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MATHEMATICAL PREPARATION OF FIRST-YEAR STUDENTS OF APPLIED INFORMATICS FOR STUDIES AT THE UNIVERSITY OF ECONOMICS

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If you can't explain it simply,
you don't understand it well enough
Albert Einstein

Abstract. Mathematics is one of the main subjects conducted in the first year of economic studies. At the Faculty of Applied Informatics at the University of Economics in Kraków, mathematics accompanies students not only in the first year, but also throughout the entire course of studies, being an essential factor of either their further success or problems in studying. Therefore, both the proper preparation in this field acquired in secondary school, as well as the awareness of the importance of this subject, are essential factors influencing the efficiency of the undertaken studies. In this article, I will present the results of the survey research conducted among the first-year students at the Faculty of Applied Informatics at the UEK on the awareness of the necessity for mathematical knowledge in the process of efficient studying. I will also discuss the results of determining their actual mathematical skills acquired in secondary school on the basis of the research conducted in the academic years 2011/2012, 2012/2013 and 2013/2014 with the use of exemplary exercises from the *matura* final exam at the basic and extended level. On this basis, the conclusions serving as the starting point for further research on mathematical classes in the first year of studies have been drawn. The obtained information can prove useful for academic teachers in the proper conducting of classes on mathematical subjects. The article also contains general reflections and conclusions on the mathematical education of students of economic studies.

Keywords: mathematical preparation, didactics of mathematics, economic faculties.

JEL Classification: A20, A23, I21.

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1. Introduction

A common question posed by students in economic classes is: what do I need this mathematics for? Will I use the mathematical knowledge acquired in secondary school throughout the entire course of studies? I decided to act somewhat perversely and it was me who posed this question as well as other questions related with school and university mathematics to students. In this

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article I will present the results of the survey research conducted among the first year students of the Faculty of Applied Informatics at the UEK on their awareness of the necessity for mathematical knowledge in efficient studying. I will also discuss the results of determining their actual mathematical skills acquired in secondary school on the basis of the research conducted in the academic years 2011/2012, 2012/2013 and 2013/2014 with the use of exemplary exercises from the *matura* final exam at the basic and extended level. On this basis, the conclusions serving as the starting point for further research on mathematical classes on the first year of studies have been drawn.

Academic teachers are fully aware that the constant changes of the education reform do not facilitate their work with students, quite the opposite – they force them to change their methods of conducting classes and adjust the lectured material to the level of students. Teachers must face new challenges as, on the one hand, they have to supplement students' knowledge from secondary school (already learnt by students), and, on the other hand, they have to cover the full range of the university curriculum. From the point of view of an academic teacher, the new curriculum implies either a complete withdrawal or a significant reduction of important branches of mathematics[1], which later translates into the obtained results of teaching mathematical subjects. On teaching mathematics, Anna Zofia Krygowska writes as follows: *Elementary mathematics for everyone should not have the form of a reduced or deformed mathematics for the elite. […] Such mathematics should be reliable and modern – in its contents, structure, language and on all levels of education* [Krygowska 1984]. What is the students' opinion on this issue? As a result of the conducted research, I try to obtain the information on what kind of difficulties future students have and how they assess the usefulness of mathematical classes.

One cannot imagine studies at the Faculty of Applied Informatics at the University of Economics in Krakow without mathematics. It is one of the main subjects conducted in the first year of economic studies. Mathematics will accompany students not only in the first year, but also throughout the entire course of studies, being an essential factor of either their future success or problems in studying. Therefore, it is important to make students

[1] In the *matura* final exam at the basic level, such branches were withdrawn as e.g. the basic concept of propositional calculus, division of polynomials, solving inequalities of homographic function (Möbius function), graphs of trigonometric functions and others. More information can be found in the statement by the Head of the CCE [Central Committee of Education] of September 12th 2007.

realize that the basics acquired in earlier stages of education are necessary for continuing education in further years. Therefore, both the proper preparation in this field, acquired in secondary school, as well as the awareness of the importance of that subject are essential factors influencing the efficiency of the undertaken studies.

2. Results of quantitative research

The research[2] was conducted in the academic years 2010/2011, 2011/2012, 2012/2013 and 2013/ 2014 among the students of the first year of the Faculty of Applied Informatics at the University of Economics in Krakow. The group of the students subjected to the research was not selected randomly, as – unlike in the case of other faculties conducted at the University of Economics – in the first year of this faculty the course "Introduction to Mathematics" was initiated. Its aim was to revise and align the level of basic knowledge of mathematics from secondary school.

