International Journal of Mathematical Research
2015 Vol.4, No.1, pp.16-26
ISSN(e): 2306-2223
ISSN(p): 2311-7427
DOI: 10.18488/journal.24/2015.4.1/24.1.16.26

THE IMPORTANCE OF COMPUTERS WITH MATLAB SOFTWARE IN THE TEACHING AND LEARNING OF GEOMETRY IN SPACE

Lupu Costică[1]

[1]*University of Bacau, Faculty of Sciences, The Department of Mathematics, Informatics and Sciences of Education, Street Calea Mărăşeşti, Bacau, Romania*

ABSTRACT

The aim of this study is to evaluate the efficiency of using computers with MATLAB software in the teaching-learning of Geometry in middle-school, by the students from the specialization of Mathematics, "Vasile Alecsandri" University of Bacau. During the pedagogical practice stage, the students in the 3rd year, although better trained in Mathematics than the students from other departments, face various problems related to their practical skills in using the computer in teaching, as well as to their lack of teaching experience. The research was conducted at the National Pedagogical College "Ştefan cel Mare" from Bacau and consisted in assisting and observing 28 lessons of Mathematics and 28 lessons of Information and Communication Technologies, involving a group of 200 students from grades 1-4, 180 middle-school students and 40 teachers of various specializations. The applied tests and questionnaires have shown the efficacy of using the computer in building active thought and competences in the graphical representation of geometrical figures and shapes, as well as in solving problems of plane collinearity. In relation to these problems, we are looking for a solution to comprise the best teaching-learning strategies using the calculus technique. With nearly 5000 functions, the MATLAB software menu provides techniques for acquiring knowledge in an electronic format, calculus techniques, explanatory mathematical texts, graphs, sounds and diagrams, e-learning solutions, including online testing and evaluation, as well as web-based learning tools designed for Mathematics (www.maplesoft.com).

Keywords: MATLAB software, Collinearity in space, Experimental research, Computing technology.

Received: 13 August 2014/ **Revised:** 10 September 2014/ **Accepted:** 13 September 2014/ **Published:** 15 September 2014

Contribution/ Originality

This study contributes in the existing literature mathematics teaching. This study uses new estimation the statistical methodology. This study originates new formula for solving the problems. This study is one of very few studies which have investigated the importance MATLAB. The paper contributes the first logical analysis to optimize teaching activity.

The paper's primary contribution is finding that modern methods. This study contains original modern documents.

1. INTRODUCTION

This paper describes an experimental research regarding the effect of introducing scientific software into the learning experience upon attitudes and the learning process. The research aims at investigating the effect of using MATLAB software in building attitudes and using strategies for learning Geometry with the help of the computer. In order to research, analyse and describe a wide range of perspectives, the research team consisted of 20 students from the department of Mathematics, attending their initial teacher training.

The objective of this study is to present a practical model for using the computer by the students in the 3rd year, from the specialization of Mathematics, during their initial teacher training stage of pedagogical practice, through teaching Geometry in middle school. In Romania, in middle school, the hours of calculus technique are few, the material support is insufficient, computer science laboratories are rarely used and crowded, and the number of teachers, system engineers and computer scientists using the laboratory is small.

The advantages of using MATLAB software in teaching-learning Geometry are:

a) MATLAB software reduces manipulation time, confirms already performed calculi, therefore poorer students may be engaged in more complex calculi with mathematical arguments;

b) MATLAB software allows students to focus on concepts, enabling them to complete the general structure of an image with ideas and mathematical proofs;

c) MATLAB software provides standard procedures and tools for plane and space drawing;

d) MATLAB software may provide students with the possibility of approaching high-difficulty problems, on a higher strategic level [1].

2. RESEARCH METHODOLOGY

2.1. Research Hypothesis and Objectives

By exploiting work in class during the pedagogical practice, we have aimed at illustrating the role of using MATLAB software in building attitudes and developing strategies for learning Geometry with the help of the computer.

