HOW TO TEACH THE FUNDAMENTALS OF INFORMATION SCIENCE, CODING, DECODING AND NUMBER SYSTEMS?

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Abstract: *The* Introduction of Informatics *subject deals with the rudiments of informatics within the education system of the College of Nyíregyháza where* informatics teachers *and* programmer mathematics *are trained as well. The problem that made us examining the subject is that there has been high rate of failed exams in this subject since years. In the first semester of 2004/2005 the 83% of the examinees failed at the first exam and after the 2^{nd}, 3^{rd} or 4^{th} exam still the 47% of the students were unsuccessful.*

The aim of this paper is to a) introduce the content, the requirements and the concrete exam requirements of the Introduction of Informatics subject, b) the mathematical background of the exercises and c) the solutions of one basic exercise of the test. Based on 646 test papers we try to determine the most common mistakes and based on the experience we make suggestions.

Keywords: informatics, education, numerical systems.

1. INTRODUCTION

Within the training system of the College of Nyíregyháza for *informatics teachers* and *programmer mathematics* the *Introduction of Informatics* subject that is about rudiments of informatics is an obligatory subject in the first semester. There is 1 lecture in every week, the number of the credit points is 2 and at the end of the semester the examinees have to take terminal examination. The problem that that made me examining the subject is that there has been high rate of failed exams in this subject since years.

The exam results of the first semester of the year 2004/2005, as it follows:

At the first exam there were 349 students with the following results:

excellent: 2 people good: 10 people satisfactory: 13 people pass: 31 people

unsatisfactory: 293 people; *average: 1,27*

The following diagram shows the marks of the first exam in percentage:

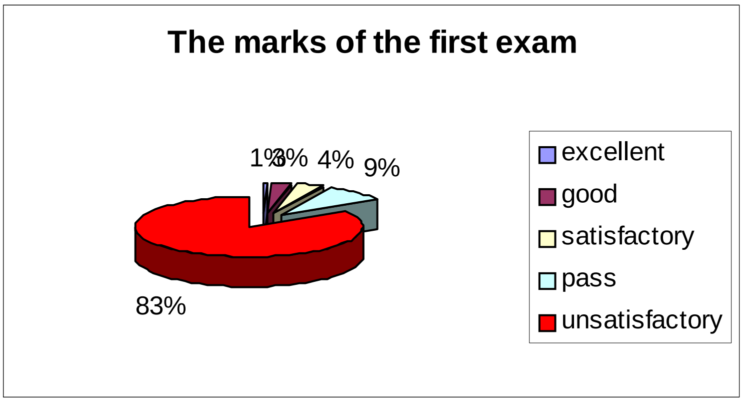

Figure 1. *The results of the first exam*

At the end of the examination season (after 2-3-4 repeated exam) not more than 47% of the students concerned passed the examination.

The total results can be seen below:

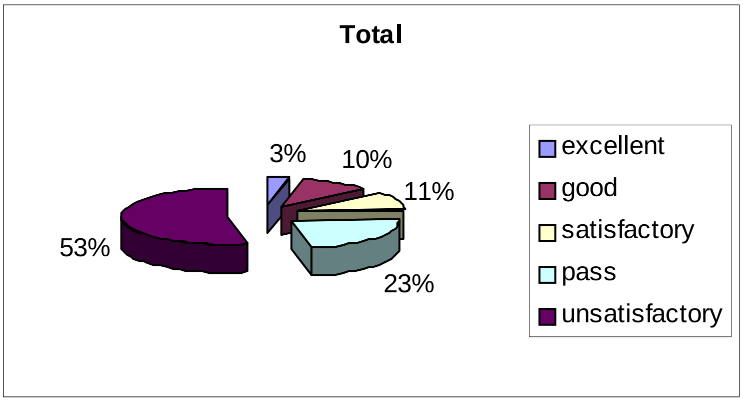

Figure 2. *Total results*

2. THE CONTENT OF THE SUBJECT, THE METHOD OF EXAMINING

2.1. The main aim of the subject is to make the students familiar with the theoretical base and technical terms of informatics.

To recapitulate: *I. The computer and the algorithm:* The notion of the computer, the Neumann-principles, inner build-up of the computer, the peripheral devices; The notion of algorithm, descriptor devices, complexity. *II. Information and data representation:* Measuring the information, entropy, decimal value number representation, numerical systems, fixed point representation, floating point representation, decimal representations, logic data, character, string representation, logic operations and their truth tables, logic operations of fixed point numbers. *III. Data structures and their representations:* Linear data structures: arrays, linked lists, ordering, special linear data structures: stack, evaluation of postfix expression, transform infix expression to postfix, progression.

