HABILITATION THESIS

QUALITY MANAGEMENT EMBEDDED IN INNOVATIVE SYSTEMS

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ABSTRACT

This Habilitation Thesis, carried out at 11 years after the Doctoral Thesis, presents my professional achievements and scientific contributions achieved during this time period in the field of Engineering and Management.

The **first section** of the thesis presents the main scientific achievements embodied in scientific publications and grants/projects/research contracts implementation on the following four research directions.

The **second section** of the thesis is intended for the presentation of the career and scientific development plan. This section presents the main achievements underlying the future development. The career development plan is structured based on the previously identified research fields and their specific perspectives, including short-term goals and long term goals for both the didactic component and the research component.

In the **third section** of this Habilitation Thesis I included my own references associated with the first two sections.

The Habilitation Thesis presents the research developed on the previously defined directions through the main results, highlighting the achievements considered relevant for each approach. The research directions take into account also a chronological development with the common denominator of quality management. It also includes a presentation of the conceptual background, drawing future research and pointing out the references used. The list of own publications is coded according to the four research directions addressed: Mainstreaming in quality management (M), A new approach on QFD method – methodology and applications (N), Quality in student support services (S) and Creativity and innovation in new product development (C).

My Doctoral Thesis “Quality Management System from the Perspective of Mining Equipment Builders and Users” was the starting point for further developed approaches structured in the first research direction. These aim the course from a quality management system that is dynamic, complex and with high integration potential treating the quality assurance as a cross-functional macro-process, all the way to integrated management systems essentially influenced by the "reference system" represented by the Jiu Valley mining industry with all its peculiarities giving it a unique character.

The first research direction concentrates the research results regarding quality management system analysis and its connection with risk management in order to assess the possibilities for implementing embedded systems in the mining industry; the analysis of the possibilities for evaluating the quality of the human factor actions in underground work system based on an original fuzzy model and also the analysis of the prerequisites to fulfill the preconditions regarding the organizational culture in the context of total quality management approach. The time period for this first research direction is 2004-2010.

The design, implementation and use of quality management systems must be supported by appropriate methodological tools that form the basis for the flexibility and dynamism required by the continuous adaptation to environmental changes. Thus, the second research direction focuses on the Quality Function Deployment (QFD) method presenting the research findings regarding the use of the QFD model in designing software tools for evaluation / self-assessment of quality.

I focused on developing a methodology to apply the QFD method for software quality evaluation and introduced a lifecycle model that includes in its representation the quality part.

In order to demonstrate the viability and applicability of the 3D Spiral Life Cycle Model Based on QFD and Spiral Method for Software Development Life Cycle, that is the subject of a registered patent (no. A 2012 00914 / 11.29.2012) published by OSIM, I conducted researches in the fields: software engineering; renewable energy; services (in combination with SERVQUAL model); new product development (NPD). This last field is the link to the fourth research direction, Creativity and Innovation in new products development.

The teaching activities were interlaced with the research activities within the third research direction that focuses on addressing quality in student support services (SSS). This research was carried out in the period 2008-2014. The addressed research aiming the SSS topics were: mentoring and tutoring in SSS; the role of academic counselling; the quality assurance in higher education; the role and importance of self-directed learning (SDL) methods in the context of modern learning; entrepreneurship education; the use of quality management methods in assessing eLearning systems and the use of innovative and creative methods like interactive games and gamification; innovation in education. The use of the QFD-based assessment model for modern learning-teaching systems represents the link to the second research direction and the innovative methods and techniques is the link to the fourth research direction, Creativity and innovation in new product development.

The latest researches results are oriented towards innovation integrating creativity techniques such as gamification and TRIZ with reference to the educational field and developing new products. Thus, the fourth research direction contains the main results presented

concerning the gamification techniques application in research activities and education led to the premises that a research methodology based on the principles of gamification could be useful both as a guide of the entire research activity and as motivational means in certain stages of it. The TRIZ creativity techniques have been explored for new product development research that led to the Patent No. A 2014 00167 / 27.02.2014 "Method for relevant medical information storage based on biometric identification".

This fourth research direction integrates the research directions previously addressed and presents the results from the period 2012-2015, opening new perspectives for future research in the current context oriented on inter-, multi-, trans- disciplinary approach, where the quality has the role of glue logic between all areas.

REZUMAT

Teza de abilitare realizată la 11 ani de la susţinerea tezei de doctorat prezintă în mod documentat realizările mele profesionale şi contribuţiile ştiinţifice de-a lungul acestei perioade de timp în domeniul Inginerie și management.

Prima sectiune a tezei prezintă principalele realizări ştiinţifice concretizate în publicaţii ştiinţifice şi implementarea de granturi/proiecte/contracte de cercetare pe următoarele patru direcţii de cercetare.

A doua secţiune a tezei este destinată prezentării planului de dezvoltare a carierei profesionale şi ştiinţifice. Această secţiune prezintă sumativ principalele realizări care stau la baza dezvoltării viitoare. Planul de dezvoltare a carierei structurat pe baza preocupărilor şi perspectivelor identificate, cuprinde obiective pe termen scurt şi obiective pe termen lung, atât pentru componenta didactică, cât şi pentru componenta de cercetare.

În **a treia secţiune** a tezei de abilitare prezint referinţele bibliografice personale asociate primelor două secţiuni.

Teza de abilitarea prezintă cercetările dezvoltate pe fiecare direcţie prin intermediul principalelor rezultate obţinute. Fiecare capitol din secţiunea a doua, conţine referinţe la realizări considerate relevante pentru fiecare temă abordată. Prezentarea direcţiilor de cercetare conţine şi o evoluţie cronologică a realizărilor având ca numitor comun managementului calităţii, dar şi o prezentare a cadrului conceptual, trasarea direcţiilor viitoare de cercetare şi sursele bibliografice utilizate. Lista publicaţiilor personale este codificată funcţie de cele patru direcţii de cercetare abordate: Abordări integratoare în managementul calităţii (M), O nouă abordare a metodei QFD - metodologie şi aplicare (N), Calitatea în serviciile suport pentru studenţi (S) şi Creativitate şi inovare în dezvoltarea de noi produse (C).

Teza de doctorat cu titlul *Sistem de management al calităţii din perspectiva constructorilor şi utilizatorilor de maşini şi utilaje miniere,* a constituit punctul de plecare al abordărilor dezvoltate

ulterior în cadrul primei direcţii de cercetare. Acestea urmăresc parcursul de la sistemul de management al calităţii dinamic, complex şi cu putere mare de integrare care tratează asigurarea calităţii ca un macroproces transfuncţional, la sistemele integrate de management esenţial influenţate de „sistemul de referinţă" reprezentat de mineritul din Valea Jiului cu toate particularităţile acestuia ce dau relaţiei caracter de unicitate.

În prima direcţie de cercetare au fost concentrate rezultatele cercetărilor în ceea ce privește analiza sistemului de management al calității și legatura acestuia cu managementul riscului în vederea evaluării posibilităților de implementare a sistemelor integrate în industria minieră; analiza posibilităților de evaluare a calității acţiunilor factorului uman în sistemul de muncă din subteran bazat pe un model fuzzy original, cât şi analiza premiselor de îndeplinire a precondiţiilor referitoare la cultura organizaţională în contextul abordării managementului total al calităţii. Cercetările acestea s-au derulat în perioada 2004-2010.

Proiectarea, implementarea şi funcţionarea sistemelor de management al calităţii trebuie susţinute de instrumente metodologice adecvate care constituie suportul pentru asigurarea flexibilităţii şi dinamismului necesare adaptării continue la schimbările generate de mediu. Astfel, a doua direcţie de cercetare s-a concentrat asupra metodei Quality Function Deployment (QFD) prezentând rezultatele cercetărilor cu privire la utilizarea acestei metode în proiectarea unor instrumente software de evaluare/autoevaluare în domeniul calităţii. Am conceput un nou model de ciclu de viaţă care are inclusă componenta calitate în întregul proces de dezvoltare a unui produs software.

În vederea demonstrării viabilităţii şi aplicabilităţii *Modelului ciclului de viaţă spirală 3D bazat pe metoda QFD şi ciclul de viaţă spirală pentru dezvoltare de produse software*, model brevetat OSIM (nr. A 2012 00914 / 29.11.2012), am realizat cercetări în domeniile: inginerie software; energie regenerabilă; servicii (în combinaţie cu modelul SERVQUAL); dezvoltarea de noi produse (NPD). Acest ultim domeniu reprezintă legătura cu a patra direcţie de dezvoltare, Creativitate şi inovare în devoltarea de noi produse. Cercetările acestei direcţii s-au derulat în perioada 2010-2014.

Preocupările de ordin didactic s-au întrepătruns cu cele de cercetare în direcţia a treia de cercetare focalizată pe abordarea calităţii în servicile suport pentru studenţi (SSS) şi desfăşurată în perioada 2008-2014. În cadrul cercetărilor care vizează SSS au fost abordate temele de cercetare: mentoring şi tutoring în cadrul SSS; rolul consilierii academice; asigurarea calităţii în învăţământul superior; rolul şi importanţa metodelor de învăţare autodirijată (SDL-Self Directed Learning) în contextul sistemelor moderne de învăţare; educaţia antreprenorială; utilizarea metodelor managementului calităţii în evaluarea sistemelor de învăţare de tip eLearning şi utilizarea metodelor inovative şi creative de tipul jocurilor interactive şi gamification pentru inovare în educaţie. Utilizarea metodei de evaluare bazată pe QFD pentru sistemele de predare-învăţare moderne face legătura cu a doua direcţie de cercetare, iar prin metodele şi tehnicile inovative se face legătura cu a patra direcţie de cercetare.

Cele mai recente cercetări au fost orientare spre inovare şi integrarea tehnicilor de creativitate precum gamification şi TRIZ, atât în domeniul educaţional, cât şi în dezvoltarea de noi produse. Astfel, metodologia bazată pe principiile de gamification conţinută în a patra direcţie de cercetare poate fi utilizată ca un ghid în activitatea de cercetare reliefând şi

componenta motivaţională. Tehnicile de creativitate TRIZ au fost explorate pentru dezvoltare de noi produse, cercetările concretizându-se în brevetul Nr. A 2014 00167 / 27.02.2014 "*Procedeu de stocare a informatiilor medicale relevante pe baza identificarii biometrice*".

Această a patra direcţie de cercetare integrează direcţiile de cercetare abordate anterior şi prezintă preocupările din ultimii ani (2012-2015) deschizând noi perspective pentru cercetări viitoare în contextul actual al necesităţii abordărilor inter-, multi-, trans- disciplinare, în care calitatea are rol de liant între toate celelalte domenii.

SECTION I

SCIENTIFIC ACHIEVEMENTS

1.

MAINSTREAMING IN QUALITY MANAGEMENT

Introduction and conceptual background

In this chapter will be presented the results of researches developed as a follow up of the doctoral thesis, related to integrated management systems applied in the mining industry, a field with high specificity, having a different perspective, oriented on the human factor as the main "actor" in the work system.

In this context, the researches were focused on the following areas: integrated management systems [09_08_M], [08_01_M], [08_02_M], [08_13_M], [07_01_M], [07_09_M], [07_22_M], [06_04_M]; evaluation of the human factor in the underground work system [10_07_M], [05_06_M], [04_07_M]; coordinates of change organizational culture in the context of Total Quality Management approach [09_14_M], [07_14_M], [07_17_M].

Focusing on Total Quality Management (TQM) in this research direction generated generous exploring topics like TQM and Reengineering treated as strategic options for an organization or in the personal life development [11_03_M], [13_02_M]; TQM and business excellence [10_02_M], [10_11_M]; assessment tools in the context of TQM [10_05_M]; Kaizen strategy in the context of TQM [08_07_M], [04_06_M].

The continued development of management system standards into areas such as quality, environment, health and safety, and information security has reinforced the calls for an integrated approach.

Contemporary organizations, permanently faced with new challenges, must adapt to change requirements. The response of the organization to these challenges can be the Integrated Management Systems. Among them we chose the path that has as starting point the Quality Management System (QMS) and Quality Risk Management (QRM) towards Total Quality Management (TQM). These approaches involve an ongoing improvement effort of the organization, including the intensive utilization of tangible and intangible resources like human and organizational resources through the implementation of suitable managerial qualitative processes and supporting systems. All the other resources in an organization are not value – adding unless Human Resources (HR) are capable of using them efficiently. The QMS and QRM have in common the HR considered in our approach both value-adding and risk factors within the organization.

The importance of HR factor and its unique role as an important resource has increased more and more in time. In any organization, HR is the main source and property of the organization playing the key role in the success or failure of organizations. The chapter contains the research results concerning the HR evaluation based on a fuzzy model, taking into account the influences between HR and the “hard” components of the work system.

There are many researches in the field of HR reliability employing Fuzzy Set Theory and the concept of possibility of failure instead of probability of failure [19]. Lian and Wang [15] used fuzzy relations to estimate the fuzzy probability. Nowakowski [20][21] observed that, when applying the fuzzy approach, probabilistic interpretations of human reliability are abandoned; instead, human

reliability is defined in terms of possibility measures. Wang [34] used the concept of fuzziness to evaluate human performance in an inspection task. Onisawa [23] analyzed human resources reliability in the events in Chernobyl accident creating a model [15] that integrates the subjectivity in specialists' opinions to reliability analysis. Szwarcman [31] presents a fuzzy-based decision support system for the analysis of human reliability in operation, maintenance and inspection activities in industrial and production processes, where the human error may have a great impact on safety and on the environment.

In mining area there are several approaches regarding the fuzzy logic application concerning mainly the "hard" components of the work systems. Bascetin et.al. [1] introduce the EQS software that automates equipment selection in mining engineering using fuzzy set theory. Karadoganu et.al. [11] present a fuzzy logic approach on the selection of underground mining method for a lignite mine in Turkey, taking into account the physical parameters such as geology and geotechnical properties of ore, economic effects and environmental effects. Lokshina et al. [16] propose a decision support system based on fuzzy methods applied to identify and process the gas dynamic images from monitoring processes of coal mining atmosphere in order to control the ventilation system. Razani et.al. [26] develop a fuzzy model to predict the roof fall rate in underground coal mines.

The "soft" component of the work system, i.e. the HR, for the case of underground mining was not very much addressed by the current researches. Yang et.al. [36] introduce an entropy-weight fuzzy method to evaluate the post safety competence of coal mine special operation staff. So, our research propose a HR evaluation model that can be used in a Quality Risk Management Integrated System and make the linkage toward TQM considering that HR as the "soft" side of TQM [27] [35].

Other results of the research presented in this chapter are related to the role of HR in the TQM context. Mehra *et al.* (2001) [18] conducted a literature survey on TQM factors and identified the future role of TQM in businesses wherein HR is considered as having a large impact on quality movement in an organization. To assure effective implementation, management should give more attention to hidden and intangible factors such as employees' perception and work climate, among others.

Reviewing principles of effective planned change implementation to TQM are proposed several assumptions: 1. TQM is a viable and effective planned change method, when properly installed; 2. Not all organizations are appropriate or ready for TQM; 3. Preconditions for successful TQM can sometimes be created; 4. Leadership commitment to a large-scale, long-term, cultural change is necessary. So, a preliminary step in TQM implementation is to assess the organization's current reality: relevant preconditions have to do with the organization's history, its current needs, precipitating events leading to TQM, and the existing employee quality of working life. If the current reality does not include important preconditions, TQM implementation should be delayed until the organization is in a state in which TQM is likely to succeed.

Abundant literature covers discussion on the contribution of HR to TQM. There are identified four factors employer, employee, customer and supplier[8]. It is important to observe their reflection in the internal organization of the firm. Once the preconditions are identified, it is possible to point out: the improvement opportunities on a formal level (human resource systems, including job design and organizational structure and design will be different under TQM: levels of management may be reduced and organizational roles will certainly change); the improvement opportunities on an informal level (a change in an organization's culture, in its norms, values, and

belief systems about how organizations function, the managers' leadership philosophies and styles at all levels); and also any valid points of resistance.

Beckhard and Pritchard (1992) [2] have outlined the basic steps in managing a transition to new integrated management systems such as TQM: identifying tasks to be done, creating necessary management structures, developing strategies for building commitment, designing mechanisms to communicate the change, and assigning resources.

There is no single theoretical formalization of TQM, but Deming, Juran and Ishikawa provide the core assumptions, as a "...discipline and philosophy of management which institutionalizes planned and continuous... improvement ... and assumes that quality is the outcome of all activities that take place within an organization; that all functions and all employees have to participate in the improvement process; that organizations need both quality systems and a quality culture".

Also, are presented the results of the researches concerning two approaches: Reengineering and TQM as strategic options of the management applied in the organization life cycle and as personal decisions in the professional development life cycle. The research focused on organizational change in the TQM context, identifying the necessary preconditions at the organizational cultural level for the implementation of TQM, research that was expanded in order to elucidate the two Reengineering and TQM approaches. Although both Reengineering and TQM “recognize the importance of business processes and customers’ needs, they differ in the magnitude of the process to be redesigned. For instance TQM believes in redesigning small processes a few at a time, by means of continuous improvement, Reengineering, on the other hand believes in seeking major breakthroughs through dramatic and radical change [29]. The literature places on opposite positions the two concepts [9]. For the organization it would be useful to combine them to achieve more substantial and practical results.

1.1. Overview on the possibilities of Integrated Management Systems (IMS) implementation in the mining industry.

The mining sector has been chosen as general study setting for exploring the possibility of Quality Management System (QMS) implementation for several reasons as follows. In Romania this industry comprises some large companies declared as being of national interest, yet stirring up controversy on the subject of their viability in a free market economy related to the economic transition period. Although there were implemented restructuring programs (including continuous downsizing) besides the critical social impact, the attendant effects on the economic performance still remain locked, especially in hard coal mines of the National Hard Coal Company (NHCC), today the Energy Complex Hunedoara (CEH), that are clustered in the Jiu Valley region. But, more than a half century the coal mining activity was the engine of welfare for this region of our country. Therefore, questioning the present-day reverse situation is a matter of a great interest for the regional development’s perspective of Jiu Valley.

After the doctoral thesis, as a expand of the results obtained, the researches focused at first on Customer-Supplier (C-S) relationship, considered the core of QMS, in order to identify the perceptions concerning the dimensions of the quality assurance both from the perspective of users and builders/suppliers of the mining machines and equipment. The researches that followed pointed out the importance of the HR, along side with the other resources of the organization, the necessity of organizational change in the integrated management system context and the evaluation of the human actions performing in the underground working system using fuzzy logic.

1.1.1. Quality Management System (QMS)

The results of the investigations conducted in the period 2004-2010, regarding the approach of the quality problems in the context of the QMS revealed some interesting and specific aspects of the C-S relationship, briefly presented next. As top priorities of the suppliers, satisfying the clients requirements and accessing new market segments are rated at the first place by importance, with the same rate (86%), followed in a similar way (with also same rate - 63%) by improving quality of products and services and reducing of the production costs (see figure 1.1.1). The real interest of the supply companies regarding the quality assurance is also confirmed by the maximum importance assigned to understanding the client's requirements as promoting element of the quality (76%). The next two rated promoting elements are the management policies (66%) and technological change & improvement (53%) (Fig. 1.1.2.).

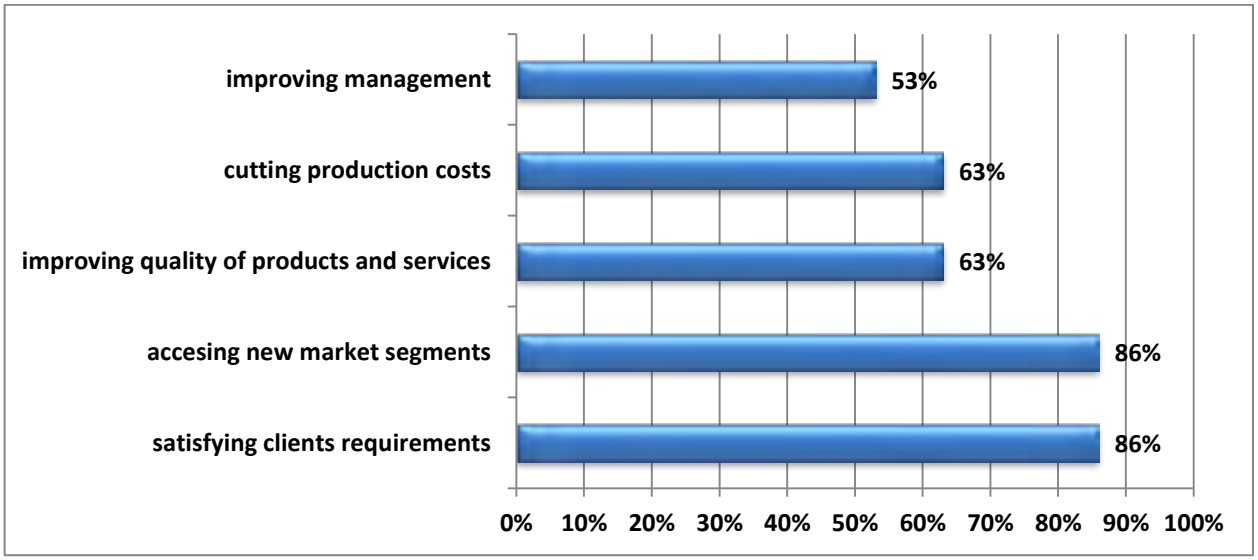


Figure 1.1.1. The top priorities of the suppliers in the QMS context.

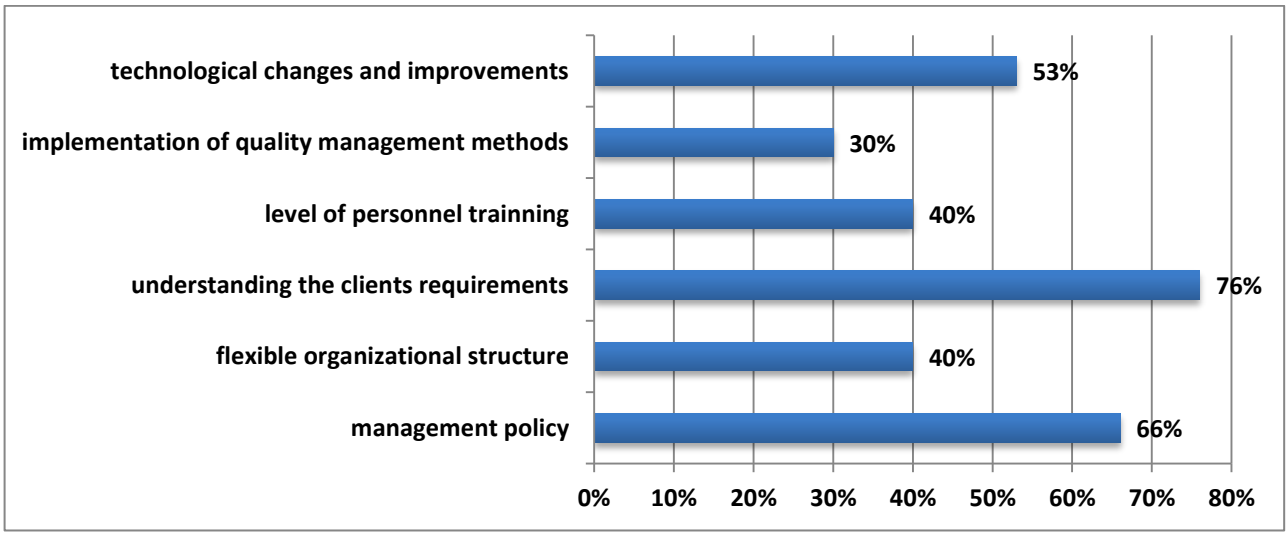


Figure 1.1.2. The promoting elements of quality

The main link between the latest aspect and the problems associated to the quality assurance at the suppliers results from the situation of reporting the nonconformities by causes, respectively by the stages (phases) of the products life cycle. Accordingly to these, the direct cause for 20% of

the recorded nonconformities is the lack in technological change and improvement, followed by their intermediate influence on capability of the production processes (10%), as well as the occurrence of nonconformities into the manufacturing stages (phases) (40%) and exploitation (in function) stages (50%) (Figs. 1.1.3. and 1.1.4).

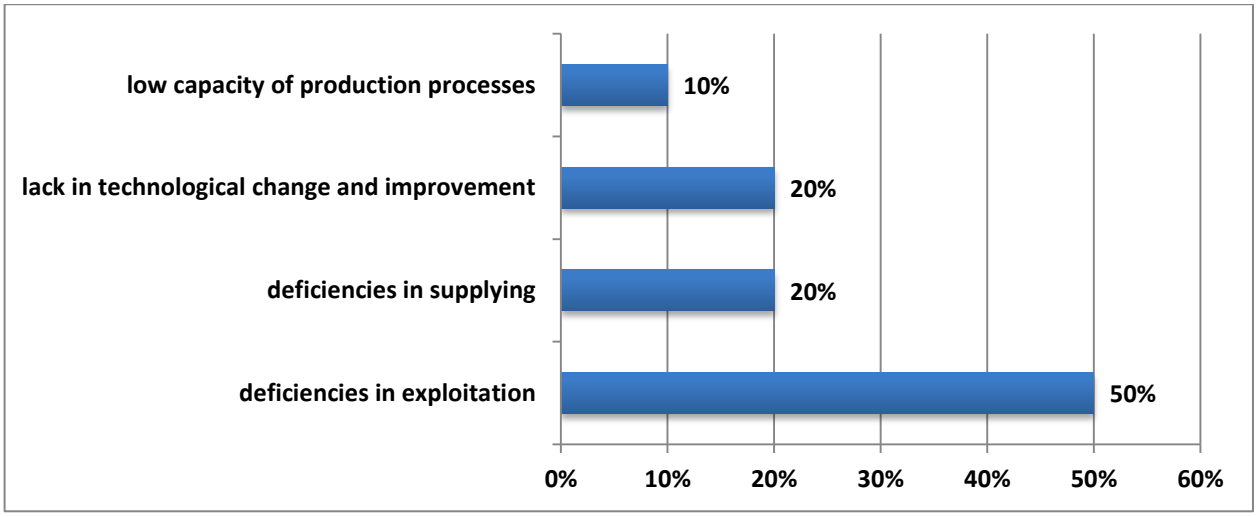


Figure 1.1.3. The situation of reporting nonconformities on causes.

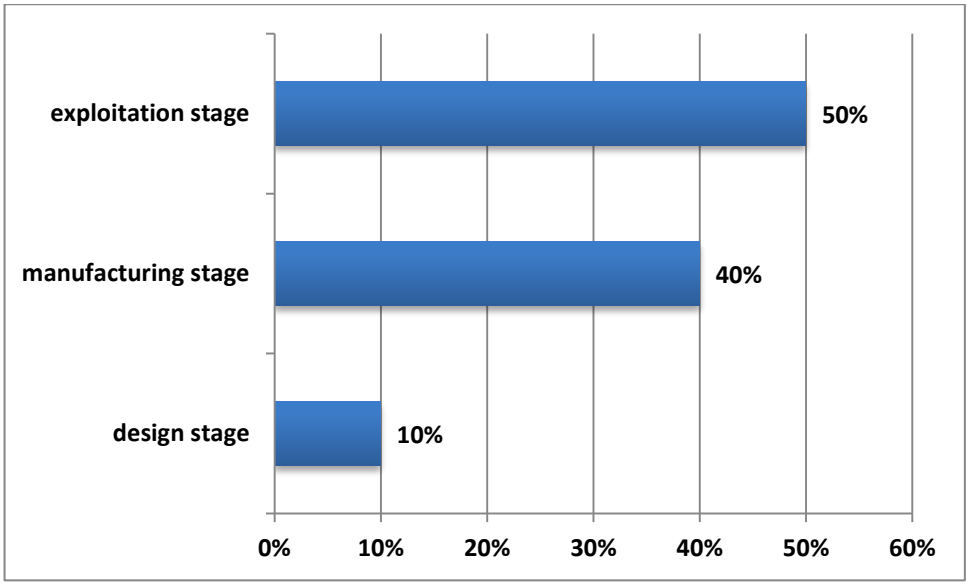


Figure 1.1.4. The situation of reporting nonconformities on the stages of the product life cycle

For evaluating the relationship with the clients, in general, and with NHCC in particular, the answers of the suppliers reveal the same aspects. On one hand, it can be noticed that there are no claims from the NHCC mines (that is explicable through their inexistence, or they were solved amiably in order to avoid their consigning and implicitly, low quotations in further actions). On the other hand, the communication with the client is considered a weak point and it is highlighted the necessity of improving the existent system for mutual supervision of the defects by using detailed procedures.

The other element of the C-S relationship, the customer point of view was revealed by the results of the investigations at the NHCC level regarding the implementation of QMS and denoted generally a good perception of the promoting elements of the quality, with a single significant

disagreement, the one of the association of improving the quality with reducing the productivity. The main promoting element of the quality is considered the management policies (54%), followed by: understanding of the clients requirements and needs (20%); technological changes and improvement (12%); organizational culture (10%); and with identical, but much more reduced rates (only 2%), flexible organizational structure and level of personnel training (Fig. 1.1.5)

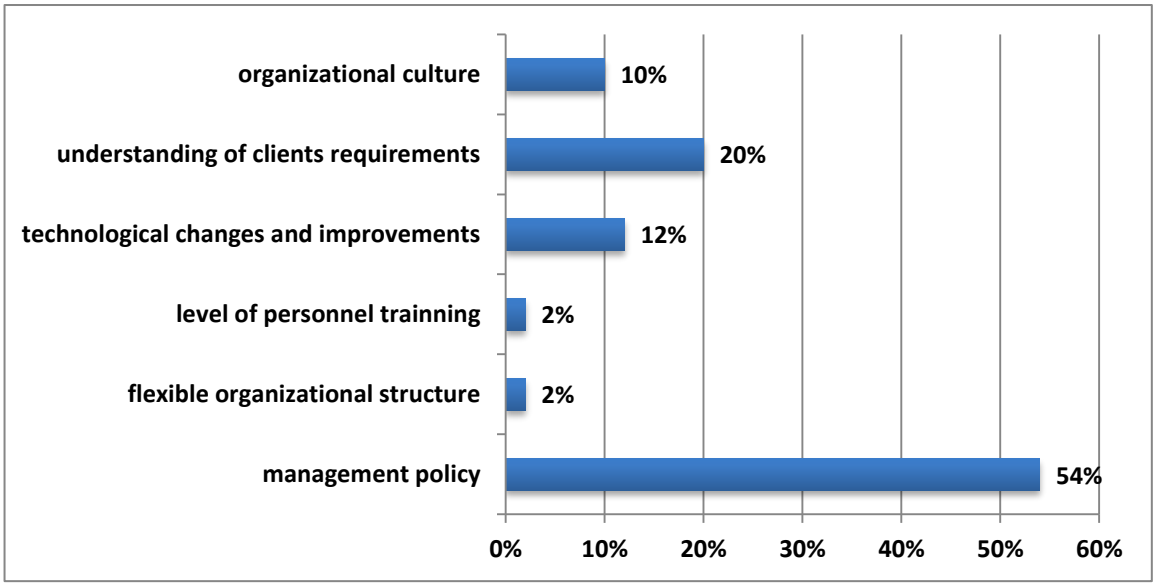


Figure 1.1.5. The promoting elements of the quality

The priorities shown in the context of implementing QMS are, in the resulted importance order: the necessity of technological changes and improvements within mines (34%); the accomplishing of a control system of technical performances (20%); the realistic supply planning, correlated to the actual needs (16%) (Fig. 1.1.6). Into the perception of the obstacles in implementing QMS it is detached the deficiencies in using the production capacities at the technical projected parameters (44%) and the lack of a control system for the specific consumption and the material and spare parts inventories (40%) (Fig. 1.1.7)

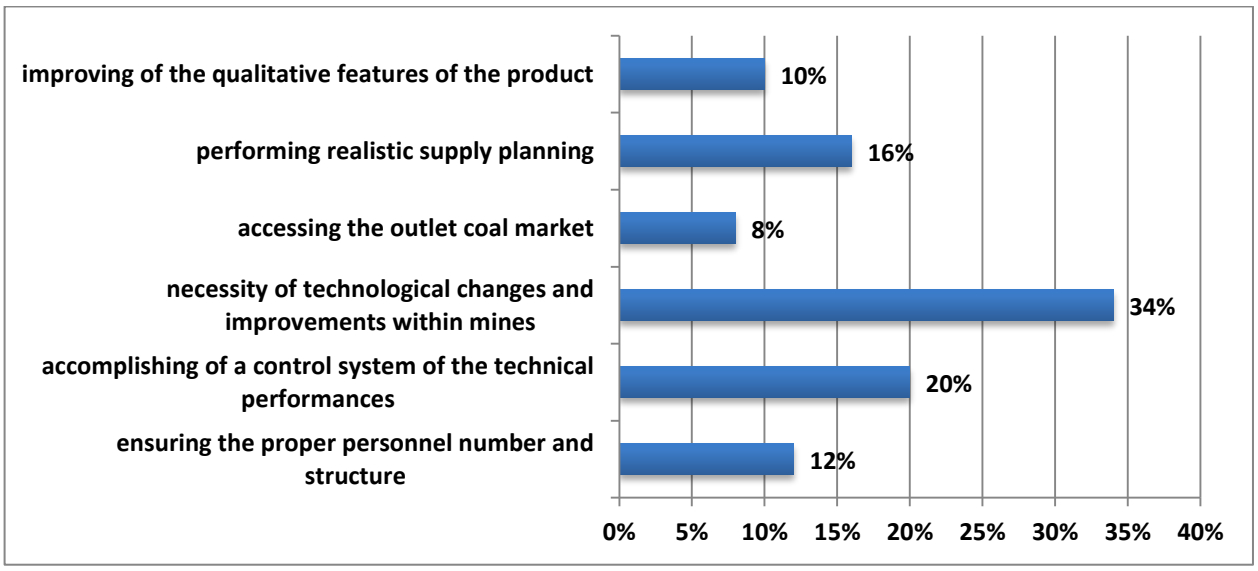


Figure 1.1.6. The priorities shown into the context of implementing QMS.

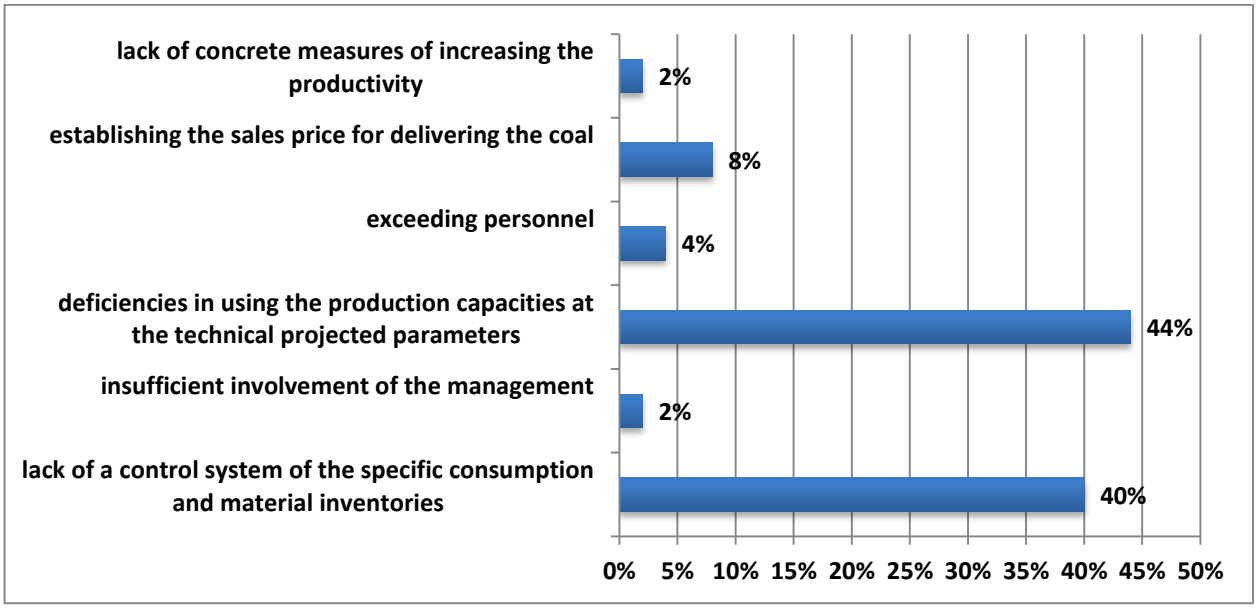


Figure 1.1.7. The obstacles in implementing QMS

As a premise of QMS implementation, the real commitment of the NHCC can be appreciated to be quite low comparative with the one resulted in case of its suppliers. Mostly, the situation can be explained by the managerial implications of the well-known mining activities particularities.

The comparative analyses of the NHCC perceptions and of the suppliers of mining equipment about C-S relation in the context of QMS implementation, allowed to identify the following aspects: (1) procedural component for evaluating and reporting the results regarding the functioning of the mining equipment is appreciated to be insufficient by the suppliers and low by the users/clients (2) it is an agreement of the two parts over the general characterization of C-S relation; (3) it is a disagreement regarding actual satisfying of the clients' requirements (the perception of the suppliers reflects the high-level of their own efforts of adapting to the user's requirements, meanwhile the latest distinguishes a low level of appliance in solving its own requirements by the suppliers.).

The mining equipment used within hard coal mines of NHCC is provided by internal producers and to a smaller extent imported, still preponderantly acquired years ago, because the financial restrictions. So, the need for technological changes and improvements is acutely perceived, but any decision in that sense (including choosing of both technological variants of coal face and proper supporting managerial systems like QMS) is double restricted (by budgetary limits and geo-mining conditions). Moreover, there is a decline in the hard coal market, exclusively related, in same periods to the internal demand. So that changing national energetic policies by directing of a great part of the production to other power groups, or by importing hard coal (that may will be a cheaper solution) may result in a dramatically cut in demand. Obviously, in these conditions the improvement of hard coal qualitative features is critical for NHCC, but our findings reflect some breaks in perception of the ways that might lead to such improvement.

