

Increasing Mathematical Skills and Understanding with Microsoft Excel

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Abstract: This article presents contemporary theories like Activity approach and Connectivism, and methods about catching the students' attention and their applications in the Mathematical education with computers usage.

Key words: Learner – software interaction, Vygotski's zone on proximal development, Scaffolding, Activity approach, Connectivism, Microsoft Excel, Extending a task, Notion parameter

INTRODUCTION

At the end of twentieth century, educators and researchers observed a decrease of interest about Mathematics and, as a result, low understanding and achievement in global plan. This is one of the reasons for many cross-national plans, reforms, educational frameworks and initiatives [2, 4]. The most prominent of them are Recommendation of the European parliament and the council on 18 December 2006 of key competences for lifelong learning [5], The European Qualifications Framework for lifelong learning in 2008 [1] and National Qualification Framework [15].

International researches PISA (Programme for International Student Assessment) [3, 18] established very low average results at Bulgarian students at the age of fifteen, so we need to search new methods for teaching mathematics with the available resources in our schools.

BACKGROUND EDUCATIONAL THEORIES

Since many years, scientists have been searching for laws in human development and methods for improving learning. Social constructivism is based on Vygotski's zone on proximal development, in which higher order cognitive skills have increased in social interaction [9]. The Bulgarian professor Ivan Ganchev, who dedicated his work on increasing motivation, understanding and accruing logical thinking in broad part of learners, transformed Vygotski's writings into working educational model (Figure 1).

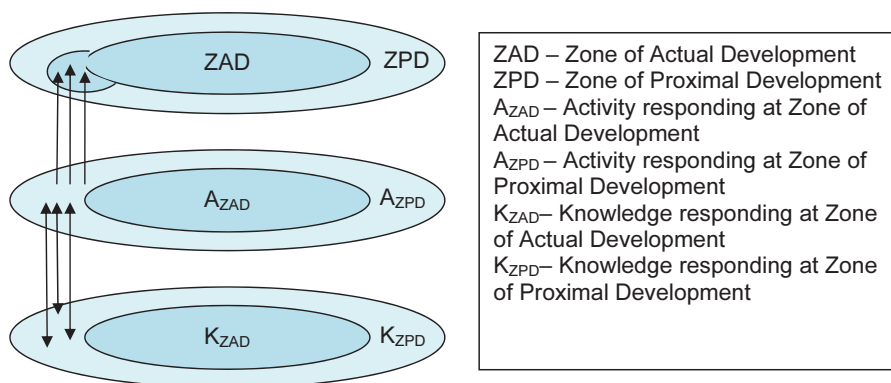


Figure 1: The model of prof. Ganchev for extending the Zone of Actual Development [10, p.31]

Activities from zone of actual development are these activities, that learner can do alone. Activity from zone of proximal development is this activity that learner cannot do alone, but can perform with help from someone. If he does some times these activities with

help, he forms a new skill and this skill is added in the zone of activities from actual development. There is a cognitive loop and the zone of actual development of learner enlarges.

In the last years in western scientific literature, this is known as “scaffolding”, in which “Learners need to be given direct support in the early stages of learning a task and to move gradually towards self-regulation and autonomy (teacher-fading)” [7, p. 32].

Nowadays, more interactive methods have been applied in the education, in which relations between teacher – learner, learner – learner and learner and technology are very important [11, p. 101]. In our approach we are considering interaction learner – software, with widespread application (not only for educational goals).

Russian researchers apply new theories as democratic constructivism, with individual learning trajectory (N. Shatalova), synergetic principles (E. Knyazeva) and activity approach (A. Borovskikh, N. Rozov, V. Dalinger). Borovskikh and Rozov interpret notion of activity as entireness, as a self-motion of society, as a fundamental category [8, p. 28]. On this base, they form three main activity principles of pedagogy:

1. The main function of education - preparing the child to participate in activities of human society;
2. Education is a specific type of activity. Therefore training activities should be built like any human activity, according to the same laws and principles;
3. Pedagogical activity is a specific type of activity, which, in the broadest sense, is managing, organizing and directing the activities [8, pp. 39-40].

Activity is implemented through steps, named action. Activities in the problem solving are: perception, or self-formulation of conditions of the problem; analysis of the conditions of the problem; reproduction or implementation needed for solving knowledge; prediction of the search process and its results, the formulation of hypotheses; making a plan of the solution; attempt to solve the problem on the basis of known methods; redesign plan solutions, finding new means; solution to the problem in a new way; verification solution, and evaluating the rationality and efficiency of the chosen solution; introduction of the resulting knowledge (method) in the existing system of student knowledge, perceptions, attitudes; starting applying to new problems [12, p. 56].