Hypothesis: The systematic use of MATLAB software in teaching Geometry contributes to building certain attitudes and competences regarding the teaching-learning of the collinearity of points in a space.

Objectives: The objective of this study is to present a practical model for using the computer by 3rd-year students from the specialization of Mathematics, attending their initial teacher training, during their pedagogical practice, by teaching Geometry in middle school.

In order to verify the hypothesis, we have established several objectives to direct and guide our activity:

1. Knowledge of the initial level of mathematical training regarding the collinearity of points in a plane;
2. Identifying the frame and reference objectives of the curriculum for mathematical education, regarding the solving of problems of collinearity of points in a plane;
3. Designing and conducting a teaching process centred on using the computer and the MATLAB software in learning Geometry;
4. Applying the final evaluation of the students' level of training, regarding the collinearity of points in space.

2.2. Characterization of the Experimental Group

The research group comprised 4 classes of 7th graders (2 experimental classes and 2 control classes), where 20 3rd-year students from the specialization of Mathematics, attending the initial teacher training study programme, have conducted, during the hours of pedagogical practice, observation, probation and final lessons.

Each student has conducted the probation lessons in the computer science laboratory, initiating the students in using the MATLAB software, for geometrical and applied calculus representations in solving problems of plane collinearity.

This fact has also led us to conduct a process of individualizing the instructive-educational act, taking into account the fact that true pedagogical artistry results from the student's ability to harmoniously combine active-formative strategies, the individual development of children and their digital competences in using the computer [2].

2.3. Research Stages

The experimental research was conducted during the 2013-2014 school year, covering three stages:

- The stage of initial evaluation (observational) was conducted between, October, 20-27, 2013. At this stage, tests were applied in order to identify the initial level of the ability to solve collinearity problems.
- The ameliorative stage was conducted between, November 11, April 30, 2014. At this stage, there were organized and conducted lessons of Mathematics, frontal as well as individual, involving group and individual work. The lessons were aimed at building the

cognitive, psycho-motor, socio-emotional components, with a focus on developing the ability to solve problems of collinearity and use the computer MATLAB software.

- The stage of final evaluation (summative) was conducted between May 15 – June 11, 2014. At this stage, tests were designed, adapted and applied in order to establish the progress recorded by children, in terms of the students' ability to use the MATLAB software in representing geometrical figures and solve problems of collinearity.

2.4. Research Methods and Techniques

In order to verify the hypothesis and achieve the research objectives, the students have resorted to the following research methods and techniques: portfolios, questionnaires, observation, the psycho-pedagogical experiment, conversation, the methods of the analysis of activity products and the research of documents, the method of the tests, as well as techniques of mathematical-statistical presentation of the research data.

The research methods were used to evaluate the level of mathematical training and the reactions of 100 middle-school students from the National Pedagogical College "Ştefan cel Mare" from Bacau, throughout the 2013-2014 school year, in relation to the new technologies and recording the competences of the 20 university students regarding the teaching-learning-evaluation of collinearity.

3. THE ORETICAL BASICS ON THE COLLINEARITY OF POINTS IN SPACE

The problems of collinearity are a particular type of Geometry problems, being problems of demonstration, the solving of which aims to establish or verify a relation, find new properties of given figures, justify a formulated assertion. The problems whose solution requires the demonstration of the belonging of several points to the same line are called problems of collinearity. The problems of collinearity require, from the solver, a high degree of inventiveness, mathematical knowledge and insight. Due to the physical limitations of this article, we shall not illustrate here the synthetic models for demonstrating collinearity [3].

The collinearity problems proving that three or more points in space can be approached through specific geometry in space methods and through planar geometry methods.

Method I. This method derives itself from the fact that if two planes have a common point then all their common points are collinear. Thus,

If the distinct points A, B, C ... can be found simultaneously in separate α and β planes then they are collinear.