1.1.2. Quality Risk Management (QRM)

Besides the quality side, an integrated approach take into consideration other elements such as environment, health and labor safety precaution, social responsibility aligned with the

organization's business objectives. Implementing an IMS is a multi-phased process which involves designing a management system that suits the business model; performing pilot tests within the operation to test the proposed IMS; refining the system based on the testing; and finally, integrating it into “the fabric” of an organization's operations.

In the mining field, characterized by a high level of specificity, an integrated approach to underground activities should not omit the influence of the risk factors. In this context QRM can be not just a solution, but also a necessity.

In our researches we tried to underline the importance of the identification of the specific risk factors, considered as a premise for an integrated approach in the underground working system. The underground working system is characterized by a high level of specificity due to the particularities of the four elements which exist and interact: operators, working tasks, production means and working environment. The existence of the risk factors is known in the underground working system. It is important to identify them in order to start a casual chain determined by characteristics, status, processes, phenomena, behaviors. In order to demonstrate their existence, was necessary to perform a systematic analysis of the characteristics of accidents and possible deviations and errors at the level of each system component.

In Romania, as well as all over the world, the malfunctions of the working system occur in the mining industry in a large number than in any other field of activity. In the context of the research, accidents and the occupational diseases are considered malfunctions/nonconformities of the work system. These dysfunctions of the work system that may lead to labor accidents or occupational diseases are produced only under the condition that the risk factors for accidents and/or occupational diseases exist and are active (Figs 1.1.8-1.1.10).

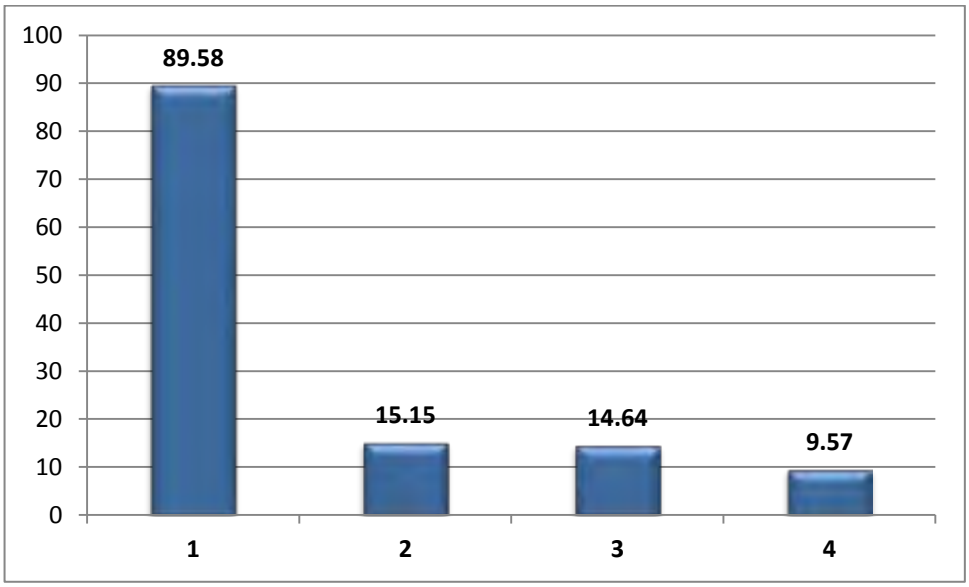


Figure 1.1.8.Classification of work accidents by causes [source: National Hard Coal Company Petrosani, Romania]

Legend:

1. The person who carries out the work
2. The production means
3. Work duty
4. The working environment

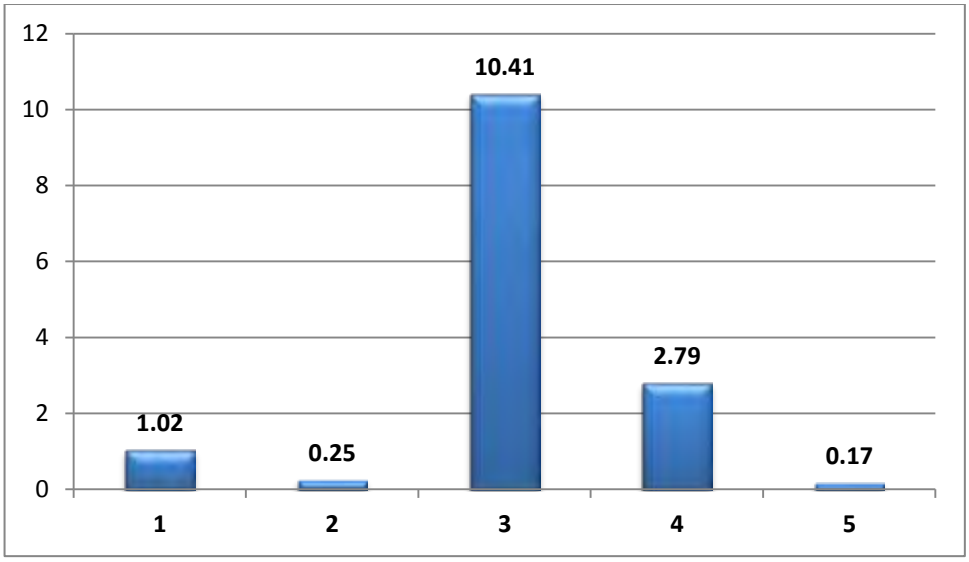


Figure 1.1.9.Classification of work accidents by causes depending on work duty [source: National Hard Coal Company Petrosani, Romania]

Legend:

1. Omission/errors in presetting working tasks
2. Unsuitable distribution of the employees on the working place;
3. Shortcoming in guidance, surveillance and control;
4. Lacks in providing suitable work condition;
5. Other causes

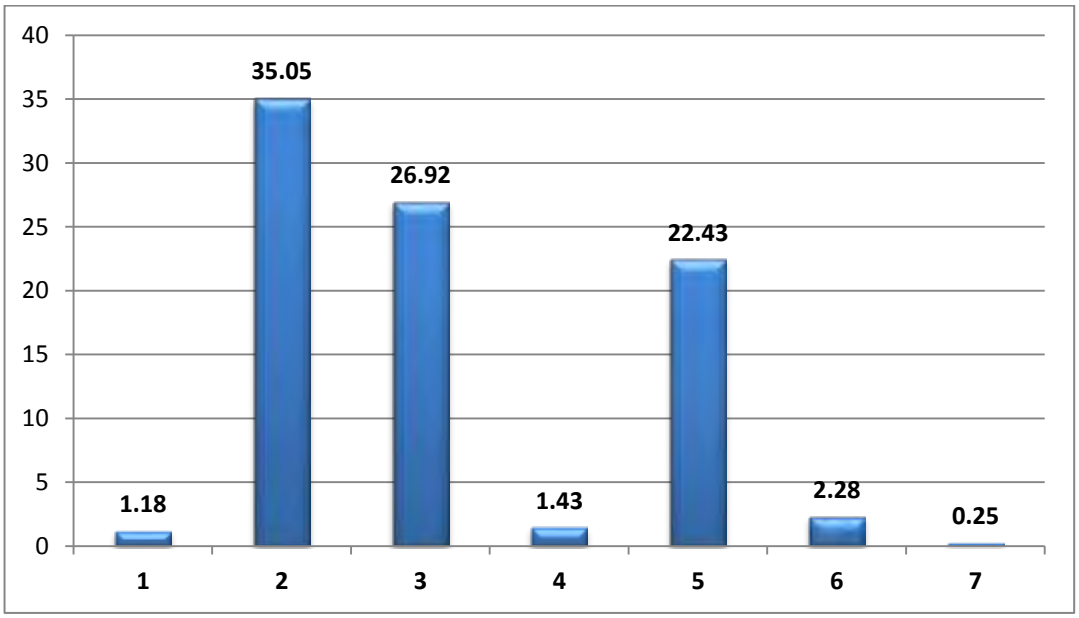


Figure 1.1.10 Classification of work accidents by causes depending on the person who carries out the work duty [source: National Hard Coal Company Petrosani, Romania]

Legend:

1. Unsuitable utilization of the protection means;
2. Failure to perform operations that are indispensable to working safety in due time;
3. Shortcoming in carrying out working tasks;
4. Exposure to hazardous factors outside the work site;
5. Falls on the same level;
6. Falls from heights;
7. Other causes.

Analyzing the risk factors, we can say that the most suitable integrated approach for underground must take into account the risk associated to the factors already presented. The response can be Quality Risk Integrated Management System that can generate new developments with regards to the safety, health, environment, risk and quality solutions within the division, which will bring together a total business solution approach and allows organizations to comply with the necessary health and safety regulations as stated in governance guidelines.

The research points out the importance of the HR, along side with the other resources of the organization, stressing the intangible and relational character of the latter.

The work system is defined by its components, their roles and the relationships between them. Any work system gravitates around the HR and the interdependencies between human factor and the other components of it. Researches in this field agreed that the human factor and its actions are difficult to quantify and predict.

The results of my researches led to an original method of human actions evaluation in order to estimate possible risks and prevent possible system faults, both at human factor level and at equipment level. In order to point out the importance of the human factor influence on all the elements of the working systems we propose a fuzzy logic based methodology for quality evaluation of human actions. This methodology has a multidisciplinary character, as it gathers ideas and methods from: quality management, ergonomics, work safety and artificial intelligence. The results presented refer to a work system with a high degree of specificity, namely, underground coal mining and are valuable for human resources risk evaluation pattern. The fuzzy logic evaluation of the human actions leads to early detection of possible dangerous evolutions of the work system and alarm the persons in charge.

In our research we have analyzed the coal mining underground work system in terms of information. This work system contains all types of information. The precise information is the one provided by the different transducers, e.g. methane concentration, power consumption etc. The probabilistic type information is the one related to probabilistic indexes specific to reliability and maintainability of the mechanized hewing. The vague information is the one related to the geo-mining conditions and the human factor. From all the above actors involved in the information interchange process, the human factor is the most unpredictable one.

The most difficult is to express the action of human factor to the executants' level and to the decisional factor level by imposing a quantification and unitary treatment of the subjectivism. Due to the complexity of the role played by the human factor, all action categories should be taken into account, and a risk evaluation pattern for a given action should include the interconnection between all the actions regarding the elements of the working system.

If the risk represents the possibility to put oneself into a possible danger, it can express a criterion for quality evaluation of performing a human action. Thus the extent to which it can produce unwanted effects is shown, including malfunctions of the working system upon the person, technical equipment or working environment., protection systems and organizational framework where the humans carry out their activities The degree of risk associated to a human action is connected to a group of internal factors of risk which shall act through the human error and external risk factors related to technical equipment.

The proposed model is based on the evaluation of the terms of the *scope-means* relationship (1). It is not a mathematical relationship, but a symbolic one [28]. The evaluation of the terms allows us to identify the correspondence between the work system elements and the groups of risk factors above mentioned.

We propose a fuzzy model, because in general the fuzzy logic is related to the science that treats the interface man and working system. Also, fuzzy logic offers “the tool” that makes possible the quantification of the subjective incertitude, and operates with the imprecise notions as nuances that describe the state of a system.

Not any human resource action generates added value. But, it is important to assess the good and the bad influence of the human factor in reaching an imposed objective. In the context of human factor actions evaluation we identified several action typologies that generate possible evaluations and interpretations.

The first category includes the human factor actions reported to the other elements involved in the work system:

- The actions of the human factor related to the execution task;
- The actions of the human factor related to the production means;
- The actions of the human factor related to the global work task;
- The actions of the human factor related to the environment.

Another category contains the classification [12] of actions based on the human factor related errors:

- A move counter to the work purpose;
- Deliberate movement counter to the work purpose;
- Behavior contrary to the aim pursued;
- Behavior inconsistent with the intended purpose;
- Behavior inconsistent with the purpose or effect followed, when incomplete behavior is serious enough.

The human factor related errors can be [28]:

- Reception errors: processing, interpretation of information, gaps in signal detection, failure to identify and differentiate signals, false identification, sensory illusions, failure to understand critical data, inappropriate combining and transforming, substituting data with other and so on;
- Decision errors: improper setting of objectives, choice of improper means and action options, incorrect assessment of the terms-of-action, etc.
- Execution errors: performing wrong operations, operations omissions, delays in conducting operations, unsynchronized and discordance operations etc.

The above presented categories of human factor actions are the basis for the human factor actions evaluation by using the *scope-means* relationship [28]. First are determined the membership values for each of the inputs and then is designed the fuzzy model of the evaluation system in order to frame the human factor into an action typology (Table 1.1).

Table 1.1. Action typologies

FULL EFFICIENT	SUCCES	100%-80%
VERY GOOD EFFICIENT	SUCCES	80%-50%
GOOD EFFICIENT	SUCCES / RISK	50%-20%
MIN EFFICIENT	RISK	20%-10%
NON EFFICIENT	RISK	10%-0%

$$S+E=M+T \qquad [28] \quad (1.1.)$$

where:

S – Scope value – the optimum level of safety of the working system (the functioning probability of the system for diminishing the risk of appearing the defect state);

M – Means value – the quantity of materials means and also the work safety measures necessary for diminishing the risk of appearing the defect state;

T – Cognitive means – quantity and quality of the knowledge and habits used for diminishing the risk of appearing the defect state;

E - Collateral effects value – the value of the prejudices followed the risk manifestation.

The terms of the relationship are in the equilibrium value; “the weight” of the left terms tips the balance for increasing the risk, while “the weight” of the right terms leads to the diminution of the risk.

S>0 if and only if M+T>E. So, the scope is rewarding only if the means are valuable, and better the means are, more valuable the scopes are.

After analyzing a human action as a scope-means relationship it must be appreciated or estimated the “value” of each term.

The estimation depends on the nature of each term, so the scope is subjective (fuzzy assessed), the means are quantitative (value and/or fuzzy assessed), the cognitive means are quantitative related to the human factor (fuzzy assessed) and effects are quantitative and qualitative (value and/or fuzzy assessed). So, the scope is represented by the levels of the functioning probabilities, the means are represented by the classes delimited on the basis of the conformity level of the equipment resulting after auditing, the cognitive means are represented by the marks (scores) obtained after being evaluated periodically and the effects are represented by the levels of defects importance.

After having applied the specific steps of the fuzzy logic, by obtaining the defuzzyfication result, it should be appreciated the action of the human factor by framing into an action typology (Table 1.1). The framing into an action typology will allow determining the role of the human factor in appearance of the deficiencies/malfunctions, even if it is about the decisional errors or the execution errors.

In order to model the fuzzy evaluation system described above there was used the Fuzzy toolbox from the MatLab simulation environment.

The variable S is the linguistic variable characterizing the relationship (1). Appealing to the theory of finite state systems there can be determined the probability of operation of mechanical systems that can be estimated based on theoretical statistical distribution functions, considering

the failure and recovery intensity system components in terms of correlation to the geometrical parameters of the hewing. Inputs can be probabilities defined in the interval [0, 1] or normal values used for reasons of consistency with the values of other linguistic variables that occur in relation (1), defined on the interval [1, 10].

The membership function is defined for the variable Scope described as meaning "optimal level of probability fulfillment operation to reduce the risk of system failure status".

The variable M is the linguistic variable characterizing the means - the amount of material resources, but also the necessary occupational safety measures that reduce the risk of fault condition.

Evaluation for M is the result of audits of the equipment for carrying out essential health and safety requirements stipulated in the "Norms on quality certification from the point of view of security equipment".

The results presented in an "Evaluation Form" will be classified based on the level of compliance (LC), from 1 to 0, in one of the following six classes:

0.91 ... 1.00 Excellent (EX)

0.81 ... 0.90 Very Good (VG)

0.71 ... 0.80 Good (G)

0.61 ... 0.70 Medium (M)

0.51 ... 0.60 Small (S)

below 0.50 Unsatisfactory (U)

The found nonconformities are transferred to a "Summary Sheet of Nonconformities" containing:

- Nonconformities found and their brief description;

- How to fix;

- Their ranking according to four classes of priorities based on the severity of the consequences.

Taken into account the symmetry considerations for representing the membership functions, we have considered only five classes instead of the six presented above.

It is defined the membership function for the variable Means described as "fulfilling an optimal level of security".

The linguistic variable E - characterizing the Effects – means the value of damages due to the risk event.

The assessment is based on the evaluation criteria of dysfunctions importance presented in Table 1.2

Table 1.2. Effects assessment

Score	Level of importance	Criteria for assessing the failure significance
10	Minor importance	Minor defects: - Stopping production less than 10 minutes; - Any noticeable degradation of material elements.
9	Significant importance	Significant defects: - Stopping production between 10 and 20 minutes, depending on the possibilities of intervention;
8	Medium importance	Medium defects: - Stopping production between 20 and 60 minutes; - Change defective parts; - Fixes necessary parts (non-quality items detected).
7	High importance	Major defects: - Stopping production between 1 hour and the period of a shift - Important interventions at subassemblies level.
6	Major importance	Emergency generating defects: - Stopping production for a period longer than a shift; - Difficult costly interventions, need intervention team; - Personnel security issues.

It is defined the membership function for the variable Effects described as "reach a minimum damage level due to the risk event".

The linguistic variable T - characterizing the cognitive means - quantity and quality of knowledge and skills used to reduce risk.

It is defined the membership function for the variable T described as "achieving an optimal level of knowledge and skills used for better efficiency and risk mitigation of human factor action".

For this purpose will be used the periodical knowledge evaluation tests results. The evaluation is designed to take into account the following factors: seniority at work, job experience, age both for personnel in executive positions and for personnel in management positions.

Obtaining a score lower than 7 generates a reprogramming of testing; and in case of scoring low again generates the employment in another work category (Fig. 1.1.11). So, figure 1.1.11. presents only the scores above 7 with the staff rearranged according to the tested competences. The periodical test is for all the personnel on different hierarchical levels and from different activity branch, like maintenance, ventilation, mechanical, energetic, production.

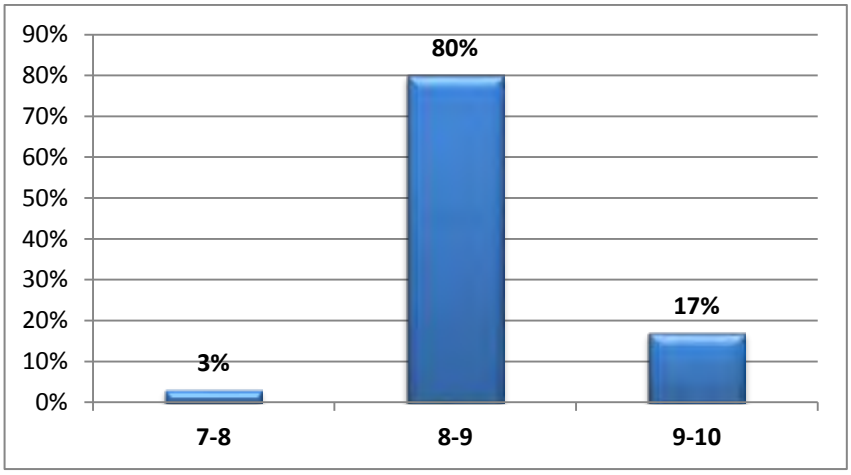


Figure 1.1.11 Assessment results for personnel periodical testing

1.1.3. Fuzzy model for evaluation of the human action in the underground work system

First, there were implemented the membership functions for all the inputs and for the output of the system (fig. 1.1.12), based on the evaluation of each linguistic variable. There were used only Gauss and trapezoidal functions.

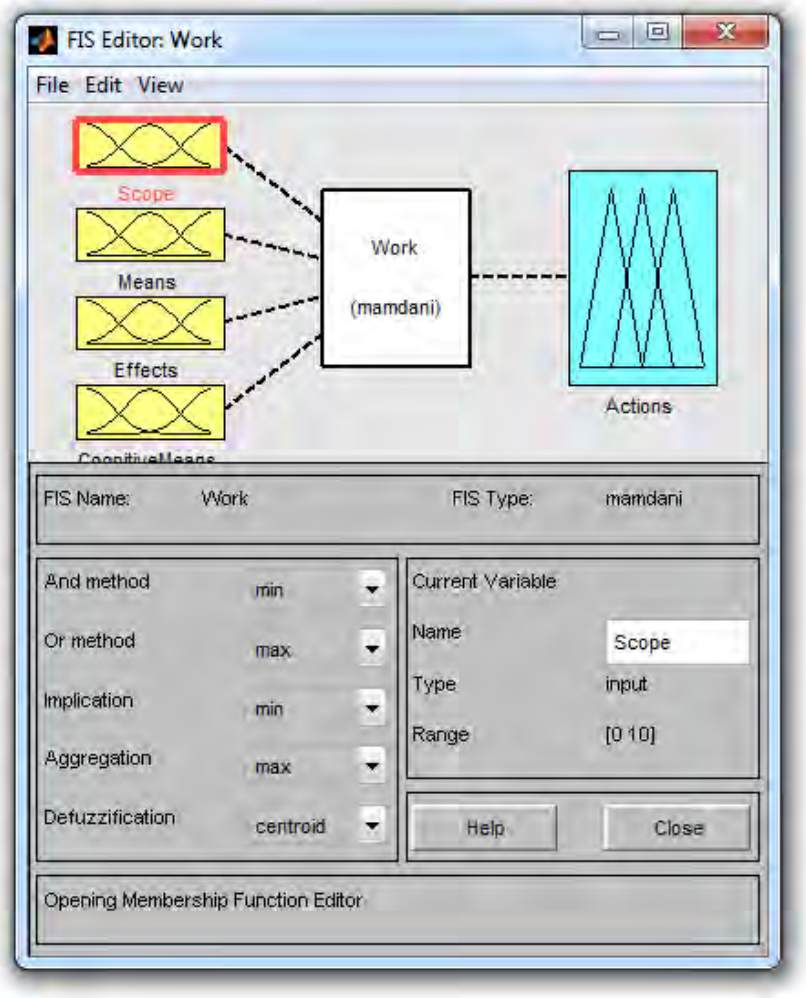


Figure 1.1.12. The fuzzy system

In figures 1.1.13 to 1.1.17 there are presented the membership functions.

Based on the consideration regarding the chosen linguistic terms presented, we have implemented the following membership forms:

- for the Scope linguistic variable (fig. 1.1.13) is used the Gauss membership function;
- for the Means linguistic variable (fig. 1.1.14) is used the trapezoidal membership function;
- for the Effects linguistic variable (fig. 1.1.15) is used the Gauss membership function;
- for the Cognitive Means linguistic variable (fig. 1.1.16) is used the trapezoidal membership function;

- for the Actions linguistic variable (fig. 1.1.17) is used a mixture between the trapezoidal and triangular membership functions.

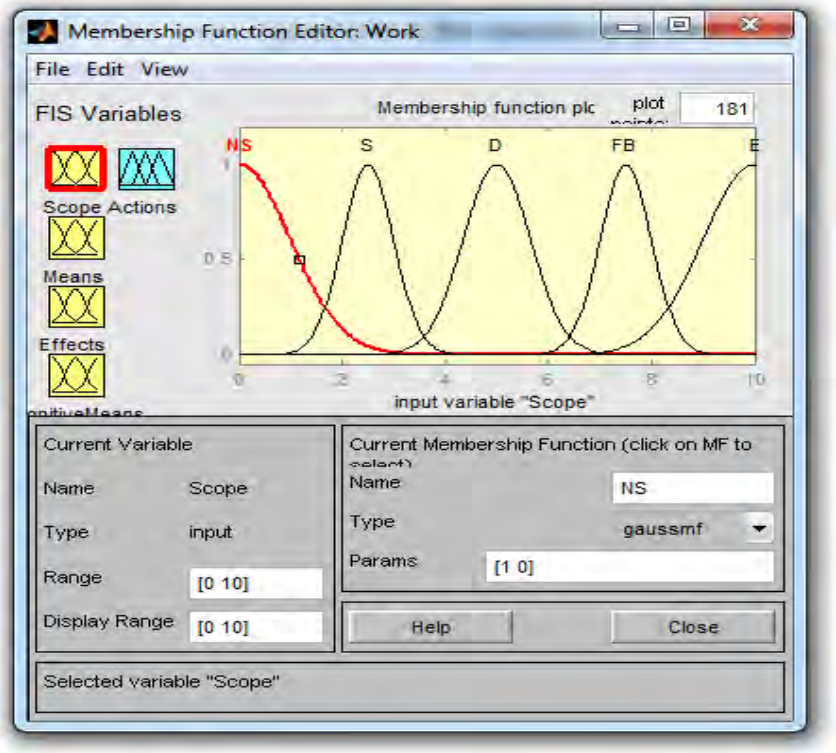


Figure 1.1.13. The description of the linguistic variable *Scope*

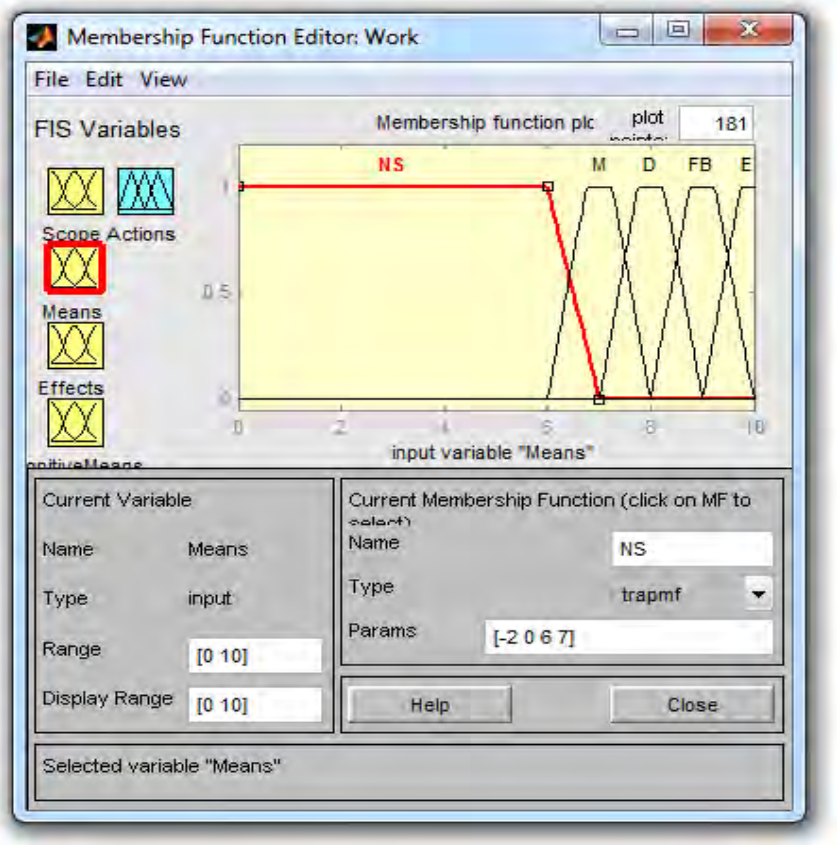


Figure 1.1.14. The description of the linguistic variable *Means*

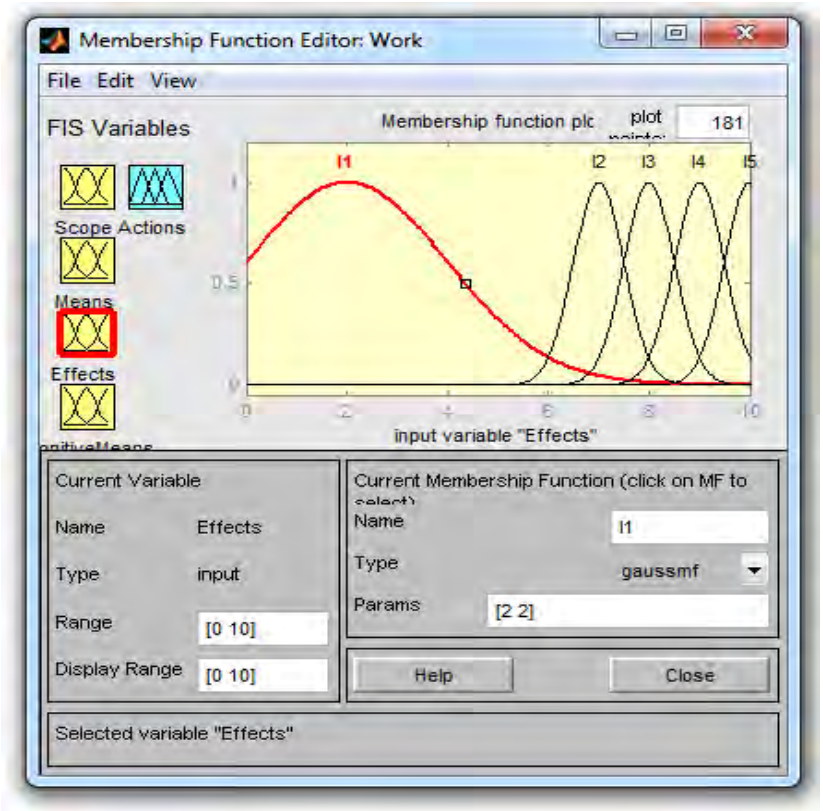


Figure 1.1.15. The description of the linguistic variable *Effects*

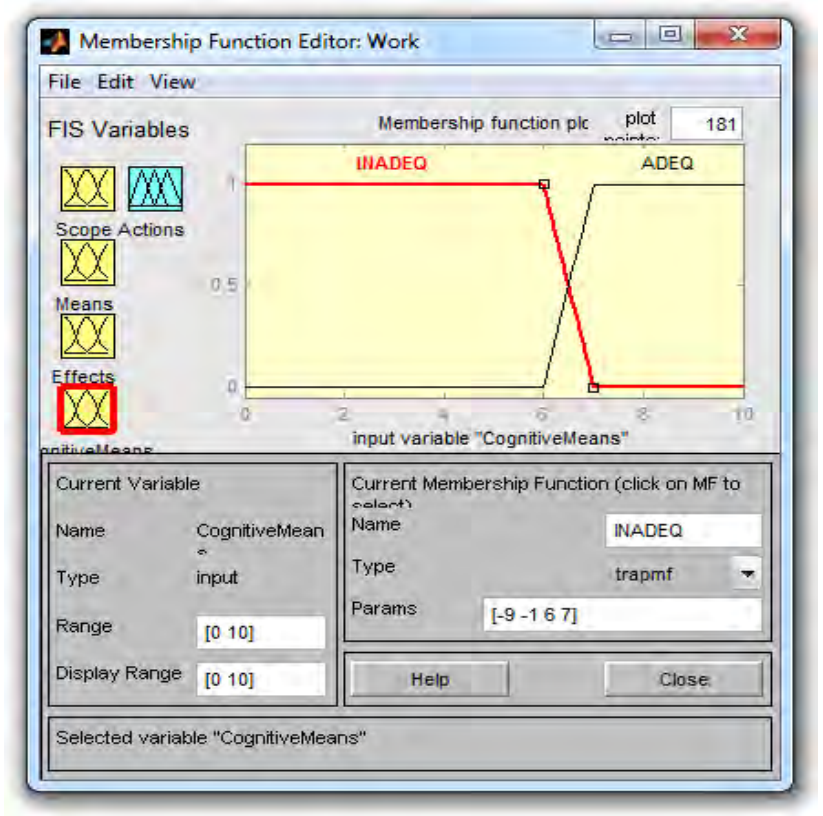


Figure 1.1.16. The description of the linguistic variable *Cognitive means*

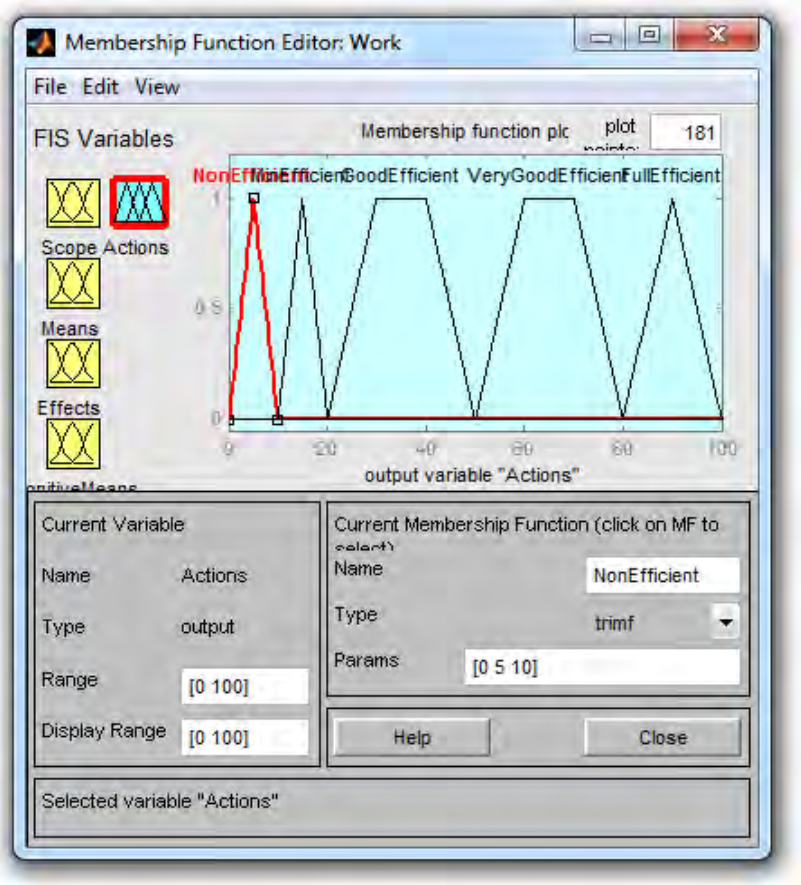


Figure 1.1.17. The description of the linguistic variable *Actions*

In order to use the fuzzy model there was built the rules database (fig. 1.1.18).

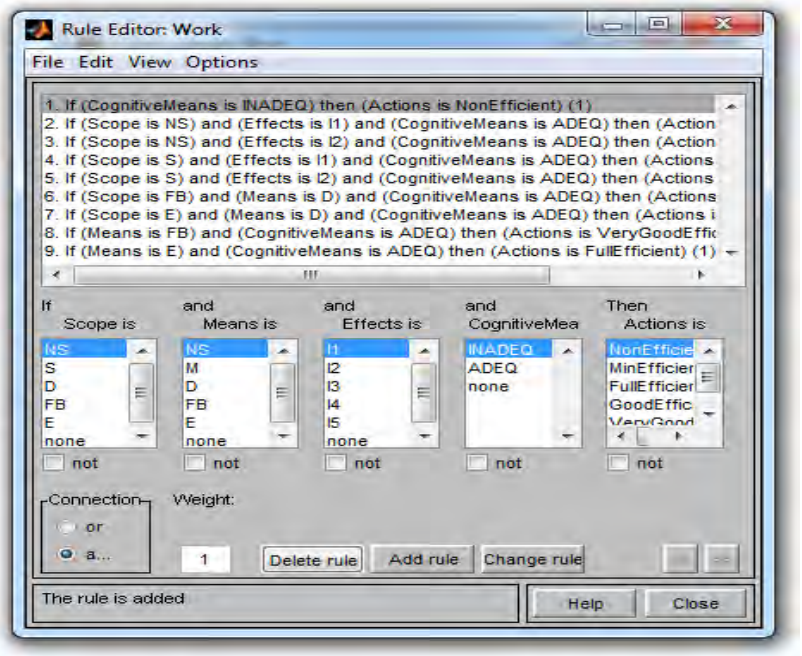


Figure 1.1.18. The data base of rules.

We have used only the connection operator AND for all the conditions without taking weight into account. The AND operator represents the intersection or minimum operator and is suited for our approach as we need to consider the most unfavorable case. The weights will be usable after applying the proposed fuzzy model and obtaining more results in order to refine the database of rules. Based on the rules database and the membership functions defined above, there were obtained the 3D surfaces representing the dependency of the output on two of the inputs. These 3D surfaces can be used to evaluate the output variation having certain input values for the considered terms.

It can be observed (fig.1.1.19) *Minimum Effective Actions* and *Non Efficient Actions,* with a significant risk associated to human action, even if the scope is valuable (high levels of the functioning probabilities), the lack of the means, significantly influences the situation.

Due to the trapezoidal form of the membership function for Means (fig. 1.1.14) and the use of intersection operator (AND), when Means are Unsatisfactory (NS) the Actions can not be Efficient. When Means are above Satisfactory (S), the Gaussian form of the membership function Scope is visible on the surface and introduces a certain slope that is important in critical points identification.

It can be analyzed the efficiency of the actions (fig. 1.1.20) that tend to *Very Good Efficient Actions*, when we have *Excellent* means, *Minor Importance* effects that do not cause long term interruptions of productive activities with impact on the all elements of the working system.

The Actions exceed the Good level only when the Means are above Satisfactory (S) and get the Gaussian form of the Effects (fig. 1.1.15).

