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RESULTS OF A COMPREHENSION TEST IN MATHEMATICS

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Abstract: In higher education the main subjects build on the knowledge acquired in high school. Research shows that students entering universities have acquired basic knowledge to different extents. It is very important to be able to apply mathematical knowledge directly. Students often treat practical knowledge separately from theoretical knowledge. They find it difficult to bind these two or see the relation between them. Meaningful learning and understanding is a basic aspect of all kinds of learning, and it is even more important in the case of learning mathematics. When students can provide the solution to something they have not learnt directly, when they can use their knowledge in novel situations, this is a sign of a different quality of knowledge, of a deeper understanding. The aim of this research was to measure students' independent thinking and problem-solving skills, as well as to investigate the way they can actively apply their knowledge when solving problems not directly connected to the curriculum. We have investigated the relationship between the different knowledge areas, and levels (operations, conceptual understanding, problem and exercise solving) in the case of one hundred economic majors at Partium Christian University.

Key words: basic knowledge of mathematics, mathematical abilities, problem solving abilities, mathematical understanding, knowledge transfer.

Introduction

"The first rule of discovery is to have brains and good luck. The second rule of discovery is to sit tight and wait till you get a bright idea". [6]

The teaching of mathematics is important not only for the application of the acquired knowledge, but for the development of the logical and rational way of thinking of the students of economic studies. Mathematics would be the most appropriate school subject to develop certain skills and abilities such as: association, selection, spotting the essence, abstract thinking, logical thinking, clear thinking, sense of locality, creativity, self control. Secondary school teaching plays an important role in the development of problem solving skills and of the knowledge needed to acquire these skills. [1] It also has a great influence upon the ability of acquiring specific knowledge, which is required for higher education subjects at the Faculty of Economics such as economic mathematics, economic statistics, probability, and accounting. [5].

One of the main features of the Romanian educational system is that students can study mathematics at different levels. A student in a Mathematics-Computer Programming class of a National College may even take a Baccalaureate examination of high level in mathematics as the programme includes: differential equations, probability theory, the basics of linear algebra, complex numbers, etc.

There are many mathematics subjects in the curriculum of BA/BSc, MA/MSc and PhD degree programs of faculties of economics. Just like physics, economics needs the synchronic use of different subjects and domains, including all the branches of mathematics. [5] In the aforementioned work there is a short presentation of the types of mathematical knowledge needed in economics. The following basic subjects in mathematics are part of the curriculum of the Economics department at our university: financial mathematics, probability theory, and financial statistics, each of these are one semester courses. There is no doubt that the students need a solid basic knowledge acquired in high school in order to become a good professional or to get a PhD degree.

In the 1970s and '80s international surveys were carried out in the fields of natural science and mathematics measuring how students acquire disciplinary knowledge and how they can apply it in

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contexts similar to what has been learned in class. The OECD PISA (Programme for International Student Assessment) investigates whether students have acquired the applicable knowledge essential for full participation in a modern society (they measure how students can apply their knowledge to novel situations) [9]. Complex problem solving was an additional assessment domain in PISA 2003, thus adding a new dimension to international assessment: measuring general cognitive abilities that are not directly connected to school subjects. [8]

There are a number of studies dealing with the question whether the mathematical knowledge acquired in school becomes part of everyday knowledge and to what extent it plays a role in the development of thinking skills. [7] Studies have shown that knowledge transfer is not automatic; the acquired knowledge is not immediately carried over to novel situations. [2]

Meaningful learning and understanding are basic aspects of all kinds of learning. [3] Investigating students' understanding, as well as studying the different layers of knowledge is not an easy endeavor. The test chosen for the present study, carried out on one hundred economics majors, contains exercises that require deep understanding in order to be solved, this makes them appropriate for investigating usable knowledge.

Hypotheses

When students can provide the solution to something they have not learnt directly, when they can use their knowledge in novel situations, this is a sign of a different quality of knowledge, of a deeper understanding. The aim of this research was to measure students' independent thinking and problem-solving skills, as well as to investigate the way they can actively apply their knowledge when solving problems not directly connected to the curriculum. In the present study it is assumed that there is a lacuna when it comes to the above mentioned skills.

We propose to investigate the results of the comprehension test and compare the achievement of students who have held a baccalaureate in mathematics to those who have not. It is assumed that there will be differences between the two groups in terms of factual mathematical knowledge as well as in the applicability of their knowledge.