With the aim of checking the level of the mathematical competences of students, in the first classes a short test was conducted. It consisted in solving a series of tasks covering the material from secondary school. The tasks had a diversified level of difficulty, comprising material obligatory at both the basic and extended final examinations, as well as material slightly exceeding the level of secondary school (derivatives and limits). The analysis of the results of the test allowed for the evaluation of the mathematical preparation of secondary school graduates for studies at economic faculties and served for the selection of the most common errors made while solving tasks from different sets[3].

In their first course, the research[4] students were informed that the sole purpose of the test was the orientation concerning their knowledge after secondary school and that it contained tasks typical of the basic-level final examination, and several tasks from the extended-level examination. The students were informed that the results would have no influence on their final grade and were asked to treat the test seriously so that the lecturers had reliable information concerning their subject preparation. While analyzing the results of the test, it occurred that in each academic year the results were

[2] A detailed research description is included in the article [Prysak 2014].

[3] Exemplary sets of tasks which students were given to solve in the first classes can be found in this paper [Prysak 2014].

[4] In the research there participated 1158 students, 527 of whom were full-time students and 631 – part-time students.

surprisingly poor. Over 40% of the students either did not attempt to solve any of the given tasks or solved the tasks erroneously. The results of the tests are given below in the table (Table 1) presenting the percentage distribution of the number of persons in the respective ranges of points.

Table 1. The percentage number of students with the division into per cent of the obtained points

Points expressed in per cent	Percentage number of students
0-29	82.21
30-49	11.74
50-100	6.05

Source: author's own sources.

The results show the weakness of the mathematical preparation of students. Adopting the scoring in the academic system, i.e. the passable score starts from 50% of all possible points, it shows that nearly 94% of persons obtained a score below 50%. When adopting the evaluation system applied at the *matura* final exam, i.e. the passable score being above 30% of all possible points, the score is slightly better. According to this system, slightly more than 82% of students would have failed the test. It is worth adding that only one student obtained the maximum score. This result proves highly surprising when taking into consideration the fact that we study the score of tests from a four-year period. The poor results of the test were surely influenced by several factors, e.g.:

- the holiday period and the four-month break from mathematics, and in the case of part-time studies – the break being even longer,
- stress connected with the first math classes in the studies,
- tasks either from the extended level of the *matura* final exam or exceeding the range of secondary school.

Despite all these different factors, the poor results achieved by the students were highly worrying.

The next approach to the test results was to observe the distribution of points obtained by students for individual types of tasks. The tasks were divided into five groups[5], and the conducted score analysis together with the division into those groups of tasks looked as follows. Full-time students

[5] The groups were divided and named according to the following pattern: I – solving equations and inequalities, II – drawing graphs of functions, III – solving trigonometric equations, IV – different arithmetic and algebraic calculations, V – derivatives and limits.

dealt best with tasks from groups I and II, while part-time students – with tasks from group II. Obviously, what I mean here are not the full solutions of the tasks, which is shown in the percentage results of the maximum number of points, but the distribution of the points obtained by the students. When analyzing the results obtained by the full-time students, it could be observed that they had the largest problems with trigonometric equations and the material exceeding the range of secondary school. The part-time students had problems with trigonometric equations as well as with different arithmetic calculations. In the case of this group of students, a better preparation from the area of derivatives and sequences could be observed. This could be the result of the fact that some students had already been graduates of other faculties or that some of them had finished secondary school several years before, when the curriculum was not reduced as much as today. When taking into consideration the total results, it can be stated that the largest number of points was obtained for the tasks connected with drawing graphs of functions, while the poorest results were in the case of tasks which required skills of different arithmetical calculations.

When analyzing the work of students, several types of errors were distinguished from which certain conclusions can be drawn. It can be concluded that students' difficulties stem from the fact that they apply certain learnt formal procedures. This results from the solutions of the tasks that students are not aware of applying theorem or definitions and for them calculations without explanations are enough. Students apply algorithms without thinking about their sense and understanding their application. There also appeared errors in drawing graphs of functions. The scheme of activities looked such that on the basis of several arbitrary selected points, usually three or four, they drew a graph of the function. Even if more points were taken into consideration, there appeared errors and, consequently, it gave a false graph of the function. Often a graph finished on "limiting" points, i.e. those selected as the first and the last one. It could be seen that the writer did not take into consideration the shape or the domain of the function. In the case of homographic functions, the students forgot about asymptotes and thus incorrectly read out properties that were to be saved by them.