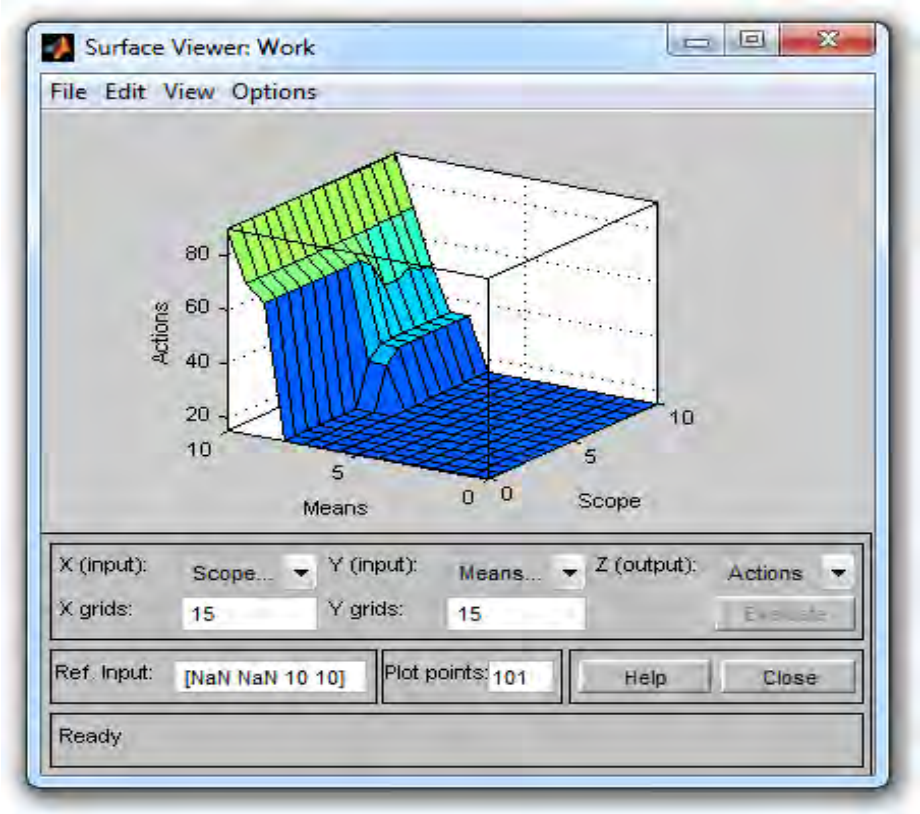


Figure 1.1.19. Scope- Means-Actions relationship surface

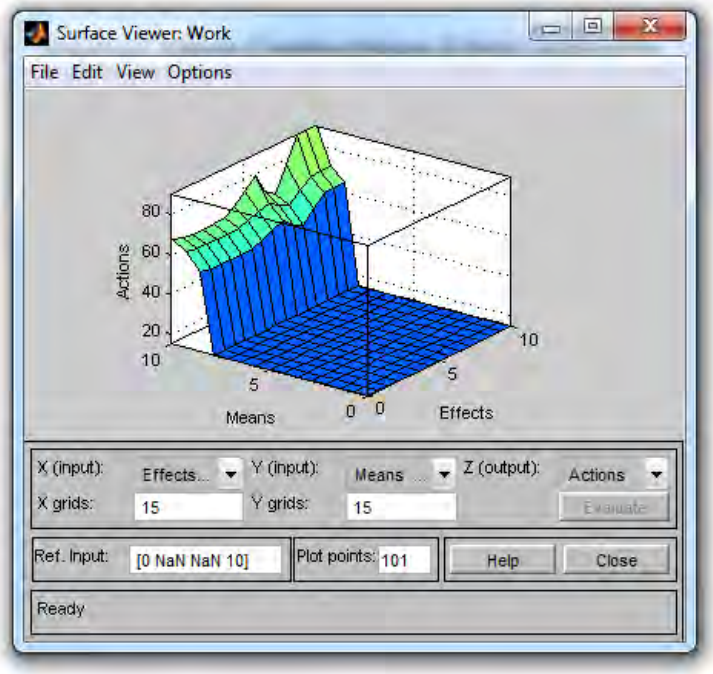


Figure 1.1.20. Effects-Means-Actions relationship surface

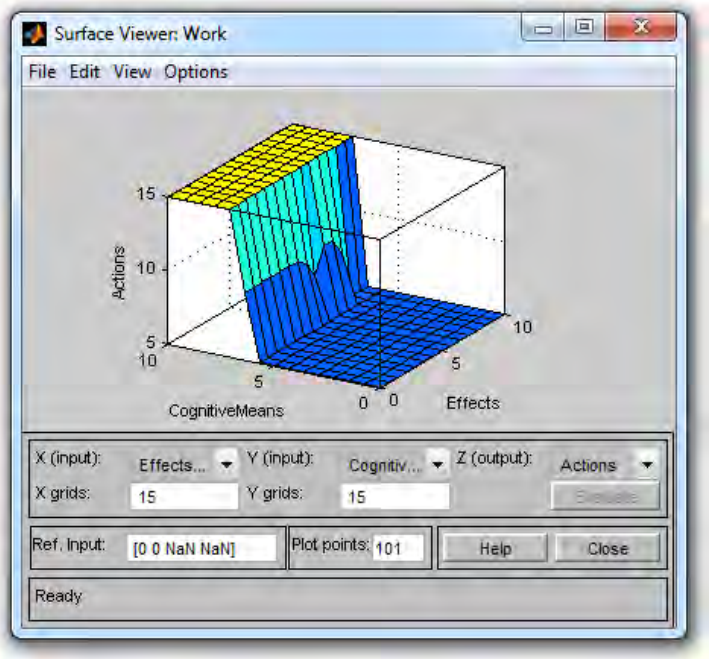


Figure 1.1.21. Effects-Cognitive Means-Actions relationship surface

It can be observed (fig. 1.1.21, fig. 1.1.22) the high level of the risk associated to *Non Efficient Actions* when the cognitive means are *Inadequate*, no matter the Effects and Means involved there are generated malfunctions in the entire working system.

The Actions gets the mostly trapezoidal form from the Cognitive Means (fig. 1.1.16).

The Means (fig. 1.1.14) and the Cognitive Means (fig. 1.1.16) are both trapezoidal membership functions and the resulting Actions function of these two variables, when the Cognitive Means are Adequate, highly depends on the level of Means, going from MinEfficient to FullEfficient.

For all the estimations, the trapezoidal form of the Means membership function and the use of the AND operator in the case of Unsatisfactory Means forces Actions to NonEfficient.

Using these surfaces there can be detected, based on the surfaces slope, the dangerous evolutions of certain input terms and flag the situation as alarm to the persons in charge. It can be emphasized the importance of the appropriate identification and evaluation of the effects and framing them in a class of importance depending on the peculiarities of the work system in order to have an adequate estimation of the actions generated which leads to better decisions and proper involvement and use of the HR both at management and execution level.

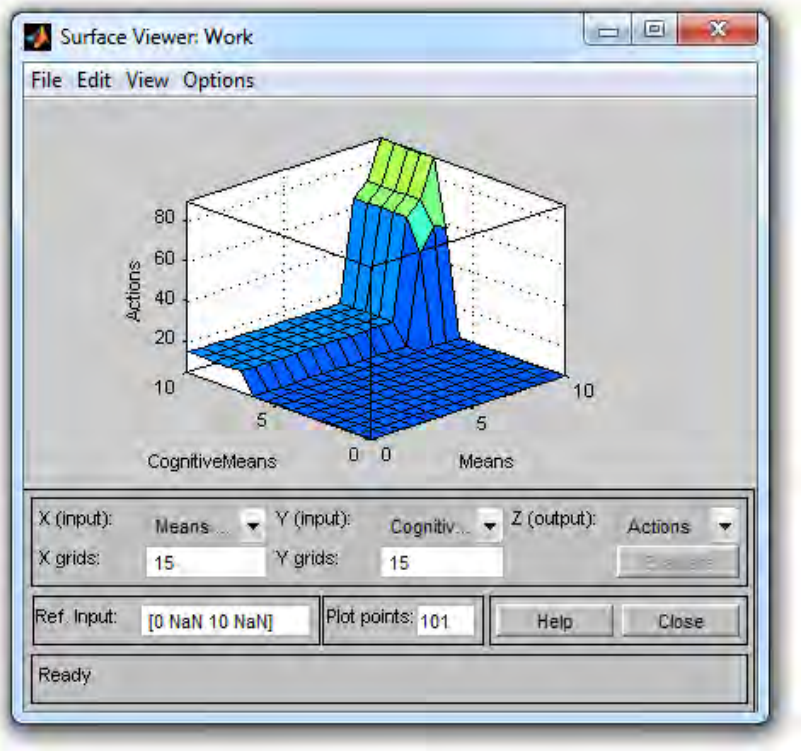


Figure 1.1.22. Means-Cognitive Means- Actions relationship surface

The evaluation of the human action performing in a work system, using fuzzy logic, generates interpretations concerning the quality improvement of the work process. The actions will concentrate, for example, on the organization at the work place (work groups dimensioned correctly, special intercession team), purchase of appropriate equipment, spare parts materials, necessity of collaboration regarding the improvement of the quality at the suppliers, staff-forming-training program. Besides assessing the human factor and framing their actions in a certain typology, the study provides a visual tool, represented by the fuzzy surfaces, useful to identify a critical moment based on the slope of the surface, which can lead to malfunctions in the work system.

1.1.4. The digraph based model for evaluating the preconditions for TQM implementation from the HR point of view

In an attempt to make a new step towards integrated management systems we used the results of the investigations on the managers of NHCC regarding the quality management approach. So, even if results denotes generally a good perception of the promoting elements of the quality - the main promoting element of the quality was considered the management policies (54%), the real

commitment of the NHCC can be appreciated to be quite low comparative with the one resulted in case of its suppliers.

These results led us to investigate a number of 50 middle and top managers from the organizational structure of NHCC. The research methodology was based on a previous documentation (organization charts, statutes, regulations and job specifications of the investigated company) which primarily considered all the jobs including tasks and responsibilities, either directly or indirectly related to the different quality problems. Then, these jobs were grouped within functional areas, so that it was revealed that the most relevant for the research are the Production, Commercial and Personnel functions. We used the technique of questionnaires and interviews applied to the persons in managerial jobs within the above-mentioned functional areas. The structure of the questionnaires and interviews included different items for gathering both general and detailed information about quality. So, the questionnaire's answers were completed with more detailed and useful information resulting from direct, structured interviewing for the middle and top managers. The proposed digraph based model provides an index that can be considered a useful tool in reviewing a current situation, to identify current levels of organizational functioning and areas in need of change.

The results of the reserches underlined that the quality perception is encouraging and, on the whole, the opinion of 60% of the questioned persons is that quality tasks are well reflected in the job description, but their level of accomplishment is low, the average answers being within the range [2.50; 3.75] and there was a uniformity of answers, which implies an agreement, the average square deviation being within the range [0.5;1.2] (Fig. 1.1.23)

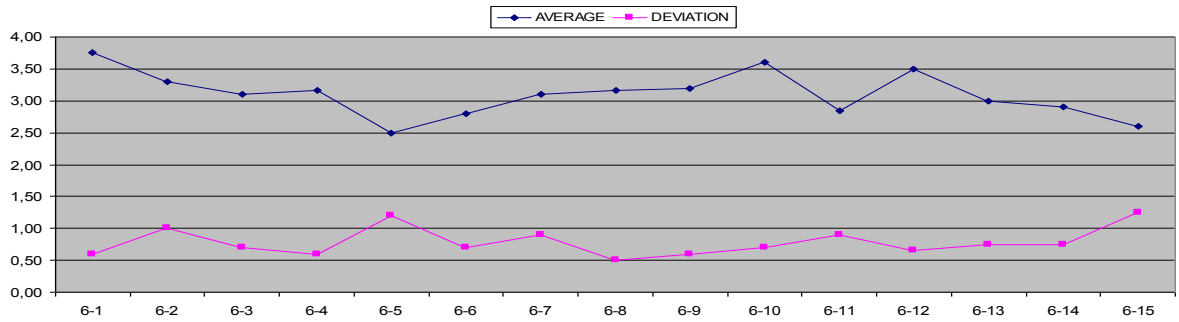


Figure 1.1.23. Levels of accomplishment of the job specification directly related to quality assurance tasks

Note: x- questionnaire items, y- average and deviation

Only three functional areas were analyzed, the questions in the questionnaire (divided into six sections) and in the structured interview mostly regard quality assurance in mining equipment, materials and technology, the way in which equipment is provided, purchased and monitored in usage, the acquisition of raw materials and spare parts and show which are the departments that should increase their efforts and what should be the real flow of the relation diagram.

We denote with: F_i – index of functional areas level of accompplishment (F_1 –index of commercial functional area , F_2 – index of production functional area and F_3 – index of human resources/personnel functional area); f_{ij} – interfaces/interactions among the main functional areas.

Relations among functions are shown in Fig. 1.1.24.

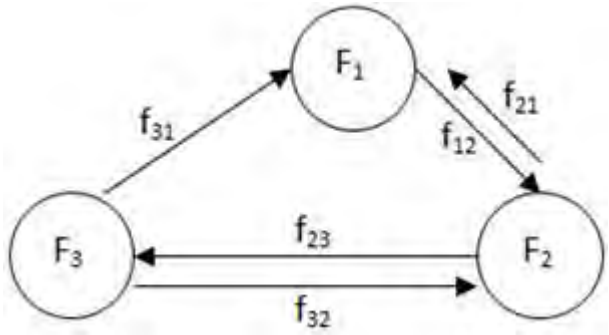


Fig.1.1.24. The digraph for the main functional areas

The *Process Management Index* is calculated by the relation:

$$I_Q=Per(Q)=F_1\ F_2\ F_3 + f_{12}f_{21}F_3 + f_{13}f_{31}F_2 + f_{23}f_{31}F_1 + f_{12}f_{23}f_{31} + f_{13}f_{32}f_{21} \quad (1.2)$$

$$Q = \begin{pmatrix} F_1 & f_{12} & f_{13} \\ f_{12} & F_2 & f_{23} \\ f_{31} & f_{32} & F_3 \end{pmatrix}$$

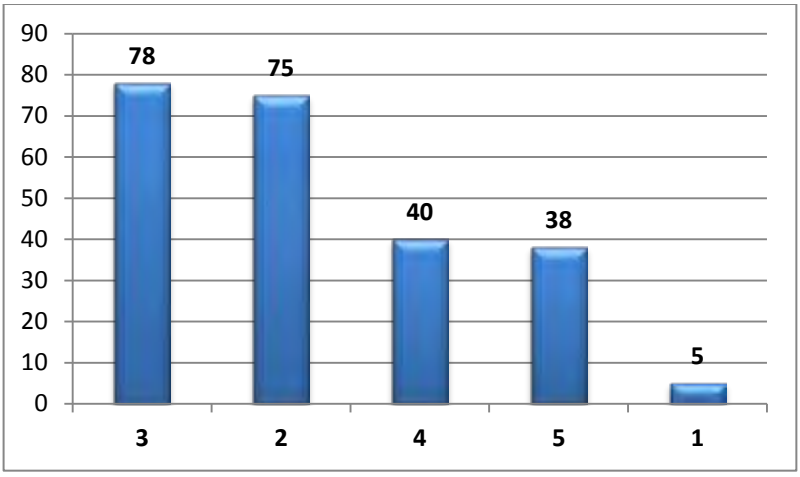
f_{12} and f_{21}– interface between F_1 şi F_2 (for instance, the management of the financial resources necessary for the activities regarding the acquisition of equipment, machine componenets, spare parts, materials, fuel, energy, all of which being part of a plan based on proposals from production units).

f_{23} şi f_{32} – interface between F_2 and F_3 (for instance, norming should ensure the complete use of production capacities at the economic and technical parameters set by designs, the rational use of work force, the efficient management of work process)

f_{31} – interface between F_1 and F_3 (for instance, the accomplishment of a acquisition plan based on production and work norming).

The interfaces among functions are quantified through the correlation coefficients. If the obtained coefficients are negative, in matrix Q element f_{ij} , will be replaced by 0, which means that the interface is non – functional.The identification of the interfaces is important for the outlining of the relation diagrams regarding quality assurance. There are strong correlations between the task accomplishment levels: *price negotiation for equipment* and *equipment acquisition* assurance *and management* defining the interface between F_1 and F_2. There are strong correlations between the task accomplishment levels: *the monitoring and control of production process* and *production and work norming* defining the interface between F_2 and F_3. There are negative correlations between the task accomplishment levels regarding t*he determination of specific consumptions, of raw materials and spare parts stocks* and *production and work norming* which denotes a different task accomplishment level and even the absence of a functional interface between F_1 and F_3 and a low correlation between production norming and a real acquisition plan (F_3 and F_1). The moderate or strong correlations among the answers reflect the same level of task accomplishment regarding different functions, not necessarily a good functioning of the interfaces, but they can represent a possibility to quantify the relations among functions if measures are taken to improve the task accomplishment level.

The index of commercial functional area level of accompplishment (F_1)



1. improving external communication
2. increasing the accessible market segment
3. accessing new market segments
4. consolidating the relations with the main clients
5. improving the relations with the main suppliers

Figure 1.1.25. Strategic priorities concerning the commercial functional area in order to create the preconditions for TQM implementation

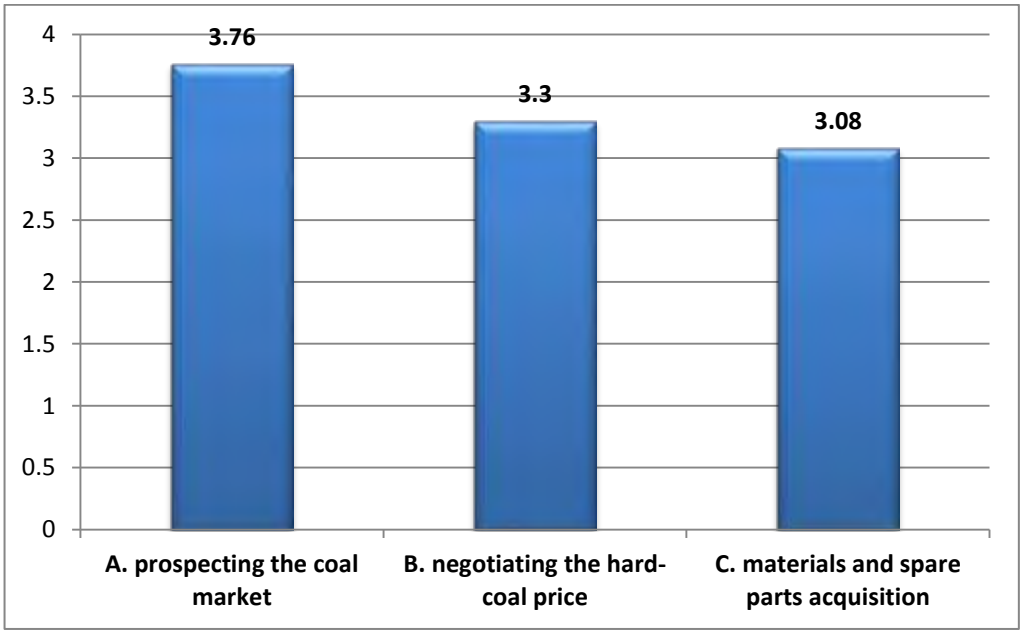


Figure 1.1.26. The least accomplished tasks on the level of commercial functional area (F_1)

The priorities are identified as influence factors on the commercial functional area level of accompplishment.

We denote with:

F_1^1- improving external communication

F_1^2- increasing the accessible market segment

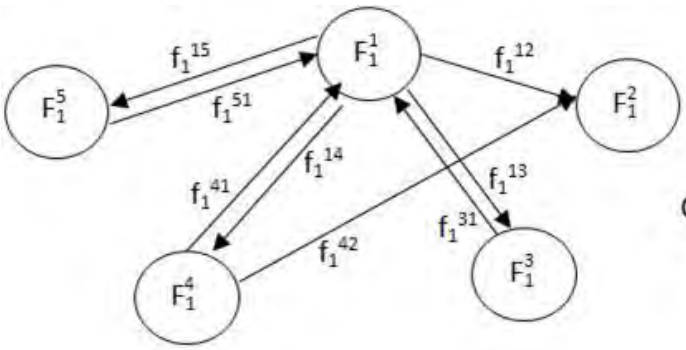
F_1^3 - accessing new market segments

F_1^4 - consolidating the relations with the main clients

F_1^5 - improving the relations with the main suppliers

f_1^{ij} - the interdependence among the contribution factors to the accomplishment level of the comercial functional area (F_1), are represented by correlation coeficients.

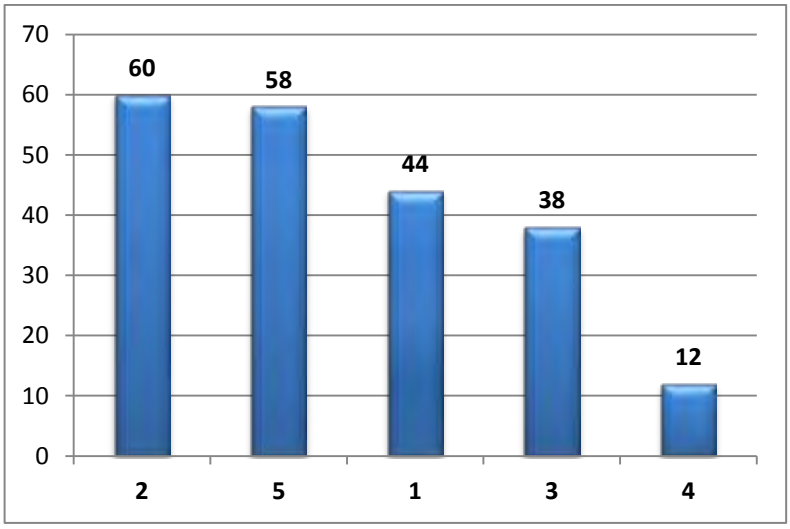
A first conclusion was drawn from the analysis of the data in fig. 1.1.25. si 1.1.26.: although identified as priorities (Fig. 1.1.25) *accessing new market segments* (78%), *increasing the accessible market segment* (75%), and *prospecting the coal market* are among the least accomplished tasks on the level of function F_1 (Fig. 1.1.26). Then, it is necessary to point out the level of accomplishment for function F_1 by an index which, in its turn, will influence the process management index. The terms on the diagonal of the matrix are to found in the priority chart and the other are replaced with correlation coefficients.



$$Q_1 = \begin{pmatrix} F_1^{\ 1} & f_1^{\ 12} & f_1^{\ 13} & f_1^{\ 14} & f_1^{\ 15} \\ f_1^{\ 21} & F_1^{\ 2} & f_1^{\ 23} & f_1^{\ 24} & f_1^{\ 25} \\ f_1^{\ 31} & f_1^{\ 32} & F_1^{\ 3} & f_1^{\ 33} & f_1^{\ 34} \\ f_1^{\ 41} & f_1^{\ 42} & f_1^{\ 43} & F_1^{\ 4} & f_1^{\ 44} \\ f_1^{\ 51} & f_1^{\ 52} & f_1^{\ 53} & f_1^{\ 54} & F_1^{\ 5} \end{pmatrix}$$

Figure 1.1.27. Digraph for the comercial functional area

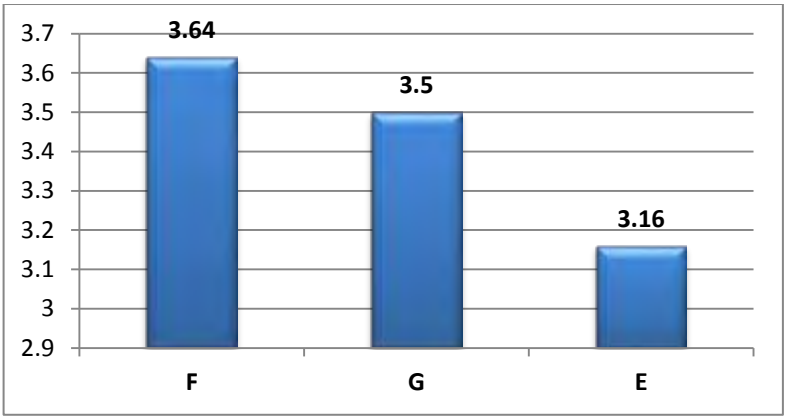
The index of production functional area level of accompplishment



1. Improving productivity
2. Improving profitability
3. Improving the controlling system for specific consumption of materials and spare parts stocks
4. Improving the working system
5. Improving the capability of the production processes

Figure 1.1.28. Strategic priorities concerning the production functional area in order to create the preconditions for TQM implementation

Figure 1.1.28. shows the identification of the improving of profitability as a strategic priority on the level of the production function, and figure 1.1.29. presents the *use of production capabilities* as the task with the lowest accomplishment level. Therefore, the first measure to take for increasing the efficiency of F_2 is to improve the accomplishment level of this task.



F. establishing the specific consumption and materials and spare parts stocks

G. monitoring the equipment performance, a recording system for the technical and economic indices

E. utilizing production processes capabilities at the technical designed parameters

Figure 1.1.29. The least accomplished tasks on the level of production functional area

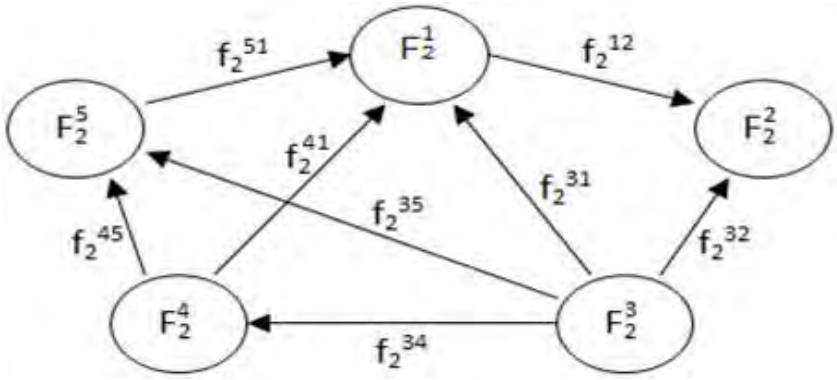
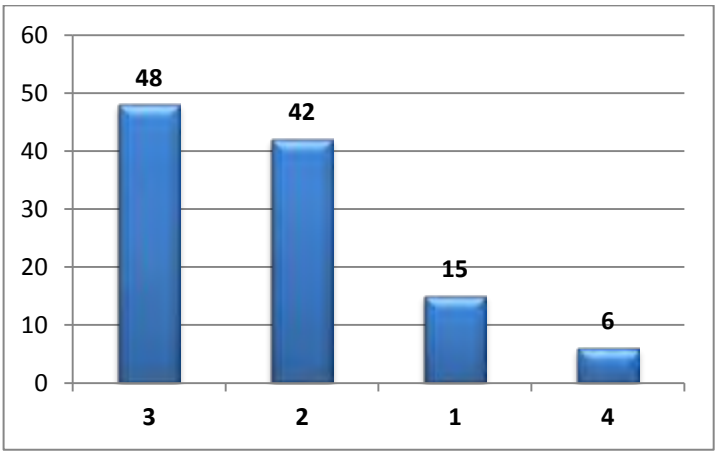


Figure 1.1.30 Digraph for the production functional area

The index of personnel functional area level of accompplishment (F_3)



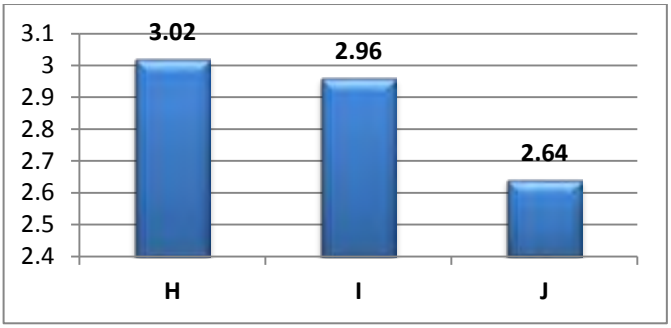
1. Improving personnel motivation

2. Improving work relations

3. Improving the elements of work environment

4. Improving internal communication

Figure 1.1.31 Strategic priorities concerning the personnel functional area in order to create the preconditions for TQM implementation



H. Production and work norming

I. Work force usage

J. Personnel training

Figure 1.1.32 Hierarchy of the tasks with the lowest accomplishment degree on the level of the personnel functional area

For exemple, the low accomplishment level of the task *production and work norming* has an impact on the interface between the personnel function (F_3) and the commercial function (F_1), which calls for measures to improve this task; the lowest level of accomplishment is achieved for *personnel training.*

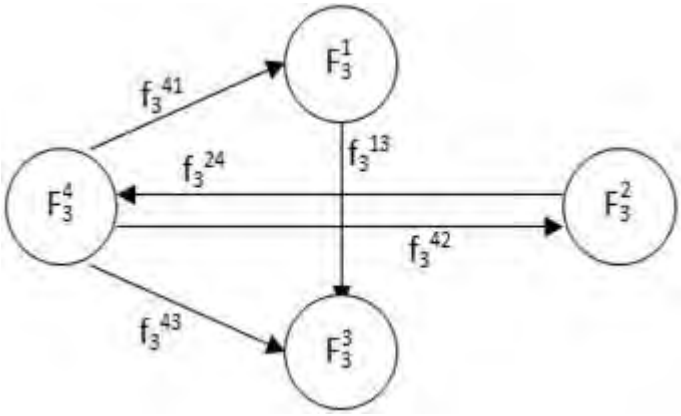


Figure 1.1.33. Digraph for the personnel functional area

In relation (1) we replaced the values of the indexes for the functions in question (F_1,F_2,F_3) and the values that represent the quantification of the interfaces among functions (correlation coefficients presented in matrix Q).

The methodology that determines the *Process Management Index* I_Q can be applied in reviewing a current situation, to identify current levels of organizational functioning and areas in need of change.The calculation of the index on the level of the organization provides a comparativ basis for future improvement. The calculation of the index on the level of functional areas provides a comparative basis between the accomplishment degree of functions (performances on the level of the functions). It is possible to establish the opportunities for improving the accomplishment level for each functional area, the detailed analysis being able to reach as far as to the level of individual performance (analyzing the accomplishment of the tasks in the job description). The interdependences among the influence factors (the determining of functional interfaces) are rigurously established through the correlation coefficients. The methodology can be used for improvement both on a formal level, (human resource systems, including job design and organizational structure and design), and on an informal level (a change in an organization's

culture, in its norms, values, and belief systems about how organizations function, the managers' leadership philosophies and styles at all levels)

1.1.5. Organizational Chance towards Total Quality Management

Applying the methodology of the digraph based model could be captured some coordinates regarding the life of the organization especially at the formal level, the informal level, strong connected to organization's culture, remains unexpressed. In this context, our researches turned to exploring the organizational culture change.

Change is a fact of organizational life, just as it is in human life. Every organization must change continually to survive and succeed in a more and more unpredictable and restrictive environment.

Therefore, the managers should try to build flexibility throughout the organization (into its people, technology, systems, processes, and thinking) to create a work environment and an organizational culture that are open to change and able to support it. So, the concept of organizational change is often related to an organization-wide transformation designating a fundamental and radical reorientation in the way the organization operates, with important cultural and human involvement prerequisites.

Implementing TQM is a such example of organization-wide change that our research investigates in the context of previous mentioned prerequisites and in the context of the particularities of the mining sector. We talk about the „force" of HR in the TQM implementation, about assuring the preconditions for this large-scale systems change, and about organizational culture as a source for the capability of the HR.

We started our investigations with the following questions:

- It is ready a company, especially one operating in a highly specific field such mining, to implement TQM?
- Is TQM just a philosophy, or a useful practical tool in obtaining QUALITY?
- It is justified the diffused expression of "fad TQM"?

While there have been quite a few success stories, for some companies TQM has become synonymous with failed efforts and wasted resources. Some believe it to be a fad that has lost its relevance in today's world. For answering these questions we must understand that implementing TQM will generate major changes at formal and informal levels, and human resources will be the most affected.

Our point of view is that, in fact, the HR is the „engine" of the change through TQM. All the other resources in an organization (either tangible or intangible) are not value–adding unless HR is able to use them efficiently.

Reviewing principles of effective planned change implementation through TQM are proposed several assumptions related to the above mentioned questions, as follows:

1. Not all organizations are able or ready to change in order to create a favorable climate for implementing TQM;

2. TQM is a viable and effective planned change tool, when it is properly understood from the holistic systemic perspective of new managerial process views, including the needed approaches of organizational culture and behavior changes focused on human resources "force" enhancement;

3. Preconditions (prerequisites) for a successful TQM implementation can and must be created;

4. Top management support and commitment to a large-scale, long-term cultural change towards continuous improvements in quality is necessary, as well as embracing the transformational leadership view about the managerial ways of influence upon people involvement in the organizational change process (as more appropriated than transactional leadership one).

So, a preliminary step in TQM implementation is to assess the organization's current reality: relevant preconditions have to do with the organization's history, its current needs, precipitating events leading to TQM, and the existing employee quality of working life (that is organizational culture related-issues). If the current reality does not include such preconditions, TQM implementation should be delayed until the organization is in a state in which TQM is likely to succeed.

In order to identify some aspects of organizational culture it was used a designed instrument [10] which contains five items that describe some aspects of organizational functioning and design. The instrument uses four scales for four basic organizational cultures:

- Power oriented culture (P);
- Role oriented culture (R);
- Achievement oriented culture (A);
- Support oriented culture (S).

Because an organization has some combination of these four basic organizational cultures, the results were interpreted based on the Existing Culture Index (ECI) and Preferred Culture Index (PCI). The Culture –Index scores are a useful way to summarize all four scales and to obtain a measure that reflects the general level of empowerment, trust, and cooperation within organization.

$$ECI=(A)+(S)-(P)-(R)\ ,\ PCI=(A)+(S)-(P)-(R) \quad (1.3)$$

TQM is, in fact, a large scale systems change. Without attention to contextual factors, well intended changes may not be adequately planned. As an important aspect of context, the expectations and perceptions of employees (either workers, executive or top managers) will be assessed, so that the implementation plan can address them. Specifically, sources of resistance to change and ways of dealing with them were pointed out.

In general terms, TQM is a change in an organization's as a whole, in its all operating formal and informal systems and processes (not only in the technological or operating ones, but also in those defining its specific culture, policies, norms, values, and beliefs). Therefore, TQM as a technological change will not be successful unless cultural and political dimensions are attended to as well.

Once the preconditions are identified, it is possible to point out:

- ✓ the improvement opportunities on a formal level (human resource systems, including job design and organizational structure and design will be different under TQM: levels of management may be reduced and organizational roles will certainly change);
- ✓ the improvement opportunities on an informal level (a change in an organization's culture, in its norms, values, and belief systems about how organizations function, the managers' leadership philosophies and styles at all levels);
- ✓ any valid points of resistance to change.

For diagnosing organizational culture within NHCC we pointed out the existence of the four above mentioned cultures – Power, Role, Achievement and Support oriented. Practical we find a combination of them, each of the four cultures being only partially compatible with one another, that is the benefits of one can only be achieved at the expense of some of the others. Regarding the organizational culture within NHCC, the value of ECI proves the existence of a Power/Role oriented culture (especially Role culture) and as a preferred culture appears the Achievement/Support orientation (and especially the Achievement oriented culture) as determined by the PCI. The results are presented in the chart represented in the figure 1.1.34. that shows the sums of the scores for both existing and preferred cultures (the black lines). The shaded lines in each column show the average of the scores of the sample of 190 mid-level managers. The Culture Index also is useful for comparing the organization's culture before and after some changes such as implementing TQM.

Both Power oriented and Role oriented organizational cultures depend on the use of the external rewards and punishments to motivate people. Organization members are expected to contribute increasingly with their personal energy in return of appropriate rewards (as a result of managerial effective actions and motivation systems based on the transformational leadership principles rather than the transactional ones).

Both Achievement oriented organizations and Support oriented organizations assume that people wants to contribute. The assumption is that people will contribute out of a sense of commitment to a group or organization for which they feel a real sense of belonging and in which they believe they have a personal stake.

The weakness of Role organizations is in the very impersonality that is their strength. They operate on the assumption that people are not able to be trusted, so they do not give individual autonomy or discretion to members at lower levels.

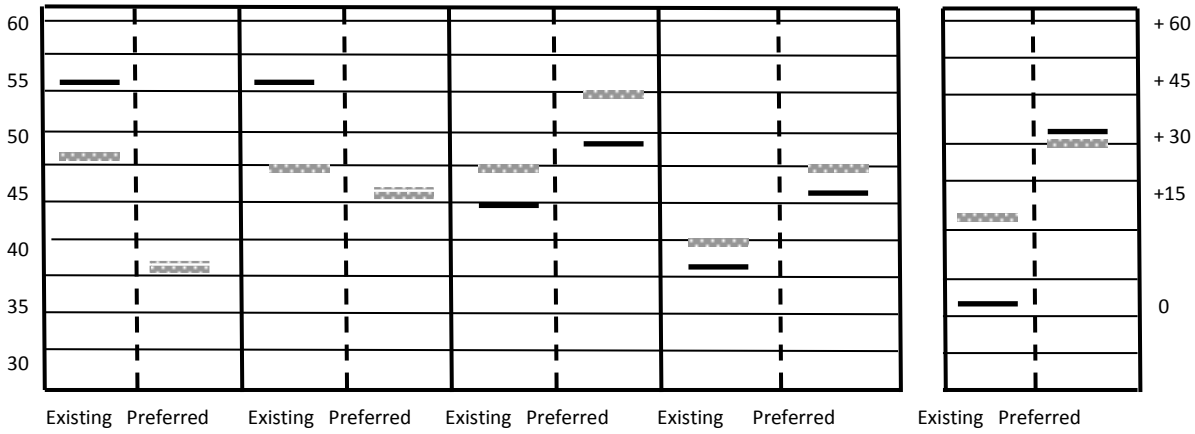


Figure1.1.34. The chart of the scores for the four organizational cultures (existing and preferred) and the values of Existing Culture Index (ECI) and Preferred Culture Index (PCI)

In rapidly changing situations, they have difficulty keeping up the circumstances. The system is designed to control people and to prevent them from committing selfish or stupid acts. It also keeps people from being innovative and from doing the right thing when the right thing is outside the rules. In the interests of rationality and order, it is difficult to change or bend the rules, and it usually takes a long time to make needed changes. The new managerial approaches of TQM implementation that attempt to blend the Role orientation's emphasis on well-designed and closely managed systems with the empowerment of employees, is typical for Achievement orientation.

