Applied Mathematics as an Improver of Analytical Skills of Students

Jelena Korolova[1] Mag.paed.; **Anda Zeidmane**[2] Dr.paed.
Latvia University of Agriculture, Latvia
jelena.korolova@llu.lv[1]; anda.zeidmane@llu.lv[2]

Abstract: The development of analytical skills for prospective economic specialists is one of the most important competencies in a changing labour market and is one of cornerstones of the mission of higher education. A significant reduction of the mathematical unit in the Bachelor study program "Economics" increases the value of the course of applied mathematics as a means of academic development and in first analytical capacity of students. The study analyzes the impact of the course "Quantitative methods in economics" on the development of students' competence. The study intensity of the students and weak motivation just study calls for a change in the study process. Students' analytical skills develop if the study process is based on the student-centred and self-directed study approach using also the distant forms of studies. Modern applied mathematics assumes the combination in the study process of such traditional and innovative methods, tools, forms of learning as integrated lectures, professionally oriented set of practical exercises with the use of the computer. Complex of applied problems actualizes the realization of interdisciplinary connections at the level of knowledge and analytical work. The solution of tasks intensifies the educational-cognitive activity of students in mastering subject knowledge and skills as professionally significant qualities.

Keywords: higher education, analytical skills, applied mathematics.

Introduction

Higher education encompasses the imparting of knowledge in teaching-studying process for receipt of specific skills and wisdoms. In the same time the university education is only the springboard for purposeful further education throughout life and the first task of higher education is to create the preconditions for self-directed learning.

The aim of the Bachelor study program "Economics" is to provide students with the knowledge and skills necessary to be work-ready and competitive economists in the national and international labour markets; to promote research skills' acquisition; to develop analytical ability and skills and to prepare students for studies on higher education level. In the program the graduates receive the sixth level diploma in the European Qualifications Framework (EQF), the appropriate knowledge, skills and competence (Akadēmiskās augstākās..., 2016). Descriptors defining six levels of EQF: "advanced knowledge of a field of work or study, involving a critical understanding of theories and principles; advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study; manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups" (Descriptors defining..., 2016). All of these descriptors indicate on the necessary competences for student as prospective specialists.

Changes in society and economics require specialist training in order to make the best decisions in a changing environment. A specific feature of the work of an economist in modern society is to work in the conditions of lack of information, time and incompleteness of the initial data. The analysis of such information requires special techniques. Currently many tasks of planning and management, as well as a great amount of private applied problems are solved by methods of mathematical programming, many of which are implemented on the computer. In this case, the time for optimal decisions' taking is determined mainly by the type of tasks, professional knowledge and skills for solving tasks of optimization.

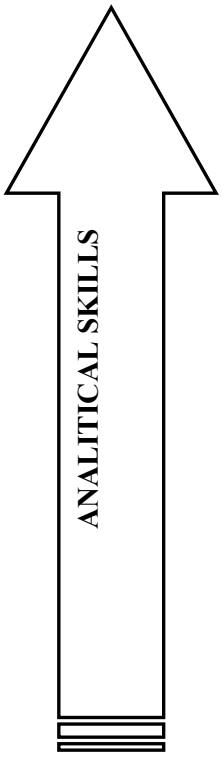
Bachelor of Social Sciences in Economics (240 ECTS) program also include the studies about some mathematics' methods: Mathematics for Economists (6 ECTS), Statistics (6 ECTS), Mathematic Statistics (3 ECTS) and Quantitative Methods in Economics (3 ECTS). That is only 7.5 % of total value of the study courses. "Unlike most other subjects, mathematical activity resides almost entirely within

the cognitive processes of a mathematics practitioner and is therefore difficult to characterise." (Samuels, 2012). Knowledge and understanding of mathematical approach to problem solving is an integral part of the general intellectual level of future economists.

The aim of the study is to analyse the applied mathematics "Quantitative Methods in Economics" (QME) course as an improver of analytical skills of the prospective economist. After completing QME the student must have knowledge and ability for optimal and environmental safety decision planning and carrying a process in economics; skills build and analyze the quantitative model of economic systems with MS Office Excel tool Solver and decision taking with Analytic Hierarchy Process (Koroļova, 2011). Applied problems are of interest to students because they reveal the mathematical nature of reality, they have educational and professional value. The implementation of interdisciplinary connections on the level of knowledge and level of activity is intensifying the educational-cognitive activity of students.

In business practice, the level of development of the analytical skills intelligently to decide, give a set of essential factors, to find a way out of difficult situations, prioritize, investigate and assess the situation, classify events, facts, plan and build a system of judgment and reasoning correctly in terms is an essential aspect of communication. Analytical skills are largely conventional and play an essential role in the ability of people to understand each other.