Method II. This method derives from the theorem:

The orthogonal projection of a straight line onto a plane (which she is not perpendicular to) is a straight line. So if three points are collinear then their projections on a plane are collinear and reciprocal.

Method III. Three points are collinear if the straight lines determined by each two are parallel with the same straight line.

Method IV. If we section a pyramid through two parallel planes that intersect its edges then the "analogue" points of its two sections and the apex are collinear.

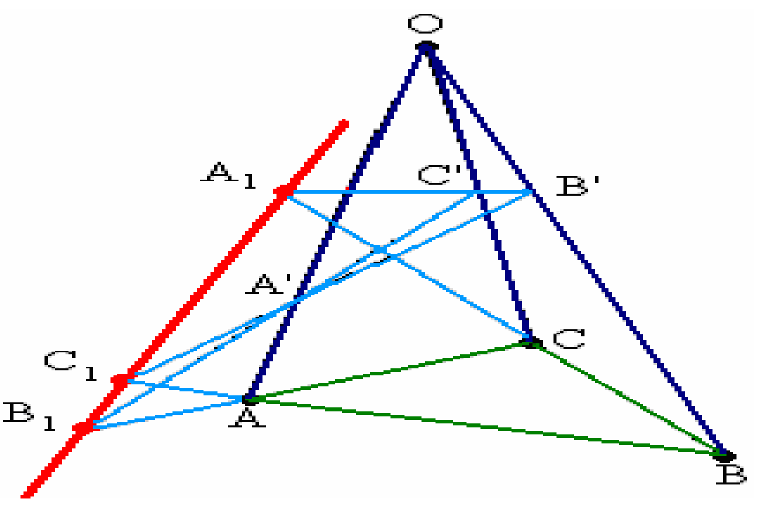
Method V. Collinearity of points $A_1, A_2, \ldots, A_n$ can be demonstrated by proving first that they are coplanar and then using planar geometry methods .

Observation: To prove that four or more points are collinear the collinearity between any three among them is shown, resulting the collinearity of all the points [3].

4. SOLVED PROBLEMS

Problem1. Let A, B, C be three non-collinear points and O a point not belonging in the (ABC) plane. The points A', B', C' shall be considered on the lines OA, OB, OC other than O, A, B, C and let A_1, B_1, C_1 be the intersections between the straight lines BC and $B'C'$, AC and $A'C'$, respectively AB and $A'B'$. Prove that the points A_1, B_1 and C_1 are collinear.

Solution



The planes (ABC) and $(A'B'C')$ are distinct. Since point A_1 is incident to the straight line BC, he is located in the (ABC) plane and also being incident to the straight line $B'C'$ he is located in the $(A'B'C')$ plane as well. Then $A_1 \in (ABC) \cap (A'B'C')$. Analogous $B_1 \in (ABC) \cap (A'B'C')$ and $C_1 \in (ABC) \cap (A'B'C')$. Following the reasoning expressed in Method I, it is clear that A, B and C are collinear.

Problem2. Let $ABCA'B'C'$ be a triangular prism with the lateral edges AA', BB', CC' and the points A_1, B_1 and C_1 are taken on the edges AA', BB', CC' so that the segments AA_1, BB_1, CC_1 have different lengths. Prove that the pairs of straight lines (AB, A_1B_1), (BC, B_1C_1) and (CA, C_1A_1) are concurrent and their points of intersection are collinear.

Solution The lines AB and A_1B_1 are coplanar. Since AA_1 and BB_1 aren't congruent then AB and A_1B_1 aren't parallel, so they intersect in a point A_2. Let B_2 and C_2 be the analogue of A_2. The points A_2, B_2 and C_2 simultaneously find themselves in distinct planes *(ABC)* and *(A'B'C')* therefore according to the method I, they are A_2, B_2 and C_2collinear.