The above errors were the most striking. They are an alarming signal that the skills students acquire in schools are purely mechanical and often applied thoughtlessly. Students show a completely wrong understanding of the sense of the performed activities. The errors they made lead them to nonsensical conclusions which did not cause any doubts.

From the point of view of a teacher of a university of economics, such skills as solving polynomial and rational equations and inequalities or drawing the basic graphs of a function should not pose any difficulties for students. The errors described above indicate that future students of faculties of economics have great difficulties in solving such a type of tasks, which will prove a huge problem throughout the further course of studies. If graduates of secondary school fail to master basic mathematical knowledge, they will have to catch up on it during studies instead of concentrating on new material. This often proves to be a barrier both for students as well as teachers, because instead of learning new things necessary in other subjects, there is the necessity of revising or learning school material. The final result is such that the university material cannot be realized, gaps in mathematical knowledge grow even larger and the problem accumulates throughout the further course of studies, especially in the case of subjects where mathematical knowledge is of vital importance. Mathematics is a specific subject that can be compared to a tall tower, of which thus spoke the eminent Polish mathematician, Hugo Dyonizy Steinhaus, when trying to explain what mathematics really is to non-mathematicians: *Mathematics is like a tower whose foundations were laid centuries ago and to which further floors are being added. If one wants to see the progress in construction, he must climb the top floor, and the stairs are steep and plenty. The task of a promoter is to take a listener to the lift from which he will see neither the middle floors nor the rooms adorned with centuries-long effort, but what he will see is that the construction is tall and still growing taller*[6]. We must make students and pupils aware that learning mathematics is a constant process which begins already in childhood. You cannot simply learn mathematics by heart, what is required is reasoning, analyzing and drawing proper conclusions. The omission of certain parts of the material, hoping that the gap would be filled in later, leads to the discouragement of a student from learning mathematics as he/she fails to understand or have a command of something important and therefore the difficulties grow even larger. John von Nuemann said: *In mathematics we do not understand things. We simply get used to them*[7].

3. Analysis of the survey research results

The survey on the awareness of the necessity for mathematical knowledge for efficient studies was conducted among full-time and part-time students of the first, second and third year at the Faculty of Applied

[6] Source: http://www.matematycy.interklasa.pl/cytaty/steinhaus.php.
[7] Source: http://www.matematyka.wroc.pl/book/o-matematyce.

Informatics at the University of Economics in Kraków who started studies in the academic years 2013/2014, 2012/2013 and 2011/2012 respectively. It was a part[8] of this group of students who wrote the test (discussed in the previous paragraph). The survey was filled in by 402 students, 245 of whom were full-time students and 157 were part-time students. The first part of the survey contained questions referring to the information on the persons examined. Although the survey was anonymous, certain data which I considered essential were found in the answers of the respondents. The second part of the survey contained questions connected with the secondary school they finished, whereas the third part included questions referring to the period of studies, or – to be more precise – the application of mathematical knowledge throughout the course of studies at the university of economics. The last part included questions connected with the didactic tools applied during mathematical classes and learning mathematics at university. On the basis of the answers to the questions included in the questionnaire, I expected to obtain not only general information about the respondents but also about their approach to mathematics, both at school as well as university. Some of the questions included in the questionnaire had a form of closed questions, while some of them required a more extensive response or the respondents' own commentary. The analysis of the answers to the survey allowed for drawing certain conclusions as well as for answering the formulated research questions. I will present some of the questions included in the survey as well as the percentage share of the given answers.

A significant majority of the examined students of full-time studies (slightly above 96%) finished secondary school in the years 2010-2013, hence each of them must have written the *matura* final exam in mathematics at least at the basic level. Slightly larger differences were observed among part-time students. Almost 25% of them were pupils when the old version of the *matura* final exam was still in force, slightly above 20% of them wrote the new version of the *matura* final exam, but not necessarily from mathematics, and nearly 51% of the students took the obligatory *matura* final exam in mathematics. The obligatory *matura* final exam in mathematics did not fully translate into the higher level of mathematical knowledge, as –

[8] The number of students who filled in the survey was significantly smaller than the number of those who wrote the test, because in the higher years of studies (II and III year) there were fewer students in each of the groups (abandoning studies, repeating a subject, repeating a year) and it was impossible to find all the students, also not everyone filled in the survey.

together with the introduction of this version of the exam – the requirements were lowered, which I have already mentioned in the introduction to this paper. The test conducted in the first classes and its results discussed in the previous paragraph reveal the extremely low level of students' mathematical skills.