We would like to investigate whether there is any correlation between the baccalaureate grade in mathematics and the results of the comprehension test. It is assumed that the baccalaureate grade does not reflect applicable knowledge.

We would like to investigate the relationship between the different knowledge areas, and levels (operations, conceptual understanding, problem and exercise solving) assuming a cause and effect relationship between these.

We would also like to investigate weather there are any gender differences in terms of test results; which areas show differences and in what way.

The research

In this research we have given a comprehension test in mathematics to one hundred students (81 first-year students and 19 MA students) studying economics (majoring in management, tourism, money and banking). The test contains exercises that require deep understanding in order to be solved; this makes them appropriate for investigating usable knowledge.

The test is divided into four sections and contains 15 exercises, i.e. 18 items. 14 items (representing 56% of the source test) are taken from a comprehension test in mathematics devised by a group of researchers from Szeged (Hungary). The test is suitable for measuring mathematical knowledge that requires deeper understating, surpassing the concrete context of the subject. It is a measuring tool with good test theory parameters, which has passed the necessary verifications and testing phases. An important feature of this tool is that it does not serve the investigation of the concrete understanding problems of individual areas. [4]

With the help of these exercises we investigate the operational background of basic mathematical notions, the knowledge of concepts, and the application of these in everyday life. One peculiarity of this test is that it is similar to the ones used for measuring knowledge in schools. The exercises can be solved using the knowledge acquired at basic level (practically the curriculum of grades 5 to 8), however, the exercises investigate the skill components of knowledge. Apart from 6 items, the rest do not connect directly to the learned material. In order to be solved they require understanding (text understanding), as well as a deeper relationship between acquired elements that need to be solidly integrated into the students' knowledge. The test is primarily suitable for indicating the problems related to understanding and for a general characterization of these problems.

When choosing the exercises, an important aspect was to choose the ones that are of basic significance due to their applicability in other subjects or areas (e.g. ratio, calculating percents, measurements, area and perimeter calculation), rather than exercises with multifarious mathematical content.

The exercises can be divided into four groups based on their content but also because they raise different understanding problems:

- Operations (5a, 5b, 5c): These are the basic operations without which one cannot do the easiest calculations in other subjects (multiplying, dividing and simplifying fractions).
- Conceptual understanding (6, 7a, 7b): In order to properly understand these questions students need to be familiar with some common concepts, how much more, how many times more, understand word problems, be able to represent the information in word problems (e.g. write the correspondence between the number of boys and that of the girls.)
- Exercises (1, 3, 4, 8, 9, 10, 11, 12): These exercises are included in the curriculum as word problems, but they consist of easier exercises that can occur outside school (area and perimeter calculation, combinatorics, all possible cases, sum of arithmetic progression, calculating percent, solution concentration, ratio and proportions).
- Problem solving (2, 13, 14, 15): This group contains more difficult problems, which require a more complex reasoning. For example: Two ports are given. A ship departs from each port at 7 a.m. every morning in the direction of the other port. The voyage takes 150 hours. How many ships will we encounter on our voyage, if we are passangers on one of these ships? (The ships are heading towards each other, the meeting time is reduced by half)

The students were allotted ninety minutes for the test. The result, i.e. each item was graded on a dichotomous scale (good/not good). Each good answer, as well as essentially good answers was allotted 1 point, while wrong, as well as essentially wrong answers were allotted 0 points.

The test used for assessment

1. A farmer wants to fence a part of his land. He only has a 240 m long wire but he wants to fence the largest possible area. The farmer is not very good at mathematics, but he knows that one of the possible solutions is the following: a rectangle with sides 30 and 90 m. How would you advise the farmer? Convince him that you have a better solution.

2. There is a port on both shores of a sea. A ship departs from each port at 7 a.m. every morning in the direction of the other port. The voyage takes 150 hours. How many ships will we encounter as passangers on one of the ships?

3. There are 9 squares on a tram ticket. The ticket punch on the tram can punch 2, 3, or 4 holes in these squares. How many combinations can the ticket punch make?

4. There are 30 rows of seats in a theatre. Each row has 2 more seats than the previous one. How many seats are in the theatre if there are 50 seats in the 15th row?

5.a) $5\frac{2}{3}\cdot 2\frac{1}{3}=$ b) $8\frac{4}{7}:4\frac{3}{7}=$ c) $120\cdot\frac{8}{10}\cdot\frac{85}{100}=$

6. The number of boys (B) in a class is the $\frac{3}{4}$ of the numbers of girls (G) in the class. Write the correlations between the number of boys and the number of girls.