Problem3. Let *SABCD* be a quadrangular pyramid with *S* its apex, *O* the intersection of diagonals *AC* and *BD* , *M* a arbitrary point located on segment *SO* . The points *A′* on *SA*, *B′* on *SB*, *C′* on *SC* and *D′* on *SD* shall be considered so that the lines *A′C′* and *B′D′* pass through *M*. Prove that the pairs of straight lines *(AB, A'B′), (BC, B′C′), (CD, C′D′), (AD, A′D′), (AC, A′C′)* and *(BD, B′D′)* intersect in six collinear points.

Solution The straight lines *A′C′* and *B′D′* determines a α plane that contains the intersection points between each pair of lines (*AC, A′C′*) and (*BD, B′D′*) denoted with *E* and *F*.

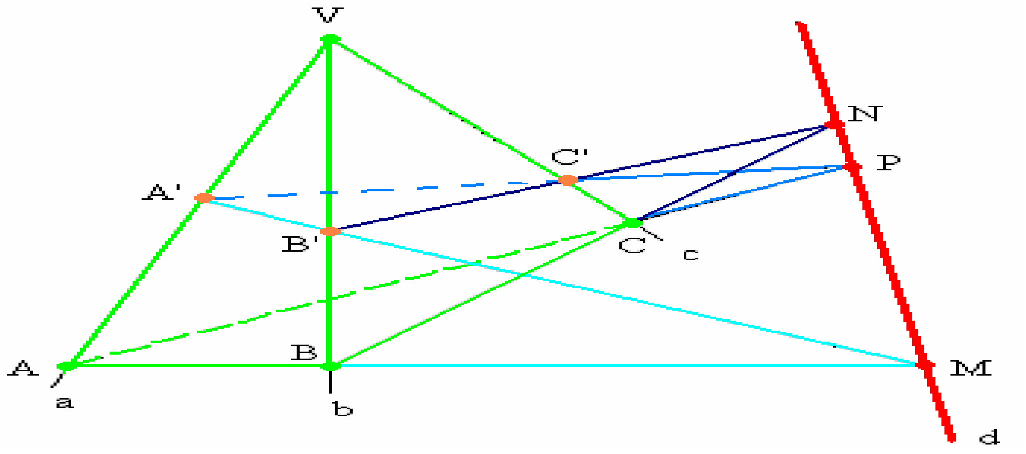
The straight line *EF* is the edge of the planes α and (*ABCD*). Let *G* be the intersection point between straight lines *BC* and *B′C′*. Then *G* is simultaneously in the α and (*ABCD*) planes and consequently he is located on the straight line *EF*. The belonging of the other six collinear points to the straight line *EF* is similarly justified.

Problem4. Let d_1 and d_2 be two straight lines and *O* a point. The (*O*, d_1) plane intersects d_2 in O_2 and the (*O*, d_2) plane intersects with d_1 in O_1. Prove that *O*, O_1 and O_2 are collinear.

Solution The (*O*,d_2) plane contains point O_2 by being located on the $d_2$straight line. At the same time by being the intersection between the straight line d_2 and the (*O*,d_1) plane is contained in plane (*O*,d_1) . Similarly O_1 by being located on the straight line d_1, is also contained in the (*O*, d_1) plane and by being the intersection between the straight line d_1 and the plane (*O*, d_2) is contained in plane (*O*, d_2). Therefore the points O_1 and O_2 are located on the line that intersects planes (*O*, d_1*)* and (*O*, d_2*)* passing though point *O* leading to the collinearity of points *O*, O_1 and O_2.

Problem5. Three semi - straight lines (bordered at one end) a, b and c start from point V, all three non coplanar. On the semi-straight line a we take points A and A′, on the semi-straight line b we take points B and B′, on the semi-straight line c we take points C and C′ so that the sides of angles ABC and A′B′C′ aren't respectively parallel. Prove that the straight lines AB and A′B′, BC and B′C′, CA and C′A′ intersect in three collinear points.