The majority of the examined students finished secondary school, including many with a mathematical profile. The diagrams presented in Figure 1 show the percentage division of types of secondary school finished by students, with a separate diagram distinguished for general secondary school so as to visualize the percentage of students finishing classes with a mathematical profile[9]. Regardless of whether these were full-time or part-time students, over 60% of them were graduates of general secondary school. Slightly above 25% of the examined were graduates of technical schools, while only a few students finished a different type of school. When taking a closer look at the general secondary school graduates, it can be observed that in the case of full-time studies significantly more than half of them finished a class with a mathematical profile. In the case of part-time studies, this makes slightly more than 50% of the respondents. To sum up, a class with a mathematical profile was finished by as many as 159 students, being a relatively large group of the examined. Hence, one could put a careful hypothesis that the motives of students choosing Applied Mathematics as their faculty were connected with their interests combined with the earlier choice of class profile in secondary school.

[9] There can be distinguished several types of mathematical profiles finished by the examined students:
- mathematical profile,
- mathematical and language profile,
- mathematical, English and geographical profile,
- mathematical and geographical profile, mathematical and chemical profile, mathematical and historical profile, mathematical and scientific profile, mathematical and economic profile,
- mathematical and physical profile,
- mathematical, physical and IT profile,
- mathematical, IT and geographical profile, mathematical, IT and chemical profile, mathematical, IT and biological profile,
- mathematical, IT and English profile.

The largest number of students finished secondary school with a mathematical and IT profile.

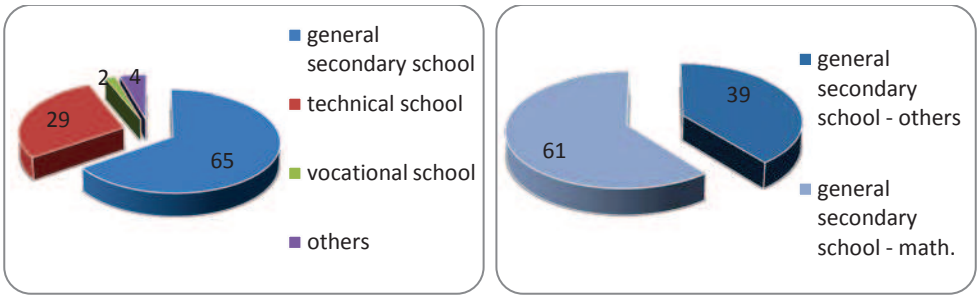

Fig. 1. The percentage division of the examined students considering a type of secondary school they finished as well as secondary schools with mathematical profiles

Source: author's own sources.

Figure 2 presents the percentage of students with satisfactory results from the *matura* final exam in mathematics at the basic level. The results are not poor, however they do not translate into students' knowledge, which is confirmed by their final grades in mathematics (discussed in the further part of this paragraph) as well as the results of the test discussed in the previous paragraph. The obtained results of the *matura* final exam, the test results and the final grade in mathematics allow for formulating the hypothesis that the fact of passing the new version of the *matura* final exam (even with a high score) at the basic level does not translate into high academic achievement and the range of mathematical knowledge it gives is clearly not sufficient enough to continue education within economic studies, especially at the Faculty of Applied Informatics, where mathematics is used throughout the entire course of studies. Out of 344 students who could have taken the *matura* final exam at the extended level, over 50% of them did not decide on this option. Full-time students usually (almost 47% of the examined) obtained a score of between 30% and 50% of all possible points, whereas the results of part-time students proved to be more uniform, excluding the best ones. Out of all the examined students, a very good score was obtained by almost as many students (6 pupils) as those who failed the *matura* final exam (5 pupils). While looking at the percentage division (Figure 3), one can observe the very low level of the results of the extended *matura* final exam in mathematics, and – as a result – the poor grades and difficulties in learning mathematics while studying economics. The grades shown in Figure 4 and the test results (discussed in the previous paragraph) confirm the above statement and allow for posing the careful hypothesis that taking the new *matura* final exam in mathematics at the extended level

helps significantly, but only a high score will facilitate continuing studies of mathematical subjects at the Faculty of Applied Informatics.

