THE COMPUTER EXPERIMENT IN SCHOOL AS A METHODOLOGICAL TOOL IN SCIENCE EDUCATION

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Nowadays our life is dynamically changing on the way to the information society. Successful modern economics requires specific improvements of qualification skills and their adaptation to contemporary achievements of the scientific and technical progress. Due to modern development of Information and Communication Technologies the traditional science subjects in school education increase their experimental content. Concerning Chemistry and Physics for example, no doubt, that teaching could not be effective without practical demonstrations. The new task here is to implement computer systems more profoundly, not only with presentation aims. As for Mathematics the computer experiments turn out to be crucial. Even more, the new technologies give possibilities to transform Mathematics to an experimental subject like Chemistry and Physics, which are such for a long time already. We will give an example.

Consider the problem of exchanging one dollar into cents, which could be formulated in the following way:

How many are the different solutions of the Diophantine equation
$$100 = x_1 + 2x_2 + 5x_3 + 10x_4 + 20x_5 + 50x_6,$$
where $x_1, ..., x_6$ are unknowns, taking non negative integer values? Here denotes the number of 1-cent coins, is the number of 2-cent coins and s. o.

This problem is among the most popular in the well-known Mathematics and Informatics books. It could be found for example in Paragraph 7 of [1] from the time before the appearance of the personal computers. It is not surprising that the authors of the cited title assert that «very often the efforts to solve this problem are discouraging because of the almost lacking hope to be fully successful».

It is more than definitive that it is suitable for students to solve the above problem and similar to it from the curricular material by computer programs that have been created by themselves for the purpose. A corresponding programming language which is appropriate of using by secondary students should answer to several criteria. Firstly, such a language should be easy to the maximum extend. A student should not meet difficulties when applying it. Further, it should be largely applicable in order to convince students in learning something which is of every day use all over the word. The language should be accessible too not including requirements for additional software installation. For several years such a programming language exists and this is JavaScript.

The language JavaScript is maximally easy for perceiving and use. Only a small part of it is necessary in writing computer programs for Mathematics solving problem. Such a part could be learned quickly. In addition, JavaScript is the most largely used programming language, presently being the language for programming in Internet on the part of clients. The majority of websites in the world now use JavaScript [2]. This language satisfies also the condition to be possibly used without additional software installation. A browser is sufficient and each computer has a browser nowadays.

Another programming language to compete with Java is PHP, which is ranked secondly in spreading. PHP is a server-side scripting language designed for web development but also used as a general-purpose programming language. PHP is now installed on more than 244 million websites and 2.1 million web servers [3]. The number increases during the last 10 years. Like JavaScript, PHP is designed to serve Internet, which determines its possibilities. It is simple to the maximum degree both for

learning and using. Also, only a small part of it is necessary in successful Mathematics problem solving. An advantage of PHP with all respect to JavaScript is its magnificent system for fixing bugs, which is a part of the language. If the consumer admits a fault in the code, the system detects it and shows the exact row where the code is incorrect. Such a possibility is of great convenience.

An advantage of PHP is also the existence of hundreds of base functions for work with strings and arrays. Such an advantage is of essential importance for some mathematical problems. Other advantages exist too, for example the possibility to use different data bases jointly. Mainly, it is applied together with the MySQL-database. A deficiency of the pair PHP-MySQL is that Internet and hosting are needed for the use of these software tools, i.e. special software is needed to be installed on the computer. Presently, there are ready programs of WAMP type, which could be installed by simple mouse click. Afterwards, PHP and MySQL could be applied without any problem. According to statistics, the most wanted developers in the world were programmers in PHP.

All listed technologies are free software and consumers are not requested to pay for them. By the way, this is one of the reasons for the success of the technologies in question. Other programming languages are offered too, mainly to universities. A professional programmer should know C/C++ and Java, obligatorily. Actually, concerning mathematical problems, PHP has an advantage with respect to C/C++, Java and JavaScript. Namely, in PHP there is an Wall-type library for work with numbers of arbitrary accuracy. However, this advantage is without any significance for school mathematical problems, because such problems require limited accuracy of the solutions up to five or ten exact digits after the decimal comma in decimals. Anyway, the possibility to obtain solutions with hundred or thousand exact digits after the decimal comma seems attractive.

We should note that PHP, MySQL and JavaScript are platform independent, i.e. they could be used with each operational system. This is an important circumstance, because some of the offered programming

languages by various companies, like C#, Visual Basic, variants of C/C++, Java etc., depend on company decisions, while practice shows that very often similar technologies are not supported later and could not be used.