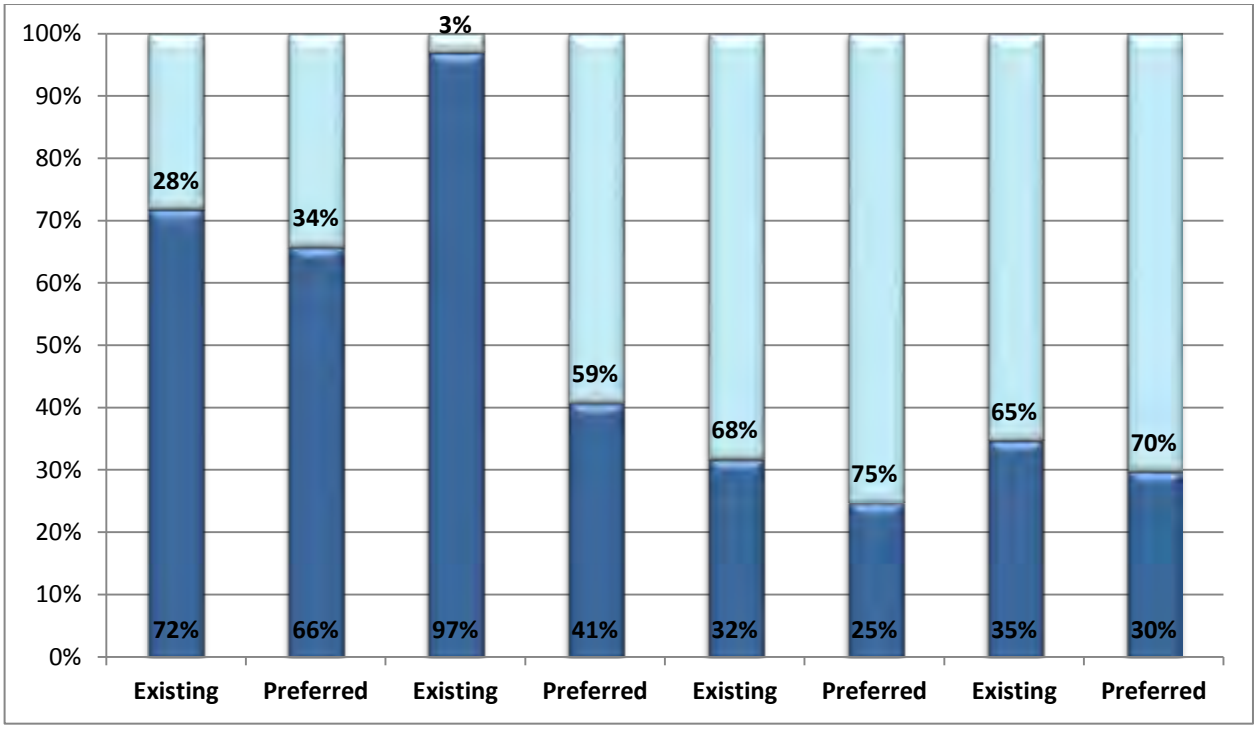


Figure 1.1.35. The percentile of the scores compared with the scores of 190 first-line and middle managers

These approaches endeavor to make the system serve the workers and, thus, to combine the economic effectiveness of the role orientation with the high energy of the achievement culture.

Some observations must be made after processing and interpretation of the results presented in fig. 1.1.35:

- scores on Power (Existing 51 and Preferred 26) are negatively correlated with those on Achievement (Existing 35 and Preferred 44) and Support (Existing 26 and Preferred 36). This means that if we obtain a high score on Power, it tent to have low scores on both Achievements and Support. The Role scores tend to fluctuate fairly independently of the other scores (Existing 52 and Preferred 36);
- for the existing culture: a score of 51 on Power indicates that 72% of the people from the sample perceived their organization as having a lower Power orientation than was perceived for NHHC; a score of 52 on Role indicates that 97% of the people from the sample perceived their organization as having a lower Role orientation than was perceived for NHCC; a score of 35 on Achievement indicates that 32% of the people from the sample perceived their organization as having a lower Achievement orientation than was perceived for NHHC; a score of 26 on Support indicates that 35% of the people from the sample perceived their organization as having a lower Support orientation than was perceived for NHHC;
- for the preferred culture: a score of 26 on Power indicates that 66% of the people from the sample perceived their organization as having a lower Power orientation than was perceived for NHHC; a score of 36 on Role indicates that 41% of the people from the sample perceived their organization as having a lower Role orientation than was perceived for NHHC; a score of 44 on Achievement indicates that 25% of the people from the sample perceived their organization as having a lower Achievement orientation than was perceived for NHHC; a score of 36 on Support

indicates that 30% of the people from the sample perceived their organization as having a lower Support orientation than was perceived for NHHC;

- when people in an organization disagree about the culture they actually have (in our case, the difference between ECI = -42 and PCI = +18, proves differences between the existing culture and preferred culture), it is because they have different expectations from the organization, or more often the culture looks and feels different from the perspective of different parts of the organization.

The results of our research pointed out the existence of a Power/Role oriented culture and as preferred culture the Achievement/Support oriented one. That might be a “signal“, in the sense that the organization knows precisely the current situation and it is ready for change through Achievement and Support oriented culture, that are more close to the TQM principles and related issues.

We considered interesting to continue the research at all the levels of the organization, not only on middle and top level, and also after attempting the change process implementation towards TQM. Such a future research is justified because the need of cultural change it usually feels different at the top than it does at the bottom. Top managers see more of the Achievement culture than do those lower down. The latter are more likely to see the organization as Power oriented. At the formal level, the results of the research are encouraging and show a good perception on promoting elements of the quality. Even if at the present time we couldn’t find all the aspects of TQM prerequisites, the organization is ready for change. The change must begin, with management policy, understanding of the clients’ needs, requirements and expectations. These imply understanding the real need of change, not only in the production or technological process and systems.

It have been noted that TQM results is a radical change in the culture and the way of work in an organization. A fundamental factor is leadership, including philosophy, style, and behavior. A full implementation of TQM does, as was emphasized earlier, represent a significant change in the culture of an organization, and a comprehensive change strategy is therefore required.

There were identified several key factors related to successful TQM. First, as many researchers have noted, top management support is necessary. This is typically represented partly through strategic planning regarding TQM. Second, a customer focus is an important precondition, since TQM often involves improving quality from a customer's point of view. In our case we deal with a special situation: about 90% of hard coal produced by NHCC is delivered to only two major clients, the thermal power plants of Paroseni and Mintia. Another particularity regards the working force generally considered to be skilled, but difficult to evaluate from the organizational behavior perspective because this field was not yet explored despite the recognition of peculiar “miners’ mentality”. In the TQM context employees must be involved early, particularly in addressing employee training and recognition and employee empowerment and teamwork issues. Attention to these issues is important in changing the organization's culture in the direction of teamwork and a customer and quality focus.

1.2. TQM and Reengineering

1.2.1. TQM and Reengineering – Strategic Options of the Management

The research aims to identify the main characteristics that cause/oppose the change in an organization towards TQM or Reengineering (RE), considered as strategic options. We follow the perception and the general implications at the HR level. The human factor is considered to be the

main “actor” in the organization. The human factor generates value only if the potentiality is acknowledged and adequately employed. The acknowledgement of the elements that define a certain typology of organizational culture allows the identification of the main forces

The methodology used is based on the technique of questionnaires and interview. Applying this research methodology allows the presentation of the diagnosis of the organizational culture, the elements that ensure the preconditions for the implementation of the TQM or Reengineering and the correlation of the results of the organizational diagnosis with the premises for implementing TQM or Reengineering. The questionnaires were applied to the Strategic Management of Business master students who study the two disciplines: TQM and Reengineering. Out of the 125 students who were questioned, 112 have jobs and 101 questionnaires were validated. The study took place during the year of study 2009-2010.

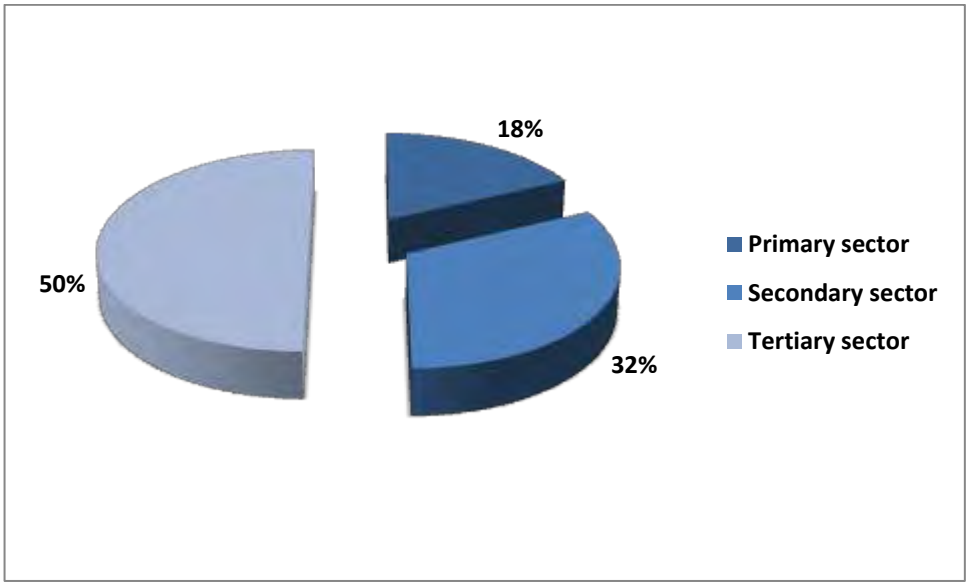


Figure 1.2.1. The structure of the analyzed organizations from the point of view of their belonging to one of the three sectors of the economy

The figure 1.2.1 shows that most of the organizations belong to the tertiary sector (commerce, finance, banks, insurance, transport, tourism, education, health) representing 50%, followed by the construction organizations with 32%, belonging to the secondary sector (industry and construction), meanwhile the organizations belonging to the primary sector represent 18% out of the total number of the analyzed organizations (Fig.1.2.1.).

Regarding the foundation year, over 90% of the respondents are working in organizations founded between 1990 and 2000. The percentage of the students working in organizations founded before 1990 is very low, under 10%.

Being asked “Did the organization design and implement a QMS according to the current standards?” the respondents gave a significant number of positive answers (60%). 40% of the respondents work in organizations that did not implement such a system of management, but consider that they are aware of the problem of quality assurance.

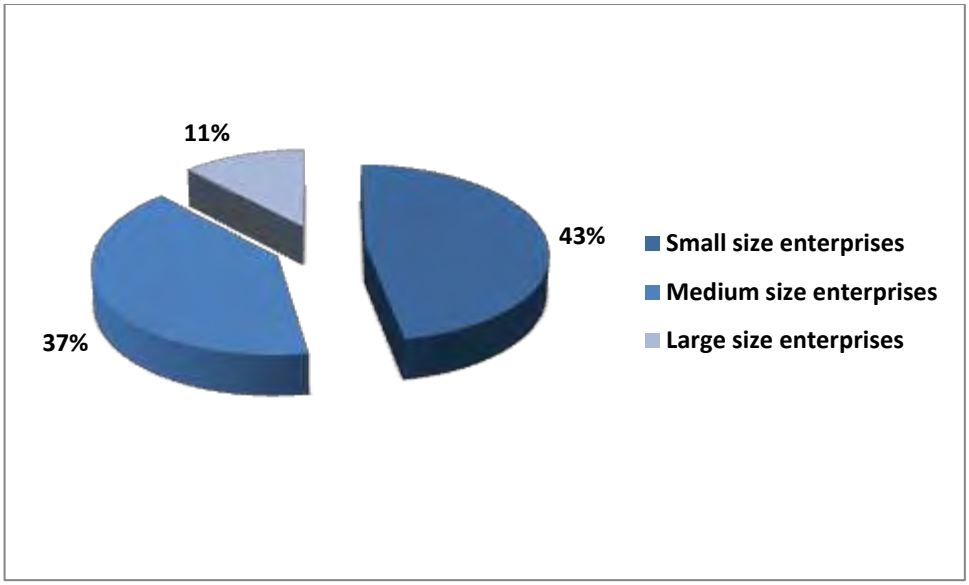


Figure 1.2.2. The structure of the organizations from the point of view of the number of employees

As far as their jobs are concerned, most of the interviewed persons have execution jobs representing 65%, and only 35% of them belong to the management. Also, most of the persons from the second category belong to the middle level and low level of management and very few belong to the top level of management.

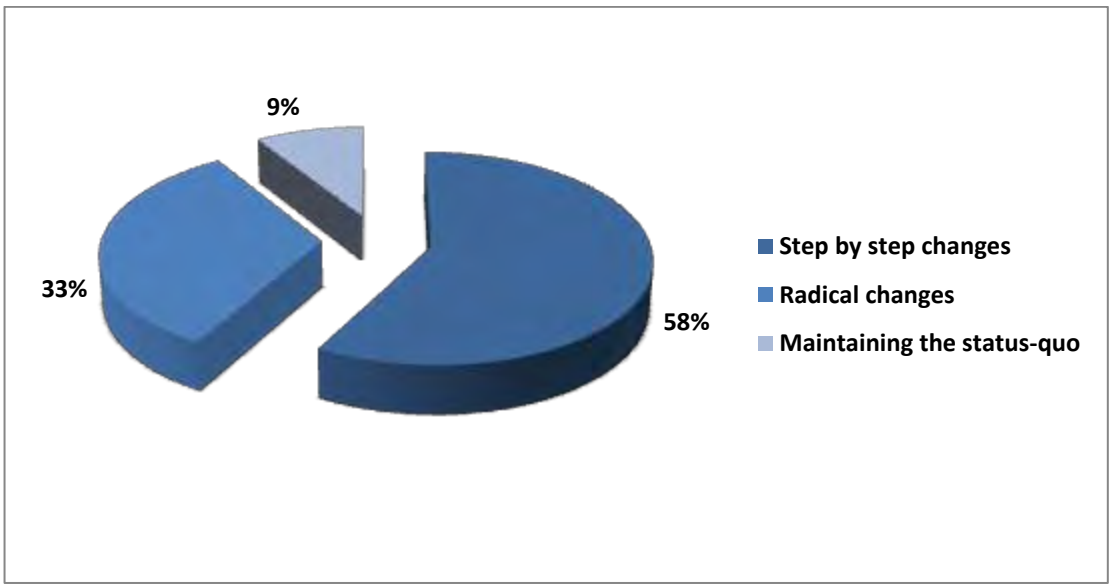


Figure 1.2.3. Potential ways to obtain the organizational performance

When the organizational performance are considered, 58% of the questioned persons believe in the gradual (step by step) change and continuous improvement, 33% choose a fundamental and radical change and only 9% think that the things should remain as they are and no change is necessary (Fig.1.2.3).

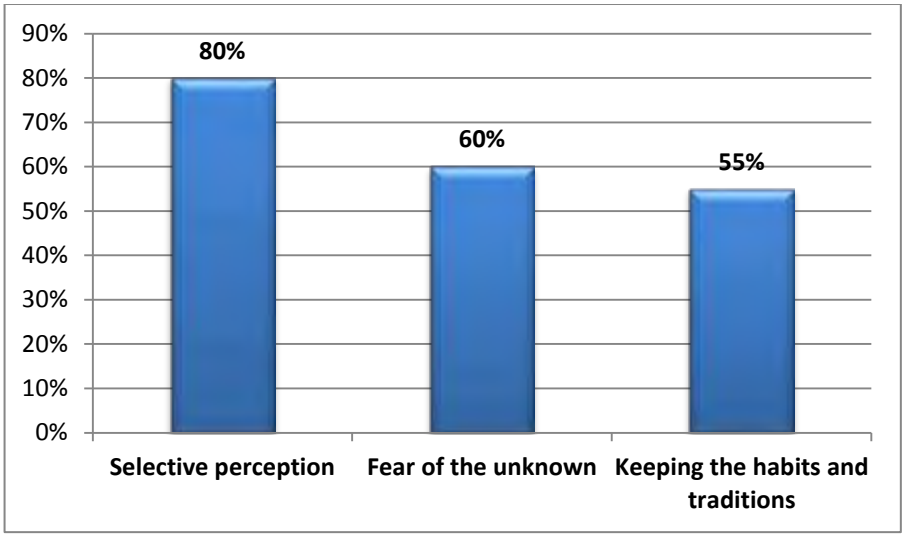


Figure. 1.2.4. The main forces that make a person oppose to the change or resist to the change

When asked about the main forces that make an individual oppose or resist to the change, 80% of the answers put on the first place "the selective perception", followed by "the fear of the unknown" having 60% and very close on the third place "keeping the habits and the traditions" (55%). "The dependence on others" and "the norms and cohesion of the group" are the factors having the lowest significance when it comes to the resistance to the change (Fig. 1.2.4).

Regarding the forces that cause the resistance to the change at the organizational level, we present below the hierarchy that places at first "the fear of the change of the power and of the influence".

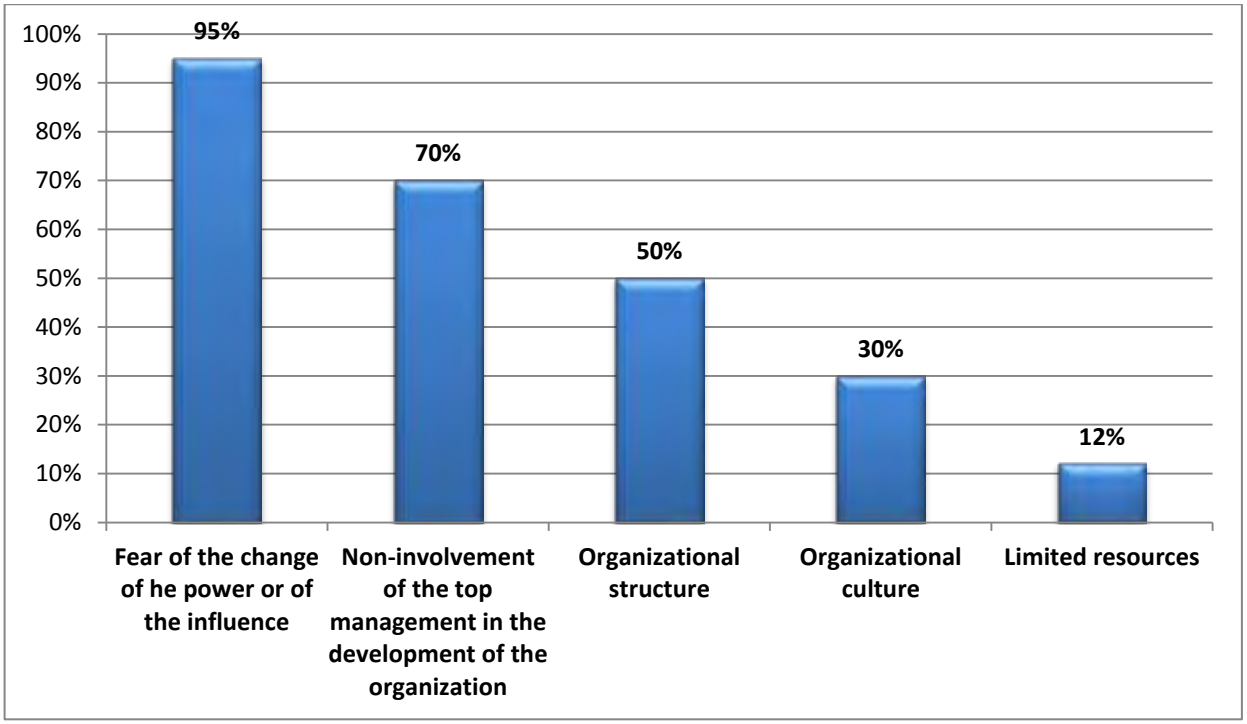
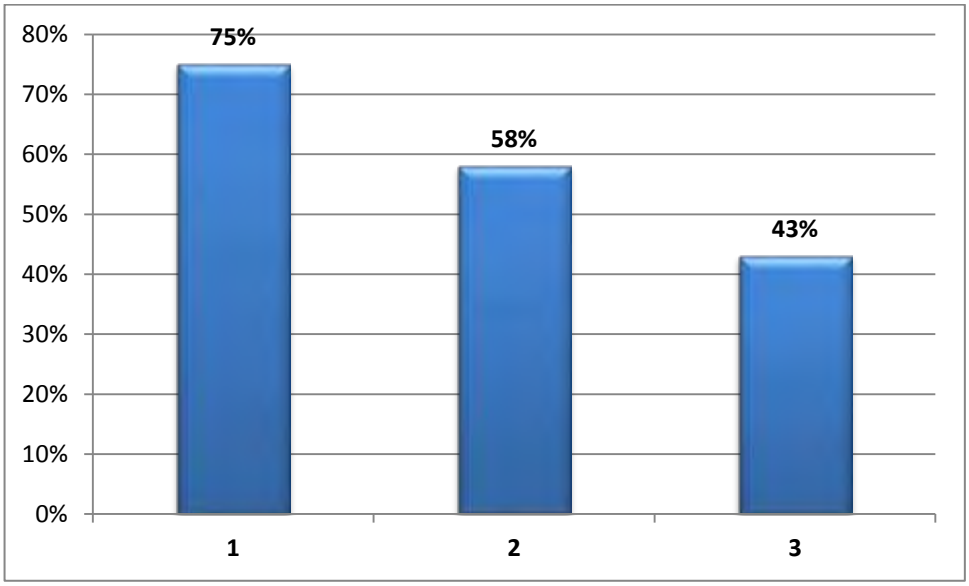


Figure. 1.2.5. The main forces within the organization opposing to the change or causing resistance to the change

Surprisingly, the respondents put on the first place, as a factor generating the change for the Reengineering as well as for the TQM the "pressure of the market competition", on the second

place “the quality of the products and of the services”, also as a common factor for both of the two orientations. Regarding the third factor, the opinions are divided, 56% agree with the low level of satisfaction of the clients as a factor determining the orientation towards a continuous improvement (TQM), the others consider the high production costs a factor to determine the organization to make a radical change (Reengineering).

The main approaches (means) to eliminate the resistance to the change identified by the participants to the study are the following: the most important was “the correct information of the persons about the business reality that determines the change”, followed by “the frequent, constant and individualized communication with the team members, encouraging the fain feed-back from them”, on which agree 58% of the respondents and “the involvement of the persons in the implementation of the change” is on the third place as importance, having 43% of the answers (Fig. 1.2.6).



1. The correct information of the persons about the business reality that determines the change
2. The frequent, constant and individualized communication with the team members, encouraging the fain feed-back from them
3. The involvement of the persons in the implementation of the change

Figure 1.2.6. The main approaches regarding the elimination of the resistance to the change

The respondents have identified the main premises of the implementation of the Reengineering or TQM, underlining that some premises are common such as “orientation towards the client”, “orientation towards the processes” and “using the trans-functional teams”. But, as far as the premises in the organizations to which the respondents belong are concerned, pre-conditions for the implementation of TQM have been identified, while the respondents were reluctant regarding the orientation towards a radical change within the organization, towards Reengineering. These results are also endorsed by the results regarding the identification of the organizational culture. The results of our research pointed out the existence of a Power oriented culture (41,6%) and a Role oriented culture (33,3%) and as preferred culture, the Support oriented (51,3%)- that is close to the TQM principles and related issues and Achievement oriented (29,4%) – that contains specific elements to reengineering. The results of the research emphasize in a comparative analysis the potential advantages generated by the implementation of the Reengineering, respectively of the TQM. We can see that if in the case of the implementation of Reengineering the opinions regarding the three variants are equally divided, each having a share of 33,3%, things

change when it comes to the advantages of the implementation of TQM, because the opinions of the questioned persons go mostly to the variant b – increasing the satisfaction of the customers (43%), then to the variant a – increasing the quality of the products (37%) and to the variant c – involvement of all the employees in achieving the goals (20%).

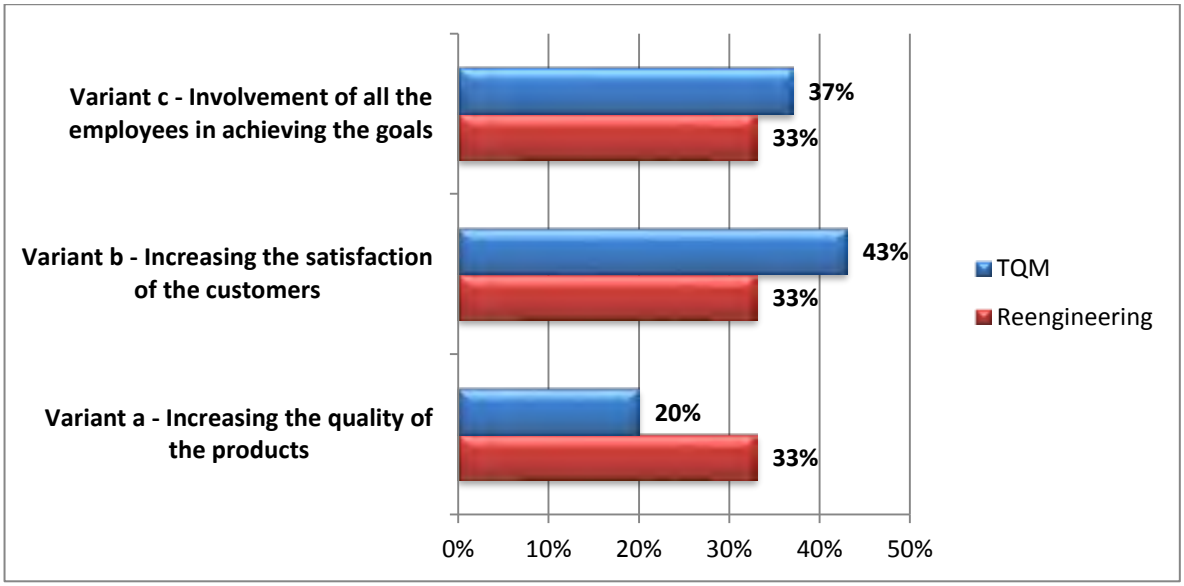


Figure 1.2.7. Potential advantages generated by the implementation of RE or TQM, respectively.

The dominant elements within the studied organizations have been identified using the instruments for organizational diagnosis. Thus, it has been observed that most of them have a culture oriented towards Power and Role, but elements of the culture oriented towards Achievement and Support have also been identified within the same organizations. Without trying to generalize to the whole Romania, we can say that the predominant culture is Power oriented, and the preferred culture is Support oriented, that is close to the TQM principles and related issues.

Regardless the dimensions of the change, we acknowledge the fact that people will find reasons to manifest their resistance to the change. This resistance will prevent reaching the organizational objectives (regardless the approach) if the change management employed is unappropriated. The managers must identify the appropriated changes that must take place in the organization by taking into account the main forces at individual or collective level that cause the resistance to the change.

The managers must act in such a way that the change produces benefits at individual and organizational level, opportunities for personal change and development, provides a new challenge, reduces the boredom of work, opportunity to participate and shape the outcome. In this respect, the managers must identify the organizational climate, must investigate if the premises for the implementation of the change towards TQM or Reengineering are known and created. The common premises of the two orientations have been identified, namely: “orientation towards the client”, “orientation towards the processes” and “the use of the trans-functional teams”, but we can state that in the organizations that have been studied there are mostly the premises of the orientation towards TQM.

1.2.2. TQM and Reengineering in the Personal Life Development

The Reengineering and continuous improvement are considered extreme approaches in the life of an organization. We underline both the major differences and the resemblances between them (fig.1.2.8). Moreover, in certain periods from the evolution of an organization these two approaches can succeed one to another or even complete each other (fig. 1.2.9).

The research consists in bringing the meaning of these two approaches into the personal life development. The orientation towards one of them depends on several individual characteristics. There were applied several tests that deal with personality, the "taste" for risk, self-fulfillment through career, adaptability to changes etc. These tests were implemented in a software system. The results pointed the correspondences between the life stage and the suited personal development model. The Reengineering and continuous improvement based on the quality standards ISO 9000 are considered extreme approaches in the "life" of an organization.

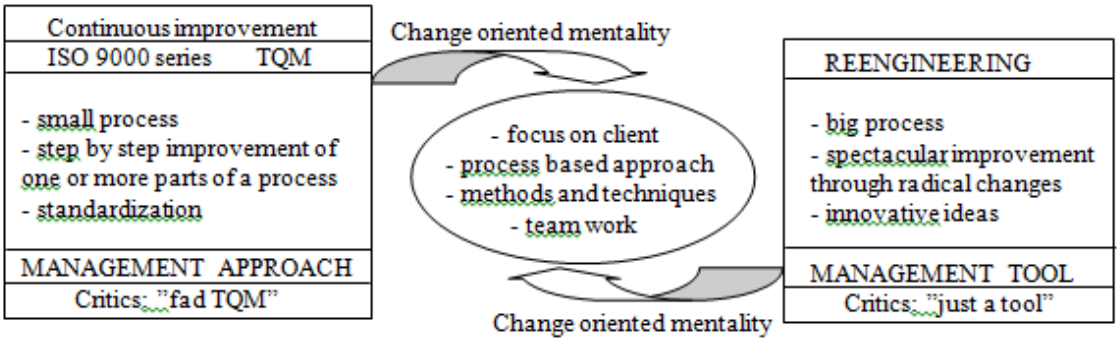


Figure 1.2.8. TQM and Reengineering overview

The orientation towards one of them depends on several individual characteristics, such as: age or stage in life, occupation, job position, personality, and attitude regarding change and so on. Both these approached need a proper culture determined by certain individual and collective mentalities. We focused on the person and how much he is willing to change in his personal life in order to achieve his targets.

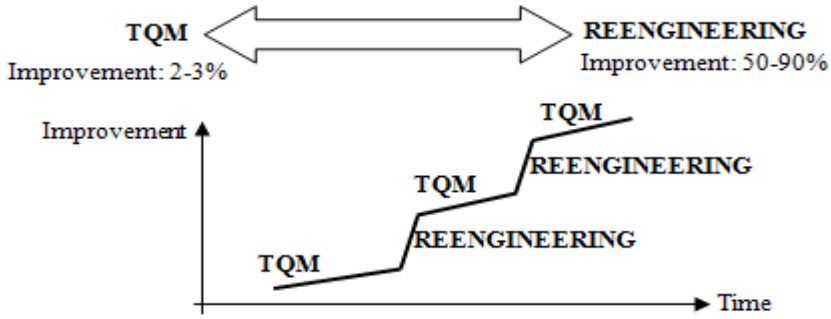


Figure 1.2.9. TQM and Reengineering interlacing for an organization

Change management in personal development through Reengineering or/and continuous improvement

The idea of self-renewal was studied by John Gardner in the 1960s pointing out that the self-development is determined by the inevitable changes that might occur. So, the renewal is a complex process and is not just innovation and change. John Gardner summarized this by: "In a

world of change, the versatile individual is a priceless asset". The personal self- development means passing from one state to another, from one period to another, from the status quo to a somehow better world searching for new ways of reaching personal and professional success. This energy of constant discovery feeds upon itself, yielding rewards that refuel the engines of new searches and new discoveries. In the context of change management we deal with both internal (self- imposed) and external (society imposed) changes. The changes are inevitable, but the most important is how the individual can adapt himself to the changing society developing and not surrendering to anything. This renewal in the personal change management context can be achieved step by step or it could be necessary a radical, fundamental change in a certain period of the individual development.

The devotees of a QMSP (Quality Management System in one's Personal life) adapted a series of quality concerning concepts from the existing standards and applied the Deming's PDCA (Plan-Do-Check-Act) cycle for continuous improvement in personal life. For example, there are considered the following similarities: organization and human being, product/service and achievement/success, quality oriented culture and integrity oriented lifestyle. We consider that the ISO 9001 could be the building foundation for designing, implementing, maintaining and developing a QMSP. In the same context the ISO 9004 could be the path to personal performance.

The design, implementation and maintenance of a QMSP are influenced by different individual needs, subjectivity, available tools and personal ambitions and targets.

Reengineering in personal life focuses on major changes done in certain life periods.

Studying the tendencies towards change, Daniel Levinson [13] identified regular cycles in personal life and defined sets of "eras" and "periods" as well as transitions within these sets. The transition periods are:

- Age 30 Transition: lasting from 28 to 33. This is a time for making changes that represent the basis for the rest of the life;
- Mid-Life Transition: lasting from 40 to 45: This is a time for reviewing and reevaluating the goals;
- Age 50 Transition: lasting from 50 to 55: This is a time for a late, maybe last, chance to achieve success and performance.

Each transition period represents a time for making changes that lead to a better life from the

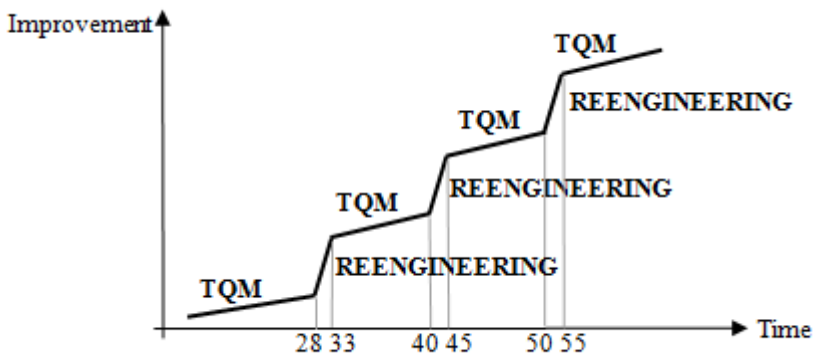


Figure 1.2.10. The transition periods for personal life

Our research started from the idea of these transition periods and tries to identify whether the tested individuals are ready to find resources and opportunities to radically change their lives. These transition periods represent life Reengineering. In figure 1.2.10. are represented the transition periods for personal life according to Daniel Levinson identified cycles.

In order to identify the areas of potential personal changes there was applied a questionnaire. The processed results will show the areas or fields that need changes either step by step or radical.

The main issue is how much an individual is ready to change in his life. The answer is not so simple and takes into account the personal characteristics. Even more, the answer may vary from one period of life to another for the same individual.

There were applied several tests that deal with own future foresight, capacity of decision, “taste” for risk, interpersonal competences, self-fulfillment through profession, leadership, adaptability to changes, profession choice, style of management, motivation for success, attitude towards progress and change.

These tests were implemented in a software system (fig. 1.2.11.) that translates the answers to the applied tests and based on these it decides the type of the further necessary tests to be applied. At the end, based on the tests results are identified the correlations between the individual’s characteristics and the suited personal development model.

Figure 1.2.11. Software “TQM versus Reengineering” in personal life

The tests were applied on a group of masters’ students from the University of Petrosani that study the subjects Reengineering and TQM. From all these masters’ students there were selected

as target for our study only those who are employed. These were the best subjects for our study because they have the knowledge about both the approaches and they find themselves in different stages of personal development, having different occupations and job positions. The potential change areas were classified using the following keys: from 1 (for areas needing step by step changes) to 10 (for areas needing radical changes). The results regarding the areas/fields of personal potential changes pointed out the following conclusions concerning the issue “I would like to be more”:

- The highest score was for the area “action oriented”, which means that 57.14% from the target group considered this area as the one needing major changes in their personal lives. From this part of the target group 42.6% has as common characteristic the age between 28 and 33 years.
- The lowest score was for the area “team oriented”, which means that 38.4% from the target group considered this area as the one needing least changes in their personal lives. This part of the target group has a heterogeneous age distribution.

In figure 1.2.12. is shown age and job position distribution among the target group.

From the applied tests there can be drawn many conclusions. For example, considering the part of the target group having management jobs, we find that 90% are expressive communicative managers and in the age period of 40-45 years 30% are continuous improvement oriented and 70% are reengineering oriented. In the age period of 46-49 years almost all are Reengineering oriented.

Other interesting conclusions are that:

- All the subjects below 28 years old, having execution jobs, are continuous improvement oriented, as expected. Among them the tests showed that 50% are undecided and 50% are potentially successful. All the subjects in the age period of 28-33 years, having all execution jobs, are Reengineering oriented;
- The subjects in the age period of 34-39 years, having all execution jobs, are 90% reengineering oriented;
- The subjects in the age period of 40-45 years, having execution jobs, are almost 50-50 oriented towards continuous improvement respective reengineering. The subjects in this age period having management jobs 30% are continuous improvement oriented and 70% are reengineering oriented;

All the subjects in the age period 46-49 years have management jobs and are mostly reengineering oriented.

From our study resulted that for execution jobs the Levinson model is left shifted by 6 years (reengineering oriented age interval resulted 34-39 years instead of 40-45 years) and for management jobs the Levinson model is right shifted by 6 years (reengineering oriented age interval resulted 46-49 years instead of 40-45 years).

It also resulted that the Levinson model applies un-shifted for the period 28-33 years, all being Reengineering oriented. As future research, the results obtained after translating the results of the test by the software system could be used for drawing a personal evolution graph for an individual evaluated at different life stages.

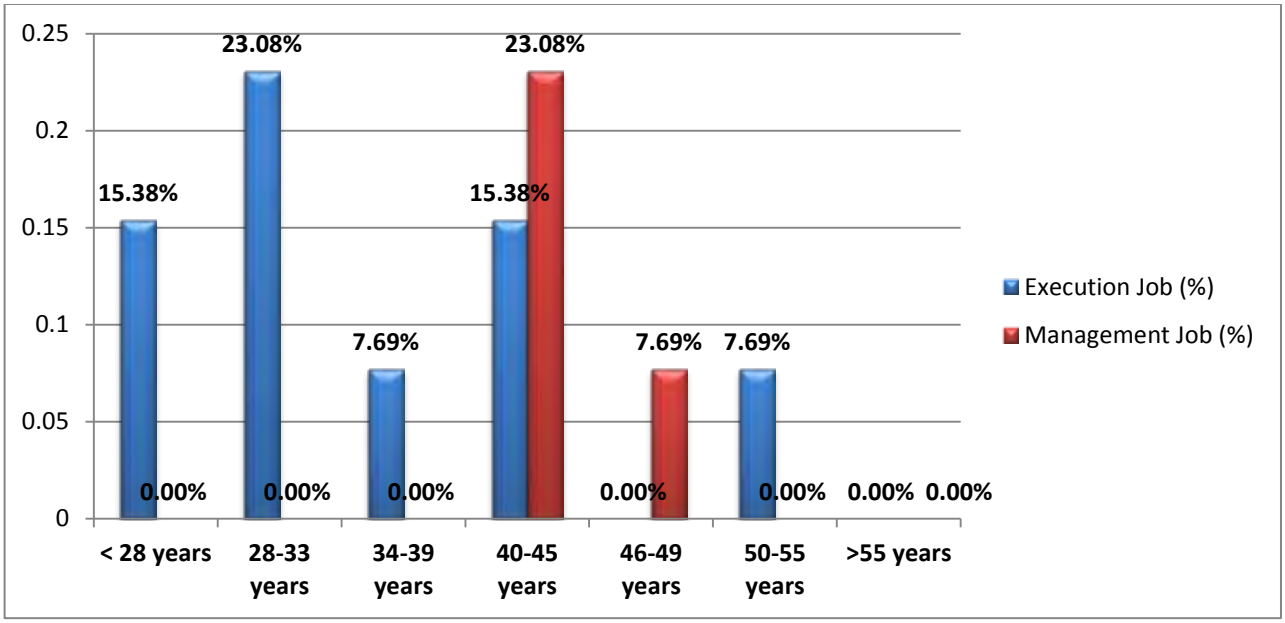


Figure 1.2.12. Age-job distribution

Conclusions and further enhancements

In this chapter were concentrated the research results regarding the analysis of QMS and QRM systems implementation possibilities in mining industry, the analysis of possibilities for human factor quality assessment based on a fuzzy logic model for the underground mining working system, the analysis of premises for the preconditions achievement in terms of managerial culture in the context of TQM approach. These researches were conducted as a follow up of the Ph.D. thesis research addressing specific aspects of QMS implementation in mining industry. Thus, the research was focused on the C-S (Customer-Supplier) relationship as a central element of the QMS. Exploring this relationship generated a number of interesting findings such as:

The comparative analyses of the NHCC perceptions and of the suppliers of mining equipment about C-S relation in the context of QMS implementation, allowed to identify the following aspects: (1) procedural component for evaluating and reporting the results regarding the functioning of the mining equipment is appreciated to be insufficient by the suppliers and low by the users/clients (2) it is an agreement of the two parts over the general characterization of C-S relation; (3) it is a disagreement regarding actual satisfying of the clients' requirements (the perception of the suppliers reflects the high-level of their own efforts of adapting to the user's requirements, meanwhile the latest distinguishes a low level of appliance in solving its own requirements by the suppliers).

