SPSS, Statistica, etc.)	1.9	1.3	0.6
Participation on forums or in interest groups	1.8	1.4	0.4
Programming (Basic, Pascal, C, etc.)	1.3	1	0.3
Games	1.3	1.2	0.1

I = Importance; U = usage; D = Difference between means

Table 7. Relationship between usage and perceived importance of computer use.

		IMPORTANCE	
		Do use (+)	Do not use (–)
USAGE	Important (+)	+ +	+ –
	Unimportant (–)	– +	– –

by 67.2 % of teachers (N = 47), but never in the case of two teachers (2.9 %). In third place is e-mail which is used at least once a week by 60 % (N=42) of teachers but never used by six teachers (8.6 %).

From the results presented in Table 4, we can conclude that teachers assess the importance of computer applications in a school work in a different order. At the top are presentations (M = 4.4; SD = 0.7), information searches (M = 4.3; SD = 0.7), word processing (M = 4.3; SD = 0.9) and the computer based laboratory (M = 4.0, SD = 1.1). The perceived importance of presentations and information searching is supported by the finding that nobody assessed these two applications as unimportant or very unimportant. At the bottom of the list come programming and games.

According to their own opinion, teachers (Table 4) are most proficient at word processing (M = 3.9, SD = 0.9), use of e-mail (M = 3.9, SD = 0.9), searching for information (M = 3.6, SD = 1.0), and presentations (M = 3.1, SD = 1.3). Only one teacher reported that (s)he had no experience with e-mail, and ten reported that they had no experience in preparing presentations. Any knowledge of computer programming has almost been lost, even though we know that, at least for some of the younger teachers, it formed part of the syllabus in high school Computer Science.

DISCUSSION

From the results of our study we were able to recognize that our biology teachers are in line with the main stream in introduction of ICT into teaching routine around the world and investment in computers does not guarantee their later use inside the classroom (Hawkins, 2002; Resnick, 2002; Hepp et al., 2004).

We can conclude that teachers use computers for school work mainly as typewriters, as a source of information and a communication tool, for their preparation, tests and administration outside the classroom, most often at homes. In the classroom paper copies of work-sheets or tests may be used later but rarely presentations. Additionally the conclusion that teachers only rarely use computers in instruction is supported by the case of programmes for presentation (PowerPoint), which occupy a high fourth place, but which are used more than once a week by only one teacher; twenty teachers (28.6 %) use such programmes a few times in a year, and 49 (70%) never. For all other applications, we should use the word "occasionally".

Because we were primary interested to find obstacles in introduction of computer supported laboratory, we can make similar conclusion as McFarlane and Sakellariou (2002) for England and Wales 'that data loggers remains token rather than having found a place in routine science classes'. The situation in Slovenia is quite similar to the situations following the introduction of data-loggers in England (Newton 1999, 2000) or Australia (Ng and Gunstone, 2003). The reason is that the most important factor in the implementation of computers in teaching and learning is whether a teacher can or cannot arrange appropriate teaching opportunities for using ICT in a classroom or laboratory (Pelgrum, 2001; Binlingam, 2009).

Teachers make their decisions about use of ICT applications on the individual basis and use of one application does not mean that some other application will be used, and upgraded version of an application will be welcomed (Zhang, Aikman and Sun, 2008). The correlations between use of computers in a school, its perceived importance for school work and proficiency in such work are highly significant (Table 5). So we can say that teachers will in most cases use ICT for work with students if they recognize an application as important, and are in a same time proficient in its use.

However from the correlations alone we cannot predict use of an application in the classroom. We can gain additional insight into the connection between importance and actual use of an application for teaching if we investigate the difference between the means of its importance for the teachers and its actual use in teaching (Table 6). Theoretically, it was possible to form four main groups of computer applications on the basis of the difference between their perceived importance and their actual use in the classroom (Table 7).

In the first group are applications that are recognized as important and that teachers are using on average at least once in month (values over 3). We put into this group applications where the calculated difference between usage and importance was less than one. In our case members of the first group include work with word processors, use of e-mail, and internet searching for information.

In the second group are applications that are recognized as important or very important and that teachers do not use regularly (values less than 3). We put into this group applications where the calculated value of the difference between importance and usage was more than one. In this second group are computer-based laboratory, work with presentation programmes, computer simulations and virtual laboratory, and specialized programmes dedicated to teaching.