7. The number of books on a shelf is A. On the other shelf there are B more books.

a) How many books are on the two shelves?
b) How many times more books are on the second shelf?

8. Which is the number in case of which its 25% is 3 more than its 20%?

9. What percent solution do we get when we dissolve 200 g sugar in 1000g water?

10. An item is sold at the same price in two shops. Which shop would offer a better price, if one of them offered a 20% discount, while the other first offered a 10% and then an 11% discount?

11. What is the percentage error if a number is divided by 5 instead of being multiplied by 5?

12. If Peter is $33\frac{1}{3}$ % taller than Paul, how much percent shorter is Paul than Peter?

13. If you successively make 84, 78, and 86 points in a 100 points test, how many points should you make in a 200 points test in order to have 90% average considering the four occasions?

14. Andrew outruns Béla with 10 metres. Taking the same running speed what would the results be if Andrew started 10 metres behind the starting line?

15. On his 11th birthday Csaba planted a 90 cm tall tree, which in 4 years has undergone uniform growth and reached the height of 270 cm. If Csaba was 135 cm tall when he planted the tree and has also undergone uniform growth reaching 165 cm at the age of 15, when will he be of the same height as the tree planted by him?

The results of the survey

Table 1 contains the results of the sub-tests and those achieved in the test. The tests have been designed according to the curriculum, they were solvable by the students, consequently their results can be correlated with the maximum solution, the 100% result. The outliers (extreme values) are the following: 5 students (5%) achieved 0 points (0%), and 1 student (1%) excelled in comparison with the others, achieving 16 points from the maximum of 18 points, i.e. completed the test 88% correctly. Taking into account that the test contained simple exercises, the results are extremely poor.

Table 1. The average performance, standard deviation and standard errors in the comprehension test in mathematics

Students	Number of students	Average performance	Standard deviation	Standard error
BSc / first-year	81	4.03 (22.42%)	2.89	0.32
MSc	19	5.10 (28.33%)	2.20	0.50
Total	100	4.24 (23.55%)	2.80	0.28

Students could score 3 point in the first sub-test (operations), 3 points in the second sub-test (conceptual understanding), 8 points in the third sub-test (exercises), and 4 points in the fourth sub-test (problem solving). Table 2. shows in detail the number of poins BSc undergraduate students could score in the sub-tests (the maximum number of points) and the number of their actual correct and wrong answers.

Table 2. The results (in points) of the BSc undergraduate students in the comprehension sub-tests and test

Sub-test	Maximum number of points to be scored	Total (for 81 students)	The numbers of wrong answers	The numbers of correct answers
1.Operations	3	243	182	61
2.Conceptual understanding	3	243	166	77
3.Exercises	8	648	493	155
4.Problem solving	4	324	289	35
Test (total)	18	1458	1130	328

Table 2. shows that students have mastered operations at a rate of 25.10 %, conceptual understanding at a rate of 31.68%, exercises 23.91% and problem solving at only 10.80%. Altogerther the test was completed 22.49%.

Table 3. shows the number of points MSc students could score in the sub-tests and the number of their actual correct and wrong answers.

Table 3. The results (in points) of the MSc students in the comprehension sub-tests and test

Sub-test	Maximum number of points to be scored	Total (for 19 students)	The numbers of wrong answers	The numbers of correct answers
1.Operations	3	57	48	9
2.Conceptual understanding	3	57	36	21
3.Exercises	8	152	103	49
4.Problem solving	4	76	58	18
Test (total)	18	342	245	97

Table 3. shows that students have mastered operations at a rate of 15.78%, conceptual understanding at a rate of 36.84%, exercises 32.23% and problem solving at 23.68%. Altogerther the test was completed 23.68%.

Table 4. summarizes the results of Table 2. and Table 3. It shows the number of poins BSc undergraduate and MSc students could score in the sub-tests and the number of their actual correct and wrong answers.

Table 4. The results (in points, summary) of the students in the comprehension sub-tests and test

Sub-test	Maximum number of points to be scored	The numbers of wrong answers	The numbers of correct answers
1.Operations	300	230	70
2.Conceptual understanding	300	202	98
3.Exercises	800	596	204
4.Problem solving	400	347	53
Test (total)	1800	1375	425

Table 5. shows the percentage of correct answers in the sub-tests for BSc undergraduate and MSc students, separately and added up.