The assessment of each element of the C-S relationship showed results that, correlated, generated further research. Thus, the major part of the nonconformities (50%) are reported by suppliers during the operational phase and reflected also at client level (NHCC) by "necessity of technological changes and improvements within mines" as a priority in the context of QMS, and as obstacle in QMS implementation resulted "deficiencies in using the production capacities at the technical projected parameters". Considering the C-S relationship as a partnership, I continued the research in order to analyze the causes which leaded to the deficiencies in optimal use of the production capacities and which are the repercussions in the underground mining work system.

Thus, a systematic analysis of the characteristics of accidents and possible deviations and errors at the level of each system component was carried out. These dysfunctions of the work system that may lead to labor accidents or occupational diseases are produced only under the condition that the risk factors for accidents and/or occupational diseases exist and are active.

The accidents classification according to their causes has revealed that a significant percentage of 89.58% are due to human factors, namely "the person who carries out the work". These results led us to design a model to quantify the actions of the human factor from the underground mining work system taking into account that the degree of risk associated to a human action is connected to a group of internal factors of risk which shall act through the human error and external risk factors related to technical equipment.

The evaluation of the human action performing in a work system, using fuzzy logic, generates interpretations concerning the quality improvement of the work process. The actions will concentrate, for example, on the organization at the work place (work groups dimensioned correctly, special intercession team), purchase of appropriate equipment, spare parts materials, necessity of collaboration regarding the improvement of the quality at the suppliers, staff-forming-training program. Besides assessing the human factor and framing their actions in a certain typology, the study provides a visual tool, represented by the fuzzy surfaces, useful to identify a critical moment based on the slope of the surface, which can lead to malfunctions in the work system.

In an attempt to make a new step towards integrated management systems I designed a digraph based model for evaluating the preconditions for TQM implementation from the HR point of view.

The methodology that determines the Process Management Index can be applied in reviewing a current situation, to identify current levels of organizational functioning and areas in need of change.The calculation of the index on the level of the organization provides a comparativ basis for future improvement. The calculation of the index on the level of functional areas provides a comparative basis between the accomplishment degree of functions (performances on the level of the functions). It is possible to establish the opportunities for improving the accomplishment level for each functional area, the detailed analysis being able to reach as far as to the level of individual performance (analyzing the accomplishment of the tasks in the job description). The interdependences among the influence factors (the determining of functional interfaces) are rigurously established through the correlation coefficients. The methodology can be used for improvement both on a formal level, (human resource systems, including job design and organizational structure and design), and on an informal level (a change in an organization's culture, in its norms, values, and belief systems about how organizations function, the managers' leadership philosophies and styles at all levels).

Applying the methodology of the digraph based model could be captured some coordinates regarding the life of the organization especially at the formal level, the informal level, strong connected to organization's culture, remains unexpressed. In this context, our researches turned to exploring the organizational culture change. The results of our research pointed out the existence of a Power/Role oriented culture and as preferred culture the Achievement/Support oriented one. That might be a “signal“, in the sense that the organization knows precisely the current situation and it is ready for change through Achievement and Support oriented culture, that are more close to the TQM principles and related issues.

I consider that it was a challenge to approach this research given the special conditions of mining industry. It would be of interest to apply the model based on digraph in the present

conditions, after the last years of major changes. Having a basis of comparison it might lead to an interpretation of developments at formal and informal organizational level.

Currently, NHCC is implementing the integrated quality-environment-occupational health and safety management system.

Even if there were not presented the results, the research on integrated management systems based on ERP, GIS and QMS have to be mentioned, to emphasize the idea of continuing this research towards integrated management systems. The research undertaken so far is the result of interdisciplinary team activities. I worked with specialists in applied computer science, setting the premises for designing and implementing of ERP, GIS and QMS integrated systems. Thus, there are established future research directions in e-Government services based on ERP, GIS and QMS.

I can say that the two formulations "TQM and Reengineering", "TQM vs. Reengineering", subject of recent research must be continued as an open research topic. In the context of QMSP (Quality Management System in one's Personal Life) we have designed a software tool "TQM versus Reengineering" for personal life that can be applied to a large number of respondents in order to obtain data as real as possible. In fact, this research is continued each year applied on students from the masters of Strategic Management of Business and Human Resource Management.

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2.

A NEW APPROACH ON QFD METHOD – METHODOLOGY AND APPLICATIONS

Introduction and Conceptual Background

The methods, techniques and tools of quality management aim solving problems related to quality in all phases of product or service development starting from concept - design going all through towards operational monitoring. Their use in solving these problems shows how to progress, step by step, from problem definition to implementation of actions taken to resolve it. Thus, the methodological tools of quality management are integrated in researches that address the relationship between project management and quality management [08_03_N], [05_12_M], using value analysis [05_11_N], quality audit [08_11_M], [07_02_M], [05_04_M], [05_14_M].

From the great diversity of quality management tools addressed over time, I chose to present my research findings on the use of Quality Function Deployment (QFD) model in the design of software tools for evaluation / self-assessment of quality.

I focused on developing a methodology to apply the Quality Function Deployment (QFD) method for software quality evaluation introducing a lifecycle model that includes in its representation the quality part. This new lifecycle has a 3D representation made out of multilevel circles spaced by an offset. The offset value is a comprehensive quantification of the accomplishment degree of the customers' requirements, based on a mathematical model.

In order to demonstrate the viability and applicability of the 3D Spiral Life Cycle Model Based on QFD Method and Spiral Life Cycle for Software Development, that is the subject of a registered patent (no. A 2012 00914 / 29.11.2012) [12_01_N] published by OSIM, I conducted research in the areas of software engineering [14_07_N], [12_04_N]; renewable energy systems [14_03_N], [13_14_N], services (in combination with SERVQUAL model) [12_02_N], new product development (NPD) [14_02_C]. This last area is the link to the development ot my fourth research direction, creativity and innovation in new product development.

The new perspective introduced by the patented model has been the subject of a plenary paper presentation by the title *QFD in Software Development: a New Perspective*, Plenary Lecture, Malta in 2012.

The project *Mobile Phone Software Development: Push Notification Framework* was the starting point for achieving this patent, a project within, as responsible for the software quality I achieved the QFD phase implementation in the software development stages.

The research focused on a new approach on the EFQM Excellence Model, by creating a mathematical model based on digraph [10_05_M] and the design of a software tool for quality self-assessment [14_06_N], [10_12_N]. The present version of the software tool based on the EFQM model is 1.1 and is integrated in the project *Information system as educational support for training in audit quality field*.

The excellence model is part of the methodological tools that indicate the status, together with the evolution, progress and performance in the framework of organizations approach towards Total Quality Management (TQM). Thus, it is created the link to the first direction of research regarding mainstreaming in quality management.

The research results from this direction were presented in the plenary of the international multiconference in Valencia in 2013, as subject of the paper *Quality Management Tools Embedded Software Development Lifecycle*.

Among the quality management tools, Quality Function Deployment (QFD) is the method that transforms the user requirements into design quality, the method that translates the client's "voice" into engineering characteristics. This is the result of combining Akao's work [2], [3] in quality assurance and quality control points with function deployment from value engineering. The main goals in implementing QFD method are: discover the spoken or unspoken users' needs, translate these needs into quality characteristics, built and deliver quality products and services by focusing on customer satisfaction.

The goal of my research was to adapt QFD for software evaluation, based on an easy to use methodology.

Regarding the existing software products that implement the QFD method, Lai-Kow Chan and Ming-Lu Wu [9] and Georg Herzwurm et.al [18], [19], [20] performed a thorough and comprehensive analysis.

From their work I can conclude that the software products implementing QFD method field is very dynamic and the majority of these products are for the purpose of general use of the QFD method. We believe that a possible enhancement, welcomed by the practitioners, would be the customization of these software products for a specific field of application.

This type of application field customized QFD software could implement the entire specific characteristics, leading to a software product easy to understand and apply by the field specialists.

Taking into account the works studied in QFD [39], [48] I strongly believe that there are no fields in which the QFD method was not applied, tried to be applied or impossible to be applied and "essentially, there is no definite boundary for QFD's potential fields of applications". [9]

Quality function deployment (QFD) is "an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production (i.e., marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, sales)" (Sullivan, 1986) [42]

In particular, QFD has been applied to expert systems for quality management (Bird, 1992), process improvement (Hybert, 1996; Richardson, 2001), quality control (Acord, 1996; Prasad, 1997), quality information systems (Chang, 1989; Lin and Fite, 1995), quality systems (Kanji, 1998), service improvement (Barnes and Vidgen, 2001; Chin et al., 2001), service quality management systems (Chang and Lin, 1991), and software process improvement (Herzwurm et al., 2000). Quality management and product development are achieved in QFD through customer needs analysis that, in fact, is always the very first step of a QFD process and is thus an important functional field of QFD.

QFDs early applications focused on such industries as automobiles, electronics, and software. In time, the development of QFD has led to applications in many manufacturing industries and also in the service sector, in education and in research. It is clear that QFD has been or could be applied in almost any field. In the context of our researches, we point out the use of QFD is software systems and other related QFD application areas, including decision support systems (Sarkis and Liles, 1995), expert systems (Ngai and Chow, 1999), human–machine interface

(Nibbelke et al., 2001), information systems (Chang and Lin, 1991), integrated systems (Wasserman et al., 1989), management information systems (Eyob, 1998), profiling systems (LaSala, 1994), and Web pages (Tan et al., 1998).

Related works include computational support tools for QFD in a graph-based modeling environment (Reich, 1996), computerized QFD system (Trappey et al., 1996), expert system for constructing/classifying/managing house of quality charts in QFD (Kim et al., 1998), expert system based extension to fuzzy QFD (Verma et al., 1998), fuzzy expert system with spreadsheet to QFD (Lopez-Gonzalez, 2001), fuzzy information system for QFD (Harding et al., 2001), fuzzy logic based intelligent tool for QFD (Liu et al., 1998), group DSS for applying QFD (Wolfe, 1994), group support systems for improving QFD process (Balthazar and Gargeya, 1995).

There are reported applications of the QFD method in many service areas, such as accounting by Booth, in 1995, administration by Hofmeister in 1992, banking by Ko and Lee in 2000; contracting process by Hybert in 1996, engineering services by Pun in 2000, food distribution by Samuel and Hines in 1999, government services by Lewis and Hartley in 2001, hotels by Dube in 1999, on-line bookshops by Barnes and Vidgen in 2001, mortgage by McLaurin and Bell in 1993, professional services by Adiano in 1998, public sectors by Curry in 1999 and Hallberg in 1999, real estate appraisal by Ferrell and Ferrell in 1994, retail by Nagendra and Osborne in 2000, technical library and information services by Chin in 2001, wholesale by Keenan in 1996 and, in particular, healthcare by Chaplin and Terninko in 2000; Einspruch in 1996; Hallberg in 1999; Lim and Tang in 2000; Matsuda in 2000 (Chan, et.al., 2002). [27]

There is a great amount of QFD resources available. Part of the QFD softwares were developed to help the QFD use in various applications, such as software evaluation (by Fawsy Bendeck of Universitat Kaiserslautern, Germany: http://www.agr.informatik.uni-kl.de/ bendeck/qfd/index.html), QFD Designer (by Qualisoft/ Fulfillment Services, USA: http://www.qualisoft.com), QFD Scope (by Integrated Quality Dynamics, US: http://www.iqd.com), QFD/CAPTURE (by International TechneGroup, US: http://qfdcapture.com), QFD2000 (by Total Quality Software, UK: http://www.qfd2000.co.uk), Qualica QFD (by Qualica Software, Germany: http://www.qualica.de), and VOCALYST (by Applied Marketing Science, US: http://www.ams-inc.com) (Chan, et.al., 2002). Herzwurm have performed a thorough analysis and evaluation of the QFD software tools.

2.1. The 3D Spiral Life Cycle Model Based on QFD Method and Spiral Life Cycle for Software Development

Software engineering involves the use of management methods in software product development. Over time there were developed many types of software life cycles for guiding the application development process. All of these life cycles include design and development phases and also phases of verification-testing-maintenance. This means that the software quality check is made in the latter part of the life cycle, when any nonconformity, defect means fully resumption of earlier phases of the life cycle. My contribution in this area is the implementation of quality management tools and techniques throughout the entire life cycle, providing early identification and correction of potential nonconformities and saving resources.

Thus, I proposed a 3D spiral model for software development life cycle based on QFD.

The life cycle model includes in its representation the quality part, quantified through the evaluation of users' requirements accomplishment. In the original spiral model the quality evaluation is an activity included in each development phase. In order to represent explicitly the quality, we included a third dimension to the original model, inspired from the conceptual model of continuous improvement of the Juran's quality spiral representation. This third dimension represents the step to a new phase in the software development, a visual representation of the quantified quality by an index called offset.

Therefore, it was achieved a three-dimensional life cycle model that is made out of multilevel plane circles spaced by the offset. Each plane circle represents a software development phase and has its own radius representing the development costs of the phase.

The offset is calculated using the quality function deployment (QFD) method that is embedded in all the activities of each phase. (fig.2.1.1.)

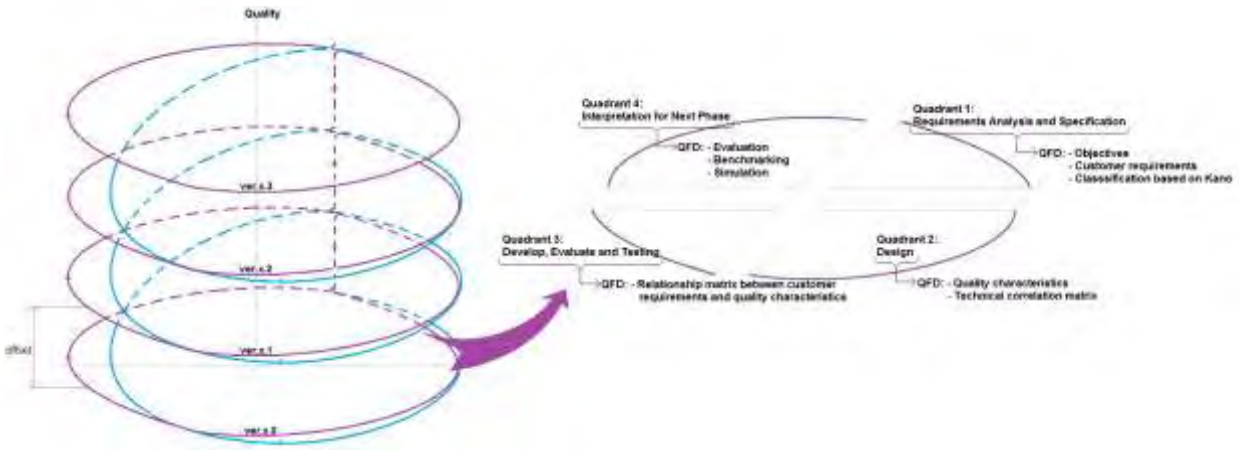


Figure 2.1.1 New 3D spiral model

In order to determine the offset, a mathematical model was developed and implemented in a software application. The variables and their signification are presented below:

n = number of customer requirements

m = number of quality characteristics

c_1 = value for Mandatory requirement; c_2 = value for Desirable requirement; c_3 = value for Optional requirement; c_4 = value for future Enhancement requirement

$CR(i)_{i=\overline{1,n}}$ = customer requirements classified according to Kano model: $CR(i) \in \{c_1, c_2, c_3, c_4\}$

$QC(j)_{j=\overline{1,m}}$ = quality characteristics distribution functions according to the difficulty level

cor_1 = value for strong positive correlation; cor_2 = value for strong correlation; cor_3 = value for neutral correlation; cor_4 = value for strong negative correlation; cor_5 = value for negative correlation;

$TQC(i,j)_{i,j=\overline{1,m}}$ = correlation matrix of quality characteristic i by the quality characteristic j: $TQC(i,j) \in \{cor_1, cor_2, cor_3, cor_4, cor_5\}$

$ICQ(i,j)_{i=\overline{1,n},\, j=\overline{1,m}}$ = influences matrix or how much of the customer requirement i is assigned to the quality characteristic j: $ICQ(i,j) \in [0,1]$

$AQ(j)_{j=\overline{1,m}}$ = achievement matrix of the quality characteristics: $AQ(j) \in [0,1]$

$RCQ(i,j)_{i=\overline{1,n},\, j=\overline{1,m}}$ = relationship matrix or how much of the customer requirement i is achieved by the quality characteristic j: $RCQ(i,j) \in [0,1]$

offset = the degree of customer requirements achievement by the quality characteristics

The first quadrant in the Boehm's spiral life cycle model regards the objectives, alternatives and constraints [20]. In ther 3D spiral model from fig.2.1.1., the first quadrant contains the following requirements analysis and specification activities from the QFD method: objectives definition, customer requirements (CR) capture and CR classification based on Kano model.

The activities of the first quadrant are all related to customer requirements capture and classification, and form an essential phase in the software development process [130]. If the customer requirements are rigorously captured and classified then the next phases are correctly developed.

In this regard, for our test applications of the 3D spiral life cycle, I have used the interview and questionnaire techniques, taking into account the model of "Summary of structured customer requirements" [18], [19], [20]. Also, I have based the classification of the requirements on the Kano model, adapted for software products. We have considered four priorities related ranking levels: mandatory, desirable, optional and future enhancement. Results the CR_n matrix.

The second quadrant in the Boehm's spiral life cycle model contains the evaluation of alternatives and identification of risks [7]. The second quadrant from our model (fig.2.1.1) is dedicated to the design phase and contains the following activities from the QFD method: quality characteristics (QC), also called technical characteristics, identification and technical correlations matrix establishment.

For each quality characteristic we have defined a level of achievement difficulty, ranked from hard, medium to easy, and an improvement direction that could be "maximize", "minimize" or "maintain".

Usually, in the system evaluation the level of achievement difficulty of the quality characteristics is not taken into account. In our model, we have considered different distribution functions for each difficulty level, like quadratic functions for hard and easy levels and linear function for medium level. According to the software features being evaluated the best suited distribution functions for the difficulty levels can be chosen. If the difficulty levels are not considered relevant, the distribution functions will all be linear. Results the QC_m matrix.

The technical correlations matrix is valuable in the context of software product evaluation providing a means to both estimate the influences and integrate the interdependencies between the quality characteristics. For the software products there are cases of non bi-univocal dependencies between the quality characteristics. So, the technical correlation matrix can be either symmetrical, in the case of bi-univocal dependencies, or asymmetrical, in the case of non bi-univocal dependencies.

The model will deal with five types of dependencies: strong negative, negative, neutral, positive and strong positive. These dependencies are introduced in the mathematical model as rated values reported to a maximum estimated possible influence. Results the $TQC_{m \times m}$ matrix.

The third quadrant from Boehm's spiral is related to development and evaluation activities [7]. The third quadrant from the 3D spiral (figure 2.1.1) is also related to the development, evaluation and testing activities. From the QFD model the third quadrant contains the activities involved in establishing the relationship matrix between the CRs and QCs.

During the development of the software product all the customer requirements are assigned to one or more quality characteristics. These assigned percentages are all quantifiable, because the quality characteristics are identified starting from the users' requirements in such a way that the result is a functional software product that satisfies the users' needs. Results the $ICQ_{n \times m}$ matrix.

During the evaluation and testing activities the accomplishment degree of each quality characteristic, using known testing tools is being determined. Results the AQ_m matrix.

The CRs and QCs relationship matrix contains the products between the accomplishment degree of QCs and the assigned percentages of CRs. Results the $RCQ_{n \times m}$ matrix.

The fourth quadrant from Boehm's spiral represents the planning for the next phase [7]. The fourth quadrant from the 3D spiral (fig.2.1.1) contains the following activities from the QFD method: evaluation, benchmarking and simulation.

The evaluation is achieved by computing the offset using the relation:

$$offset = \sum_{j=1}^{m} \sum_{i=1}^{n} \frac{RCQ(i,j) \cdot CR(i)}{\sum_{i=1}^{n} CR(i)} \qquad (2.1.)$$

Where:

$$RCQ(i,j) = ICQ(i,j) \cdot \frac{QC(j) \cdot \left[AQ(j) + \sum_{i=1}^{n} TQC(i,j) \cdot AQ(j) \right]}{1 + \sum_{i=1}^{n} TQC(i,j)} \qquad (2.2.)$$

The offset value is a comprehensive quantification by the resulted software product of the accomplishment degree of the customers' requirements. The offset could be a comparison basis for different software products also useful in the benchmarking analysis. The simulation provides the inputs for the next phase, which represents in our model the transition to a new subversion (a new plane in the 3D spiral). The simulation could also be considered a means to perform a risk analysis as part of Boehm's spiral.

The main contribution of our research is the 3D spiral lifecycle model and methodology. From the development and application of this model steams the other contributions that will be highlighted below.

Besides the methodological aspects of the model, previously presented, this model offers a suggestive 3D visual representation of the current stage of the software development process. For the 3D visualisation there are equipment available that are nowadays of common use.

Moreover, the 3D representation is also useful for the graphical representation of the software development process efficiency, because the radius of each plane circle represents the costs of

each phase activities. So, if the representation is in the form of an inverted cone (fig.2.1.2.a) the process has increasing improvement costs and decreasing efficiency.

An acceptable and desirable version would be a spiral form that can be inscribed in a cone (fig.2.1.2.b), which means that the process has decreasing improvement costs and increasing efficiency. Such a form is a representation of the continuous improvement principle, synthetically containing the idea that generated our research.

We'll consider an intermediary version of the 3D spiral to be the one having the approximated form of a cylinder (fig.2.1.2.c). This is the version obtained should we not take into account the development costs.

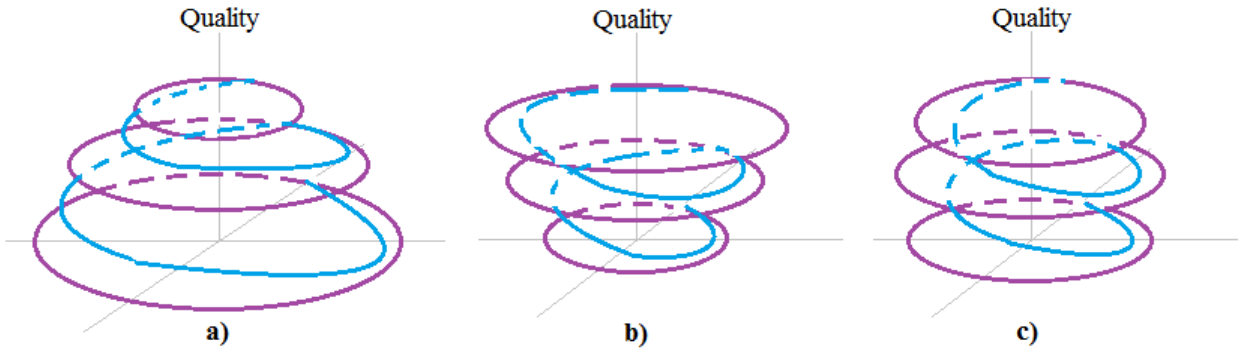


Fig.2.1.2. 3D spiral lifecycle forms: a) increasing costs; b) decreasing costs; c) constant costs

Another visual estimation offered by the 3D representation of the software life cycle is "how much" the software product satisfies the customers' requirements after n phases of development. This is measured by a mean that we called offset. There are two types of offsets, an absolute and a relative one. The relative offset is a measure of the improvements resulted from the current phase's activities and represents the distance between two consecutive phases, in our model represented by two consecutive planes. The absolute offset is a measure of the cumulative step by step improvements and is, in fact, the 3D spiral's height. The existence of a pre-set or an objective offset leads to the identification of the right moment for the release of the current version software product. The opportunity to produce a new version after the release of the current one can be analysed, according to past experiences and new requirements. When starting a new version two ways can be followed: one consists in starting the new version as a completely new software product employing a new spiral model (the case of major changes in the requirements of the new versions) while the other consists in continuing the spiral by translating the xOy plane along the z axis till it reaches the starting point of the new version (the case of maintaining a global view of the developed software product throughout all the versions).

The value of the offset is computed according to the developed mathematical model based on the general principles of the QFD method and its particularities in software product application.

Thus, the inputs of the mathematical model in order to determine the offset are: n, m, CR_n, QC_m, $TQC_{m \times m}$, $ICQ_{n \times m}$ and AQ_m.

All these generate the relationship matrix $RCQ_{n \times m}$ as a state and the offset as output.

Compared with other approaches, this mathematical model contains the following:

- The use of different distribution functions for the characterisation of the different difficulty degrees of the quality characteristics;
- The generalisation of the correlation matrix with the asymmetrical form due to the different dependencies between the quality characteristics;
- The measurement of the achievement level of each quality characteristic;
- The use of the influence matrix between the customers' requirements and the quality characteristics. The influence matrix together with the achievement matrix determines the relationship matrix. Thus, the relationship matrix contains exact values resulted from measurements instead of generally used estimations {0, 1, 3, 9}.

Now, I present some key elements that prove the applicability of the 3D spiral model.

2.2. Life cycle model application in M.O.V.E. software development

I choose to present the ground up development of a software product. The idea behind this software product was a new type of human machine interface. For this reason, I have started from the users' requirements capture, by using the interview and questionnaire techniques applied to graduate students. The results of the interviews and questionnaires showed that the users expect an online virtual environment that allows them to interact with 3D objects by gestures. These led us to the name M.O.V.E. (My Online Virtual Environment) for this new application.

The interviews and questionnaires also generated the customers' requirements matrix CR_n consisting of all the identified requirements grouped in priority classes (fig.2.2.1.b). The design team established the main quality characteristics (fig.2.2.1.c) of the system that meet the users' expectations.

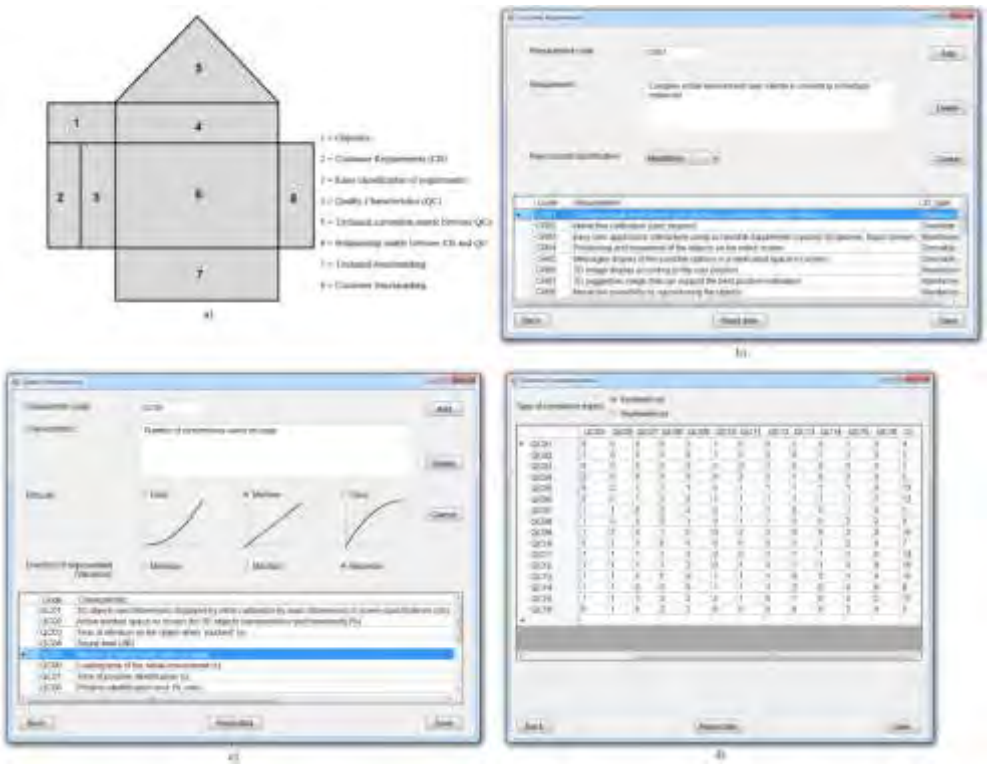


Fig.2.2.1. QDF software tool: a) QFD method; b) CR; c) QC; d) Correlation matrix

As a result the quality characteristics matrix QC_m created also contains the achievement difficulty level for each characteristic. These characteristics were assigned to routines. Each routine has well defined purpose, inputs and outputs. The “routines map” is useful in generating the influences matrix $ICQ_{n \times m}$ (fig.2.2.2.b), that contains the way of distributing the users’ requirements on quality characteristics, and the correlation matrix $TQC_{m \times m}$ (fig.2.2.2.d), that contains the interdependencies between the characteristics. The coding team implemented the routines and the testing team applied different methods of evaluation and validation of the routines, prompting the achievement level of each characteristic and thus the achievement matrix AQ_m (fig.2.2.2.a). The achievement matrix and the influences matrix determine the relationship matrix $RCQ_{n \times m}$. This matrix shows the accomplishment level of the users’ requirements by the implemented quality characteristics. Based on all these matrices we can compute the offset (fig.2.2.2.c).

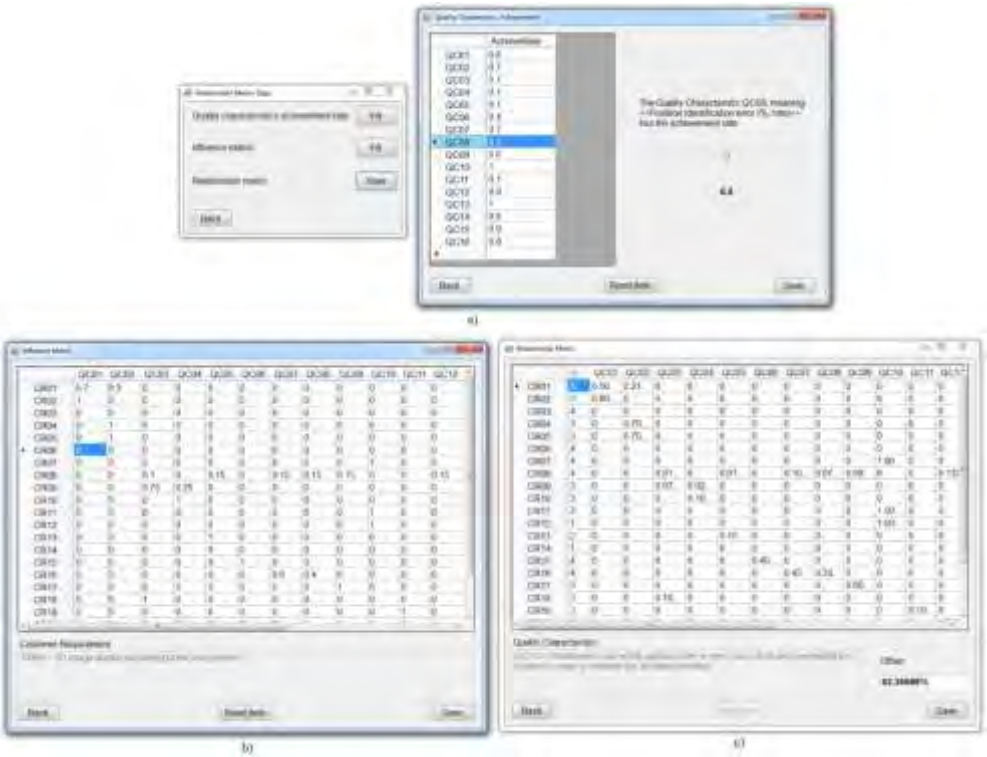


Fig.2.2.2 QFD software tool: a) QC achievement matrix; b) Influence matrix; c) Relationship matrix and resulting offset

The offset is a measure of customers’ satisfaction level regarding the software product. The offset only by its value is not very useful, but becomes important in the following contexts:

- If a pre-set target value was set, representing the acceptability threshold of the software product, then the computed absolute offset will be compared with the target value in order to decide whether to release the product or to go on to the next phase;
- If a multiple development phase product is analysed then several relative offsets are computed in order to evaluate the results of the continuous improvements achieved.

Using this method for software products development evaluation, could be a reference database containing acceptability offset values for different categories of software applications.

2.3. Life cycle model application in renewable energy systems field

The results obtained from applying the methodology developed for 3D spiral software lifecycle based on QFD confirmed the viability of the model. So I adapted the methodology for other types of products and services.

An original approach resulted from the above methodology consists in the development of a QFD based Expert System (ES) for Renewable Energy Systems. An expert system can be assimilated as a computer simulation of a human expert. In our research, the expert system rules have been designed to capture the knowledge of the experts and the data of customer requirements. After that the system is able to process these data in order to fill in the QFD specific matrixes. The QFD method provides the tools to evaluate by an overall index the correlation between the customer requirements and the quality characteristics of the available wind turbines. It will produce the best fitted three options and a benchmarking instrument to compare between these and decide the chosen one.

The approach consists in the following issues. First, there is defined a database of existing wind turbine characteristics. Then, there are established the QFD matrix patterns. For the customer requirements matrix (CR) all the requirements are captured using a predefined form together with the importance for the customer. For this wind turbine expert system case study, we have considered four main customer requirements, as follows:

CR1: the estimated installed power, which is an estimation of the maximum required energy for the customer selected spot;

CR2: the available budget, which is the maximum investment that the customer can afford;

CR3: the distance from the inhabited area, which reflect in the possible height and diameter of the wind turbine;

CR4: the geographical location, which is closed related to the annual rated wind speed available from wind maps. An example of the Europe macro wind map is presented in Fig. 2.3.1.

For the quality characteristics matrix (QC) there are used if...then...else rules in order to select from the database the corresponding characteristics, based on the algorithm from Fig. Figure 2.3.2. The QC matrix gets the data from the database containing real wind turbine characteristics, like: QC1: rated power; QC2: cut-in wind speed; QC3: cut-out wind speed; QC4: diameter; QC5: height; QC6: price.

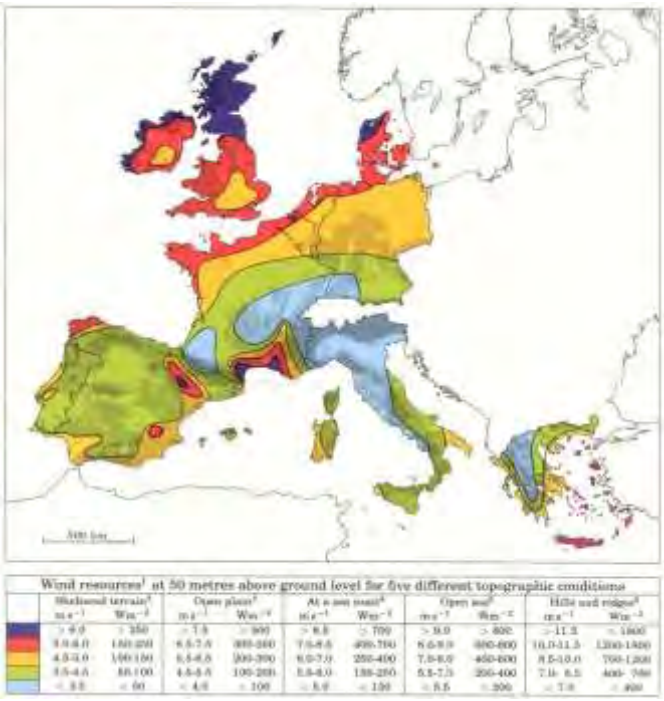


Figure 2.3.1. Europe wind map (http://www.windatlas.dk/europe/landmap.html)

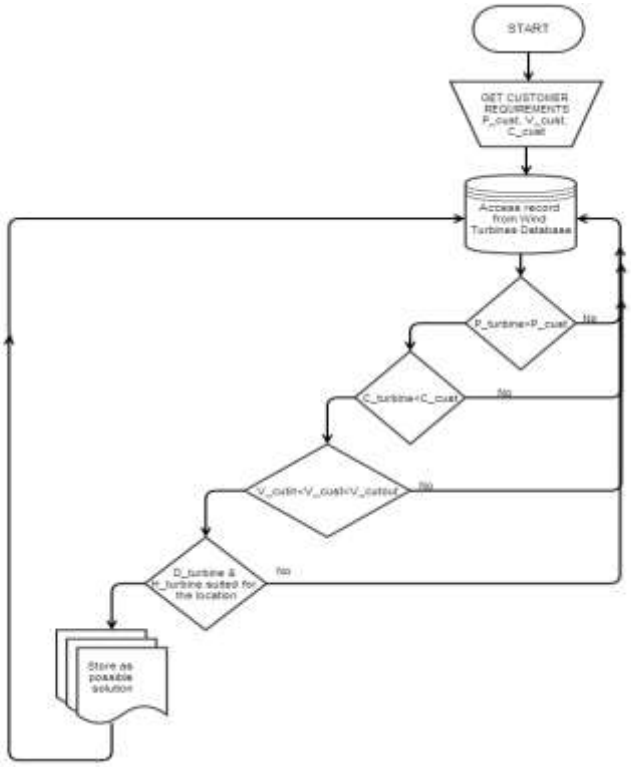


Figure 2.3.2. if…then…else rules algorithm

For each QC matrix there is a predefined correlations matrix (TQC) that is based on the wind turbine characteristics, like rated power versus wind speed, rated power versus height and

diameter and price versus power. In Figure 2.3.3 is presented an example of rated power versus rated wind speed characteristic. The power increases as the square of the rotor diameter and more significantly as the cube of the wind speed (Ragheb, 2011; Ragheb and Ragheb, 2011). In Figure 2.3.4 is presented the maximum power as a function of the rotor diameter and the wind speed.

