ERGONOMIC RESEARCH FOR THE QUALITY OF THE ENGINEERING TRAINING

ЕРГОНОМИЧНО ИЗСЛЕДВАНЕ КАЧЕСТВОТО НА ИНЖЕНЕРНОТО ОБУЧЕНИЕ

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***Abstract**: In ergonomic aspect engineering training is complex and intense human activity. It is a subject of research and analysis in order to optimize it. Quality of education is seen as a trinity of effectiveness, efficiency and satisfaction – criterias, which are defined, tested and evaluated by a specially developed original methodology by the authors.*

Keywords: QUALITY OF TRAINING, ERGONOMIC RESEARCH, EFFECTIVENESS, EFFICIENCY, SATISFACTION

1. General characteristics of the problem

Training of students in engineering universities is highly intense intellectual activity associated with acquiring specific knowledge and expertise in various fields. Like any other human activity training is subject to optimization, which requires permanent research and evaluation. Ergonomics is a scientific field aimed at continuous improvement of human activities, by considering the "human factor" as at an individual level (each person is a unique individual with his physique, psychology, anatomy, etc.) and in organizational plan of activities which he/she performs to achieve predefined objectives (activities). The criteria for making such an ergonomic evaluation of each activity are [1]:

• good and excellent results in labor;
• protect the health of each worker;
• providing conditions in which a person feels satisfied.

"Usability" [8] and "usability engineering" [6] have been developing and specifying these "ergonomic" criteria during the last decade. At the beginning these criteria applied only to evaluation of usability of software products [9]. Gradually they are shown to apply to the evaluation of other products, systems, services - activities [3]. The essence of "usability" is concluded in: the quality of every product, system or service is assessed by users themselves in the summary criteria: effectiveness, efficiency and satisfaction. The meaning and content of these criteria are defined in international standards such as series of standards ISO 9242.

In ergonomic aspects the quality of engineering training includes research and evaluation of engineering training in order to reach aims of training considering students' efforts and satisfaction in the process of training. In its essence, the quality of education is regarded as a trinity of its **effectiveness, efficiency and satisfaction**.

The Ergonomic study of the quality of engineering training enables students-users of "service" – training to assess the achievement of the main goal: acquisition of high quality and adequate to the time training. (Axiomatic is a link training – education. High quality training is essential for highly quality education).

The quality of training depends on the specific conditions under which it occurs. The survey, represented in this article, includes the activities of students with their success, efforts and satisfaction with: fulfillment of academic tasks (examinations, development and defence of a projects); characteristics of training such as: the level of teaching, consisting content, complexity, actuality, organization and informational cover, laboratory and IT equipment (hardware, software), physical and not least the social and professional environment at the university.

2. Methods of Ergonomic research

2.1 Tasks

The tasks of the ergonomic research of quality of engineering training include:

• Definition of the terms quality of training, effectiveness and efficiency from the Ergonomics point of view;
• Development of adequate methods for ergonomic approach for obtaining the necessary information for defining and measuring quality of engineering training;
• Research and evaluation of quality of training, according to the ergonomic approach.

2.2 Definitions

In this article under the term ***Ergonomic quality of training*** we understand: the degree of achievement of the goal: *accomplishment of high quality and adequate up to date training, evaluated by the users-students themselves, which is effective, efficient and satisfactory.*

Effectiveness (EF) reflects the degree of attainment of training objectives – the successful solution of academic tasks (command of basic theory, special, specialized and practical knowledge and skills through good teaching and methodical work).

Efficiency (EC) reflects efforts in passing exams, development and defence of projects: as time, cost of resources in psychological, health, social and material aspect.

Satisfaction (ST) reflects the attitude (positive or not) of the user-student to the overall process of training, expressed in the sensation of comfort or discomfort in the university intellectual, social and physical environment.

Experience shows that it is possible by using objective or subjective tests (measurements) to obtain data associated with each component of the ergonomic quality of every human activity, including in training [4]. For satisfaction, for example, we can draw conclusions and by objective measurements concerning behavior – demonstrated confidence, activity outside the university and academic activities. The effectiveness and efficiency can be assessed by subjective opinion of the users about their work and results during their training [5].