Solution



The points A, B and C determine a α plane. The points A',B' and C' causes another β plane. Planes α and β are concurrent because in the plane determined by a and b extending non parallel segments AB and $A'B'$ we get a intersection point M. Since $M \in$ AB then $M \in \alpha$. But $M \in A'B'$ so $M \in \beta$ where the following planes α and β having a common point M they have a common straight line which we denote with d. Obviously, $M \in d$.

We repeat the reasoning for the straight lines b and c, respectively a and c and we get the intersection points: N of BC with $B'C'$, respectively P of AC with $A'C'$, where $P \in d$ and $N \in d$. In conclusion the points M, N and P are collinear.

5. RESULTS

The pre-test and post-test questionnaires have included a series of questions related to the use of the Maple software in teaching-learning Geometry in middle school.

To what extent do you believe that the use of the computer and the Maple software is useful in learning Geometry in the current educational context? The answers may be provided on a scale from 1 to 5, where: 1= to a very small extent/ not at all and 5 = to a very high extent.

Table-1. Questionnaire on the use of the computer and the Maple software in learning Geometry

	1	2	3	4	5
1. To what extent do the computer and the MATLAB software help you in learning Geometry?					
2. To what extent does your level of Mathematical knowledge help you in learning Geometry?					
3. What role does the attitude regarding the use of the computer play in learning Geometry?					
4. What role does the experience in using the MATLAB software play in learning Geometry?					
5. Which is the level of engagement in exploration as a learning strategy?					
6. How relevant is graphical representation (visual strategies) as a support in solving problems.					
7. Mention the things you liked about using the MATLAB software in learning Geometry?					
8. Are you going to continue using the MATLAB software in learning?					

The students' answers to the eight questions included in the pre-test and post-test questionnaires were:

Computer confidence: 62% - 67%.

Confidence in mathematical training: 62% - 65%.

The attitude towards the use of the computer: 55% - 64%.

The relevance of the experience in using the MATLAB software: 65% - 78%.

Commitment to exploration as a learning strategy: 61% - 65%.

The relevance of graphical representation as a support in problem solving: 64% - 70%.

We may observe a slight percentage increase regarding the computer confidence, confidence in Mathematics and the attitude towards the computer throughout the semester. There is also a slight percentage increase regarding the two strategy scales.

In relation to question 7, the things they liked most about using the computer, the students made frequent references to the following aspects:

• Graphics and visualization is helpful also for understanding;

• The speed and usefulness of building geometrical shapes and performing calculi;

• The accuracy in understanding problems as a result of graphic and calculus exploration;

• The ability to verify written calculi and confirm answers.

Many students have reacted to using the computer in solving problems as if these had been a game. Approximately half of the questioned students say they would continue to use the Matlab software. The tutors have also reported certain difficulties related to the use of computer science laboratories and the specific software. There were no relevant differences based on gender. The relevance of knowing the English language was generally recognized.

We shall further present only the final evaluation test.