Non-linear data structure: record data structure, graph data structure

2.2. The terminal examination is in written form. The test (10 exercises) has to be solved within 30 minutes and calculator cannot be used. The examinees get the test in printing, they can count on the test, the results should be copied in a box beside the exercises. During the correction these results are taken into consideration. The maximum points for the exercises are 0, 0,5 or 1 point. The marks depend on the points and are counted the following way:

9,5-10 excellent (5) 8,5-9 good (4) 7,5-8 satisfactory (3) 6,5-7 pass (2)

To be able to solve the exercises of the test the following knowledge is required:

1. Convert from decimal system
2. Convert to decimal system
3. Conversion infix expression to postfix
4. Conversion to binary complement
5. Counting information content
6. Logic operations
7. Convert from floating point form
8. Convert to floating point form
9. Convert between numerical systems
10. Conversion from binary complement

It can be seen from the test that the most stressful – expect two exercises it occurs in every exercise – topic is the *numerical system* topic.

If we take into consideration the efficient solutions we can draw the conclusion that expect the exercise 10. less then 50% of the students can solve the exercises (the average is under 40%!). The following diagram shows the efficiency by exercises:

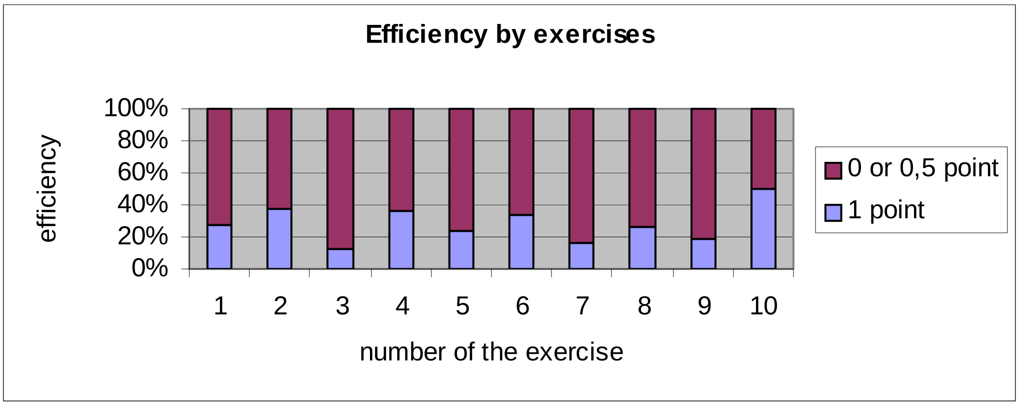

Figure 3. *Efficiency by exercises*

3. MATHEMATICAL BACKGROUND OF THE EXERCISES [1]

3.1. The notion of the decimal value numerical system

The *r* based decimal value numerical system is defined by the following theorem:

$$(\ldots\bar{a}_2\bar{a}_1\bar{a}_0.\bar{a}_{-1}\bar{a}_{-2})_r = \sum_{i=-\infty}^{\infty} a_i r^i = \cdots + a_2 r^2 + a_1 r + a_0 + a_{-1} r^{-1} + a_{-2} r^{-2} + \cdots \qquad (1)$$

The number r is the base figure of the numerical system, the signs $\overline{a}_i$ are the numerals of the number, the a_i number marked by the $\overline{a}_i$ is called the formal value of the number, the r^i power is the decimal value of the number $(i = 0, \pm 1, \pm 2, ...)$, and . is the point of reference.

3.2. Switch from one numerical system to another one

3.3. theorem

Let $r \geq 2$ be a natural number. In this case an arbitrary $v \geq 0$ real number can be noted in the r based decimal value numerical system

$$v = (\overline{a}_n \overline{a}_{n-1} ... \overline{a}_2 \overline{a}_1 \overline{a}_0 . \overline{a}_{-1} \overline{a}_{-2} ...)_r \qquad (2)$$

form, where $0 \leq a_i \leq r-1$ natural number for all $i = n, n\text{-}1, \ldots$ and $a_n \neq 0$, if $n \geq 1$. v integer part:

$$[v] = (\overline{a}_n \overline{a}_{n-1} ... \overline{a}_2 \overline{a}_1 \overline{a}_0 . \overline{0})_r , \qquad (3)$$

fractional part:

$$\{v\} = (\overline{0} . \overline{a}_{-1} \overline{a}_{-2} ...)_r . \qquad (4)$$

Let $v \geq 0$ is a given number in the R based numerical system. Define the numerals of v in the r based numerical system.