2.3 Model and methods of the study

Fig. 1 shows definition of the aims of ergonomic research.

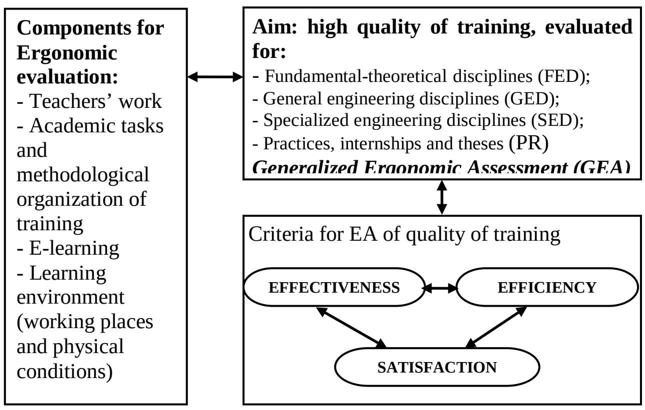

*Fig. 1 Model of Ergonomic **research and evaluation** of quality of engineering training*

The aim of the survey is the increase of the quality of engineering training. This aim is investigated by sub aims**,** which include improving education in:

- Fundamental-theoretical disciplines (FED);
- General engineering disciplines (GED);
- Specialized engineering disciplines (SED);
- Practices, internships and theses (PR).

Every one sub aim is evaluated for ***effectiveness, efficiency and satisfaction*** through a set of assessments for deferent indicators**.**

Description of the components of ergonomic research and evaluation

The teachers' work – assessed trough parameters which reveal their professional and pedagogical competence and their ability to work with new IT.

Academic tasks and methodical organization of training – assessment of the characteristics of academic tasks that affect **the ergonomic** quality of training as content and complexity of educational information, provision of textbooks and other materials, methodical organization of seminars, optimization of the schedule of classes, deadlines for the learning of material, frequency and duration of the academic tasks, success and difficulties in examinations, etc.

Learning environment – assessment of important characteristics of the physical and social environment such as equipment for classrooms and workplaces with the necessary technical equipment, availability of libraries and their informational and technical support, computer networks, equipment, furniture, assessment of physical environment: microclimate (temperature, relative humidity), lighting, noise, social and cultural environment (e.g. internships, organizational structure).

E-learning – assessment of important characteristics for e-learning, such as availability of educational and informational materials uploaded for the specific field of training, in different subjects, the degree of free access to information and usage of specialized software.

Ergonomic assessment of the quality of training (EAQT) with Ergonomic checklist (ECL)

The method of ECL allows evaluation of multiple single, private or complex ergonomic factors and indicators through questions, answers of which include using of multi-scale system [1, 2]. Each factor, indicator or component has its own weight, which is part of a complex ergonomic assessment of EAQT. The value of the weight coefficient is determined by the expert method and depends on the degree of influence of the factors and its structural defined place in the hierarchical model of EAQT**.** The complex EAQT is evaluated by the equation below:

$$\textbf{(1)} \qquad \boldsymbol{E = \alpha_{EF} EA_{EF} + \alpha_{EC} EA_{EC} + \alpha_{ST} EA_{ST},}$$

where **E** is **EAQT; $\mathbf{EA_{EF}}$; $\mathbf{EA_{EC}}$; $\mathbf{EA_{ST}}$** are ergonomic assessments (EA) of: effectiveness, efficiency, satisfaction with training; α_{EF}; α_{EC}; α_{ST} are weights for effectiveness, efficiency, satisfaction with training.