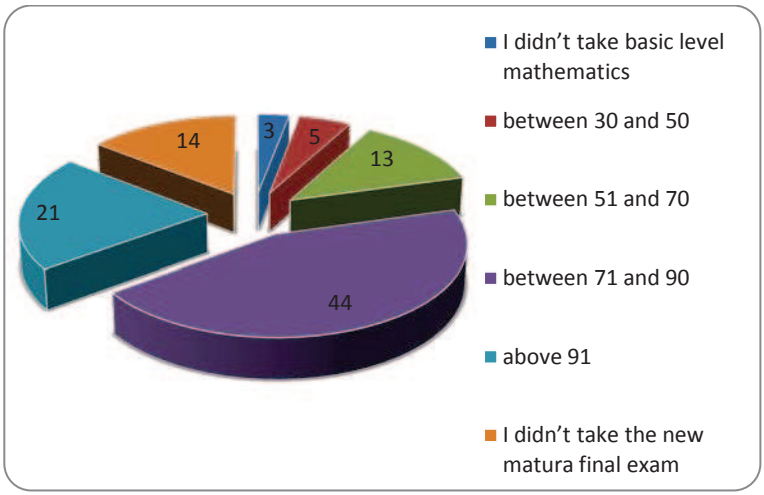

Fig. 2. The percentage division of the number of students obtaining satisfactory results in the *matura* final exam at the basic level

Source: author's own sources.

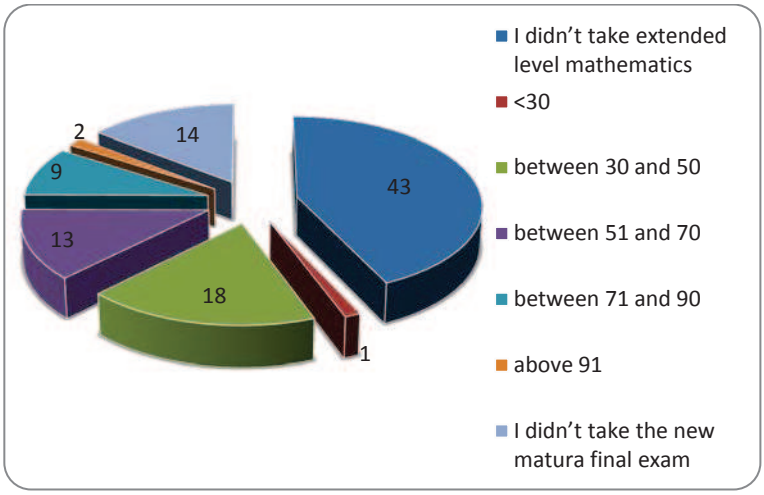

Fig. 3. The percentage share of the number of students obtaining satisfactory results in the *matura* final exam at the extended level

Source: author's own sources.

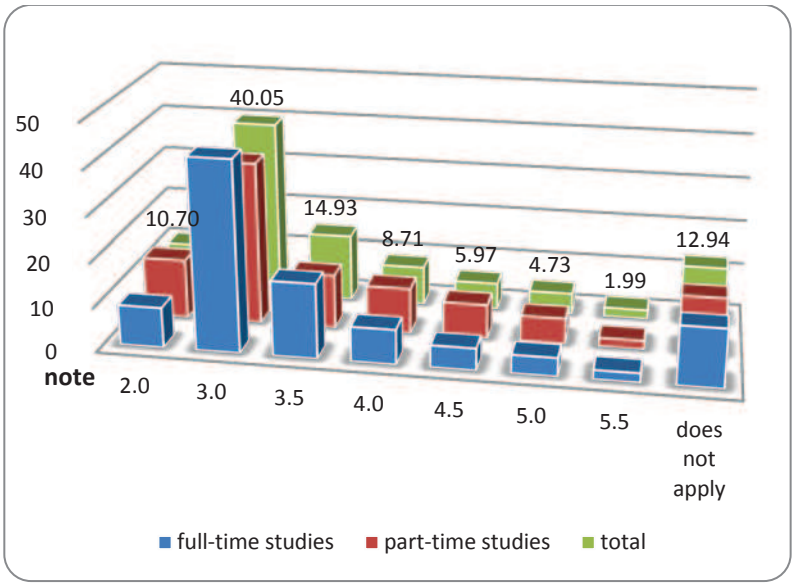

Fig. 4. The percentage distribution of the number of students obtaining satisfactory final grade in mathematics in the first year of studies

Source: author's own sources.