For the relationships matrix $RCQ_{n \times m}$ (RM), the central part of the house of quality (HoQ), having the matrixes CR and QC it can be computed the overall index, called offset, based on a mathematical model.

All the obtained offsets are classified in order to provide the best fitted three offsets and the corresponding wind turbines. The customer can choose from these three identified wind turbines the best suited one, using a benchmarking tool for comparing the three solutions.

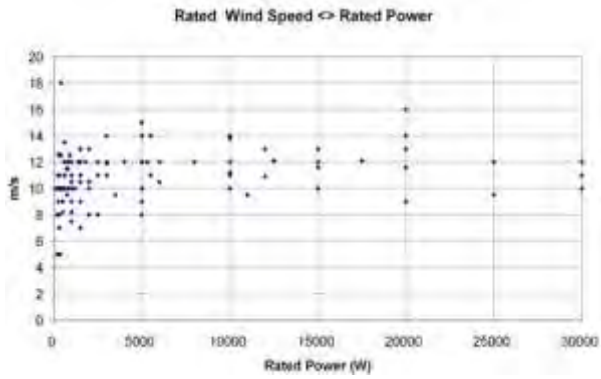


Figure 2.3.3. Rated power versus rated wind speed characteristic

(http://www.wind-energy-the-facts.org/en/part-i-technology/

chapter-6-small-wind-turbines/technology-status.html)

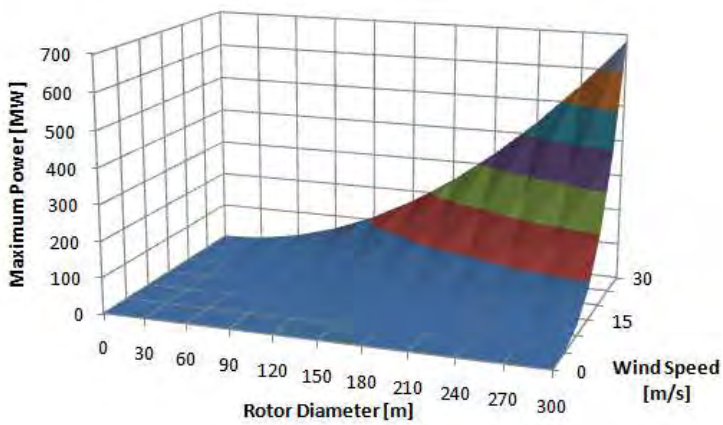


Figure 2.3.4. Maximum power as a function of the rotor diameter and the wind speed

(http://www.intechopen.com/books/fundamental-and-advanced-topics-in-wind-power

/wind-turbines-theory-the-betz-equation-and-optimal-rotor-tip-speed-ratio)

QFD based expert system is designed to provide a useful evaluation tool in order to overcome one of the specific problems of the expert systems, namely to find a solution that best meets the customer requirements. We chose to prove the viability of our approach on an interesting case study that is the choice of a wind turbine according to some simple not technical customer requirements. We think that this is an interesting case study because nowadays we are witnessing to the worldwide trend towards renewable energy systems. Our expert system can be used by any user that wants to find a wind turbine suited for small and medium usage (Fig. 2.3.5).

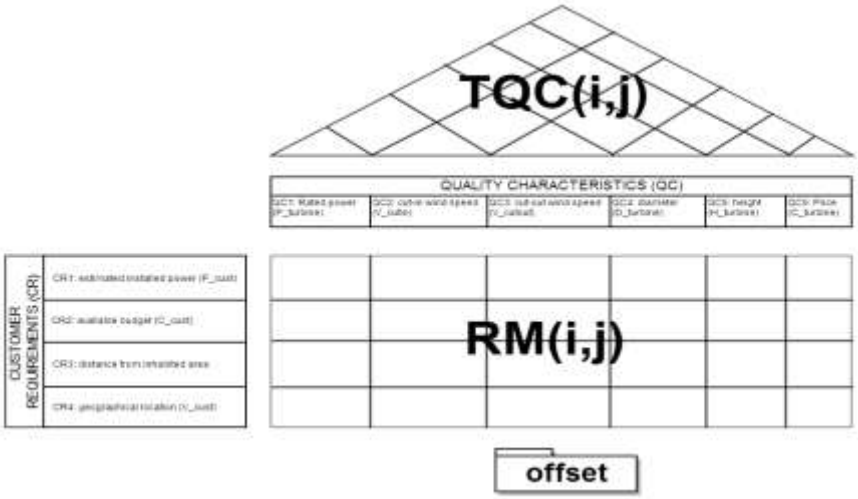


Figure 2.3.5. QFD method applied for wind turbine evaluation

I have proposed a pattern of four customer requirements chosen from the most common needs of small-medium applications, but it can be customized to any number and form of customer requirements. Also, the database containing wind turbine characteristics and types is continuously updatable by adding new wind turbines that are produced or relevant technical characteristics and by deleting the ones that are out of the market.

Our solution combines the advantages offered both by ES and QFD method. From the ES it gets the knowledge database and the simple if...then...else reasoning rules. From the QFD method is gets the possibility to evaluate the degree of customer requirements satisfaction by the technical quality characteristics of the product and also an easy to use benchmarking tool.

The novelty of our QFD based ES consists in the implementation of an algorithm that combines the ES specific logics with a mathematical model that computes an offset representing the evaluation of how much the turbine characteristics meets the requirements, very important in making the best choice.

2.4. Life cycle model application in services

For the field of services I developed a new model, called Service Quality (SQ), which combines QFD and SERVQUAL methods. This model takes from the SERVQUAL method the five dimensions of requirements and three of characteristics and from the QFD method the application methodology. The originality of the SQ model consists in computing a global index that reflects the

customers' requirements accomplishment level by the quality characteristics. In order to prove the viability of the SQ model, there was developed a software tool that was applied for the evaluation of a health care services provider.

Combining the SERVQUAL and QFD methods, the customers' requirements were grouped in five classes as follows:

Table 2.1. Customers' requirements grouped in classes

SERVQUAL class	**Code**	**Requirement**
Reliability	CR1	Easily solve the requests
	CR2	Prepare recipes in own laboratory
Responsiveness	CR3	Treated with professionalism
Assurance	CR4	Get clear and precise information
	CR5	Friendly environment
Empathy	CR6	Treated with kindness and compassion
Tangibles	CR7	Free additional services

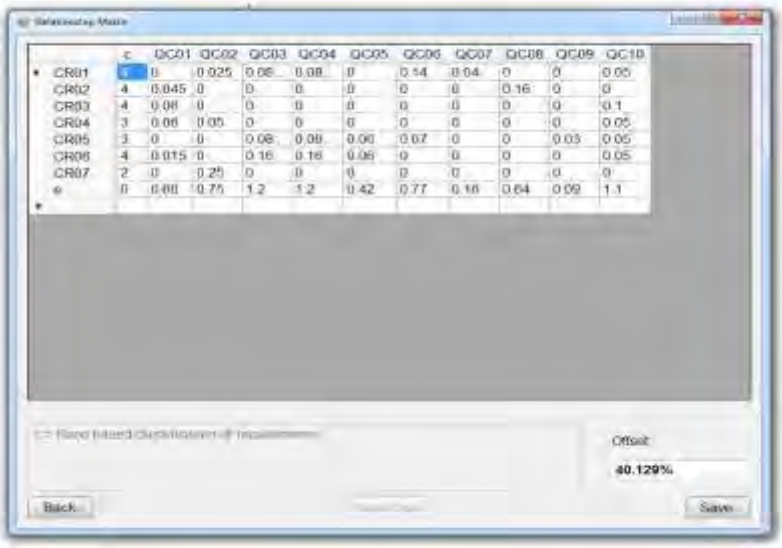
The quality characteristics were also grouped in classes as follows:

Table 2.2. Quality characteristics grouped in classes

SERVQUAL class	**Code**	**Characteristic**
Process	QC1	Waiting time in the queue
	QC2	Free blood sugar measurement
	QC3	Free HTA measurement
	QC4	Free cholesterol measurement
	QC5	Free body weight measurement
People	QC6	Explain understandable to the client
	QC7	Personnel with communication abilities
	QC8	Kind reception
	QC9	Well trained personnel
Physical environment	QC10	Pleasant environment

In order to apply the model resulted from the combination of QFD and SERVQUAL we designed and developed a software application that computes the global index that reflects the customers' requirements accomplishment level (fig. 2.4.1). In figure 2.4.2 is presented the global index resulted after improvements on the QC2 characteristic, by including the supplementary services of free blood sugar measurements for more clients. In order to increase the customers' requirements accomplishment level, we focused on introducing new or improved free supplementary services.

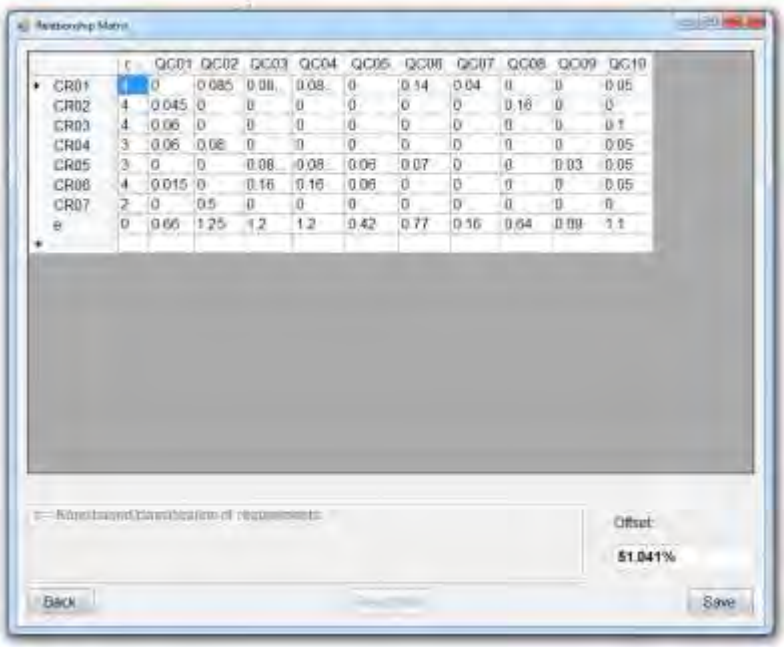
Initially, the only free service offered by the pharmacy was blood sugar measurements only as occasional offer once a month for 50 clients. In figure 2.4.1. is shown the case of this free service improvement, by offering blood sugar measurements one a week for 25 clients. As can be seen the global index increased from 40.129% to 51.041%.



	c	QC01	QC02	QC03	QC04	QC05	QC06	QC07	QC08	QC09	QC10
CR01	4	0	0.025	0.08	0.08	0	0.14	0.04	0	0	0.05
CR02	4	0.045	0	0	0	0	0	0	0.16	0	0
CR03	4	0.06	0	0	0	0	0	0	0	0	0.1
CR04	3	0.06	0.05	0	0	0	0	0	0	0	0.05
CR05	3	0	0	0.08	0.08	0.06	0.07	0	0	0.03	0.05
CR06	4	0.015	0	0.16	0.16	0.06	0	0	0	0	0.05
CR07	2	0	0.25	0	0	0	0	0	0	0	0
e	0	0.66	0.75	1.2	1.2	0.42	0.77	0.16	0.64	0.09	1.1

Offset
40.129%
Back
Save

Figure 2.4.1. Global index



	c	QC01	QC02	QC03	QC04	QC05	QC06	QC07	QC08	QC09	QC10
CR01	4	0	0.085	0.08	0.08	0	0.14	0.04	0	0	0.05
CR02	4	0.045	0	0	0	0	0	0	0.16	0	0
CR03	4	0.06	0	0	0	0	0	0	0	0	0.1
CR04	3	0.06	0.08	0	0	0	0	0	0	0	0.05
CR05	3	0	0	0.08	0.08	0.06	0.07	0	0	0.03	0.05
CR06	4	0.015	0	0.16	0.16	0.06	0	0	0	0	0.05
CR07	2	0	0.5	0	0	0	0	0	0	0	0
e	0	0.66	1.25	1.2	1.2	0.42	0.77	0.16	0.64	0.09	1.1

Offset
51.041%
Back
Save

Figure 2.4.2. Global index after QC2 improvement

There can be established a satisfaction grill based on the correlation between the general information resulted from the first phase of questionnaires and the computed index values. The proposed grill is presented in table 2.3.

Table 2.3. Satisfaction grill

Satisfaction level	**Index value**
Completely unsatisfied	0 – 20 %
Unsatisfied	20 – 40 %
Satisfied	40 – 60 %
Very satisfied	60 – 80 %
Completely satisfied	80 – 100 %

2.5. Life cycle model application in EFQM based self-assessment software development

I achieved using the patented model the link between the QFD Method and the EFQM Excellence Model, as quality management tools.

The researches present the use of the 3D Spiral Lifecycle Model applied on the EFQM based self-assessment software. This software introduces a graph representation of the EFQM elements, taking into account the relationships between components. This way there can be applied the graph specific algorithms. There are discussed two approaches for the graph processing algorithms. The first approach, implemented in the version 1.0, consists of the use of matrix permanent for determining a value representing the current global state of the system. The second approach, implemented in the version 1.1, involves introducing a mathematical model for determining a quality index, which specifically include the current state of the system. The development of the software product from version 1.0 to version 1.1 is presented and analyzed based on the values of a global index, called offset. This offset is provided by the model, having the role of highlighting the current state and the evolution of software product from one version to another, based on the degree of achievement of the customer requirements or of the problem to be solved.

EFQM (*European Foundation for Quality Management*) Excellence Model is a well-known model that was implemented in several software instruments used with success in business self-assessment for quality oriented organizations. The improvements of the EFQM model have mirrored in updates of the associated software instruments. Ever since the introduction of the EFQM model, it was subject to continuous improvements and updates in the context of new quality oriented business models.

The EFQM model is characterized by nine criteria, classified in Enablers and Results. Our approach is based on the research conducted by Bou-Llusar, J.C. et al. (2008) [8] which consider that EFQM captures the main core concepts of TQM containing both a social dimension as well as a technical one. At the Enablers level, the social or soft dimension is represented by the Leadership and People and the technical or hard dimension by Processes, Products & Services and Partnership & Resources while the Strategy connects these two dimensions (Dotchin, J.A. and Oakland, J.S., 1992) [14]; (Yong, J., Wilkinson, A., 2001); [48] (Prajogo, D.I.and Sohal, A.S., 2004); [32] (Rahman, S., 2004); [35] (Rahman, S.and Bullock, P., 2005); [36] (Lewis, W.G., Pun, K.F.and Lalla, T.R.M., 2006) [25].

The Results can be expressed in intangible or less tangible terms concerning the employee motivation, perception and perspective of the customers, satisfying the society, or about tangible and economic terms concerning the quality of raw materials, the sales per employee, profitability, and so on.

In order to develop the EFQM software based on 3D spiral lifecycle we took into account the internal structure of the EFQM model, the main relations between criteria, interrelationships caused by latent factors and their contribution to an overall index. The EFQM Excellence Model, as a Total Quality Management (TQM) framework, considers that excellence involves satisfying and maintaining a balance between the needs of all the stakeholders, like: employees/people, consumers/customers, partners/suppliers, environment, society, community and so on.

We analyzed the development process of the self-assessment software based on EFQM model, using the 3D Spiral Lifecycle Model. The 3D Spiral Lifecycle Model consists in following all the development steps (requirements capture, design, implement, test and validate) with continuous monitoring of the level of customers' requirements fulfilment in order to determine the best suited graph processing algorithm to be used.

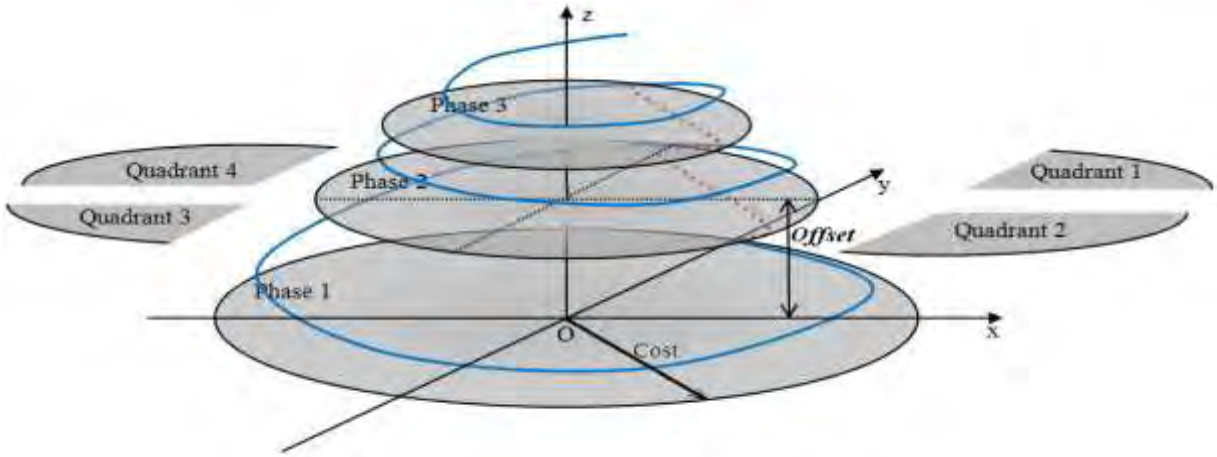


Figure 2.5.1. 3D spiral model for a product software development life cycle

In figure 2.5.1 there are presented the software development phases as they are addressed according to the above mentioned lifecycle. Each phase consists of four quadrants in xOy plane, related to requirements capture, analysis, design and test. Also, each phase represents a version or subversion along the software product development process. The step between phases is represented by the value of the offset. The offset, along z axis, is determined as the degree of requirements achievement by the quality technical characteristics of the software product.

The implemented algorithm uses a digraph representation to model the interactions between the EFQM Excellence model criteria, for the systemic analysis in order to evaluate the real organization achievements and needs. The adjacency matrix representation for the digraph is useful in mathematically analyzing the model and for computer processing.

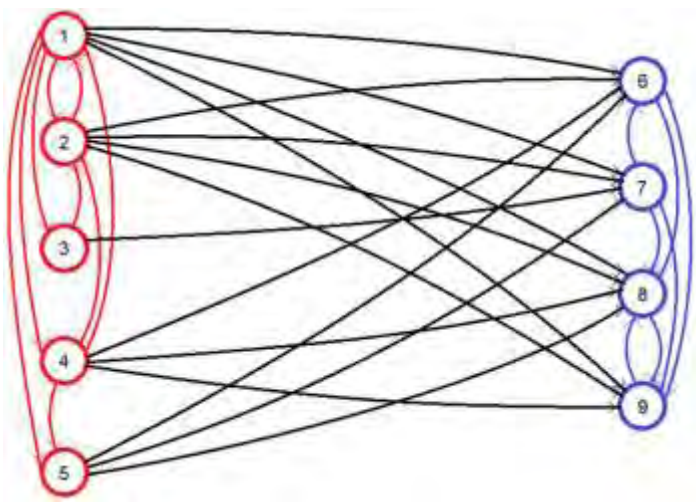


Figure 2.5.2. The diagraph representation of the Enablers, Results and the relationships

The research approach consists of developing a digraph model of the interactions between the EFQM Excellence model criteria, as presented in figure 2.5.2. This model is implemented as dedicated software to evaluate the overall system performance.

The 3D Spiral Lifecycle Model based on QFD, applied for the case of EFQM based self-assessment software, offered the possibility to continuously estimate the current state of product development by means of an offset, that is an overall index computed based on the mathematical model embedded in our methodology. The offset represents the level of customer requirements achievement by the quality characteristics of the product. For our case the 3D Spiral Lifecycle Model allowed the identification of the relationships to be used in the digraph representation.

By applying the 3D spiral lifecycle model for the EFQM based self-assessment software product, we have released two subversions as presented in figure 2.5.3.

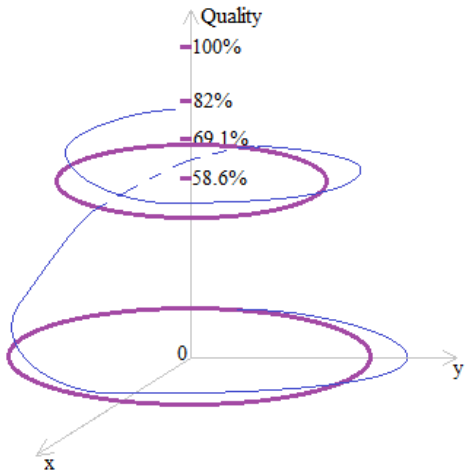


Figure 2.5.3. Software product development subversions

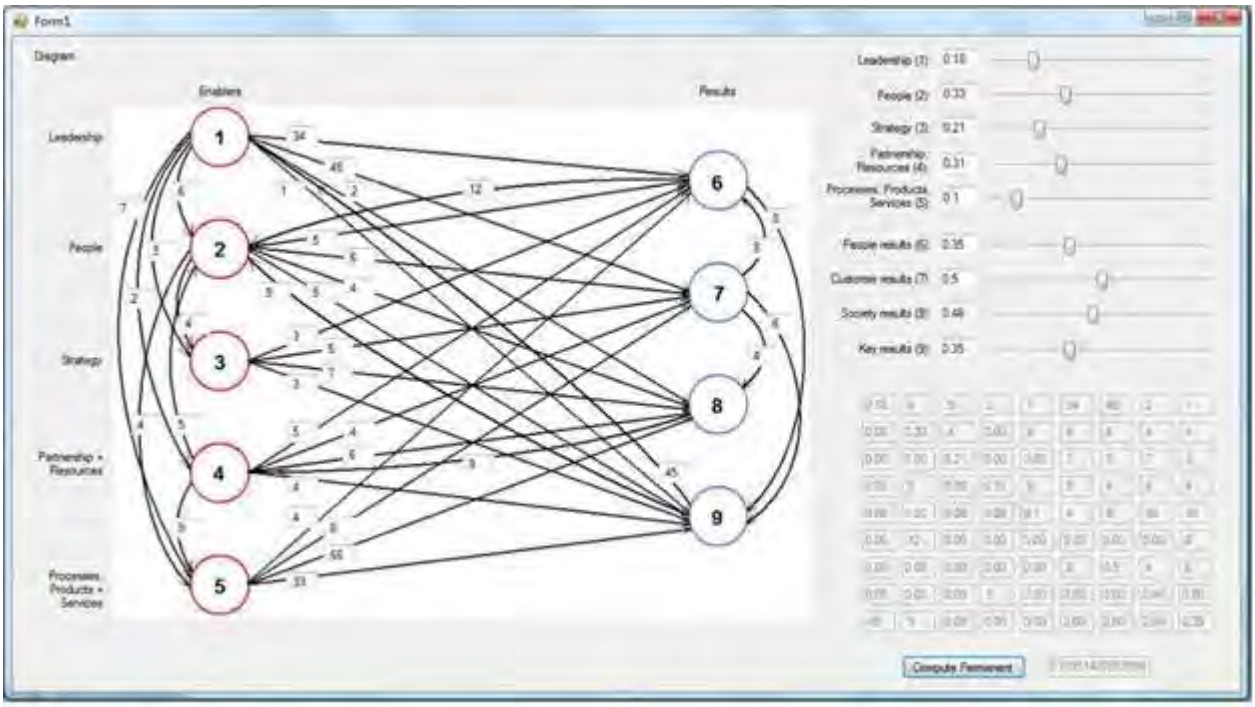


Figure 2.5.4. Version 1.0

The version 1, subversion 0, was designed based on the 2010 EFQM model. It used a digraph representation and had the possibility to manually introduce the values representing the level of achievement of each criterion. These levels had to be determined offline. In order to obtain the Quality Index which represents the performance of the system (organization) by a single number, the permanent of the matrix was calculated, as presented in figure 2.5.4. The permanent is a multinomial and a standard matrix function, which has been used and defined in combinatorial mathematics by Ryser (1963) [40].

I have analyzed for this version the degree of requirements fulfillment by the resulting software product and we have obtained an offset value of 58.6%. This was considered feasible for a first release of the product.

The version 1, subversion 1, was designed based on the 2013 EFQM model. The digraph representation was updated to the new model at sub-criteria level. There were also introduced online questionnaires in order to determine the criteria accomplishment levels. The Quality Index was also updated to a new mathematical model. (fig. 2.5.5)

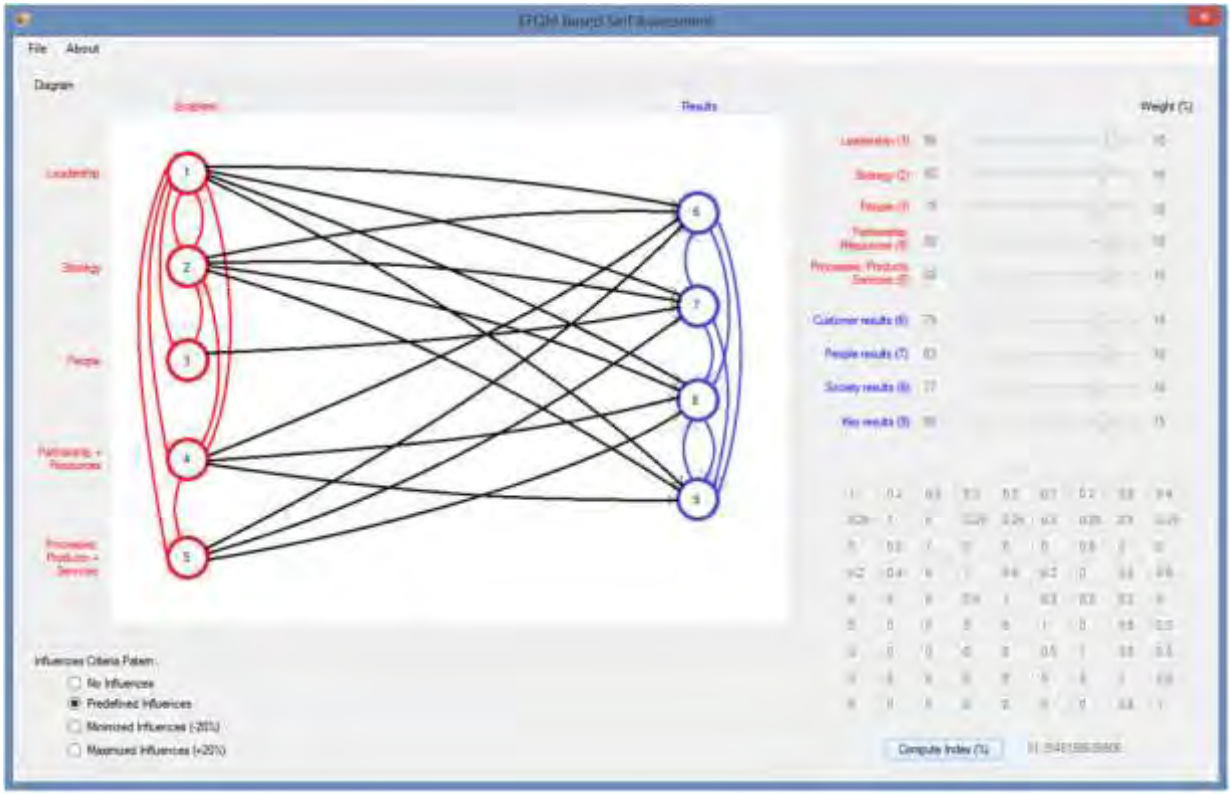


Figure 2.5.5. Version 1.1

For the version 1.1 we have determined an offset value of 69.1% for the current state of software development, taken into account that we have implemented questionnaires only for one Enabler (Leadership). After implementing all the questionnaires we expect to reach a target offset of 82%.

The research presents how the 3D Spiral Lifecycle Model was implemented in the EFQM based self-assessment software. The main advantage of the use of this model is that the offset

provides a measure of the current accomplishments and allows fast changes in software subversions.

The necessity to develop a new subversion was related mainly to the changes in the EFQM model. But, updating only these changes wouldn't have improved too much the offset. The high improvement was due to the implementation of the customers' requirement related to the online evaluation of each criterion by means of questionnaires.

The present improvement introduced by the second subversion mirrored in the 9.5% of the offset might be seen as a highly significant one, but it represents the milestone for the reaching the target offset of 82%. This means that over 80% of customers' requirements are fulfil by the software product, representing the premises for a high acceptability grade among the future users.

2.6. Life cycle model application in New Product Development (NPD)

The research presents the use of 3D Spiral Lifecycle Model based on QFD applied on an innovative biometric product development. This innovative product is a biometric identification system to be used in emergency cases for the identification of accident victims. There are discussed three approaches for the biometric identification and storage algorithms. The first approach, implemented in the version 1, consists of the use of microcontroller level identification and storing. The second approach, implemented in the version 2, involves introducing a SQL server for database operations and PC software level biometric identification algorithms. The third approach, implemented in the version 3, replaces the SQL server with a MongoDB database solution for higher flexibility and storage space and refines the PC software level biometric identification algorithms. The development of the software product from version 1 to version 3 is presented and analyzed based on the values of a global index, called offset. This offset is provided by the model, having the role of highlighting the current state and the evolution of software product from one version to another, based on the degree of achievement of the customer requirements or of the problem to be solved.

The application of the 3D Spiral Lifecycle Model based on QFD consists in following all the development steps (requirements capture, design, implement, test and validate) with continuous monitoring of the level of customers' requirements in order not to waste resources on dead end or not performant paths. Our research methodology was oriented on interdisciplinary team work in order to develop the innovative product.

The 3D Spiral Lifecycle Model based on QFD, applied for the case of innovative biometric system development, offered the possibility to continuously estimate the current state of product development by means of an offset, that is an overall index computed based on the mathematical model embedded in our methodology. The offset represents the level of customer requirements achievement by the quality characteristics of the product. For our case the 3D spiral model allowed the identification of biometric hardware related problems that led to early redesign of the entire system.

Next is presented the application of the model in NPD for our innovative product, the biometric identification system for emergency cases. First, the focus will be on the phase of customers' requirements capture. The main customers' categories are presented in fig. 2.6.1.

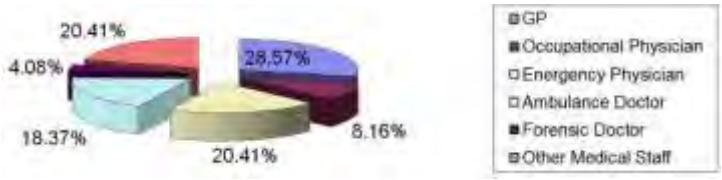


Figure 2.6.1. Customers' categories

Thus, we identified the customers' requirements, as follows:

CR1: autonomy;
CR2: efficiency;
CR3: safety and security;
CR4: portability;
CR5: accuracy;
CR6: affordable price;
CR7: warranty insurance, service and updates.

The customers' group used for requirements capture phase consisted in several categories, as presented in figure 2.6.1. These requirements were prioritized at each customer category level and then was determined the global importance of each requirement, as presented in figure 2.6.2.

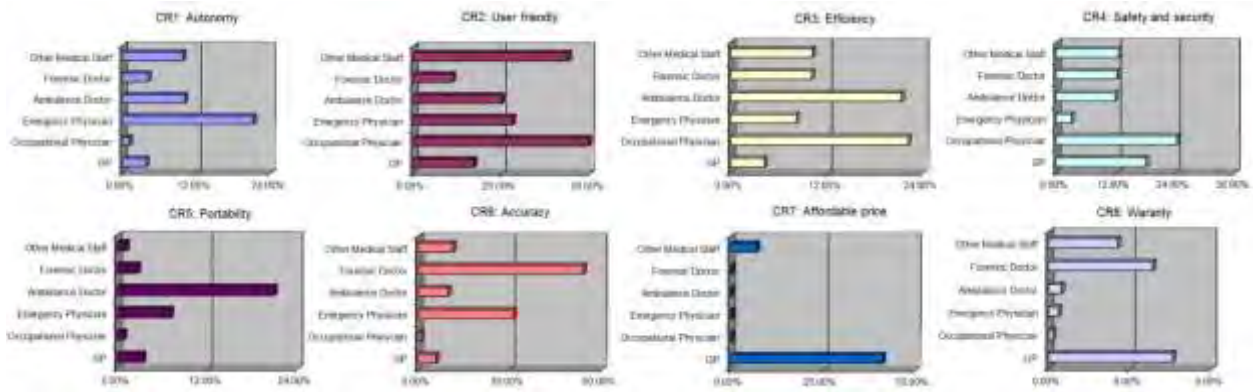


Figure 2.6.2. Customers' requirements prioritization

All respondents consider that the device would be important for the patients benefit and would improve significantly information management by: decreasing the time to identify patients, decreasing the time for the investigations and ensuring prompt treatment.

The highest importance (1) is attributable to *Safety and security of data* criterion (46.67%), followed by *Insurance warranty, service and update* (30.00%) and *Portability* (13.33%). The following criteria: *Affordable price* (53.33%), *Autonomy* (20.00%) and *Insurance warranty, service and update* (16.67%) are situated on the last places. The last criterion, as can be observed is found among those considered very important (Fig 2.6.3 a and b). This is because the respondents were classified into four categories, and the responses are linked to specific activities submitted. In this context we considered relevant for our research, the representation of the results for each level of the respondents category.

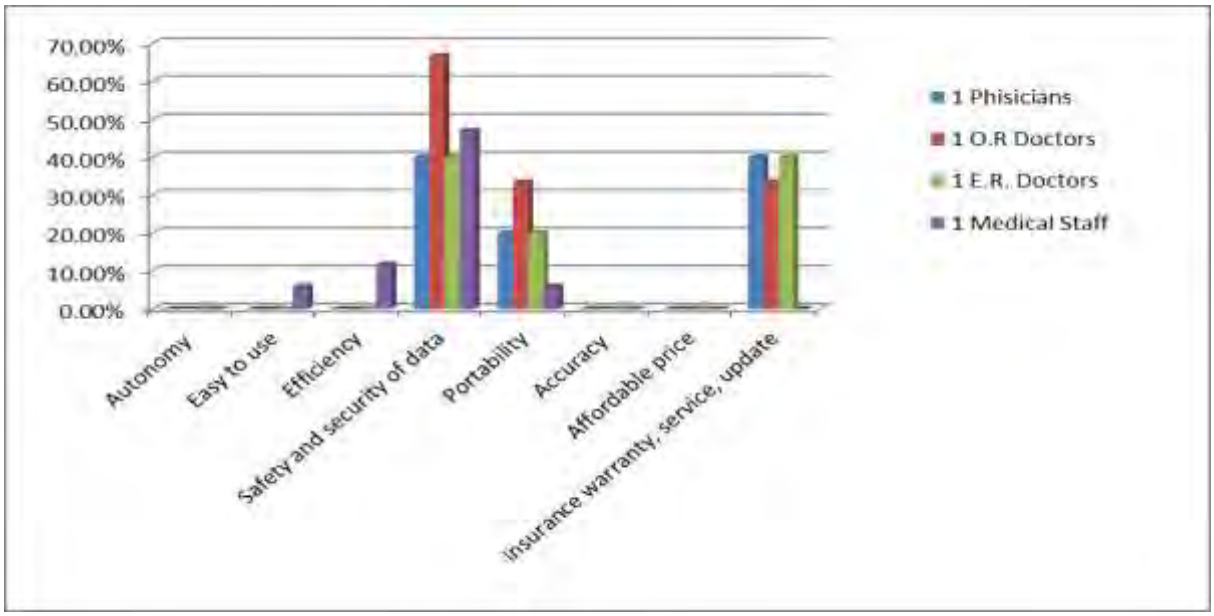


Figure 2.6.3.a. Respondents' distribution on requirements groups

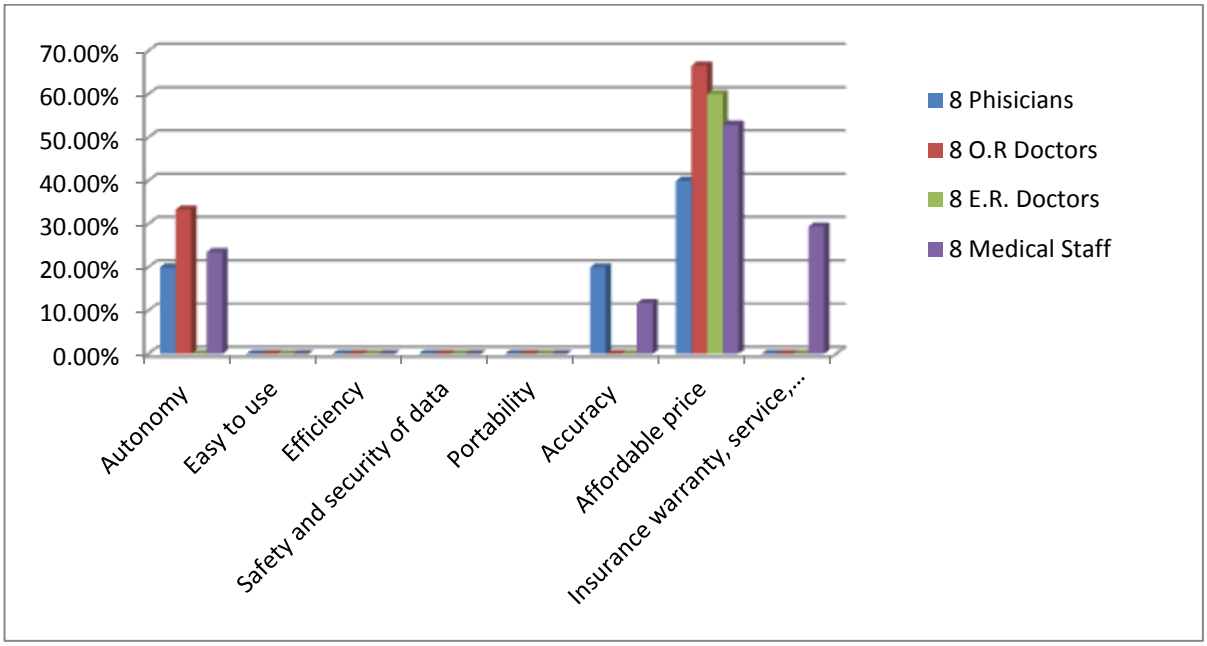


Figure 2.6.3.b. Respondents' distribution on requirements groups

I present further, the 3 versions of the biometric product resulted from the application of the 3D Spiral Lifecycle Model. The product development began with the phase of requirements capture and refine in order to determine the technical characteristics of the product. The resulting requirements were grouped into 8 categories, as presented in figure 2.6.2. The relationship between requirements groups and the respondents' categories is presented in figure 2.6.3.a and b and it reflects the fact that the most important groups of requirements are related to the Safety and

security of data and Insurance, warranty, service and update and the requirements group considered the least important is related to the Affordable price.