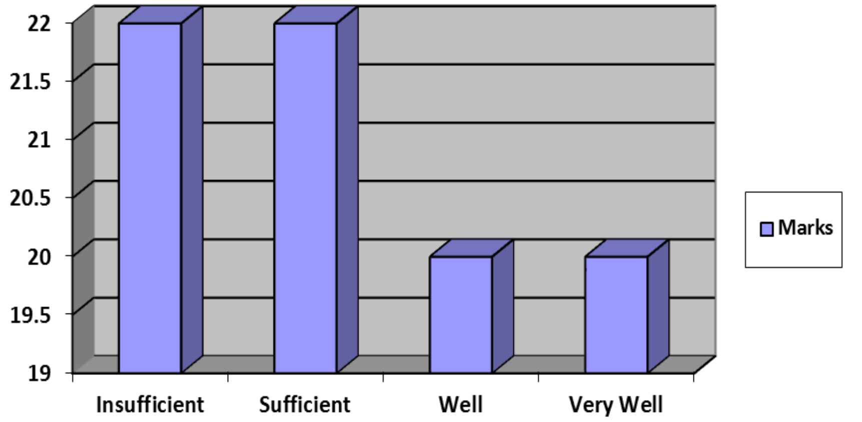
1. Build a triangle ABC and the interior and exterior bisectors of the angles ABC and ACB.
2. Build points D, E, F, G as projections of A on the interior and exterior bisectors of the angles ABC and ACB.
3. Given a triangle ABC and D, E, F, G the projections of A on the interior and exterior bisectors of the angles $\measuredangle ABC$ and $\measuredangle ACB$. Prove that points D, E, F and G are collinear.
4. In triangle ABC, the interior bisector BB' is parallel with the tangent to the circle circumscribed to triangle ABC, taken to point T, which is diametrically opposed to A. Prove that B', belonging to edge AC, the centre O of the circle circumscribed to triangle ABC and the centre M of edge BC are collinear.
5. One line intersects the edges BC, AC and AB of a triangle ABC, in points A', B' and respectively C'. Given the symmetrical points M, N and P of each of these points to the centre of the edge on which it is located. Prove that points M, N and P are collinear.

Table-2. Giving marks based on performance descriptors

Mark / Item No.	Very well	Well	Satisfactory
Item 1	Builds triangle ACB and the exterior bisectors	Builds triangle ABC and the interior bisectors	Builds triangle ABC
Item 2	Builds points D, E, F, G as projections of A on the interior and exterior bisectors of angles ABC and ACB	Builds points F, G as projections of A on the exterior bisectors of angles ABC and ACB	Builds points D, E, as projections of A on the interior bisectors of angles ABC and ACB
Item 3	The parallel through C′ at BC is a middle line in triangle ABC, it results that C′E also passes through B′, the centre of edge AC. Analogously, D and E are on the line C′B′, therefore F and G are on the line B′C′.	Since ∡C′EB ≡ ∡ABE ≡ ∡EBC, it results that C′E || BC.	The quadrilateral ADBE is a rectangle, therefore DE passes through C′, the centre of AB.
Item 4	We mark by P the point in which the tangent in T to a circle intersects the line AC, it results: m (∡CPT) = 90^0 – m (∡TAC) = m (∡ABC).	Since m(∡CPT) = m(∡AB′B) it results that m(∡B′CB) = 1/2·m(∡ABC), therefore, B′M ⊥ BC	Since OM⊥BC, it results that points B′, O and M are collinear.
Item 5	Since A′, B′ and C′ are collinear, it results: $\frac{A'B}{A'C}\cdot\frac{B'C}{B'A}\cdot\frac{C'A}{C'B}=1.$	From the hypothesis, since A_1 is the centre of edge BC, it results: A'B/A'C = MC/MB. Analogously: B'C/B'A = NA/NC; C'A/C'B = PB/PA .	Given: $\frac{MB}{MC}\cdot\frac{NC}{NA}\cdot\frac{PA}{PB}=1$ According to the converse of Menelaus theorem, it results that points M, N and P are collinear.