Table 5. The breakdown (in percentage) for sub-tests of the correct answers in the comprehension test

Sub-test	BSc	MSc	Total
1.Operations	25.10 %	15.78 %	23.33 %
2.Conceptual understanding	31.68 %	36.84 %	32.66 %
3.Exercises	23.91 %	32.23 %	25.50%
4.Problem solving	10.80 %	23.68 %	13.25%
Test (total)	22.49 %	28.36 %	23.61%

In the simplest sub-test, operations, the correct answers amount only to 25.1% (BSc), and 15.78% (MSc) respectively. The difference between the two groups is almost 10% in favour of the BSc undergraduate students. The explanation for this might be that they graduated from highschool this year and they have been using these operations recently, some of the students have even taken a Baccalaureate examinayion in mathematics. The MSc students have had more time to forget the rules for operstions.

In the case of conceptual understanding the percentages are slightly higher, i.e. 31.68%, and 36.84% respectively. The difference between the two groups is 5% this time in favour of the MSc students.

In the exercises sub-test 23.91%, and 32.23% respectively, difference around 8% in favour of thr MSc students. These exercises did not require too complicated calculations or reasoning. 25.5% of students succeeded in the test.

The problem solving sub-test didn't contain difficult problems either, however only 10.80% and 23.68% respectively could solve the problems, i.e. 13.25% of the total number of students. The two groups show the highest difference in results in this sub-test (13%).

MSc students did better in conceptual understanding, exercises and problem solving. The explanation for this might be that they have more experience, they have studied for more years, and their motivation, ambitions are also different. They have enroled for enroled for a MSc programme, they have been screened, thus they are a selected group.

Investigating what schools students came from, and what courses they studied we have found that nearly 60% of the students studied mathematics in high school in 3, 4, or 5 hours per week (attending science, mathematics, or informatics classes) and they have taken a baccalaureate examination in mathematics. 40% of the students came from humanities classes, and had studied no or hardly any mathematics, in 1-2 hours per week at most, and they have not taken a baccalaureate examination in mathematics.

Table 6. The breakdown of students with a baccalaureate in mathematics

Students	BSc	MSc	Total
Baccalaureate in mathematics	59.25%	57.89%	59%

Investigating the results of the comprehension test and sub-tests of the students with a baccalaureate in mathematics and those without a baccalaureate we can find differences between the two groups but not as considerable differences as expected considering the fact that one of the groups has hardly studied mathematics or hasn't studied at all, while the other group has had 3-4-5 classes per week.

There are some significant differences in the operations sub-test, but as we move from the conceptual understanding sub-test towards problem solving, the differences in the results of the two groups continue to decrease.

Table 7. compares on the basis of exercises solved the results of student who have taken a Baccalaureate in mathematics with the results of students who have had less mathematics classes in high school and did not take a Baccalaureate in mathematics.

Table 7. Results (in points) of the sub-tests and the comprehension test for BSc students with a baccalaureate in mathematics and those without a baccalaureate

Sub-test	Correct answers of the 33 students without a baccalaureate in mathematics	All possible good answers of them	correct answers of the 48 students with a baccalaureate in mathematics	All possible good answers of them
1.Operations	12	99	49	144
2.Conceptual understanding	23	99	54	144
3.Exercises	49	264	106	384
4.Problem solving	11	132	24	192
Test (total)	95	594	233	864

Table 8. compares the results in the sub-tests of the students who have taken a Baccalaureate in mathematics with those who haven't. Results are given in percentages.

Table 8. The breakdown (in percentage) of good answers in sub-tests for BSc students with a baccalaureate in mathematics and those without a baccalaureate

Sub-test	**Correct answers of the 33 students without a baccalaureate in mathematics**	**correct answers of the 48 students with a baccalaureate in mathematics**	**Total**
1.Operations	12 %	34 %	25.10 %
2.Conceptual understanding	23 %	37.5 %	31.68 %
3.Exercises	18.56 %	27.6 %	23.91 %
4.Problem solving	8.5 %	12.5 %	10.80 %
Test (total)	15.99 %	26.96 %	22.49 %

Table 7. and Table 8. show that there is a huge gap in the results in the case of operations. It is obvious that those who have taken a Baccalaureate are better at operations because they have studied this in depth on more occasions. In the case of the other sub-test this difference decreases visibly, the numers are very low for both groups.