By the present time, there were developed 3 versions of the biometric product, as presented in figure 2.6.4.

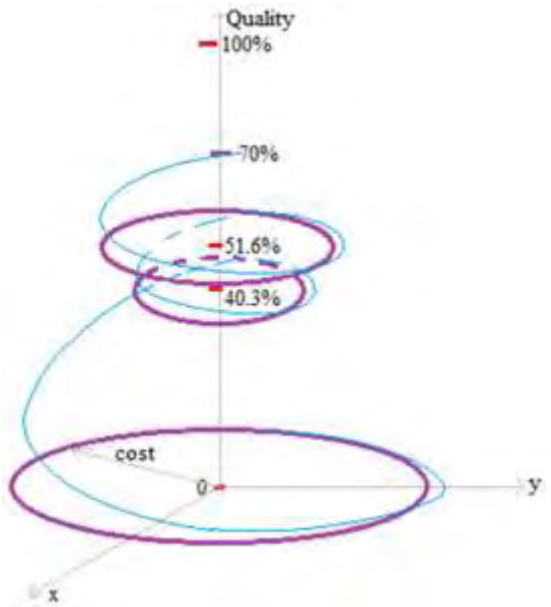


Figure 2.6.4. Product development versions

The version 1 is characterized by the following: Atmel microcontroller based hardware solution with local identification of the biometric characteristics. This solution was proposed for the case of Emergency Hospital from Petrosani, Romania.

The basic fingerprint reader hardware contains a fingerprint sensor connected to the microprocessor, via a serial protocol. This biometric assembly work together with the PC (developed database) through USB cable (Fig. 2.6.5.).

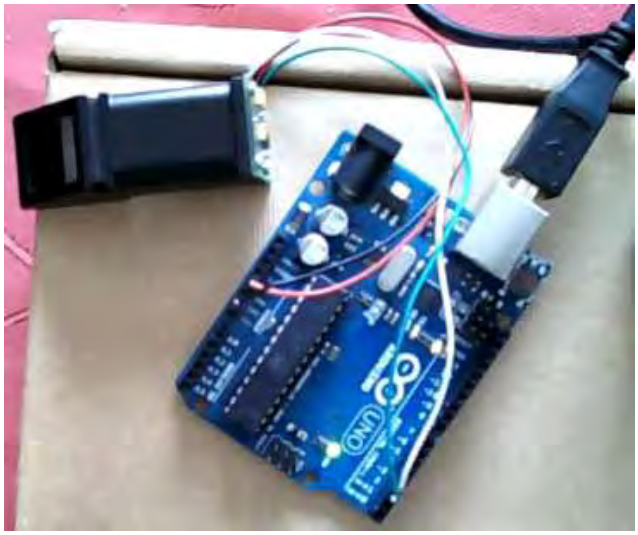


Figure 2.6.5. Basic fingerprint reader hardware

The fingerprint technology can be used for identification even within large databases. Figure 2.6.6. presents database graphical interface developed in Visual Basic .NET, in which we tried to identify a new person which does not have the fingerprint template stored in database.

For version 1 we determined the offset value as 40.3%. This value, representing the degree of requirements achievement by the technical characteristics of the product, is not acceptable. There were identified weaknesses that need improvement measures. Of these, the most important is related to the limited number of data that can be stored in the biometric identification hardware device (about 150 templates).

Figure 2.6.6. Database interface – identify person routine

The version 2 has eliminated the shortcomings identified in the previous version, replacing the hardware solution based on local identification with a software solution based on a biometric identification SDK, a SQL database and client-server application developed in C # .NET (figure 2.6.5.).

For version 2 we determined an offset value of 51.6%. This value is acceptable, but not enough. There are still weaknesses that need improvement measures. Of these, the most important is the lack of flexibility of the data that is stored in the SQL database.

Version 3 is the current version and is characterized by using a MongoDB database type that can store large volumes of data and ensure greater flexibility in the structure of data collection. To date, we have analyzed the version 3 and applied the methodology. It was determined a target offset value of 70%.

The main advantages of the use of this model are that the offset provides a measure of the current accomplishments and that it allows the identification of the elements or characteristics to be improved or redesigned in order to increase the offset. For the three versions it was achieved the product improvement using as references the determined offset values: an offset of 40.3% for version 1, an offset of 51.6% for version 2 and a target offset of 70% for version 3. The offset gives an overview of each developed version, and a detailed analysis of the evolution of the product from the initial version to the current version shows briefly that: the transition from version 1 to version 2 was determined by the need to increase the target group of product's users, so the solution has to turn from hardware orientation of the first version to the software orientation, solution based on

SQL database, of the second version. The transition from version 2 to version 3 (current version) was determined by the need of flexibility in the database structure for stored, updated and processed data. Thus, it was switched from SQL database to MongoDB database. The current version is in development, in order to achieve the target offset of 70%. For this reason, the activities undertaken are: web user interface redesign and software modules (biometric feature extraction and identification modules, MongoDB processing modules) integration.

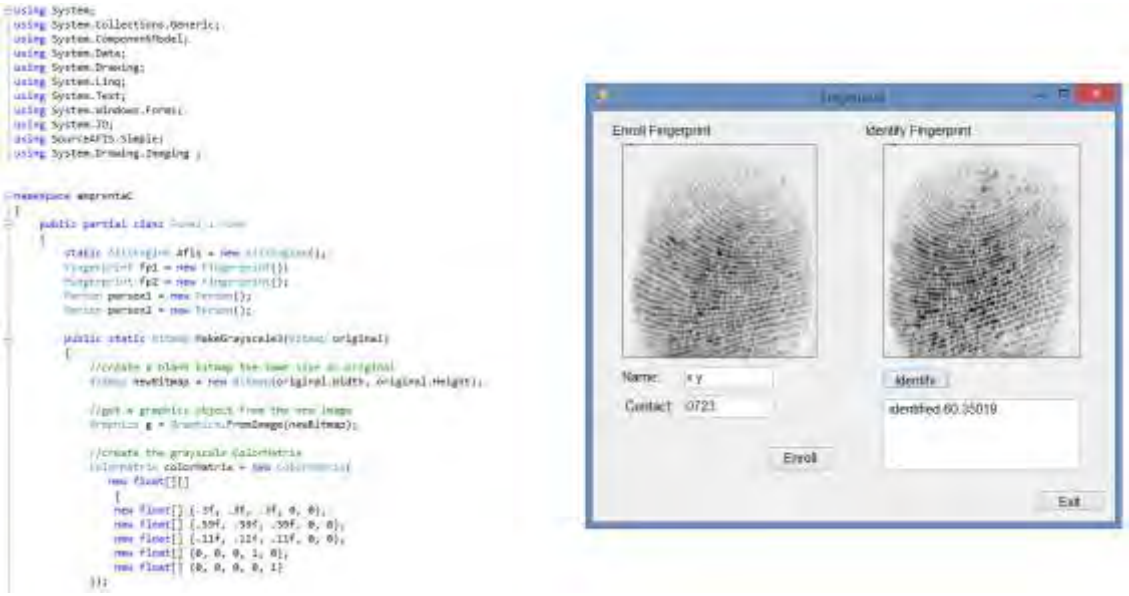


Figure 2.6.7. Version 2 user interface

Conclusions and future enhancements

The development methodology for the implementation of the 3D Spiral Life Cycle Model Based on QFD Method and Spiral Life Cycle for Software Development presented in this chapter, contains many intrinsic elements from the fields of quality management tools, but we have highlighted mainly the novelty and originality issues presented by our method, the others being considered a well-known background theory.

The general purpose of QFD based software products is for the evaluation of a wide variety of products and services. Without pretending to having achieved the “perfect” QFD software tool we have developed the first version, surely subject to improvement, of the 3D lifecycle QFD embedded model software tool.

The model was applied for the software development that was a new type of human machine interface called M.O.V.E. and was the result of research carried out having students involved.

The very important and actual field of renewable energy systems was also subject for the application of the patented model, by integration it in an expert system designed to provide a useful evaluation tool in order to overcome one of the specific problems of the expert systems, namely to find a solution that best meets the customer requirements. We chose to prove the viability of our approach on an interesting case study that is the choice of a wind turbine according to some simple not technical customer requirements.

For the services field, the model was customized by embedding the SERVQUAL model resulting in Service Quality (SQ). In order to prove the viability of the SQ model, there was developed a software tool that was applied for the evaluation of a health care services provider.

I analyzed the development process of the self-assessment software based on EFQM model, using the 3D Spiral Lifecycle Model. The implemented algorithm uses a digraph representation to model the interactions between the EFQM Excellence model criteria, for the systemic analysis in order to evaluate the real organization achievements and needs.

The 3D Spiral Lifecycle Model based on QFD, applied for the case of innovative biometric system development, offered the possibility to continuously estimate the current state of product development by means of the calculated offset which has the role of highlighting the evolution of software product from one version to another, based on the degree of achievement of the customer requirements or of the problem to be solved.

There are several aspects from our methodology that could be the subject of future researches, like: a more thorough benchmarking, the simulation of possible enhancements in the next phase of software product development based on the inverted mathematical model and the development of similar methodologies customized for other types of products/services.

The possibility to simulate the effect of the accomplishment degrees of the quality characteristics upon the offset represent a very useful instrument that can be applied in order to improve the final functionality of the product/service with minimum resources and eliminate as much as possible of the nonconformities that might occur.

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3.

QUALITY IN STUDENT SUPPORT SERVICES

Introduction and Conceptual Background

The many facets of quality, and also the teaching activities carried out, have generated the interest for Student Support Services (SSS) domain exploration. The SSS research aimed topics like mentoring and tutoring in the SSS context [09_11_S]; academic counseling role [10_10_S], quality assurance in higher education [05_10_S], [05_09_S]; role and importance of self-directed learning methods (SDL-Self Directed Learning) in the context of modern learning [10_09_S]; entrepreneurship education [09_12_S], [08_10_S], [08_17_S]; use of quality management methods in the evaluation of eLearning systems [13_01_S], [12_06_S] and the use of innovative and creative methods, like interactive games and gamification [14_09_S], [13_12_S] [13_09_S], [13_05_S]; innovation in education [13_03_S]; quality management system in the University of Petrosani [10_18_S].

The use of the QFD-based assessment method for modern learning and teaching systems connects to the second research direction, while the innovative methods and techniques is the link to the fourth research direction, creativity and innovation in new product development.

This research direction is related to the research activities from the projects: Increasing the quality of staff related to vocational guidance (ACCESS), GRU-10-P-LP-151-HD-TR (vocational counseling, mentoring and tutoring); Improvement of university management POSDRU / 2 / 1.2 / S / 4 Priority Axis 1 "Education and training in support of economic growth" (improving the quality of university management); eQuality Trainnig System CC/8/ 9.04.2013 and InterConformity Academy CC/11/01.05.2014 (development of quality oriented courses in a modern approach based on MOOC, having as starting point the research on Self-Directed Learning SDL); Training for the job of Quality Manager in the Quality Management Systems - for the line managers from construction companies in the North-East region, "PHARE project /2006/018-147.04.02 (training in quality management); Alternative training solutions using information systems - a solution for the conversion of the mining workforce, POSDRU 82 / 5.1 / S / 59756, Higher education human resources development in the use of e-Learning system, POSDRU 87 / 1.3 / S / 64273 (the use of eLearning systems in training).

Student Support Services (SSS) are very successful in helping students pass through the University, especially those students who are considered under-represented and/or underprivileged. The SSS proved their efficiency through different programs implemented over time. The need and importance of SSS are visible in some statistics related to supporting SSS programs. Over the years, such programs were expanded, becoming nationally known for the assistance they provide to the targeted population and its specific results (Loggins et al., 2009) [15]. It is the case of TRIO support service program, established in 1968 with the intention of increasing college retention rates for first-generation students, students from low-income families, and/or students with disabilities (Council for Opportunity in Education [COE], 2008) [24]. As concerns the results, Walsh stated four years ago “More than 80% of TRIO students persist in their academic goals each year. The graduation rates, transfer rates, and GPA (Grade Point Average) levels of these students far exceed those of similar students who are not enrolled in the TRIO program as documented in annual program evaluations” (Walsh, 2000, p. 12) [24]. Within this general framework, TRIO programs have certain characteristics that make them effective, especially related to services that complement the students' experience by integrating issues of

leadership, civic engagement, and personal/academic development in order to support their shaping as lifelong learners and leaders. Some of the resources offered by TRIO programs and other such supporting programs include basic skills training, tutoring services, personal/career counseling, and mentoring, to name a few. However, each supporting program must tailor to the specific needs of the university.

In general, the term of SSS refer to a range of services covering different intervention areas like academic support, pastoral, administration, financial and also different stages in the student life cycle starting with aspiration raising, pre-entry activities, continuing with the first term activities, moving through the courses and ending with employment.

One essential way to enhance the student participation in the university is to design programs that acknowledge their individual needs. Program planning focused on the institution's mission and students' needs can result in a dynamic advising system having the capacity to adapt to internal and external change. Obviously, the academic advising practices vary from institution to institution, making it difficult setting of blanket recommendations that guarantee positive results of specific decisions within each university. However, the many cases presented in the international literature can provide some relevant aspects that should be consider when deciding. Thus, there may be many ways in which academic advising contributes to students' success by increasing their opportunities to interact with a faculty/professional adviser, to feel more connected with the university, to clarify how to make course options, eventually serving as an educational and/or vocational checkup. Precisely because the Romanian universities are rather at the beginning of this long way towards a good academic advising, we consider important to point out some shortcomings revealed by the international experience. So, let’s learn from the others and don’t repeat the same mistakes.

Firstly, according to Tinto (as cited in Dyer & Myers, 2005, p. 284) [3], “more students leave college before completing a degree than stay and graduate” and a relevant aspect in this low retention rate is consider to be students' dissatisfaction with the institution. In its turn, this dissatisfaction frequently resides in academic advising related issues (Corts et al., 2000) [2]. These include mainly the advisers' lack of time to pay attention to individual students, the poor quality of advising actions, and the perceived coddling of students.

On the one hand, tutoring and especially peer tutoring often relate to a common view that, for tutors, it is the so-called “learning by teaching”. This view reflects the old saying “to teach is to learn twice”. However, by its nature, the act of tutoring involves further cognitive challenges, particularly with respect to simplification, clarification and exemplification.

On the other hand, mentoring as a learning and development tool includes sharing experience, offering encouragement, insight through reflection and mutual learning. Many conceptual approaches of mentoring were in relation with areas such as career development, management/leadership, study skills, teaching and learning. After the year 2000 the concept becomes more and more explicitly addressed as: (1) support for education; (2) support for day-to-day living; (3) support in the workplace.

For a better understanding of the current meanings of the two concepts may be useful a synthesis of the main differences between tutoring and mentoring as presented below:

	TUTORING	MENTORING
FOCUS	**Academic learning**	**Life skills**
LOCATION	**Usually in the classroom**	**Often outside**
SCOPE	**1 to several**	**Usually 1 to 1**
DURATION	**Few weeks**	**Several years**

Schemes for involving students as tutors and mentors are now in place in many countries with numerous students, pupils and teachers benefiting from this activity. The main challenge is to integrate mentoring and tutoring in the basic structures of the universities

A program initiated at University of Delaware ("Mentor program matches college students with kids") pointed out the fact that "participation in a school-based mentoring program led to improvements in students' self-efficacy, aspirations and ideas of what they could be - their possible selves. Kids get help from trained tutors and mentors; college students contribute to schools and the community in a meaningful way" (Lee & Cramond, 1997) [14]. In addition, the mentoring programs during some work activities proved out to be very efficient for young people. For instance "Cornell Youth Apprenticeship Demonstration Project" – which emphasizes opportunities for youth to learn at work, begins in students' junior year of high school and involves workplace teaching, advising and mentoring. Students can obtain a number of credits and a formal certification on course completion.

Another framework in which mentoring appears as having successful practice experiences in many countries is in the HE field (see Frierson, 1997 [4]; Fullerton, 1996 [6]).

Projects like those implemented within the SSS programs of the Universities of Cambridge and Chelmsford (entitled "Employer Mentoring Scheme") pointed out the positive effects of the relationship developed between mentors and mentees. "This Anglia Ruskin University Scheme matches second year students with employees from local companies. The employees act as 'Business Mentors' providing a career related voice of experience for the student. The Scheme is designed to assist students in improving their employability through developing workplace skills and business awareness"(ANET online community, 2005) [25]

A new setting for the mentoring practices, as developed in the recent years, is the electronic environment. "It appears that online mentoring offers important opportunities that are not afforded by exclusively face-to-face mentoring, while presenting several practical and ethical challenges" (Rhodes et al., 2006) [21].

In the SSS context an important approach regards Self Directed Learning. Recent research on teaching is usually interpreted as guidelines for improving how to teach students the curriculum. Teachers are urged to apply the research on learning styles, for example, by designing their lessons to accommodate the different ways—visual, auditory, tactile, and kinesthetic—by which students most readily comprehend and apply what they are taught.

When brain research shows that people learn better when new concepts are tied to what students already know, teachers are encouraged to connect the lesson to students' past experience and to begin with their current state of knowledge about the subjects they are teaching. Such responses are commendable and promising for Teacher-Directed Learning (TDL). With a shift in perspective, however, we can also see, in these and many other findings, the outline of another paradigm in which students exercise their individual learning styles in creating their own meaning. That paradigm is Self-Directed Learning (SDL) (Gibbons, M., 2003) [7].

Literature provides different forms of the multifaceted concept of SDL as Self-Regulated Learning and Learner Expert. SDL was initially used by American adult educator Malcom Knowles (1975). The first theoretical syntheses that founded the whole field of SDL belong to R. Caffarelli and MJ-O'Donnel (1988), P. Galvani (1991) and Ph. Carré (1997). Their works, which have become classics, summarize previous work or propose typologies of the main ways to address the issues of SDL. Ph. Carré introduced the suggestive phrase "la galaxie de l'autoformation", referring to the multitude and diversity of "self – educational" activities such as SDL and identified the main approaches in the field.

The appropriate assessment for SDL is student self-assessment. In self-assessment, students evaluate the complete process of action learning from conception through performance to the outcome or product. Students assess themselves because it is an essential skill for successful self-direction. It is meta-learning; learning how to learn includes learning how to assess how well one is learning. It provides the questions that students must always have in mind: "Is this the right task for me to be doing now?" ,"Am I doing it well?" and "Is this a worthy result?".

Self-assessment applies not only to individual activities or courses, but also to the overall educational and life programs that students are shaping for themselves. It is essential that the SDL student regularly ask, "Is what I am doing a demonstration of who I am or want to be?" (Gibbons, M., 2003) [7].

Today it is possible that the upcoming generations, especially those for whom the web is becoming natural habitat, are adapting to change by developing a SDL orientation. Confessore and Barron (1997) studied the learning orientation of "preboomeers" (49 over), "boomers" (30-49) and "postboomers" (under 30). The three age groups had significantly different learning orientation. Confessore and Barron question whether this is a function of general life experiences of each cohort or whether the orientations will change as they move through life stages. Nevertheless, they conclude that institutions will have to accommodate an evolving spectrum of learning orientations, particularly by providing more SDL opportunities (Kerka, S., 1999) [13].

The spectrum refers to degrees of SDL ranging from entirely TDL to SDL. The spectrum includes more stages or degrees of movement toward SDL, from the occasional introduction of SDL activities into courses or programs that are otherwise teacher-directed, to courses or programs, in which students choose the outcomes, design their own activities and pursue them in their own way.

3.1. Mentoring as an Educational Partnership: Model, Experiment and Interpretations

The mentoring concept (seen by many authors as having its roots in the well-known "Odyssey" of Homer) acquires today new valences, revealing a new philosophy that emerged around the relationship Mentor-mentee/protégé (M-m) which must develop and manage on a partnership basis.

A key part of such an educational partnership is the effective detection of priority needs of mentee/protégé. The four basic needs are the need for achievement, the need for recognition, the need for power, and the need for control (as revealed in the renowned research conducted by David McClelland of Harvard). Furthermore in such an M-m partnership relationship, the two parts may have common needs, but with a different relative importance. The "art" of mentoring is to combine them into a scheme of effective working together while maintaining the focus on learner discovery and independence. For this, Bell considers as being crucial the following qualities: balance, truth, trust, abundance, passion, and courage (Bell, 2008) [1].

Thus, the assessment of personal attributes of the potential participants in a mentoring relationship may provide useful information about their availability and capability to involve in building a successful partnership for learning. According to Bell, the Mentor Scale (MS) is an adequate tool for such an assessment, used to measure at one point in time a mentor's need for sociability, dominance, and openness, three generic issues related to significant personal attributes and skills including those above-mentioned. In simple terms, MS is a self-checking test of the potential of mentoring that aims not to judge or criticize the person (there are no right or wrong answers) but to take "a snapshot" of its mentoring qualities, or weaknesses (Bell, 2008) [1].

Considering all the aspects presented up to this, we initiated a small-scale experiment (at the level of our university department/year of study) in order to explore the mentoring potential by using MS. The experiment consisted of the following: (1) applying the MS test to teachers; (2) applying the MS test to students; (3) interpreting the results and comparative analysis.

For discussing the results relative to the attributes/skills interpreted as enablers of a successful M-m relationship (according to MS), firstly we focus on the issues of sociability and openness.

Sociability: 77% of the teachers and respective 70% of students tend to be sociable, to easily interact and create new relationships.

Openness: 66% of teachers and 80% of students tend to be honest people showing their feelings easily, having the willingness to share their knowledge and experiences, looking to be trustworthy persons able to imply in building a M-m relationship on a mutual basis.

It is noticed the strong correlation between the attributes of sociability and openness both in the case of teachers and students. Thus, most of them (representing a significant percentage of 66% for teachers and 70% for students) seem to be at the same time sociable and opened people.

As concerns the attributes of dominance, the results are somewhat different, showing an almost equal distribution between those who tend to dominate and those who tend to be dominated. However, a greater percentage of subjects have scores showing a relative balance between the two tendencies (55% of teachers and 60% of students). This confirms and Bell's opinion that today, the entire concept of education is based on a relationship of shared authority (Bell, 2008) and extremely important is to find suitable "dosage" for an effective partnership.

For that reason we consider significant the relative homogeneity of responses (individual scores without extreme values for any of the attributes/skills considered by MS) suggesting a common perspective of approaching the issues in a relative balanced manner. Furthermore, around 22% of teachers and 20% of students have answers with similar scores almost of balance for all the three areas considered. They are the ones with the greater potential to sustain and develop an effective educational partnership, having personal qualities and skills showing not only their availability but also their capability to adapt to the particular conditions that make possible such a complex M-m relationship.

Creativity and gamification in mentoring

The known creativity techniques studied and used for many years completed with the most recent gamification techniques represent means to improve the existing and to develop new types of M-m partnerships.

There can be considered that creativity is within everyone's reach. In fact, for anybody who wants to do things thinking differently. Usually it makes things easier, but the start is often hard, because it means to break the routine boundaries. Once rid of this "burden", it may become attractive, interesting or even a game. The creativity techniques have to be adapted for each different case, like the personalities of mentor and mentee or the problem to be solved. There are many creativity techniques commonly used, but for our research in M-m partnership our attention was drawn by the TRIZ applications in education [17]. To improve the motivation and fun of the M-m partnership in solving various problems there are used the gamification principles bonding all the elements in an amazing way.

Next we'll present some theoretical details regarding the above key elements: creativity, TRIZ and gamification that were significant for our researches.

Speaking about creativity we have to understand that there are two different types: the technical creativity, which means that people create new ideas regarding theories and technologies, and the artistic creativity, which is an innate ability. In our study we will refer only to the technical creativity.

There is a wide variety of creativity based tools and techniques used to solve different problems. The techniques that could be used in the context of M-m partnership are: Reversal and SCAMPER; Attribute Listing, Morphological Analysis & Matrix Analysis; Brainstorming; Random Input; Concept Fan; Reframing Matrix; Provocation; DO IT; Simplex and TRIZ.

These tools were used by many scientists to drive their creativity. A classic example is the one of Albert Einstein who used an informal form of Provocation technique to trigger ideas that lead to the Theory of Relativity.

The technical creativity splits into two directions: programmed thinking and lateral thinking. Programmed thinking consists in logic structured approach on innovation. The techniques employed are: Morphological Analysis, Reframing Matrix and the powerful TRIZ process. TRIZ is a human-oriented knowledge-based systematic methodology of inventive problem solving, which produced spectacular results in many application fields.

Lateral thinking consists in breaking out of the human specific patterned way of thinking. The techniques employed are: Brainstorming, Random Input and Provocation. The lateral thinking approach can produce new brilliant solutions for existing problems.

Even if there is no commonly accepted definition of gamification, we can take into account the definition given by Werbach and Hunter in "For the win" saying that "Gamification is the use of game elements and game-design techniques in non-game contexts". The term "gamification" is still a debate subject among game developers and researchers. Maybe in time gamification will be called differently, but the most important is that the main aspects of it, which are game elements, game design techniques and non-game context, will surely remain.

No matter what the future of education will bring, the elements of games, innovation and creativity will increase the motivation and outcomes of learning "adventure" in all of its aspects and for all the actors involved.

Playing with Games, Innovation and Creativity in an Educational environment means to gain knowledge by discover in a fun and motivating way. That's why we call this blend GaInCrEd.

Successful M-m partnership in a GaInCrEd environment

The objective of our research is the mentoring approach in the context of Student Support Services (SSS) applied in Higher Education as an educational partnership. In this partnership we highlight the items / ingredients that make it successful. These are: creativity tools, game elements and TRIZ principles. Playing with Games, Innovation and Creativity in an Educational environment means to gain knowledge by discover in a fun and motivating way. That's why we call this blend GaInCrEd and we approach mentoring in this environment. We propose as research approach a toolkit consisting of game elements, creativity and innovation tools. In order to prove their viability there are presented the principles and tools applied for the proposed Mentor – mentee (M-m) partnership in a GaInCrEd environment for solving a problem. In our case we have considered the problem: "the need to improve learning outcomes". In order to evaluate the M-m relationship resulted after applying the above creativity and gamification techniques we used a model that integrates the best elements of SERVQUAL and QFD methods. The proposed model computes the overall index that represents a quantification of the M-m relationship from the point of view of the mentee.

The idea of using gamification in higher education specific activities was addressed before in a project called Just Press Play [23]. The objectives of the project were to motivate students in higher education in order to improve their learning outcomes.

The main achievements were related to the identification of what students really need and the means of accomplishing these needs through gamification. The main issues identified were that the students perform better when:

- they know at least one professor to call on for advice;
- they learn how to work in a team with other students;
- they are connected with the community of learning within the entire school.

The gamification solution used by the Just Press Play project to determine students to know better their professors was the collectible cards. Each student had to find the cards that the professors hidden in their offices. For doing this they had to engage in a conversation with the professor that would lead them to find the hidden card. By this, without noticing they had the chance to know the professor and consolidate their relationship.

The second issue, related to the team working, was aiming the freshmen results. The gamification approach was to build teams of students that had as target to achieve over 90% pass rate in order for all of them to receive a collective prize. The project reported that the students' teams were doing it not for the reward but for the fun of the game. Both juniors and seniors enjoyed the peer to peer study sessions and they wanted to continue the team work.

The third issue can be considered as a consequence of the first two, because if the students get to know better their professors and be part of a study team surely they will feel highly motivated and connected to the entire school learning community. So, in this project, the gamification solution proved to be successful for each of the above issues.

From the point of view of our research we have noticed that every solution that proved viable in this project had embedded mentoring and tutoring aspects. The mentoring and tutoring is a key component of the student-professor and student-student relationships.

This is why we had a different approach on the use of gamification in improving students' outcomes. This approach consists in applying the gamification and the creativity techniques in order to build a successful M-m relationship. In this context we propose a toolkit consisting of game elements, creativity and innovation tools. These can be applied according to the specific of M-m relationship.

First, based on the attributes, skills and gamification player types we have divided the types of mentors and mentees in four categories, as presented in figure 3.1.1.

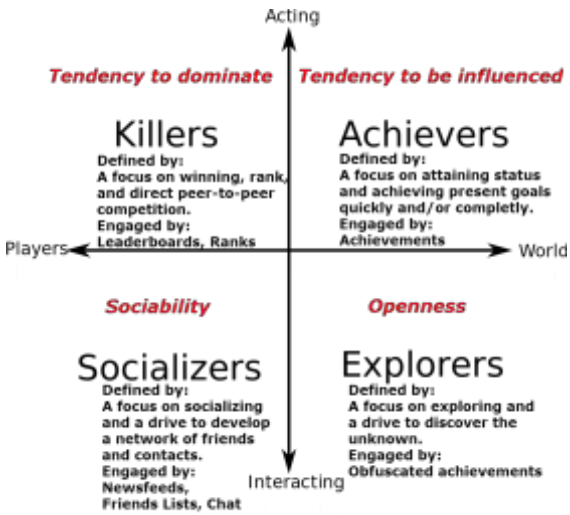


Figure 3.1.1. Gamification player types

The figure 3.1.1. was obtained by combining the attributes and skills identified in the initial experiment regarding M-m relationships with the gamification player types. The attributes and skills are: sociability, openness and dominance. The last one was divided into tendency to dominate and tendency to be influenced. The gamification player types are: killers, achievers, socializers and explorers. The killers focus on winning, rank and direct peer to peer competition and are engaged by leader-boards and ranks. The achievers focus on attaining status and achieving preset goals quickly and/or completely and are engaged by achievements. The socializers focus on socializing and a drive to develop a network of friends and contacts and are engaged by newsfeeds, friends-lists and chat. The explorers focus on exploring and a drive to discover the unknown and are engaged by obfuscated achievements.

The four categories identified in figure 3.1.1. provide a first picture regarding the actors that can be involved in the M-m partnership. And thus appears the questions: "Are there any relationships that are 100% compatible or 100% incompatible?" and "Are there any preset pairings?"

We used the Reframing Matrix (Fig. 3.1.2.) tool in order to determine the different perspectives of solving the mentees problem. This tool helps the mentor and the mentee in solving the mentee's problem, choosing possible solutions from four different perspectives, using brainstorming for problem related factors.

We will present the principles and tools applied for the proposed M-m partnership in a GaInCrEd environment and in order to prove their viability we will show their use for solving a problem. In our case we have considered the problem: "the need to improve learning outcomes".

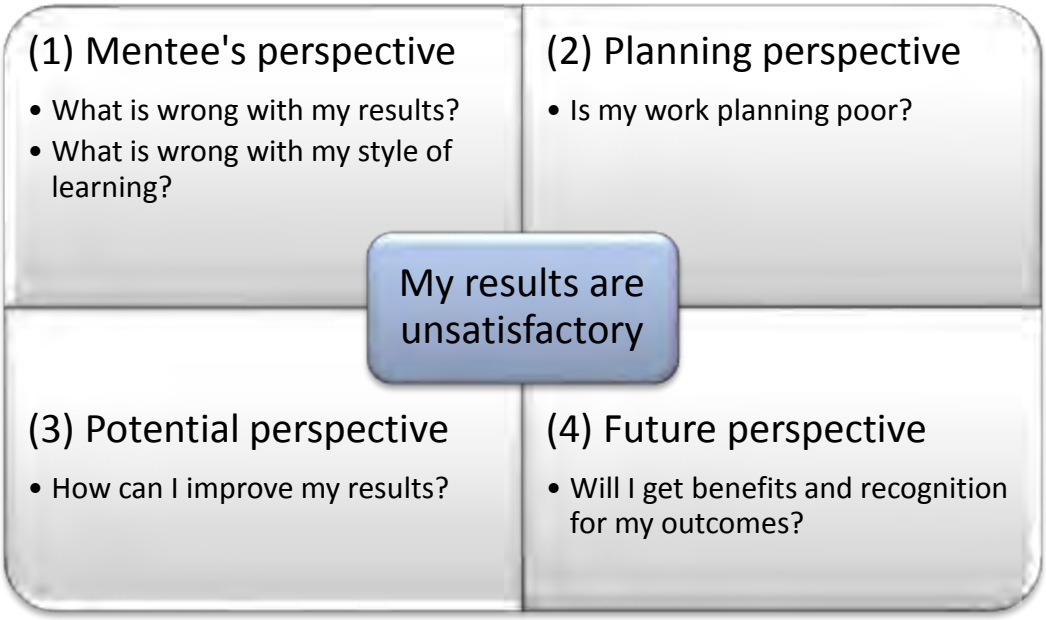


Figure 3.1.2. Reframing matrix example

The questions that the mentee asks and the solutions that the mentor guides the mentee to find define the particularities of their relationship. An interesting technique that the mentor can use is the Perceptual Positions “Seeing Other Points of View” in order to see the problem from the mentee’s point of view. The problem represents a need of the mentee. For translating the identified need to requirements, the mentor will use the “Critical to Quality (CTQ) Tree” technique.

The mentor uses this tool starting from the mentee problem. Then, for each need, he identifies the quality drivers that have to be in place to meet those needs. Finally, the mentor identifies measurable performance requirements that each driver must satisfy.

In order to provide the mentor with a toolkit for efficiently using the CTQ-Tree, we propose the use of several gamification, creativity and TRIZ techniques. For the link between the need and the drivers we found useful the DO IT technique. DO IT is a process for creativity, bundles the general purpose creativity techniques together, and introduces formal methods of problem definition and evaluation. These help the mentor to get the best out of the creativity techniques. DO IT is an acronym that stands for: D – Define problem; O – Open mind and apply creative techniques; I – Identify best solution; T – Transform.

For the considered problem, we identified by using DO IT the main drivers, which are: Learning styles, Plan of activities, Means to improve activities and Motivation system. Next, for each identified driver, the mentor finds the corresponding game elements, TRIZ principles and creativity tools that can be used. There are defined 40 inventive principles of TRIZ with applications in education as follows: 1-Segmentation; 2-Taking Out; 3-Local Quality; 4-Asymmetry; 5-Merging (Combining); 6-Universality; 7-Nested Doll (Matreshka); 8-Anti-Weight (Counter-weight); 9-Preliminary Anti-Action (Prior Counter-Action); 10-Preliminary Action; 11-Beforehand Cushioning (Cushion In Advance); 12-Equipotentiality; 13-The Other Way Round (Inversion); 14-Spheroidality – Curvature; 15-Dynamics; 16-Partial Or Excessive Actions; 17-Another Dimension; 18-Mechanical Vibration; 19-Periodic Action; 20-Continuity Of Useful Action; 21-Skipping (Rushing Through); 22-Blessing In Disguise (Turn Lemons Into Lemonade); 23-Feedback; 24-Intermediary; 25-Self-Service; 26-Copying; 27-Cheap Short-Living Objects; 28-Mechanics Substitution; 29-Pneumatics And Hydraulics (Intangibility); 30-Flexible Shells And Thin Films; 31-Porous Materials; 32-Color Changes; 33-Homogeneity; 34- Discarding And Recovering (Rejecting And Regenerating Parts);

35-Parameter Changes (Transformation Of Properties); 36-Phase Transitions; 37-Thermal Expansion (Expan-sion Of Events Or Processes); 38- Strong Oxidants (Boosted Interactions); 39-Inert Atmosphere; 40-Composite Materials [8].