One could apply the programming language PHP to solve the above mentioned problem. Actually, to write the corresponding computer program means to describe the way the problem should be solved. The clear description is known to be algorithm. Concerning the transformation of the algorithm into a code in a programming language is a straight line procedure, which could be well learned easily after a certain short training.

We should be acquainted with the notion of array. Using 1-cent coins we need 100 coins at most. For this reason we define an array, denoted by $X1$, whose elements are the integers 0, 1, 2, ..., 100. Similarly, using 2-cent coins we need 50 coins at most. Thus, we define the corresponding array $X2$ with elements 0, 1, 2, ..., 50. The next arrays are $X3$, ..., $X6$, whose elements are the types of coins with corresponding numbers. Here is the code:

```php
<?php
echo "Money-exchanging problem.<br>";
echo "Given 1 dollar and denominations of 1,2,5,10,20,50 cents.<br>";
for ($i = 0; $i <= 100; $i++)
{
$X1[$i]= $i;
}
for ($i = 0; $i <= 50; $i++)
{
$X2[$i]= $i;
}
for ($i = 0; $i <= 20; $i++)
{
$X3[$i]= $i;
}
for ($i = 0; $i <= 10; $i++)
{
$X4[$i]= $i;
}
for ($i = 0; $i <= 5; $i++)
{
```

```
$X5[$i]= $i;
}
for ($i = 0; $i <= 2; $i++)
{
$X6[$i]= $i;
}
```

We are ready to check whether a 6-let of non-negative integers is a solution of the problem. For each possible 6-let computations are carried out by the computer. The 6-lets, which are solutions, are included into an array denoted by $A. We define also a variable, denoted by $n, whose values are the numbers of the elements in $A. For the purpose one could use the built-in PHP function **count()**:

```
foreach ($X1 as $x1)
{
foreach ($X2 as $x2)
{
foreach ($X3 as $x3)
{
foreach ($X4 as $x4)
{
foreach ($X5 as $x5)
{
foreach ($X6 as $x6)
{
$c = 1*$x1 + 2*$x2 + 5*$x3 + 10*$x4 + 20*$x5 + 50*$x6;
if ($c == 100)
{
$A[] = "($x1,$x2,$x3,$x4,$x5,$x6)";
}}}}}}}
$n = count($A);
```

It remains to visualize the solution on the browser screen, i.e. to visualize the elements of the array $A:

```
echo "<br>Answer:<br>";
echo "There are $n exchanges.<br>";
echo "List of all exchanges:<br>";
```

```
for ($i = 0; $i < $n; $i++)
{
$j = $i + 1;
echo "$j.   $A[$i]<br>";}
?>
```

The answer is produced as a HTML file, and if we want, we could copy this file to the computer disk. Here is a part of the browser screen in the case of the Bulgarian currency lev and stotinka, corresponding to dollar and cent:

Money-exchanging problem.
Given 1 lev and denominations of 1,2,5,10,20,50 stotinki.

Answer:
There are 4562 exchanges.
List of all exchanges:
1. (0,0,0,0,0,2)
2. (0,0,0,0,5,0)
3. (0,0,0,1,2,1)
4. (0,0,0,2,4,0)
5. (0,0,0,3,1,1)
6. (0,0,0,4,3,0)
7. (0,0,0,5,0,1)
8. (0,0,0,6,2,0)
9. (0,0,0,8,1,0)

Thus, we see that 1 dollar could be exchanged into cents in 4562 different ways. The first of the above 6-lets announces that 1 dollar could be exchanged into two coins of 50 cents, the second – 1 dollar could be exchanged into five coins of 20 cents and so on. Of course, it depends on our choice what should be the visualized type of the answer according to its definition in the code.

The problem of exchanging one dollar into cents is the only one of many illustrations showing the difference between writing a code and computation. To ask the computer to carry out computations is one thing, while doing computations by ourselves is another thing. The first one is easier almost always. In the example under consideration the code is on one page totally, while the answer requires one hundred pages in the file,

which is in PDF format. Not always the difference is as large as in this problem but almost always we are awarded by the circumstance to save the computations. And something else, once written the computer program could be used frequently with some small changes eventually.

THE MAIN THESIS

After the entering of computers into school, strong possibilities appear to make education more effective. It is suitable for students to solve problems from the curricular material and beyond it by computer programs that have been created by themselves. Corresponding activities could start just after perceiving basic knowledge in Informatics. It should be noted however, that writing of programs for solving problems requires only a small part of a programming language. Also, students do not need full acquaintance with the Informatics curricular material in order to understand and to apply this small part. For such reasons the use of programming language in solving problems could start early in lower grades. This concerns not only Mathematics, but also Chemistry, Physics and the other subjects.

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