Technology has reorganized our life, communication and education. The quantity of information has grown up significantly so new understanding and theories as connectivism take more important role. Connectivism takes into account some important trends in learning [6]:

1. Many learners will move into a variety of different unrelated field.
2. Informal learning is a significant aspect of our learning experience.
3. Learning is a continual process, lasting for a life time.
4. Technology is altering (rewiring) our brains. The tools we use define and shape our thinking.
5. The organization and the individual are both learning organisms. Cognitive information processing can now be off-loaded to, or supported by, technology.
6. Know-how and know-what is being supplement with know-where.

Nowadays it becomes more important not to learn and reproduce the knowledge but to know where to find valuable and reliable information and how to transform it for our needs. Connectivism is the integration of principles explored by chaos, network, and complexity and self-organization theories. Learning is a process, which occurs within nebulous environments of shifting core elements – not entirely under control of the individual. Important principles of connectivism are [6]:

1. Learning is a process of connecting specialized nodes or information sources.
2. Learning may reside in non-human appliances;
3. Nurturing and maintaining connections is needed to facilitate continual learning.
4. Ability to see connections between fields, ideas, and concepts is a core skill.
5. Decision-making is itself a learning process.

Skills to see the analogy, relations and logical connections are developing through learning mathematics and decision-making is an inseparable part of problem solving.

These principles and results from research PISA [18], showing that our students do not use effectively computer technology in solving problems, lead us to realize the necessity of increase learning with computers in Bulgarian schools.

SUPPORTING POINTS FOR CONSTRUCTING NEW EDUCATIONAL APPROACH

Based on mentioned above recommendations and covered evaluation criteria, we can extract some important principles for mathematical education:

1. Learning by heart and applying several rules are without sense and gained knowledge this way will be forgotten very fast, so this is a waste of time and budget;
2. Students must:
 - 2.1. Aware importance of mathematics in their career;
 - 2.2. Set goals and strive to achieve them;
 - 2.3. Recognise structures and constrains of problem situation;
 - 2.4. Realise that experiment is a good way for finding solution of unknown problem;
 - 2.5. Use appropriate tools and technologies;
 - 2.6. Work in collaboration;
 - 2.7. Be able to apply acquired knowledge and skills in everyday situations.

We are trying to cover these guidelines for constructing new approach in teaching and learning mathematics with electronic spreadsheets.

INCREASING MATHEMATICAL SKILLS WITH MICROSOFT EXCEL

We do not refuse using different kinds of software, installed on computers and tablets or available online. We suggest teachers to develop the mathematical skills of students with the available resources in schools. Every school has computer laboratory with widespread software like Microsoft Excel so the teacher do not need to search for the program, ask a supervisor to install it. When it is used a new software product, it is usually necessary pre-training. About Microsoft Excel, this period is really short. Excel is a part of the Microsoft Office so the user can transfer the knowledge, the skills and the objects, that he/she made in one application to other applications of the Office package. Skills to work with spreadsheets are part of computer literacy and the use of Excel is a base for acquiring skills to work with another applications. Using software which is not created only for educational goals, improve teachers' and students' ability to transform tools (one of principles of connectivism).

Students learn how to use it, how to organise and generalise information in classes of Information Technology starting at fifth grade. They can improve their collaborative skills too, working on pairs with one PC. After graduating it is very likely they will use this software in their work because with spreadsheet they can facilitate planning, can calculate fast and exactly, may use integrated functions from different fields.

We are starting with the easiest examples to show that every mathematical teacher without sophisticated computer skills may use this software like a helping tool in some classes at very low educational level.

It has proved that pupils think by images so they or teacher may illustrate word, related with real life problems with simple graphical pictures.

School pupils can understand deeper mathematical notion „fraction” using a grid for visualisation. They will see, that they cannot sum different fractions. First, the students have to divide the whole parts into equal pieces. Multiplication can be shown like a crossing two multiplied fractions. For example, colour in yellow two of five columns, colour in red three of seven rows and you will receive the multiplication of fractions – the section,

coloured in orange (when you mixture two colours, you receive a new one). They may understand deeper dividing (Figure 2).

$$\frac{2}{3} : 2 = \frac{2}{6} = \frac{1}{3}; \quad \frac{1}{3} : 2 = \frac{1}{6}; \quad \frac{1}{6} : 2 = \frac{1}{12}; \quad \frac{1}{12} : 2 = \frac{1}{24} \text{ and that } \frac{1}{3} : 2 = \frac{1}{6}$$

is the same like $\frac{1}{3} \cdot \frac{1}{2} = \frac{1}{6}$.