First define the numerals of v integer part: based on the theorem 1.3. $[v]$ can be written

$$a_n r^n + a_{n-1} r^{n-1} + \cdots + a_1 r + a_0 \qquad (5)$$

form, in another way

$$(...((a_n r + a_{n-1})r + a_{n-2})r + \cdots + a_1)r + a_0 \quad (6)$$

Perform the residuum division with r ; the residuum – based on their increasing decimal value – give the formal values of the numerals in the r based numerical system:

$$\begin{aligned} [v] &= v_1 r + a_0 \\ v_1 &= v_2 r + a_1 \\ v_2 &= v_3 r + a_2 \\ &\vdots \\ v_{n-1} &= v_n r + a_{n-1} \\ v_n &= 0r + a_n \end{aligned} \qquad (7)$$

Now define the numerals of the fractional part of v : based on the theorem 1.3. $\{v\}$ can be written in

$$a_{-1} r^{-1} + a_{-2} r^{-2} + \cdots \qquad (8)$$

form. Thus

$$\{v\} \cdot r = a_{-1} + a_{-2} r^{-1} + \cdots , \qquad (9)$$

where the integer part of $\{v\} \cdot r$ is a_{-1}, the fractional part is $a_{-2} r^{-1} + \cdots$. Multiply by r the fractional part of the products of multiplication. These products are always from the preceding steps. The integer part of the products give – by decreasing integer part – the formal values of the numerals in the $\{v\} \cdot r$ based numerical system.

Since we did the operations in the origin (*R* based) numerical system the formal values of numerals as the results of the steps taken are also in this numerical system. After this we write the numerals which mark the formal values of the numerals in the *r* based numerical system, in the places of the formal values: so we get the form of *v* in the *r* based numerical system.

4. THE COMMON MISTAKES IN THE EXERCISE 1.

The concrete exercise: *Convert the given number from decimal system to numerical system of based thirteen in a way that the fractional should be 3-digit correct! The number is:* $\mathbf{126.23_{10}}$

~The students note the exercise wrongly, they do not count with the numbers in the exercise.

~Counting mistakes

- The most of the counting mistakes occur in the dividing. The students determine wrongly the numerals in the quotient or the residuum, but mostly both. They cannot do division with 2-digit divisor confidently.
- In the multiplications the typical counting mistakes that primary school students also often make are frequent, for example: 9 x 9 = 18; 6 x 3 = 12.

  They have problem in multiplying with 2-digit number, they multiply the multiplicand with only one decimal value. Very frequently they define wrongly the place of the point of reference (decimal point).

~ Defectiveness in the rudiments of mathematics

  In some test there are mistakes that indicate the defectiveness in the rudiments of mathematics.

~ Defectiveness of making algorithm

5. MISTAKES IN COUNTING THE INTEGER PART

Most of the students (7) use algorithm to count the integer part. Occurring mistakes:

5.1. The student applies the algorithm properly, counts correctly, but the result or the part of the result is wrong.

5.2. The student chooses good algorithm, applies it well, counts correctly but does less division than required.

5.3. The student chooses good algorithm, but unable to execute it correctly. He or she confounds the place of the quotient or the residuum in the same exercise several times.

5.4. He or she tries to use the algorithm in the exercise 2. based on the decimal values of the decimal numerical system or the numerical system of based thirteen.
5.5. The student does not use the algorithm acquired. He or she divides the integer part by 13 and chooses the quotient and residuum as results.

6. MISTAKES IN COUNTING THE FRACTION PART

6.1. The student chooses good algorithm, uses the algorithm well, counts well, interprets the result badly.
6.2. He or she puts the fraction point at the wrong place in the product.
6.3. He or she counts with the integer part in the multiplications.
6.4. He or she uses the same algorithm (divisions) for counting the fractional part and the integer part.
6.5. The student writes down the following relation: $0.4210 = 0.abc = a \cdot 13^{-1} + b \cdot 13^{-2} + c \cdot 13^{-3}$
6.6. He or she multiplies by 13 or 3 by turns.
6.7. The multiplication is good, but the taking down is wrong.
6.8. The student counts the fractional part with the algorithm used in the exercise 2.

7. THE REASONS OF FAILURES

7.1. Their previous mathematical knowledge is imperfect.
7.2. The students' problem-solving and algorithm using ability is in low level.
7.3. There is a big difference between the abstraction level of the new and the previous knowledge.
7.4. One lecture a week is not enough to practise the empirical exercises beside the theory.
7.5. Probably the learning methods of the students are not convenient.
7.6. The students do the algorithms mechanically and unable to interpret the results.
7.7. They are not familiar enough with the algorithm or the way the algorithm is written down is embarrassing because it is different from the common form of the division or the multiplication.

8. REFERENCES

[2] Knuth: Art of Computer Programming, Volume 1 Műszaki Könyvkiadó Budapest.
[1] Dr. Várterész Magda: Matematikai programozás (főiskolai jegyzet)