The answer to the question: *which of the following branches of mathematics did you find mo*st *difficult in secondary school?* looked as follows. Trigonometric functions proved to be the branch of mathematics in secondary school posing the largest problems for students. This is certainly the result of their significant removal[10] from the standards of the *matura* final exam in mathematics. For students of the Faculty of Applied Informatics at the University of Economics this is an essential branch of mathematics, as they use it in the first year when learning complex numbers as well as in higher years at the courses on programming and numerical methods. From the conducted survey research I received the answers that a large number of students had problems with complex numbers, being the result of the problems with trigonometric functions. The next branch the students had problems with were exponential and logarithmic functions, which is also connected with the reduced material in secondary school. The third position

[10] According to the statement by the Head of the CCE of September 12th 2007, from the basic level there was removed the definition of trigonometric function of any angle, graphs of trigonometric functions, trigonometric equations, and – from the extended level – reduction formulas.

in terms of problems with learning was occupied by mathematical logic, currently totally removed[11] from the mathematical curriculum in secondary school. Students usually explained their problems with the selected branch of mathematics in various ways: a poor teacher, their laziness, material being difficult, not sufficient number of classes on a given topic, generally not sufficient number of mathematical classes at school and the gaps of knowledge from secondary school. As it was one of the open questions, students presented their argumentation when giving answers to the above questions. I will cite[12] several of the most frequently appearing explanations.

A large group of students justified their answer by stating that teaching was poor, e.g. "the teacher did not have sufficient skills.", "the explanation of subjects was not clear enough.", "poor preparation of the teacher for classes, the lack of skills in communicating the knowledge.", "the explanation of the material was too fast.". This clearly shows that students do not have the awareness of their own responsibility for acquiring knowledge.

An equally large group of students responded that they were responsible for their poor preparation from a given part of the material. To cite some of their answers: "I hadn't been learning mathematics until I started studies and saw the difference in levels", "I was too lazy to work it out. I was discouraged by this topic and I never tried to understand it in a satisfying way", "I wasn't learning systematically", "my laziness and lack of engagement", "I didn't spend enough time on learning this topic".

Some of students found a given part of the material too difficult and thus argued: "difficulties with understanding the material, logic was not logical", "it was simply a difficult branch, especially inequalities", "a lot of theoretical problems, rules and principles", "the overloaded curriculum of mathematics", "I found some problems difficult to grasp", "trigonometry and logarithms are not intuitive for me. I was able to do easier tasks but I had problems with more difficult ones". There emerges the question of why – with such an assessment of their abilities – they chose this faculty of studies.

There also appeared other answers of students: "the teacher was changed final times in the final form", "not sufficient number of classes on

[11] From my point of view, this decision is absolutely incomprehensible, as all mathematics is based on logic.

[12] In this paper I will cite literal statements given by students, thus certain formulations provided by the examined can depart from the Polish language, sometimes they use everyday language (students' slang).

this topic", "too little time devoted to these problems as well as gaps in knowledge from secondary school", "too few classes", "rush in classes, the lack of good teaching materials (books)", "improper education system for middle schools and secondary schools which exists today in Poland".

The distribution of answers of students to the question: *Did the mathematical knowledge acquired in secondary school prove to be sufficient to study mathematical subjects at university?* was almost equal (YES – 54%, NO – 46%), hence it cannot be clearly stated on the basis of their opinions if the knowledge acquired in secondary school proved to be sufficient to continue education at university. From the position of an academic teacher assessing the results obtained by students, I can clearly state that this knowledge is by no means sufficient, especially in the case of those students who took the new version of the *matura* final exam in mathematics, but only at the basic level.

Similarly as in the case of the previous question, the answers to the question: *Did you have any difficulties with math classes in the first year of studies?* were distributed almost equally (YES – 56%, NO – 42%, no answer – 2%). This is how they argued why they had or had no problems with mathematics in the first year. Those who did not have problems in the first year answered that everything was clearly, well and precisely explained by the teacher, they had a good basis from secondary school, they had studied previously at a different university, it was mainly a revision from the secondary school or that systematical work brings results. Here are some of their answers: "I had a good basis from the secondary school", "I devoted a lot of time to learning this subject + knowledge from secondary school", "in the classes everything was clearly explained". Those students who answered that they had difficulties in math classes argued this fact by the poor level of teaching in secondary school, they had only taken basic *matura* final exam in mathematics, there was too much material to learn and it was covered too quickly, they did not learn systematically, the leap from secondary school was too large, classes were poorly conducted, they had too little time for learning because of work and that they had a long break in learning since finishing secondary school. Some of the answers looked as follows: "there was too much of new material", "gaps from secondary school, break in learning", "gaps in elementary knowledge", "I had too little time for learning, I was working elsewhere", "I had a year's break in education and I remember very little from secondary school", "the lecturer couldn't explain the material", "I neglected regular learning".