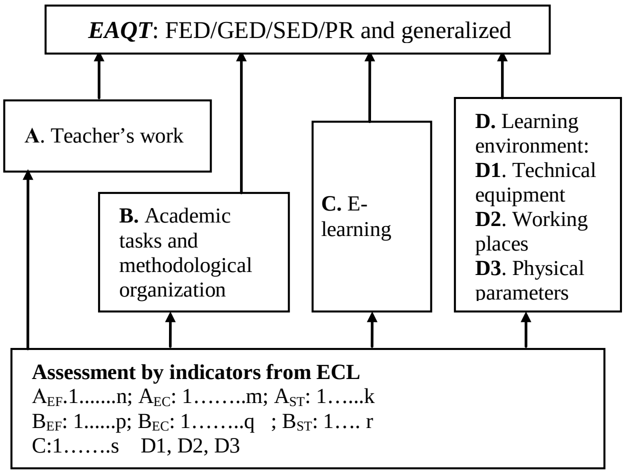

Fig. 2 The structural scheme of the ECL

Each of the assessments of key criteria (effectiveness, efficiency and satisfaction) is also the result of a hierarchical system of assessments of specific for the component ergonomic factors and indicators. This requires a thorough analysis of the influence of each investigated factor/indicator and its weight in the structural model of EAQT as well as the mathematical model for processing the experimental results. The development of ECL is a long and responsible process which requires multiple inspections, adjustments and optimization in order to obtain maximum reliable ergonomic assessment for the investigated system. Fig. 2 shows a structural scheme for the evaluation of training for criteria ***effectiveness, efficiency, satisfaction*** for each group of subjects (FED, GED, SED and PR) and GEA.

The effectiveness of training for each group of subjects (FED, GED, SED and PR) is formed by assessments of the indicators from ECL:

- The work of teacher according to criteria – A_{EF} 1 .... n;
- Academic tasks and methodical organization – B_{EF} 1 ...... p;
- E-learning environment – C: 1 .... s;
- Learning environment, D1, D2, D3.

The efficiency of training *f*or each group of subjects (FED, GED, SED and PR) is formed from the assessments of indicators different from those for EF:

- The work of teacher according to criteria – A_{EC} 1 .... n;
- Academic tasks and methodical organization – B_{EC} 1 ...... p;
- E-learning environment – C: 1 .... s;
- Learning environment, D1, D2, D3.

Satisfaction with training for each group of subjects (FED, GED, SED and PR) is formed by assessments of special questions asked in the ECL for:

- The work of teacher according to criteria – A_{ST} 1 .... n;
- Academic tasks and methodical organization – B_{ST} 1 ...... p;
- E-learning environment – C: 1 .... s;
- Learning environment, D1, D2, D3.

Technical and technological preparation of the study

Technology of research includes consideration of the following requirements:

- The respondents have completed a particular specialty with a bachelor degree in a recent one or two years, which draws the attention of some researchers to students in master degree in related disciplines;
- Preliminary study of the objects of study – curricular, specifics of the courses for the specific specialty in bachelor degree and other academic tasks;
- Preparation of printed and/or electronic materials for each group of respondents.

For the study seven ECLs have been developed for different engineering specialty in bachelor degree in three universities: University of Chemical Technology and Metallurgy (UCTM), University of Forestry (UF) and Technical University - Sofia (TU).

Each checklist contains questions (total 355), requiring assessments in 5 degree levels scale of effectiveness, efficiency and satisfaction. Questions on the checklist have been grouped into four sections for evaluation of training in:

- Fundamental-theoretical disciplines (FED);
- General engineering disciplines (GED);
- Specialized engineering disciplines (SED);
- Practices, internships and theses (PR).

3. Results and analysis of the research

The research was conducted during the school year 2010/2011. The students who were surveyed were 150 and all were MA students. The results are presented summarized below. (Summarized results help to show general trends for the optimization of engineering training while any assessment of single or private ergonomic factors and indicators is an indicator of success or problems in the training of students in different engineering specialty in a certain university.)

Table 1 and Fig. 3 present the results of evaluations of the effectiveness of engineering training. These assessments have been arranged from good to very good. The lowest assessments are those of fundamental training and there is a trend for their increase for GED and SED.

Table 1: Effectiveness of engineering training

Effectiveness of training	UCTM	FU	TU
FED	4.13	4.09	4.05
GED	4.22	4.38	3.81
SED	4.43	4.24	4.29
PR	4.55	4.96	4.35
EA_{EF}	4.33	4.42	4.13

The highest assessments of the effectiveness of the activities of the students are in PR.