Table 9. compares on the basis of exercises solved the results of MSC student who have taken a Baccalaureate in mathematics with the results of students who have had less mathematics classes in high school and did not take a Baccalaureate in mathematics.

Table 9. The results (in points) of the sub-tests and the comprehension test for MSc students with a baccalaureate in mathematics and those without a baccalaureate

Sub-test	**Correct answers of the 8 students without a baccalaureate in mathematics**	**All possible good answers of them**	**correct answers of the 11 students with a baccalaureate in mathematics**	**All possible good answers of them**
1.Operations	3	24	6	33
2.Conceptual understanding	8	24	13	33
3.Exercises	14	64	35	88
4.Problem solving	6	32	12	44
Test (total)	31	144	66	198

Table 10. compares the results of the sub-test of the MSc students with a Baccalaureate in mathematics with the results of students who do not have a Baccalaureate. Results are given in percentages.

Table 10. The breakdown (in percentage) of correct answers in sub-tests for MSc students with a baccalaureate in mathematics and those without a baccalaureate

Sub-test	**Correct answers of the 8 students without a baccalaureate in mathematics**	**Correct answers of the 11 students with a baccalaureate in mathematics**	**Total**
1.Operations	12.5 %	18.88 %	15.78 %
2.Conceptual understanding	33.33 %	39.39 %	36.84 %
3.Exercises	21.87 %	39.77%	32.23 %
4.Problem solving	18.75%	27.27%	23.68 %
Test (total)	21.52 %	33.33%	28.36 %

Table 9. and Table 10. show that there are differences in the results of the two groups when it comes to operations. Hovewer, the difference is not as significant as in the case of BSc students. This difference

decreases visibly for the other sub-tests. The numbers are low for both groups. When compared the two groups show the most marked difference in the case of exercises, almost double. It is also striking that there is a very slight difference between the two groups in terms of conceptual understanding.

Table 11. and Table 12. summerize the results of Table 7., Table 8., Table 9. and Table 10, the distribution of correct andwers in percentages.

Table 11. The results (in points) of the sub-tests and the comprehension test for students with a baccalaureate in mathematics and those without a baccalaureate (summary)

Sub-test	Correct answers of the 41 students without a baccalaureate in mathematics	All possible good answers of them	Correct answers of the 59 students with a baccalaureate in mathematics	All possible good answers of them
1.Operations	15	123	55	157
2.Conceptual understanding	31	123	5467	157
3.Exercises	63	328	141	472
4.Problem solving	17	164	36	236
Test (total)	126	738	299	1062

Table 12. The results (in percentage) of the sub-tests and the comprehension test for students with a baccalaureate and those without a baccalaureate (summary)

Sub-test	Correct answers of the 41 students without a baccalaureate in mathematics	Correct answers of the 59 students with a baccalaureate in mathematics	Total
1.Operations	12.19%	35.03%	23.33%
2.Conceptual understanding	25.20%	42.67%	32.66%
3.Exercises	19.20%	29.87%	25.50%
4.Problem solving	10.36%	15.25%	13.25%
Test (total)	17.07%	28.15%	23.61%

Comparing the results of the comprehension test with the grades students received in the mathematics baccalaureate (for the 58 BSc and 11 MSc students who have taken a baccalaureate in mathematics) we have found that the Pearson’s correlation coefficient is r = 0.148147. This shows a very weak relationship, i.e. there is no connection between the two evaluations. Even if students do well in the classroom this shows an isolated knowledge. They cannot apply the same knowledge in a novel, rather simple situation.

The table below contains the correlations between the sub-tests. The Pearson’s correlation coefficients are in general of medium strength. The operations and exercises sub-tests show the strongest connection to the other sub-tests. The strongest connection is between conceptual understanding and exercises (r = 0.46), problem solving and exercises (r = 0.45), as well as conceptual understanding and problem solving (r = 0.44).

Table 13. Correlation of the mathematical comprehension sub-tests (BSc)

Sub-test	Operations	Conceptual understanding	Exercises
Operations	0.22	-	-
Exercises	0.32	0.46	-
Problem solving	0.34	0.44	0.45

Table 14. Division by gender of the average performance, standard deviation and standard errors in the comprehension test in mathematics

Students	Number of students	Average performance	Standard deviation	Standard error
Male	52 (52%)	4.92 (27.33%)	3.0668	0.42
Female	48 (48%)	3.5 (19.44%)	2.2878	0.33
Total	100	4.24 (23.55%)	2.80	0.28

Conclusions

Overall, students have poor mathematics skills and poor usable mathematical knowledge. Students should have the elementary knowledge of mathematics which was sufficient in order to solve the test. So how can we account for these results?