An interesting and important - from the viewpoint of a lecturer – was the following question: *Which branch of mathematics in the first year of studies did you find difficult?* The answers to this question are presented in Table 2 containing 8 out of the 22 mathematical branches difficult for students. The table presents only those branches where the number of students ticking a given answer was more than 100 persons.

Table 2. The sorted comparison of the number of students having problems with a given branch of mathematics

	The number of students		
Branch of mathematics	Full-time studies	Part-time studies	**Total**
1) Differential equation	114	58	**172**
2) Integral and its application (geometrical, economic)	96	57	**153**
3) Mapping and cyclometric functions	90	49	**139**
4) Relations and their properties	97	37	**134**
5) Integral calculus of function of one variable (indefinite, definite, improper integrals)	69	39	**108**
6) Sequences and their limits	60	46	**106**
7) Complex numbers	57	44	**101**
8) Trigonometric functions	61	39	**100 (184)**

Source: author's own sources.

Both full-time as well as part-time students reported the largest difficulties with differential equations and integrals. These branches of mathematics are interlinked and therefore I think that those who had problems with integrals as a consequence must have had difficulties with differential equations. Other branches causing problems with learning were relations and trigonometric functions. In point 8 there was a number of students who reported problems with a given branch right after secondary school. After the university course, a large improvement can be observed, as the number of students having problems with trigonometric functions is reduced by nearly 50%. This shows that classes in the subject "Introduction to mathematics" certainly bring results.

One of the more important questions was: *Do you think that in the first year of studies the mathematical material from secondary school should be revised and supplemented?* The answers to it, however, should be assessed carefully, as students' answers were not always reliable. A large number of students (YES – 82%, NO – 17%, no answer – 1%) want their knowledge from secondary school to be systematized, and – in some cases – even supplemented. 329 students answered the above question positively, so they find the subject "Introduction to mathematics" necessary. Maybe this fact should be seriously taken into consideration by the university authorities and included also into the curricula of other faculties of economic studies, not only into Applied Informatics. This would greatly facilitate both the work of academic teachers as well as students' learning.

Almost a half of the examined students (44%) said that they apply mathematics in other subjects (Mathematical Analysis and Linear Algebra, Probability Theory and Mathematical Statistics, Economics, Workshop Programming) during the first year of studies. In the case of applying mathematical knowledge and the contents in higher years of studies, the distribution is more equal (YES – 28%, NO – 33%, does not refer – 37%, no answer – 2%). Among the subjects mentioned by students were: Numerical Methods, Economics and Business Finance and Accountancy. When looking closer at the results while taking into account the year of studies, it shows that the higher the year of studies, the less mathematics is used in classes. Mathematics is most widely applied in the second year of studies, which is understandable, as this is when there is the largest number of classes in the above mentioned subjects.

When responding to the question: *Were academic textbooks helpful in learning mathematics?,* a significant majority (75% of the examined, Figure 5) answered that they either did not use textbooks or said that academic textbooks were not helpful in learning mathematics. 19% of the answers were positive and among the mentioned publications there appeared: Krysicki, L. Włodarski, *Analiza matematyczna w zadaniach cz. I i II* (*Mathematical Analysis in Exercises*, part 1 and 2) and A. Gryglaszewska, M. Kosiorowska, B. Paszek, *Ćwiczenia z matematyki cz. 1 i 2* (*Mathematical Exercises,* part 1 and 2). Particularly interesting seems to be Figure 6, which illustrates the aids used by the examined students when they did use books. Modern techniques, i.e. the Internet and films with ready solutions to exercises as well as Internet forums or special www sites devoted to mathematical problems make nearly 60% of the total share in the negative answer given to this question. It shows that the Internet and computers have

replaced books for good and this fact is hard to fight against. Nonetheless, it still seems worth trying, as not everything presented ready is the best solution to problems in learning mathematics.

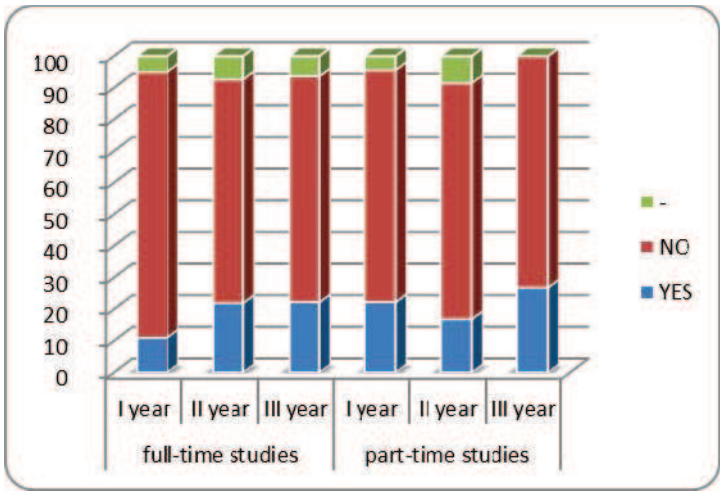

Fig. 5. The percentage distribution of the number of students using textbooks Source: author's own sources.