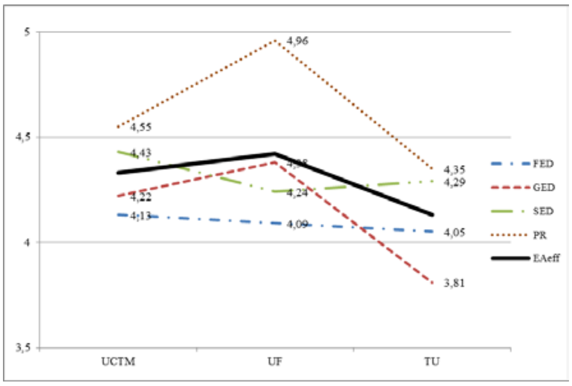

Fig. 3 Effectiveness of engineering training

Students give a fairly good estimation for the effectiveness of engineering training, which means that they successfully deal with the set of academic tasks.

Table 2: Efficiency of engineering training

Efficiency of training	UCTM	FU	TU
FED	4.09	3.93	3.83
GED	4.08	4.36	3.71
SED	4.45	4.2	4.11
PR	4.27	4.75	4.64
EA_{EC}	4.22	4.31	4.07

Table 2 and Fig. 4 show the results of assessments of the efficiency of engineering training. The results shows a reduction in assessments in comparison with those of effectiveness, i.e. the efforts, which students put to execute academic tasks and are the main part of the assessments of the efficiency of training, are the reason for these lower assessments.

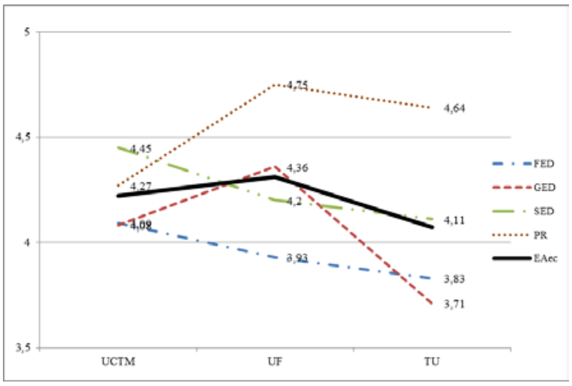

Fig. 4 Efficiency of engineering training

Once again, we could notice the relatively low assessments for FED, but in assessments for GED we also could notice decline for two of the universities (UCTM and TU). This is an indicator for a need of improvement of training in this group of subjects.

In terms of PR UF and TU show even very good assessments, but for UCTM we could notice decrease of assessments compared to those of the SED. This is also an indication of the level of organization and achieved good results in this group of engineering training.

Table 3 and Fig. 4 present the results of generalized ergonomic assessments (GEAs) for the three universities and the assessment of student satisfaction with the e-learning.

Table 3: EAQT and EA of E-learning

	UCTM	FU	TU
EA_{EL}	3.42	3.34	3.33
EAQT	4.35	4.37	4.14

Generally, conclusion is that the available e-Learning is underdeveloped and this could be one important direction to improve the quality of education.

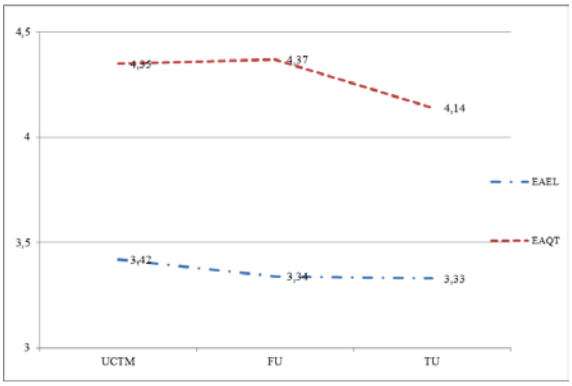

Fig. 5 EAQT and EA of E-learning

Table 4 and Fig. 6 show the results of evaluations to the satisfaction with engineering training.