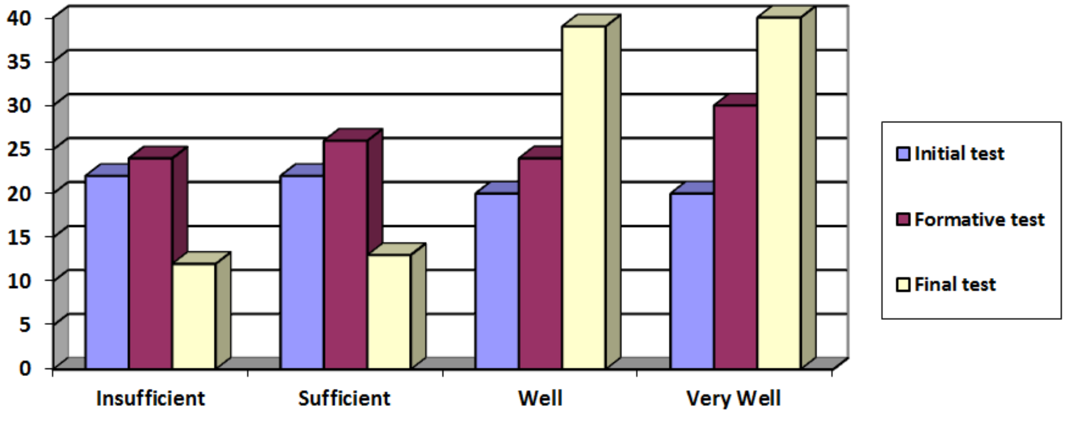
Table-3. The results obtained

Marks	Frequency
Very well	*39*
Well	*38*
Sufficient	*14*
Insufficient	*13*



Graph-1. The results of the experimental sample to the final test

Observations: Typical errors: mistaking the bisectors for the median; identifying the line which contains the points D, E, F, G; difficulties in transposing the problematic context into an exercise. Measures for correcting the errors: resuming the explanations regarding the differences between bisectors and median; exercises of transposing the context of the problem into an exercise.



Graph-2. Comparative analysis of the evaluation test results

Following the analysis and interpretation of the data collected during the initial evaluation, there were applied differentiated learning tasks, providing support particularly to children with knowledge gaps or poor mathematical skills. Proper methods and procedures were applied to approach these issues (exercises on correct graphical representation of geometrical figures, exercises on the collinearity of points in space and solving collinearity problems).

These elements have changed the children's attitude towards Mathematics. The students have organized their own activities better, becoming increasingly critical towards them, as well as towards the actions of the other children.

Concerned with ensuring an active participation of children in the activities they have conducted, the university students have tried to give an accurate motivation for tasks, stimulate and maintain their interest by means of procedures that engaged them emotionally, use the computer and other attractive materials in the most appropriate moments of the lesson [4].

6. CONCLUSIONS

The children's attitude towards Mathematics and the use of the computer, the role of technology in the process of learning Mathematics have also been analysed in connection with the paradigm of scientific, pedagogical, psychological and technological training for the teaching-learning-evaluation of Mathematical knowledge, achieved during faculty studies through courses, pedagogical and technological training but, especially, through pedagogical practice. The questionnaire confirms the formative and emotional potential of using technology.

Many teachers (75%) appreciate the relevance of the efficient use of the computer in enhancing the motivational potential, in relation to learning Mathematics. They also believe that the graduates from the specialization of Mathematics should build the skills needed to exploit the available technological resources. The students from pedagogical practice and the children from the lessons of Mathematics are encouraged to use the AEL lesson packs, widely available, as well as special software such as GEOGEBRA, ALLGEBRA, MATLAB, MAPLE, MATHEMATICA [5] .

Funding: This study received no specific financial support.

Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

[1] C.-V. Muraru, *Matlab - guide study*. Bacau: Publisher Edusoft, 2006.

[2] C. Lupu, "The contribution of the new technologies to learning mathematics," *Procedia - Social and Behavioral Sciences*, vol. 128, pp. 240-245, 2014.

[3] C. Lupu, "The efficiency of computer use geometric, representation and problem solving of the concurrence," *International Journal of Innovation in Science and Mathematics, ISSN (Online)*, vol. 2, pp. 2347–9051, 2014.

[4] V. Postolică, E. Nechita, and C. Lupu, "The Romanian mathematics and informatics education," *British Journal of Education, Society & Behavioural Science*, vol. 4, pp. 226-240, 2014.

[5] C. Patricia, H. Chris, E. Nerida, and F. Gerard, "Investigation into the effects of scientific software on learning," *Mathematics Education Research Journal*, vol. 12, pp. 219-233, 2000.