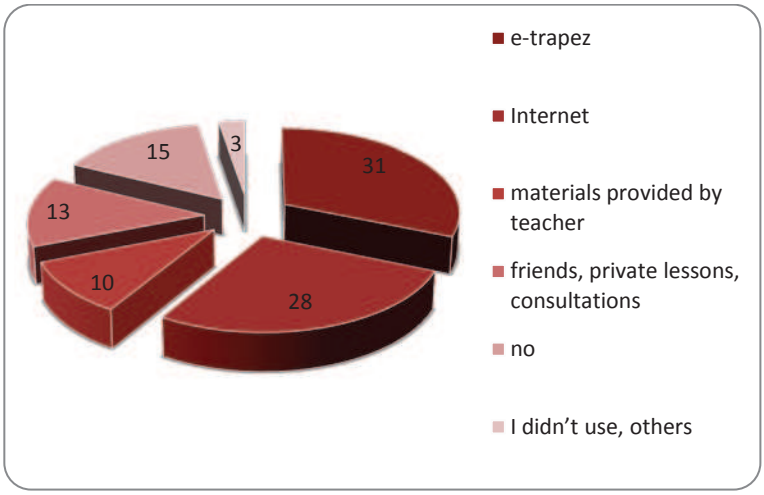

Fig. 6. The use of sources different than textbooks – the percentage distribution of answers Source: author's own sources.

The last question was: *Do you think that a special didactic aid (e.g. in the form of textbook or extra classes) with mathematical contents most necessary for the realization of other subjects at the university of economics would be useful?* A very large group – 74% of students – answered that some kind of an extra didactic aid to mathematics would be useful. Thus, it turns out that students need something more than just the Internet.

The answers obtained in the surveys addressed to students will be compared with the results of the surveys addressed to teachers conducting classes (from subjects where mathematical knowledge and contents are necessary to apply) at the University of Economics. This problem will be the topic of the further research.

4. Summary and conclusions

Summarizing, I am of the opinion that the changes [Maciuk 2011] introduced in recent years are particularly perceptible in the case of math classes, as they significantly reduce students' range of knowledge of this subject. There can be distinguished several reasons for this state of knowledge: the alterations to the mathematical curriculum in secondary school, the liquidation of entrance exams at universities, the new trend (pressure) of having higher education, the forthcoming demographic decline and the competition between universities leading to a reduction in recruitment requirements. This all means that the math culture of beginning students has been drastically reduced in recent years. For future economists (IT engineers), mathematics is an invaluable help in their professional life, especially in these times when the world around us is changing so fast. This rapid and dynamic development of civilization has made it impossible to live without mathematics. Functioning in the present reality is connected with the fast and accurate interpreting of information, calculating and making decisions.

From the survey research it clearly shows that the mathematical knowledge acquired in secondary school is very helpful and simply necessary throughout the course of studying. A good preparation obtained at school as well as taking the extended *matura* final exam in mathematics very often significantly facilitate – in the case of students – their learning, and in the case of an academic teacher – teaching these subjects. In the work [Miśkiewicz 2011], the author reflects on similar problems, namely whether the mathematical curriculum in secondary school sufficiently prepares future students for studying at universities of economics as well as whether

the obligatory *matura* final exam in mathematics will facilitate learning mathematics at universities of economics. The results she obtained are similar to those obtained in my research, which confirms the important role of teaching mathematics in secondary schools.

With a view to confirming the obtained results even more strongly, I will conduct the further research among the employees of the University of Economics in Kraków, who conduct classes in subjects where mathematical knowledge and contents are applied.

In summarizing, I would like to emphasize that the aim of studies is not to obtain a university certificate, but to acquire knowledge and skills which can prove useful in the modern labor market. Nonetheless, education is something that will remain with us after we have already forgotten what we have learnt. Wilhelm von Humboldt wrote: *A disciple is mature when he has learnt from others enough to be able to learn by himself*[13].

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[13] Cit. in: [Schevill 1947, p. 242].