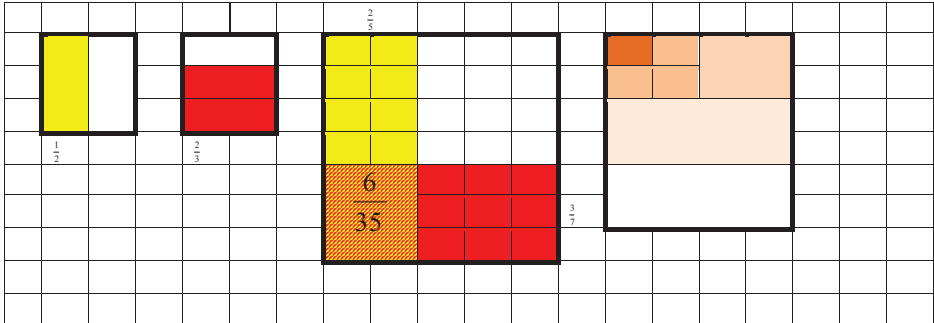


Figure 2: Visualisation of operations with fractions

Some students cannot understand without visualisation why power is rising but fraction is decreasing (Figure 3).

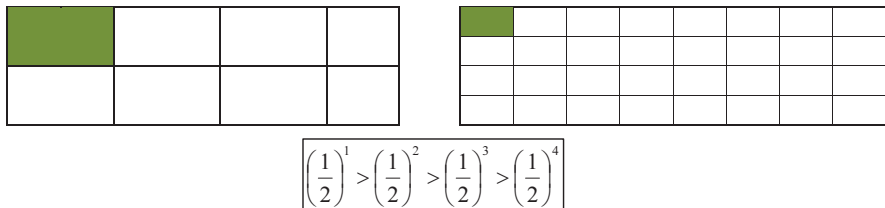


Figure 3: Comparing by visualising part of whole

Learners can also use a pie diagram to present a part of the whole and they will learn the notion of percentage. When they, alone or in pairs, visualise different number tasks with fractions, they add this notion in their zone of actual development. They will not forget it for a short period and when paying attention for the rationality of the results, they will be able to correct their mistakes because they can visualise the fractions in their mind or on paper.

Next, they may use table to recognise a pattern. For example we might use the problem from PISA 2012: “A farmer plants apple trees in a square pattern. In order to protect the apple trees against the wind he plants conifer trees all around the orchard.

Complete the table:

n	Number of apple trees	Number of conifer trees
1	1	8
2	4	
3		
4		

There are two formulas you can use to calculate the number of apple trees and the number of conifer trees for the pattern described on the previous page:

Number of apple trees = n^2

Number of conifer trees = $8 \cdot n$, where n is the number of rows of apple trees.

There is a value of n for which the number of apple trees equals the number of conifer trees. Find the value of n and show your method of calculating this.

Suppose the farmer wants to make a much larger orchard with many rows of trees. As the farmer makes the orchard bigger, which will increase more quickly: the number of apple trees or the number of conifer trees? Explain how you found your answer."

PISA measures the skills of fifteenth-year old students, but with electronic tables this problem may be given on pupils in third grade. Teacher may lead student's reasoning by asking questions and extend the table as in Table 1 (Is this a good way to count conifer trees?; How many conifer trees are there on the one side of the fence, between conifer trees on the corners, when n is changing what pattern can you recognise? How can you calculate the needed trees for fence when n is equal at 5?). With this variant of the task, pupils persevere to reach the goal, improve their skills to observe and specify relationships.

Table 1: A problem from PISA 2012

Number of apples at one row - n	Apple trees	Conifer trees on one wall between corners	Number of conifer trees at whole fence
1	1	1	8
2	4	3	16
3	9	5	24
4	16	7	32
5	25	9	40

Following D. Pólya's recommendations [17, pp. 39-42], teacher may extend the task and encourage students to set new questions and goals. In sixth grade, students learn how to write formula in cells and fill automatically with dragging down, so teacher may ask: "How many green trees the farmer need, if there are 10 apple trees on one row?". Some students may use a recurrent relation with cell from previous row. So follow the next teacher's questions: "Is it good to drag down if $n=100$ or $n=250$ for example? Can you see the relation between conifer trees and n ". It is preferable educator to require students to draw new small table calculating immediately number of trees when n changes (Figure 4). In Excel you may give a name at a range of cells or for one cell and you can use this name instead of the address of the cell, so students may write formula like in math classes. They may give a name n on cells B1 and write a formula = $n*n$ in cell B2, and formula = $8*n$ in cell B3.