Strong analytical skills are a balance of analytical and synthetic activities of thinking. Basic components of analytical skills are represented in Figure 1.



critical thinking - ability to question accepted and well-established judgments and arguments, to modify the original hypothesis, formulate questions, allowing to complement or revise the situation
skill search and create algorithms (solving problems, operations), the ability to apply them or adapt to new situations
the skill of formulating hypotheses, ability to work with facts and assumptions to understand the difference between them
the ability to think systematically, give a set of essential factors to build information into a hierarchical logical levels
the skill of identifying essential and sufficient for the decision-making factors, prioritization and the ability to disregard less relevant
the ability to think and express ideas coherently, logically and draw conclusions
ability to structure, organize information
the skills of comparison, evaluation and monitoring
the ability to see significant relationships between objects and phenomena: interference, causality, etc.
the ability to find the common essential features of private events – **the skill of abstraction/generalization and classification**
the ability to divide and differentiate the set of data (objects, data) into its component parts on any essential features or categories

Figure 1. Basic components of analytical skills (author's construction).

For developing appropriate analytical skills students can use the tools that already exist in the relevant application area. For example, the practice of applying structured analytical approach to decision making in courses of applied mathematics. Study process during course QME carried on basic pedagogical principle - to study from simple to difficult and familiarity with appropriate tools and techniques.

Methodology

The study was carried out during 2014-2016 in Latvia University of Agriculture. Respondents are 84 the 3rd year full time students of the Bachelor study program "Economics".

Analytical skills of students were tested before study courses QME. There were three tasks: logical test with non mathematical chain; formation of linear one argument function; developing the simple algebraic algorithm. Evaluation of study course "Mathematic Statistics" during 2nd year of Bachelor program was used as a start level of analytical skill, too.

The combination in the study process of such traditional and innovative methods, tools, forms of learning, as integrated lectures, professionally oriented set of practical exercises with the use of computer, the complex applied problems in actualizing the implementation of interdisciplinary connections on the level of knowledge and level of activities intensify the educational-cognitive activity of students in mastering subject knowledge, abilities and skills, and in mastering professionally significant qualities.

The learning outcomes of QME course evaluated by four parts during pedagogic experiment:

- Linear and Integer Programming for optimal use of limited resources (40 %) – solving of analogous problems with analytic analysis;
- Critical Parts Methods and Linear Programming for optimal project planning (20 %) – solving of analogous problem;
- The Analytic Hierarchy Process (AHP) for optimal alternative decision in economics (20 %) – creative homework with on-line support - teacher consultations;
- The tests theory quantitative methods in Economics (20 %).

Methods of the study also are questionnaire pool and statistics' data processing (MS Excel, SPSS).

Results and discussion

Examination of analytical skills before QME study course display the situation in the beginning of the 3rd study year: correct formation of linear one argument function had 73 % of students, only 40 % developed the simple algebraic algorithm for problem solving, but logical test with non mathematical chain stayed as "secret". Those indicate the exigency to grow up academicals skills of students.

The relationship of the achievements of students between the courses of applied mathematics - QME evaluation correlate with evaluation of "Mathematic Statistics" (Spearman correlation 0.49, p-value<0,05). A positive correlation was also due to individual capabilities of students and specify the opportunities for growth their potential.

The study highlighted the following steps for solving optimization problems:

- analysis of the conditions of the problem;
- devising a mathematical model;
- in the form of mathematical models to determine which class is the task of choosing a suitable method of solution;
- solution of the problem according to the algorithm selected method;
- if necessary verification or investigation of the decision;
- formulation of response objectives;
- conduct analysis of the solution.

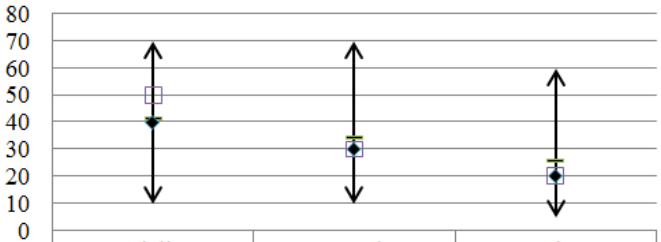
In accordance with the stages of solving optimization problems considered the following skills:

- to highlight the state of objects, their characteristics, task requirements;
- schematically write the problem statement (in the form of a table in Excel);
- read the problem statement, written in detail;
- to determine the relationships between variables;
- write an objective function, constraints, boundary conditions;
- to formulate a mathematical model of the problem;
- to determine to which class of optimization problems belong to this task;
- to select the appropriate method of solution;
- to apply the algorithm to solve the problem;
- provide economic or geometric interpretation of the solution;
- to develop the best plan for solving the problem;

- to give economic interpretation of the initial response;
- to select the appropriate method of decision analysis;
- apply the appropriate method of analysis to solve.

The need for further development of logical-mathematical intelligence, which as a unit of information uses a symbol system (Гарднер, 2007) indicates relatively low ability to formulate mathematical models.