The test was completed by 22.42% of the BSc first-year students, 28.33% of the MSc students, i.e. an average of 23.55%. The MSc average was one correct answer more than the firs-year student's average.

Investigating the relationship between the sub-tests of the comprehension test it is clearly discernible that students have achieved different results in the sub-tests, which suggests that mathematical comprehension depends on the content.

Nearly 60% of the students have studied mathematics and have a baccalaureate in mathematics, while nearly 40% of them have attended humanities classes, have studied hardly any mathematics if at all, and do not have a baccalaureate in mathematics.

Despite the fact that students have been assessed using a rather 'schoolish' test, on an elementary level, with only the method being less common (they were not addressed direct questions), the results are rather poor. There isn't a great difference between students who have taken a baccalaureate in mathematics and those who haven't. We assume that there are differences between the two groups as regards practical knowledge as well as the applicability of their knowledge. Compared to the fact that one of the groups has hardly studied mathematics or hasn't studied at all, while the other group has had 3-4-5 classes per week, the first group solved on average 3 exercises out of 18, while those with a baccalaureate solved 5. Thus, regarding the number of classes there is no proportional difference between the two groups.

Among BSc students one can notice that when it comes to operations there is a great difference between the results of the two groups. Those with a Baccalaureate are better at operations, which is obvious, since they have gone into depths in more classes. This difference decreases with the other sub-tests. The numbers are very low for both groups.

There is also a difference between the two groups of MSc students when it comes to operations. However, it is not as significant as in the case of BSc students. The difference decreases visibly for the other sub-tests. The numbers are low for both groups. When compared we find the greatest difference in exercises, almost double. It is also remarkable that in terms of conceptual understanding there is a very slight difference between the two groups.

Comparing the results of the comprehension test with the grades students received in the mathematics baccalaureate (for the 59 students who have taken a baccalaureate in mathematics) we have found that the Pearson's correlation coefficient is $r = 0.148147$. This shows a very weak relation, i.e. there is no connection between the two evaluations. Even if students do well in the classroom this shows an isolated knowledge. They cannot apply the same knowledge in a novel, rather simple situation. The baccalaureate grade does not reflect the applicable knowledge.

Investigating the correlations between the different knowledge areas, and levels (operations, conceptual understanding, exercise solving and problem solving) we have found a cause- effect relation between them: the strongest correlation is between conceptual understanding and exercise solving ($r = 0,46$), between conceptual understanding and problem solving ($r = 0.44$), as well as, between exercise and problem solving ($r = 0.45$). It is self -evident that until students do not interpret the exercises correctly, they cannot find a solution, and until they do not master exercises they won't be able to solve problems.

If we consider the distribution by gender of the average results, standard deviations and standard errors in the comprehension test we find that male students have achieved better results. They managed to solve correctly one and a half exercise more than female students.

References

[1] Ambrus, A. (2004): *Bevezetés a matematika- didaktikába*, ELTE Eötvös Kiadó, Budapest.

[2] Csapó, B. (1998): *Az iskolai tudás,* Osiris Kiadó Budapest, p.170.

[3] Dienes, Z. (1973): *Építsük fel a matematikát!*, Gondolat Kiadó Budapest.

[4] Dobi, J. (1998): Megtanult és megértett matematikatudás. In : Csapó B. (1998): *Az iskolai tudás*, Osiris Kiadó Budapest, p. 23- 29.

[5] Kánnai, Z.; Pintér, M. & Tasnádi, A. (2010): Matematikaoktatás a bolognai típusú gazdasági képzésekben, *Közgazdasági Szemle*, Volum LVII., Nr.3, Budapest, p. 261-277.

[6] Pólya, G. (1945): *How to solve it.* Princeton University Press.

[7] Skemp, R. R. (2005): *A matematikatanulás pszichológiája*, Edge 2000 Kiadó, Budapest.

[8] Tóth E., Csapó B. & Székely L. (2010): Az iskolák és osztályok közötti különbségek alakulása a magyar iskolarendszerben, *Közgazdasági Szemle*, Volum LVII. Nr.10, Budapest, p. 798-814.

[9] http://www.pisa.oecd.org

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