The third group should comprise applications that would be recognized as unimportant or very unimportant and that teachers would use. The difference should be a negative number. We did not find any application that could be assigned to the third group. However we can expect the emergence of such applications in the near future when some applications will became obligatory. Teachers may not find such an application useful but will be obligated to use it (for

example, computer-supported administration of absenteeism).

The fourth group comprises applications that are recognized as unimportant and that teachers do not use. The difference between means is, as in the first group, less than one. Games and computer programming are typical members of this group.

Recognition of the difference can be important in the introduction of an application into a school. We can predict that in a case where teachers recognize an application as important and do not use it, there must be underlying barriers and obstacles that must be eliminated. In most cases the barriers are related to overloaded curriculum and lack of computers or appropriate training or support. In cases where teachers do not recognize an application as important, there is no use giving them such an application. They will not use it anyway. So the first step in introducing such an application in a school is to make it important to the teachers. It can be suggested that teachers are likely to adopt practices with computers that are in line with their beliefs about teaching (Tondeur, Hermans, van Braak, Valcke, 2008).

CONCLUSIONS

From the results, we can say that most Slovene biology teachers know how to use computers at least on a basic level and are using them at least occasionally. Here or there some non-users may persist, but with additional compulsory applications (school administration, e-mail contact with parents, etc.), we can predict that such teachers will became an extinct rarity. The majority of teachers have access to computers at home and in their schools. From the results, we can conclude that teachers use computers for school work predominantly as advanced typewriters, for communication and as desktop libraries. Because of the insufficient number of computers in schools, which must be shared between teachers, the major part of computer work is done at home.

The situation is different when computers are to be used in the classroom. Schools are generally well equipped with computers for instruction in Computer Science and Informatics, but not for teaching Biology. The majority of biology teachers have access (besides the school library or staff room) to one computer in a preparatory room, which is normally unavailable to students. Computers situated outside Biology classroom do not guarantee their use in Biology instruction. There is a positive correlation with the use and availability of computers only if they are located in a biology classroom or laboratory. But even then possession of the equipment is only a prerequisite and not a guarantee that it will be used for instructions. At the time of our study data-loggers were available to all biology teachers in the sample, but only a quarter (28.5%) of them ever used the donated equipment.

Knowing this, we can conclude that the number of demonstrations and presentations will increase over time with the installation of additional computers in classrooms, but will increase significantly only in cases when the teachers will be able to prepare materials for instruction at home and use these later on stationary computers with the projector in a classroom. Portable computers and computers on trolleys that must be transported to the classroom and that need to be installed before the class will be used only sporadically. Those applications that are unavailable at home (data-loggers) or that need longer preparation time in school are condemned to disuse.

Providing a sufficient number of computers is only the first step. In our opinion, a more important barrier to the wider use of computers is teacher perception of the importance of an application, as well as teachers' proficiency. The optimal combination is proficiency in using an application and a sense of its importance. This combination applied to teachers' conceptions of word processors, internet searches and e-mail. An additional factor that can enhance use of these applications is help from the family when needed, because such programmes can be used for private purposes as well. For school work, such use of ICT can add value to teacher preparation, the search for information, or administration, but is of limited importance for teaching and learning. For example, it is fine to prepare tests with a word processor, and it is great to have a database of previously used questions, but at the end of the day, the task will be same as if it were written with ink.

The other group includes programmes that are already recognized as important, but that teachers rarely use in the classroom. Beside the buying computers the magic circle what must be broken is this: because they do not use them, they do not feel comfortable using them, so they do not use them. Unfortunately these are programmes that can be used in direct instruction, and can be of help in raising the quality of teaching and learning. There is no need to send apostles to the teachers preaching the importance of such programmes but, instead experts to help with problems. We believe that the best solution can be found in presentations. Teachers will make more frequent use of these when every classroom will be equipped with a computer and an overhead projector. Work with interactive programmes dedicated to school, computer simulations and virtual laboratory, and computer based laboratory (data-loggers) can all be introduced into teaching in the optimal way, when students can work alone, in pairs or small groups. The same is true for sources available online. As long as Biology teachers do not have access to fully equipped computer laboratories on the demand, they will not use them. But even in this case we think

that the solution lies with the internet. It is very unlikely that anyone would get help in using of these programmes from family members, and this may help to limit their use.

At the moment, maintaining home pages is within the capacity of only a few teachers, and the introduction of educational computer games or programming into biology teaching is far from realistic.

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