For evaluation the developing of analytical skills during study course only results of two control tests were selected, excluding homework and theoretical tests. QME course evaluation results correlate (Spearman correlation 0.835, p-value<0.05) with evaluations of 1st test - mathematical modeling and solving problems with analytic analysis.



	Modelling	Excel	Analysis
MAX	70	70	60
MIN	10	10	5
AVERAGE	41	34	26
MODE	50	30	20
MEDIAN	40	30	20

Figure 2. The complexity of modelling, solution with Excel and analysis of specific tasks according to students (%) in QME study course.

Most efforts in solving problems among students required mathematical modeling - the analysis of specific problem, devising a mathematical (symbolic) model and determining of which class is the task of choosing a suitable method of solution (mode 50, median 40) (Figure 2).

The evaluation of 1st test depends on the ability of mathematical modeling (Pearson correlation 0.66, p-value<0.01), the capability to analyze optimal decision and give economic interpretation (Pearson correlation 0.52, p-value<0.01), that was required in only one task out of three during 1st test in QME study course.

Distinct and quite significant difficulties (mode 30, median 30) for students are the forming table and decision of tasks by means of a computer in MS Excel (Figure 2). One of reason may be the exception course of "Informatics in economics" in study program for 2016 student group. Evaluations of the 1st test for 2014-2015 student groups significantly positive correlate with the evaluation of "Informatics in economics" (Spearman Correlation 0,516, p-value<0,05).

The 2nd tests results low correlate with 1st tests results (Spearman Correlation 0.27, p-value<0,05). This means that growth is possible even if no luck in the beginning of the course. Successful of the mathematical modelling during 2nd test weekly correlated (Pearson correlation 0.34, p-value<0.01) with the ability to create the algorithm during tests before QME course. When comparing the results from 1st and 2nd test 86 % of students observed significant positive dynamic growth of analytical skills.

Errors in decision making arise for several reasons: lack of information about the situation; inadequate evaluation of the received information; inadequate assessment of the situation based on the received information; incorrect method of solution; incorrect assessment of the consequences of decisions.

The main reasons of mistakes and unsuccessful results on student opinion in QME study course are the inattention (mode 50 %, median 45 %) and low motivation for better achievement (mode 50 %, median 28 %).

Some students noted the lack of time for communication during the course. The decrease in the mention of time constraints in the questionnaires was in the 2015-2016 academic year when the lectures were integrated in the laboratory work with the computer. Work only in small groups gives the opportunity to increase the time for analysis and discussion during the course.

Conclusions

A significant reduction of the mathematical unit in the Bachelor study programme "Economics" increases the value of the course applied mathematics as an improver of academic development and in first analytical capacity of students.

Most efforts in solving problems among students required mathematical modelling - the analysis of specific problem, devising a mathematical (symbolic) model and determining of which class is the task of choosing a suitable method of solution.

One of the reasons is quite significant challenges (mode 30 %, median 30 %) for students are the creation of the table and the solution in Excel can be an exception of course “Informatics in Economics” from the curriculum.

Despite the fact that only 73 % had correct formation of linear one argument function before QME study course, in general within three years of the study 85 % of students received an assessment of their work in QME above 50 % and 86 % of students improved analytical skills during this course.

The low intensity of study and weak motivation for better achievement calls for a change in the study process.

Bibliography

1. *Akadēmiskās augstākās izglītības bakalaura studiju programma - Ekonomika* (2016). (Academic Higher Education Bachelor's Program – Economics). LLU, Ekonomikas un sabiedrības pārvaldes fakultāte. [online] [28.01.2016]. Available at http://www.esaf.llu.lv/ekonomika (in Latvian)
2. *Descriptors defining levels in the European Qualifications Framework* (2016). EU: Learning Opportunities and Qualifications in Europe. [online] [28.01.2016]. Available at https://ec.europa.eu/ploteus/en/content/descriptors-page
3. Koroļova J. (2011). *Kvantitatīvās metodes ekonomikā* (Quantitative Methods in Economics). Kursa programma (Study course program). [online] [28.01.2016] Available at https://lais.llu.lv/pls/pub/kursi.startup?l=1 (in Latvian)
4. Samuels P. (2012). Capturing and communicating advanced mathematical activity, *Journal of Learning Development in Higher Education*. [online] [28.01.2016]. Available at http://www.aldinhe.ac.uk/ojs/index.php?journal=jldhe&page=article&op=view&path%5B%5D=181
5. Гарднер Г. (2007). Структура разума: теория множественного интеллекта (Frames of Mind. The Theory of Multiple Intelligence). Москва: Вильямс, 512 с. [online] [28.01.2016]. Available at lib100.com/book/superlearning/frames_of_mind/_Говард_Гарднер,_Структура_Разума.pdf (in Russian)