Table 4: Satisfaction with engineering training

Satisfaction with training:	UCTM	FU	TU
FED	4.08	4.02	3.94
GED	4.14	4.4	3.8
SED	4.41	4.09	4.12
PR	4.75	4.61	5.3
EA_{ST}	**4.5**	**4.39**	**4.23**

Assessments for the satisfaction with FED, GED and SED, with few exceptions (UF - GED), are lower than the assessments of effectiveness and efficiency. The highest assessments for the entire research are assessments of satisfaction for the PR.

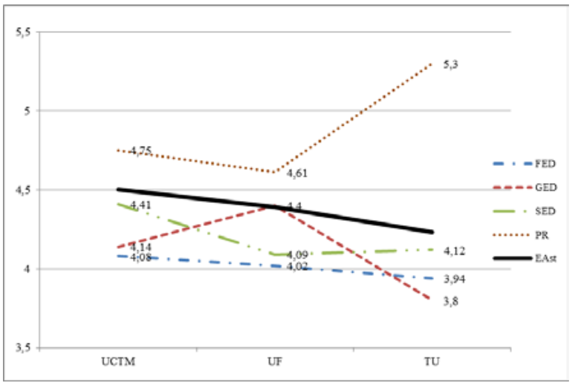

Fig. 6 *Satisfaction with engineering training*

Table 5 and Fig. 7 summarize the ergonomic assessments for the three universities in the three components: effectiveness, efficiency and satisfaction.

Table 5: Generalized ergonomic assessments (GEAs)

	UCTM	FU	TU
EA_{EF}	**4.33**	**4.42**	**4.13**
EA_{EC}	**4.22**	**4.31**	**4.07**
EA_{ST}	**4.5**	**4.39**	**4.23**

The results show a sustainable trend for a good assessment of the effectiveness of training, decrease in the assessment of the efficiency and very good assessments for satisfaction with engineering training.

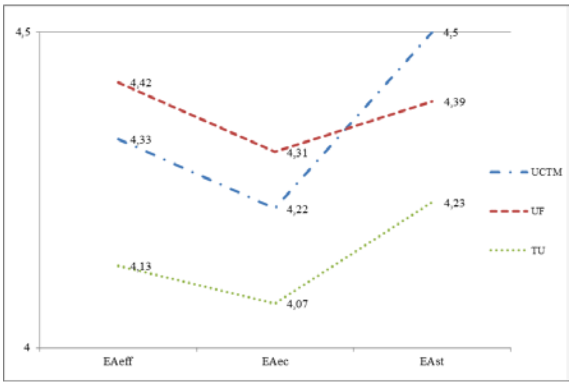

Fig. 7 Generalized ergonomic assessments

The analysis of the overall results shows the following:

- The students from the investigated speciality in the three universities cope successfully with the academic tasks (the average $EA_{EF} = 4.29$)

- The efforts which students put are relatively higher. The students have some claims to the quality of teaching, methodical work and equipment. (This affects the efficiency of training, the average $EA_{EC} = 4.2$)

- As potential for improving the quality of engineering training assessments of student satisfaction could be considered (the average $EA_{ST} = 4.37$). This potential should be utilized towards increasing individual assignments and initiative of students themselves.

Conclusion

The Ergonomic approach of research of the quality of engineering training has the following advantages:

- The investigated aspects of ergonomic quality of engineering training are an essential part of the overall assessment of the quality of education.

- The success of training (effectiveness and efficiency of the training) and satisfaction of consumers-students can be used to assess the quality of engineering training in a particular university.

- The assessment of the effectiveness and efficiency of engineering training and user-students satisfaction is the basis for comparison of the quality of training among universities.

- Quality of training can be defined, documented and verified, and this could be a significant moment as part of the quality plan of each university.

In ergonomic aspect the quality of engineering training can be improved by bricking those characteristics and properties that are known to be friendly to the user-student in each educational context. It is important and necessary dynamic characteristics and parameters of training to be monitored and evaluated, such as:

• rates of penetration of informational technology and e-learning;

• updating of teaching and conditions of training,

• optimizing the content and complexity of the educational content, increasing actuality, problematic in training;

• modernization of facilities with modern equipment for effective study laboratories, auditoriums.

In ergonomic aspect the raising of the quality of engineering training is a prerequisite to improve educational outcomes and attainment of educational goals.

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