$n =$	6
Number of apple trees	36
Number of conifer trees	48

Figure 4: An immediate calculation with a formula

Very good possibility at spreadsheets is that in one cell you can write formula, which one uses values from other cells, and this cell can be part of another formula. In this way, we have a web of data and if the user changes one value in a cell, he immediately

receives a new response. With this interaction people can experiment or search for constrains of the problem, immediately.

Teacher may encourage learners to formulate new questions, in order to extend and explore this task (“When apple trees are more than conifer trees?”) or to formulate new problems, with prise of trees, area of fruit garden. They can reach more practical problem when the farmer has got field with fixed area: “How many apple trees can he plant, if every tree needs from a 4 m² square free space?”. Problem may be transformed in economical: to choose from some sorts of apple trees with different prices and different kilos crop.

Solving and exploring practical problems, which are made from them, taking decisions, these things improve the motivation, deepen the understanding and they strive to reach the set by them goals. In this way, it may integrate knowledge from different subjects. Students improve their skills about reasoning inductively, inferring, predicting, choosing appropriate computation, thinking divergently, using appropriate tools and collaborating. They will be able to apply mathematics in everyday situations.

With problems like this and using spreadsheets, students construct for themselves the notion *changing value n* – “variable, which can be arbitrary, and take on any value, be any number” [8, p.59]. Notion of arbitrary value of variable is a meta-subject problem, because it is not natural for the students and causes many difficulties.

Students can use ready-made educational tools, as a calculator for solving square equation (Figure 5), to gain immediate feedback after solving a part of a problem in their notebook. Also they may use it when they solve more sophisticated problems which mathematical model contains a square equation. In this way, they do not lose time, do not make technical mistakes and can concentrate in more important aspects of the problem.

In the next stage, they may improve their logical thinking, inventing their own “calculators” using only combination of logical functions: *If, And, Or*

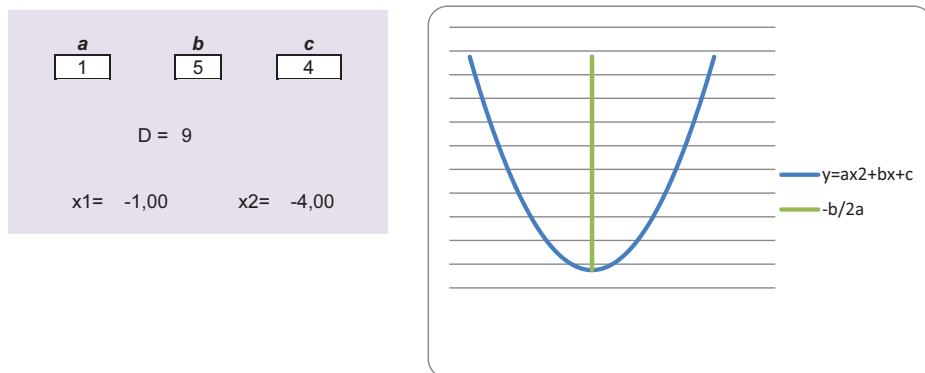


Figure 5: An educational tool for solving a second-order equation

Coefficients from this calculator may be related with graphic of a square function and when the learner change one value, he/she immediately sees the transformation of the function, its line of symmetry and intersection points with abscissa. Nowadays, the skills to draw the graph of a function, to produce diagrams and to extract data from them are really important.

In high school through the additional mathematical classes, students can use more sophisticated possibilities of Microsoft Excel, as macros and integrated programming language *Visual Basic for Applications*. Good examples for this use are given from the educator P. Penev [16].

CONCLUSION

Technology has reorganized our life, communication and education, so new theories have arisen. The activity approach postulates that the main function of education is preparing the youths to participate in activities of human society. Learners should be actively included in learning process.

Electronic tables, formulas and integrated functions, charts and graphics of functions, simple drawing, concept mapping, macros and developed programs, that are part of Microsoft Excel, can be used to support critical and analytical thinking about net of mathematical concepts. Teacher, who knows topical principles of mathematical education, can use computers in some of his classes. We can remark that not all of the mathematical classes can be conducted in computer labs.

Through classes, with shown approach, learners realise that the observing, the searching, the trying and the experimenting are good methods for finding solutions of unknown problem, even in real life.

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