Table 3.1. Need – Drivers – Performance Requirements

Need		Drivers			Performance Requirements
Achieve better learning results	D O I T	1. Learning styles			Determine and follow the basic guidelines according to the style of learning and the objective of the courses
		Game elements	TRIZ principles	Creativity tools	
		Dynamics (“big picture”): • Constraints • Emotions • Narrative • Relationships	**1 - SEGMENTATION** Break down teaching goals (objectives) into sub-goals. **3- LOCAL QUALITY** Utilize flexible grouping to meet individual student needs. Create educational modules different in content and duration for different organizational levels. **4- ASYMMETRY** Offer asynchronous opportunities to learn. Create interest in learning through unexpected events. (Asymmetrical with respect to the normal schedule) **5- MERGING (COMBINING)** Organize action research groups to study influences, practices, and results of curriculum design. **9- PRELIMINARY ANTI-ACTION (PRIOR COUNTER-ACTION)** Use virtual modules to test out of annual professional development requirements. **13- THE OTHER WAY ROUND (INVERSION)** Allow students to choose preferred learning experiences within course requirements. Let the students teach and the teachers learn.	**BRAINSTORMING** Generating many radical, creative ideas **KANO MODEL ANALYSIS** Achieving the requirements **ARE YOU A POSITIVE OR NEGATIVE THINKER?** Learn about and change how to think	
		2. Plan of activities			The level of accomplishment of immediate goals and long term goals
		Game elements	TRIZ principles	Creativity tools	
		Mechanics (“basic processes”): • Challenges • Chance • Competition • Cooperation • Feedback • Resource acquisition	**1 - SEGMENTATION** Set short-term and long-term goals for successful reform efforts. **2- TAKING OUT** Match new programming and curricula to AYP (Adequate Yearly Progress).	**BRAINSTORMING** Generating many radical, creative ideas **BRAINWRITTING** Getting more from the idea sessions **STARBURSTING** Understanding new ideas by	

		• Rewards • Transactions • Turns • Win states	**3- LOCAL QUALITY** Create differentiated professional development programs. Create differentiated staffing programs. **10- PRELIMINARY ACTION** Provide sign posters and route maps as directions for students and parents. Create a climate for learning that is collaborative, supportive, challenging, and fair. **15- DYNAMICS** Use self -paced learning.	brainstorming questions **REFRAMING MATRIX** Generation different perspectives **THE DISNEY CREATIVE STRATEGY** Fusing imagination and planning	
		3. Means to improve activities			
		Game elements	TRIZ principles	Creativity tools	
		Components: • Achievements • Boss fights • Combat • Content unlocking • Gifting • Levels • Quests • Teams	**3- LOCAL QUALITY** Organize the classroom with worktables, movable seats, and resource centers versus podiums, lecterns, and raised platforms at the front of the room. **4- ASYMMETRY** Create an engaging and welcoming environment. **5- MERGING (COMBINING)** Create a cafeteria /auditorium **6- UNIVERSALITY** Utilize test scores for regulatory statistics as well as student grading. (Program evaluation as well as individual student evaluation) **8- ANTI-WEIGHT (COUNTERWEIGHT)** Create interesting homework assignments. **13- THE OTHER WAY ROUND (INVERSION)** Have students assess themselves. **14- SPHEROIDALITY – CURVATURE** Build the curriculum in a spiral manner that enables students to continually build on what they have already learned. **17- ANOTHER DIMENSION** Use experiential learning rather than theoretical learning. Create homework hotlines and virtual support beyond school day. **21 - SKIPPING (RUSHING**	**BRAINSTORMING** Generating many radical, creative ideas **REVERSE BRAINSTORMING** A different approach to brainstorming **CRAWFORD'S SLIP WRITING METHOD** Generating ideas from many contributors **RANDOM INPUT** Making creative leaps **METAPHORICAL THINKING** Using comparisons to express ideas and solve problems **PROVOCATION** Carrying out thought experiments **SCAMPER** Means of improvement **PRACTICAL INNOVATION** Managing ideas effectively **GENERATION NEW IDEAS** Think differently and spark creativity **SYNECTICS** A useful "backstop" creativity process **COGNITIVE RESTRUCTURING** Reducing stress by changing the way you think	Reduce and eliminate anger, stress, anxiety

			THROUGH) Utilize formative assessment e.g., fail fast - learn fast. **22 - "BLESSING IN DISGUISE" (TURN LEMONS INTO LEMONADE)** Eliminate fear of change by substituting fear of competition. **38 - STRONG OXIDANTS (BOOSTED INTERACTIONS)** Create an interactive learning environment. **39 - INERT ATMOSPHERE** Maintain atmosphere free of judgment and criticism at brainstorming sessions.		
		4. Motivation system			Improve outcomes, grades; obtain scholarship
		Game elements	TRIZ principles	Creativity tools	
		Components: • Badges • Collections • Leader-boards • Points • Virtual goods	**6- UNIVERSALITY** Utilize test scores for regulatory statistics as well as student grading. (Program evaluation as well as individual student evaluation) **7- "NESTED DOLL" (MATRESHKA)** Use practice, homework, and assessment techniques to make students accountable. Provide cognitive dissonance during classroom teaching. **8- ANTI-WEIGHT (COUNTERWEIGHT)** Create special events to reward student effort. Use special events to showcase student talents. Use technology to create interest and to minimize non-essential tasks. **35 - PARAMETER CHANGES (TRANSFORMATION OF PROPERTIES)** Motivate students by providing them honors degrees and certificates. **37 - THERMAL EXPANSION (EXPANSION OF EVENTS OR PROCESSES)** Utilize methods to encourage students to be excited about their subjects.	**BRAINSTORMING** Generating many radical, creative ideas **TURN YOUR IDEA INTO REALITY** Getting good ideas off the drawing board **THE HAMBURGER MODEL** Finding the right path to happiness **BOOSTING YOUR SELF-ESTEEM** Improving the way you feel about yourself	

In order to evaluate the M-m relationship resulted after applying the above creativity and gamification techniques we used a model that integrates the best elements of SERVQUAL and QFD methods. The proposed model computes the overall index that measures the level of the requirements accomplishment in the M-m relationship context. There were followed the well-known steps involved in the QFD method.

Table 3.2. Requirements grouped in classes

SERVQUAL class	Code	Requirement
Reliability	CR1	Easily solve the requests
	CR2	Determine and follow the basic guidelines according to the style of learning and the objective of the courses
Responsiveness	CR3	Accomplishment of immediate goals
	CR4	Accomplishment of long term goals
Assurance	CR5	Reduce and eliminate anger, stress, anxiety
	CR6	Friendly environment
Empathy	CR7	Treated with kindness and compassion
Tangibles	CR8	Improve outcomes, grades
	CR9	Obtain scholarship

Table 3.3. Quality characteristics grouped in classes

SERVQUAL class	Code	Characteristic
Process	QC1	Flexible and open meeting schedule
	QC2	Establish together learning objectives
	QC3	Organize study and research groups
	QC4	Guided self-paced learning
	QC5	Guided self-assessment
	QC6	Create special events
People	QC7	Explain understandable to the mentee
	QC8	Good communication abilities
	QC9	Use motivational approach
	QC10	Wide range of competences
Physical environment	QC11	Engaging and welcoming environment

The detailed requirements of the M-m relationship from the mentee's point of view are derived from the performance requirements from table 3.1 and were grouped in five classes as presented in table 3.2. The quality characteristics were also grouped in classes as in table 3.3.

In order to apply the model resulted from the combination of QFD and SERVQUAL we used the technique of questioners. The global index that reflects the mentee's requirements accomplishment level is shown in figure 3.1.3.

We obtained an offset of 75.84%, representing the mentee's requirements accomplishment level by the quality characteristics in the M-m relationship context. This value represents a quantification of the M-m relationship from the point of view of the mentee. The same relationship could be evaluated from the point of view of the mentor, using the same methodology. The analysis of similarities and differences between the resulted offsets are subject to further research.

SERVQUAL - QFD evaluation of the Mentor - mentee relationship

~ from the mentee point of view ~

			Process						People				Physical environment
		c	QC1	QC2	QC3	QC4	QC5	QC6	QC7	QC8	QC9	QC10	QC11
Reliability	CR1	4	0.075	0.040	0.110	0.068	0.041	0.038	0.079	0.066	0.092	0.070	0.045
	CR2	4	0.000	0.240	0.028	0.136	0.082	0.038	0.040	0.033	0.092	0.070	0.000
Responsiveness	CR3	3	0.075	0.160	0.055	0.068	0.082	0.000	0.079	0.000	0.184	0.070	0.000
	CR4	2	0.075	0.160	0.055	0.102	0.082	0.000	0.040	0.000	0.184	0.070	0.000
Assurance	CR5	3	0.075	0.000	0.055	0.068	0.082	0.076	0.079	0.066	0.092	0.070	0.090
	CR6	4	0.150	0.000	0.000	0.000	0.000	0.076	0.158	0.132	0.184	0.000	0.090
Empathy	CR7	2	0.075	0.000	0.000	0.000	0.000	0.076	0.158	0.132	0.184	0.000	0.180
Tangibles	CR8	4	0.000	0.080	0.110	0.136	0.082	0.038	0.079	0.066	0.138	0.000	0.000
	CR9	1	0.000	0.000	0.110	0.204	0.205	0.000	0.000	0.000	0.230	0.000	0.000
	e		1.65	2.24	1.54	2.176	1.681	1.14	2.291	1.65	3.818	1.12	1.17

OFFSET	75.84%

Figure.3.1.3. SERQUAL – QFD evaluation result

There can be established a satisfaction grill based on the computed offset values. The proposed grill is presented in table 3.4.

Table 3.4. Satisfaction grill

Satisfaction level	Index value
Completely unsatisfied	0 – 20 %
Unsatisfied	20 – 40 %
Satisfied	40 – 60 %
Very satisfied	60 – 80 %
Completely satisfied	80 – 100 %

The offset of 75.84% obtained for the mentee is placed in the “Very satisfied” category. This proves that the creativity and gamification approach leads to a successful M-m partnership.

3.2. Self-Directed Learning – Challenge for and Necessity of the Education

Another component of the SSS is linked to the Self-Directed Learning (SDL). Our research focused on the complex concept of Self-Directed Learning, with the main objective to explore the possibilities of using SDL values in the transfer of knowledge within new learning. We have used two methods of research: a quantitative method (the questionnaire) and a qualitative method (the focus group). We have also used the targeted sampling, the questionnaire being applied to four categories of respondents: students in day courses, students from distance learning, Master students and students in an adult training program. The targeted sampling applied to these distinct categories was achieved with the purpose of highlighting the differences between the respondents’ perception and use of SDL in the context of modern learning.

The research is highly specific, targeting SDL in the field of quality. We have chosen this area to meet the ever growing importance of the implementation of quality management systems and the increasing demand for certain specific jobs in the quality field on the labor market. For that, we selected the categories of respondents that have in common “quality management”, as it follows: students in day courses and distance learning that have “Quality management” courses in the

academic curricula, Master students in “Management and Quality Assurance”, students in the adult training program “Quality manager in the construction field” .

We structured the questionnaire in three sections. First section provide background information (structure of respondents by age and education form), the second contains questions focused on SDL issues and third section is dedicated to SDL in the quality field. The questionnaire was applied to all students from the four forms of education, which have presented on examinations (a total of 98 validated questionnaires), being completed by a focus group with students in day courses. The research was conducted during July 2009-February 2010.

The structure of respondents (students) grouped by education forms and age groups is showed in the Figure 3.2.1. and Figure 3.2.2.

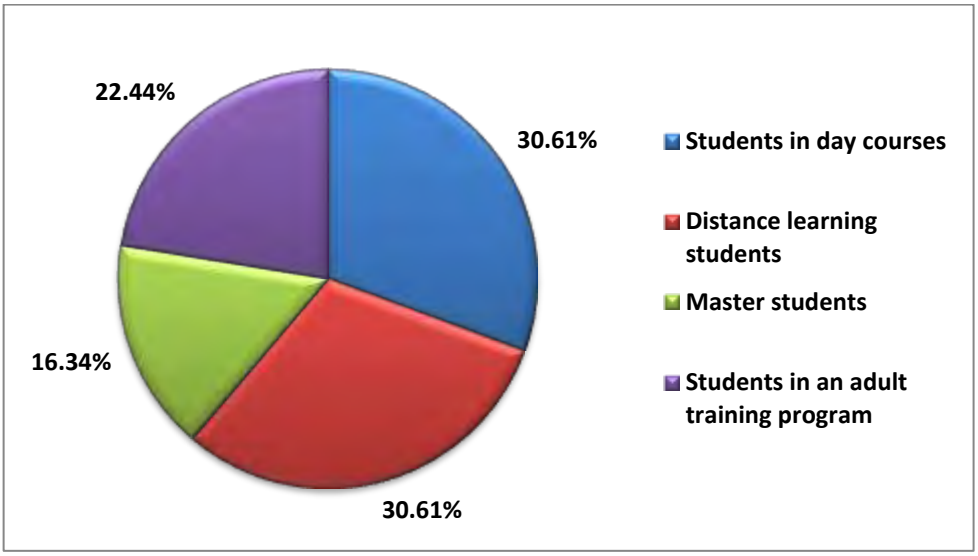


Figure 3.2.1. Students’ structure by education forms, %

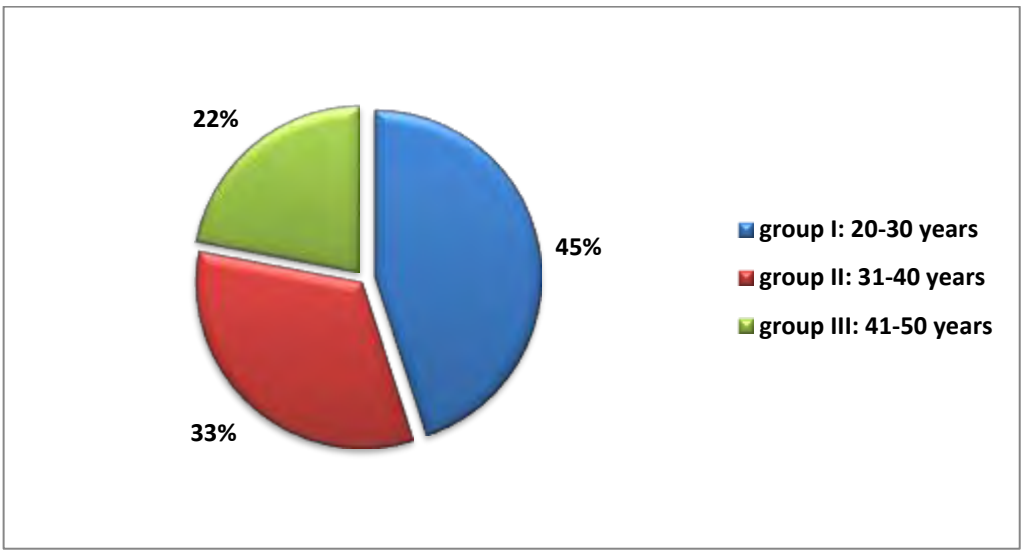


Figure 3.2.2. Students’ structure by age groups

Figure 3.2.3. reflects the interest shown by respondents to the research topic. The results show that most respondents (93.33% of students from distance learning, 91.66% of students from

training adults program, 82.74% of students in day courses and 75% of Master students) have rated their own interest in SDL with high scores (5 and 4 points), suggesting that it is perceived as an important issue by the many of students.

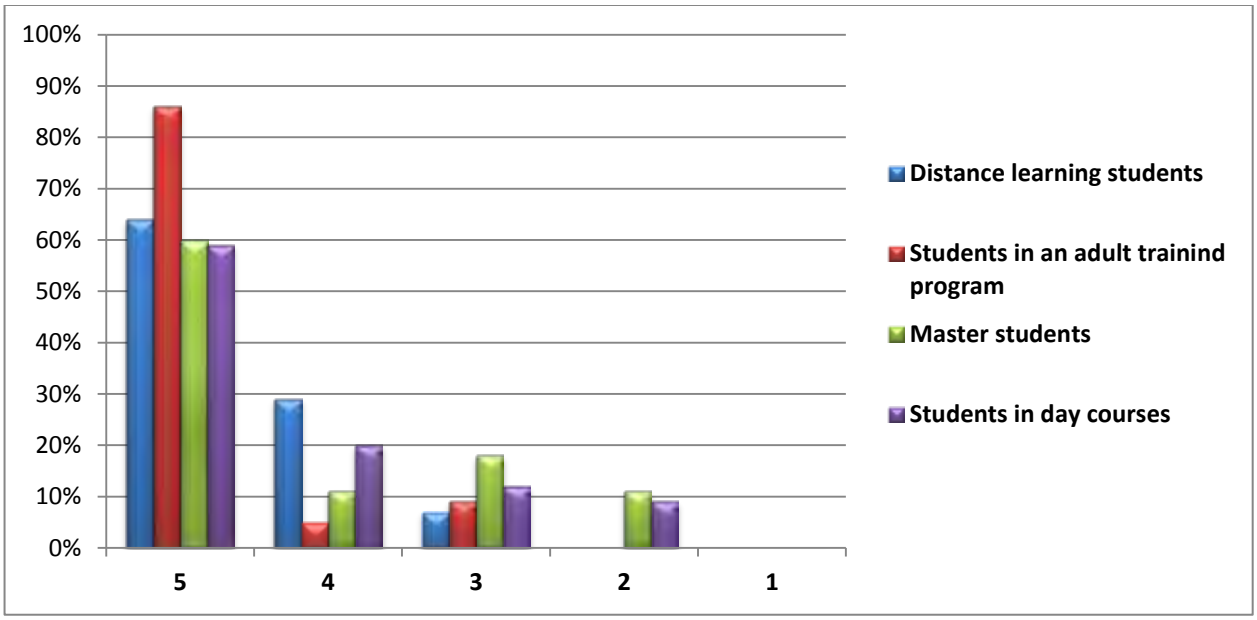


Figure 3.2.3. The perceived importance of SDL

A significant part of respondents (average 44.89%) thinks they know “in a relative measure” how to learn (self-learning).

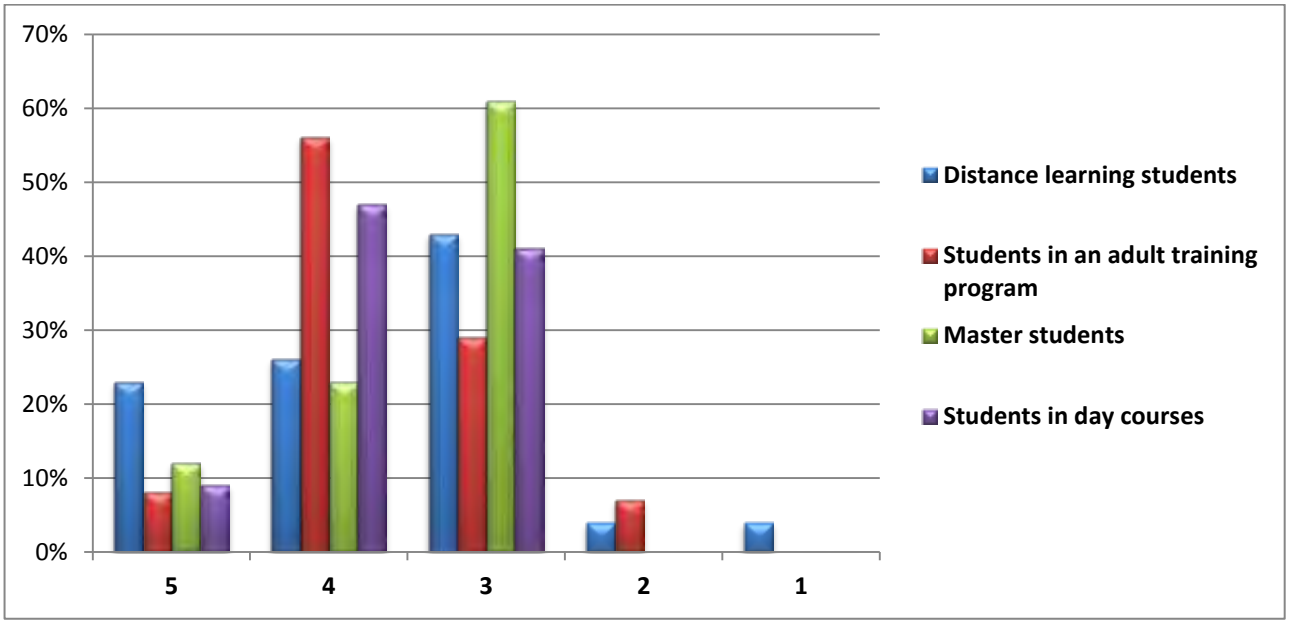


Figure 3.2.4. The measure to which respondents believe they know how to learn

Concerning the ways of acquiring knowledge, skills and abilities of self-learning, the respondents have focused on 2 versions in most of their answers (Fig. 3.2.5.), showing that they think have acquired these knowledge, skills and abilities themselves during the years of study (a) and during the class hours (d).

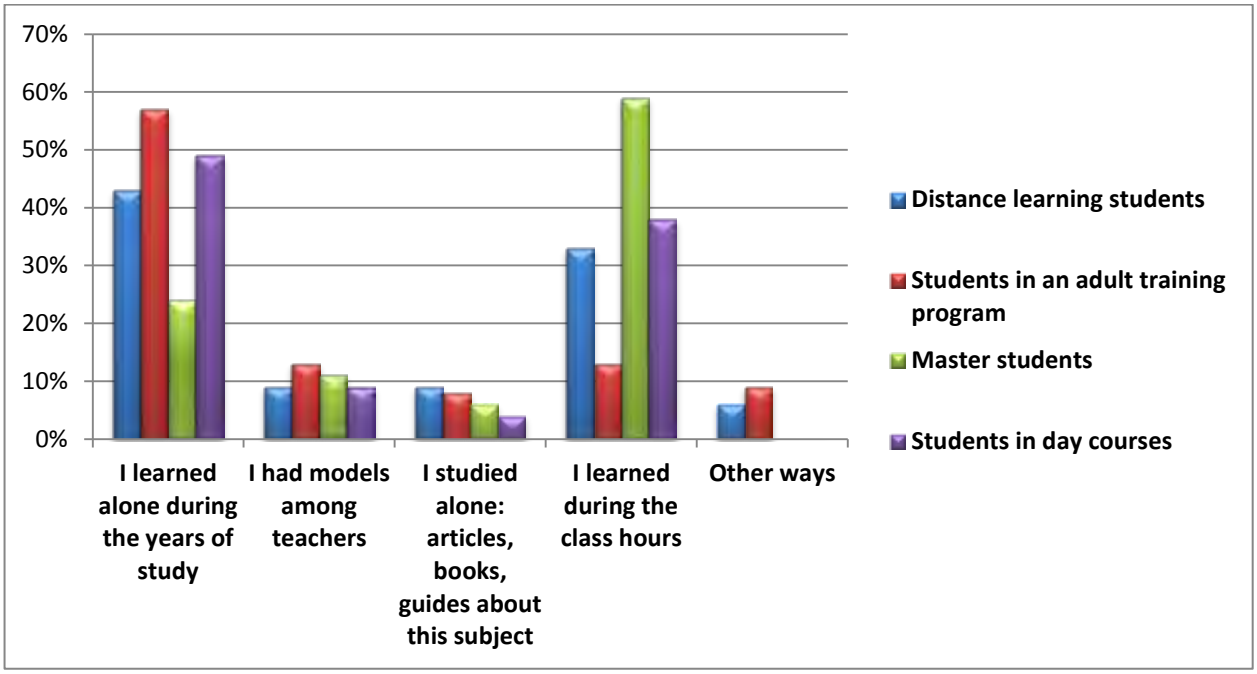


Figure 3.2.5. The ways of acquiring knowledge, skills and abilities of SDL

The students' motivation for attendance courses is presented in the Figure 3.2.6.

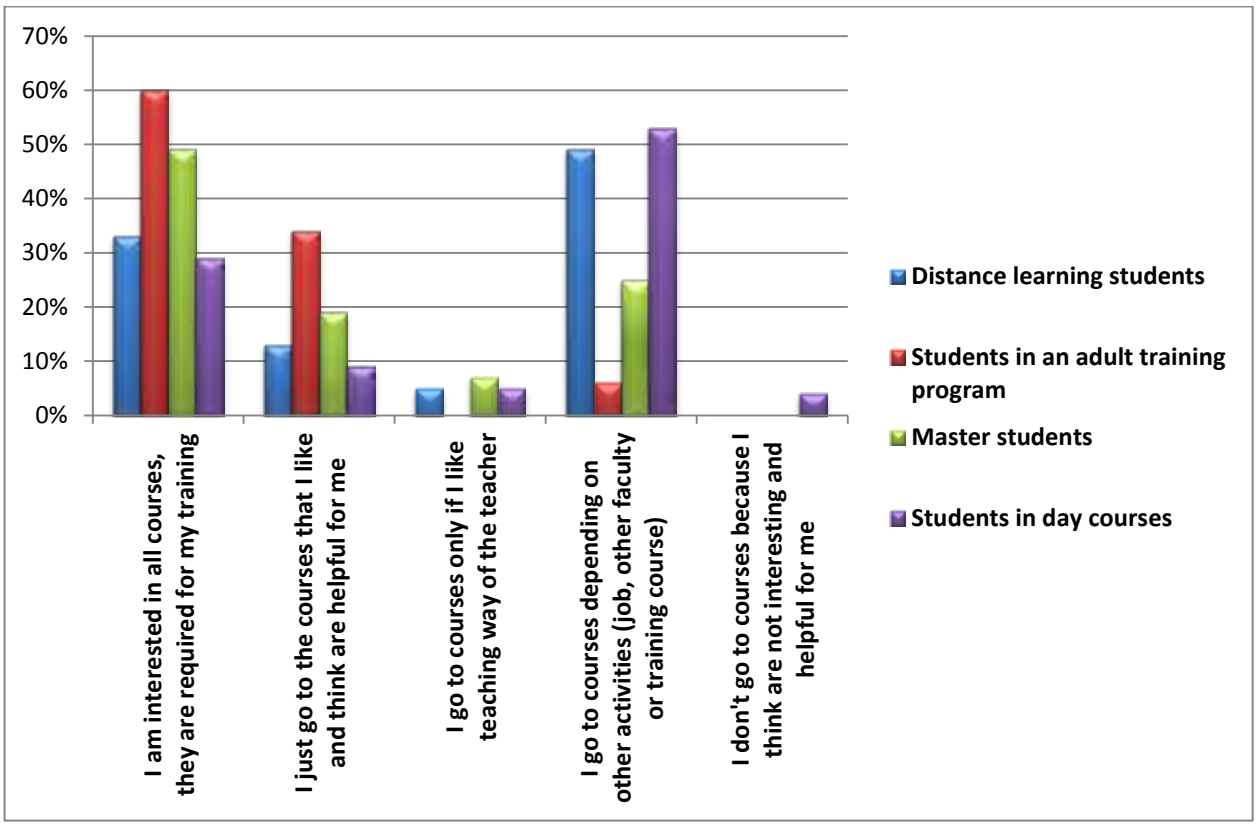


Figure 3.2.6. The students' motivation for attendance courses

As we can see, the many students from the training adults program (60.86%) and from Master (50%) believe that all courses are required for their professional training, while students from the

day courses (53.33%) and distance learning (50%) admit to attend classes depending on other activities (job, other faculty, etc.).

The lack of SDL courses in academic curricula is clearly perceived by students, their answers showing that about 80% of respondents would attend such courses. In this context the main reasons why students believe should attend SDL courses are shown in Figure 3.2.7.

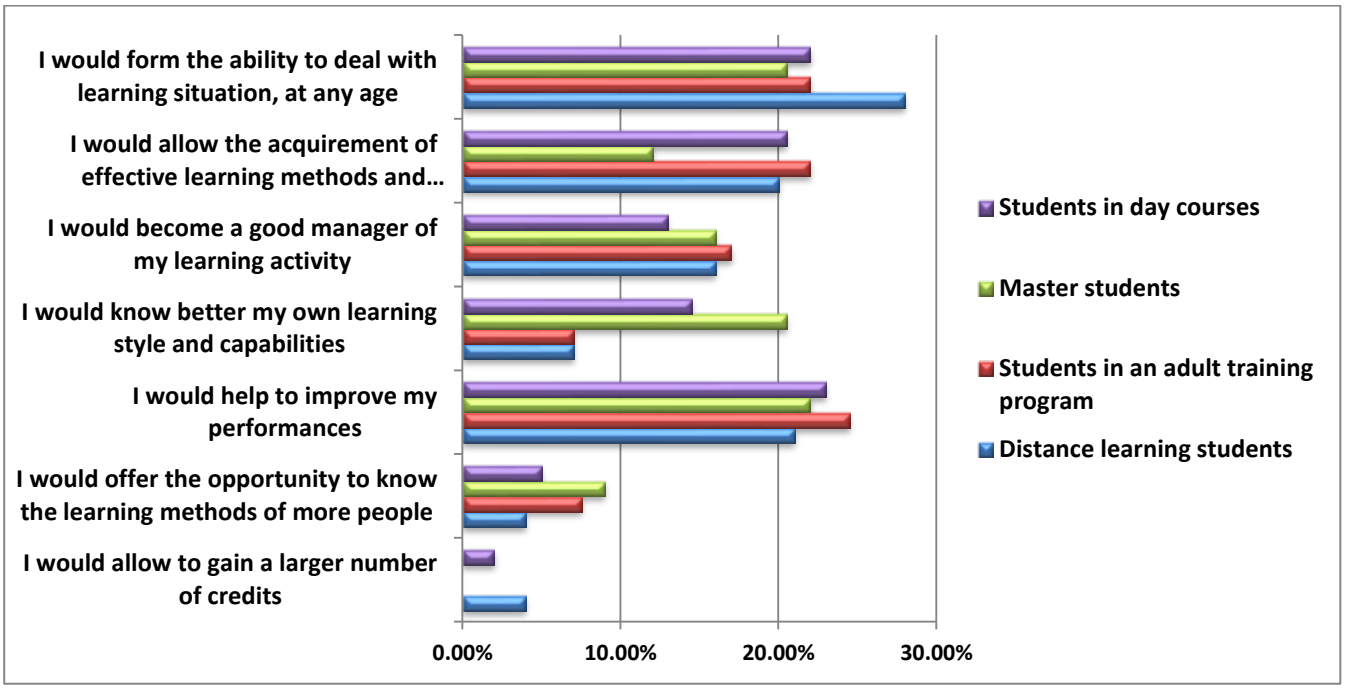


Figure 3.2.7. The reasons why students believe should attend SDL courses

In terms of the specific SDL techniques (Figure 3.2.8.), the answers show that the most known and used by many respondents is the clear setting of the learning purpose (a), except Master students which place on the first rank the timely preparing of themes and topics for exams (d).

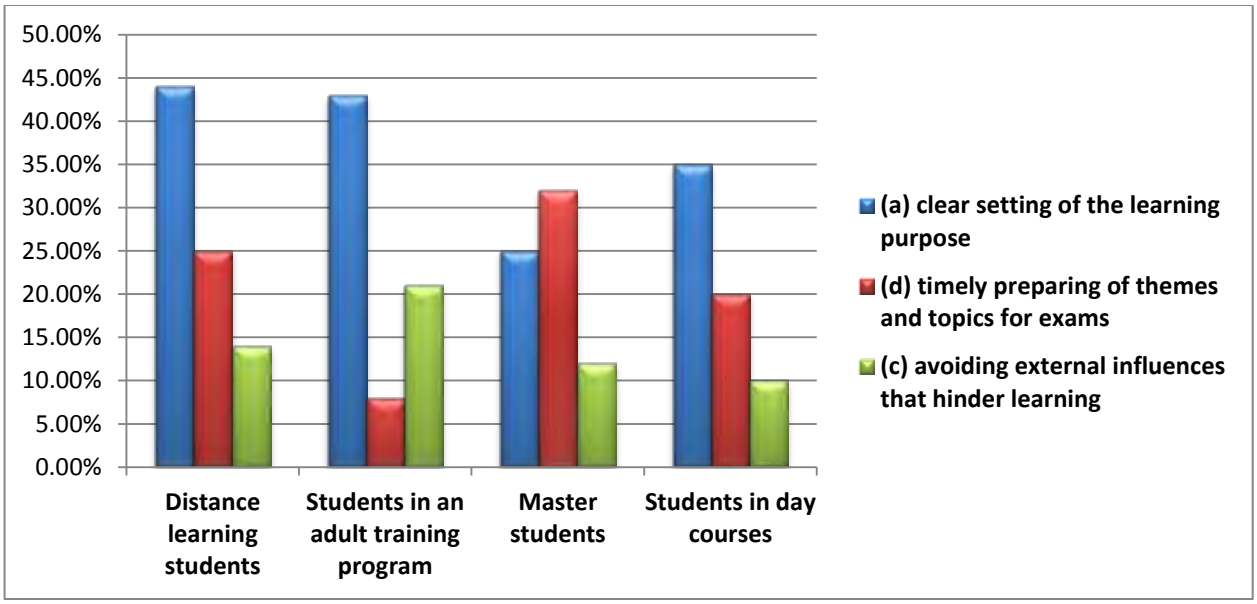


Figure 3.2.8. The use of the most known SDL techniques

(b) planning the steps of the study
(e) optimal dosing of the amount of information per time unit

The section of the questionnaire dedicated to SDL in quality field show an encouraging situation: 80% of respondents consider that topics related to quality management contributes in a great or a very great measure to the formation of a "quality culture", and that SDL help to acquire such a quality culture.

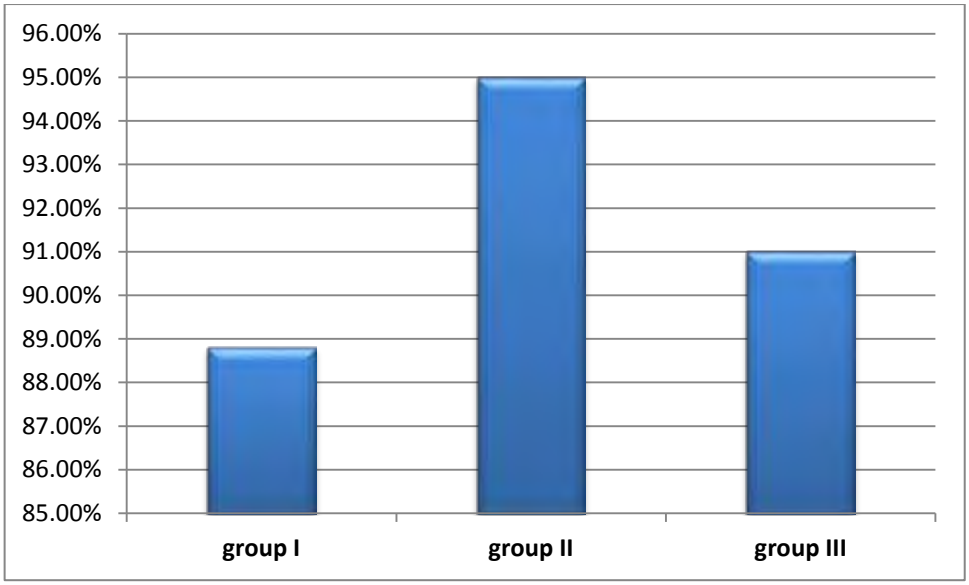
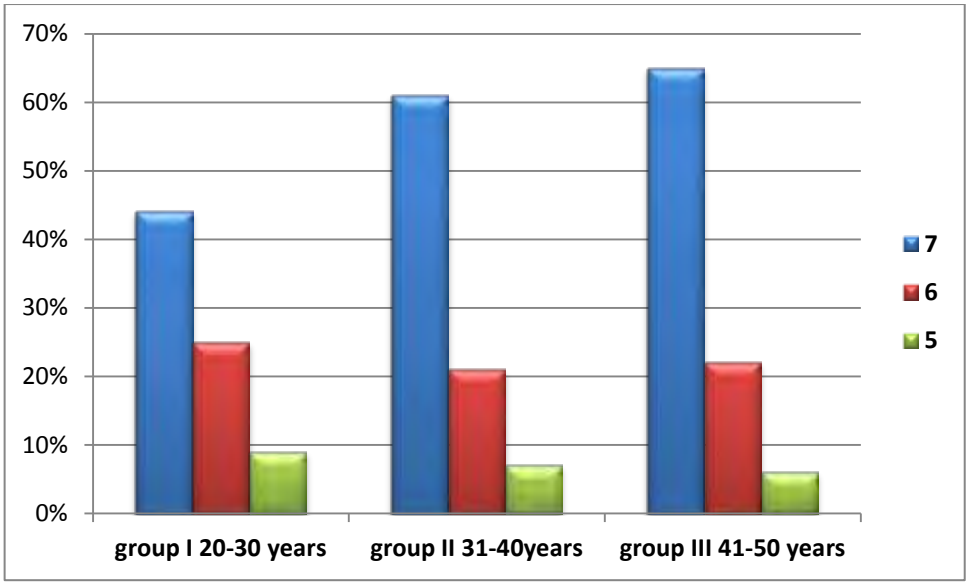


Figure 3.2.9. The importance given to SDL by age groups



(7) I would form the ability to deal with any learning situation, at any age
(6) I would allow the acquirement of effective learning methods and techniques
(5) I would become a good manager of my learning activity

Figure 3.2.10. Top three reasons why students believe should attend SDL courses, by age

Analyzing the main reasons why students would be willing to appeal to self-learning for addressing the quality issues we noticed that all respondents have ranked first their interest in the quality field. However, the other specified reasons were differently ranked by the four categories of students. Thus, the students from Master and from distance learning have placed on the following two positions (rank 2 and 3): the specific requirements of the job (b) and perspectives of career development in the quality field (f). These reasons are found also for the students in day courses category, but in reverse order. At the same time, for the category of students from training adults program the two following important reasons are: perspectives of career development in the quality field (f) and requirements of implementing quality management system in the organization (d).

Finally, we believe that is interesting also to highlight few overall findings of our study related to the three age groups of the students respondents. Thus, we noticed that the importance given to the research topic (SDL) is significant for all age groups (Figure 3.2.9.) and such a relative similarity appears also in top three reasons considered determining in attendance the specific SDL courses (Figure 3.2.10.).

On the other hand, best known and used SDL methods and techniques seem to be different between age groups. While the most respondents of group I (20-30 years) have ranked first the techniques for reading fast and efficient (f), the many respondents of group II (31-40 years) and III (41-50 years) have placed first the clear setting of the learning purpose (a).

Regarding the main reasons why respondents would be willing to appeal to self-learning in quality field, the first reason is the same for all age groups (the interest in the field), but the second reason is different (specific requirements of the job - for group I and the perspectives of career development in quality field - for groups I and III).

Even if our study initially focused on the implications regarding the students (SDL development courses in the academic curricula, SDL programs for teaching students), we have noticed that the educational system should mainly support and encourage SDL practices since the beginning of school, and that there also should be a solid partnership between training/education and working environments.

3.3. Entrepreneurship Education: Meanings and Needs

As we noticed the student's life cycle ends with the employment. So, we tried to find out if the entrepreneurship education and training prepares them to be successful entrepreneurs. The starting point was a survey on students from the University of Petrosani concerning the generic skills required to start-up and successfully run a small business.

A number of 241 students from the University of Petrosani (undergraduate in economics, Management specialization, full time and distance-learning) defined the survey area. The poll's base was made of the entire student body attending courses of "Business Administration" included as optional discipline in the educational programme of management specialization during the period of survey (October 2008-February 2009)

The applied questionnaire (consisting of 50 items) estimates the chances of becoming a successful entrepreneur, as related to the main personal characteristics and skills required to start-up and profitably run a small business more than two years after starting. By scoring in accord with these terms are distinguished five categories of possible respondents as follows:

(1) 93 – 150 points: respondents with the more chances of success (a probability of 75% to start-up and profitably stay in business more than two years).

(2) 87 – 92 points: respondents with considerable chances of success (about 60% may run the business in profit at least two years after the start-up) which grow on if a partnership with a right person is undertake.

(3) 82 – 86 points: respondents with some chances of success on their own account (about 20%) but with a possible increasing (to around 60%) by jointing in a franchise business system.

(4) 76 – 81 points: respondents with fewer chances of success (only around 10% of these people can stay in business more than two years).

(5) 0 – 75 points: respondents with the minimum chances of success (the many goes to bankrupt in less than one year).

The overall distribution of the students of our sample within the five scoring categories as resulted after applying questionnaire is exhibit in the figure 3.3.1.

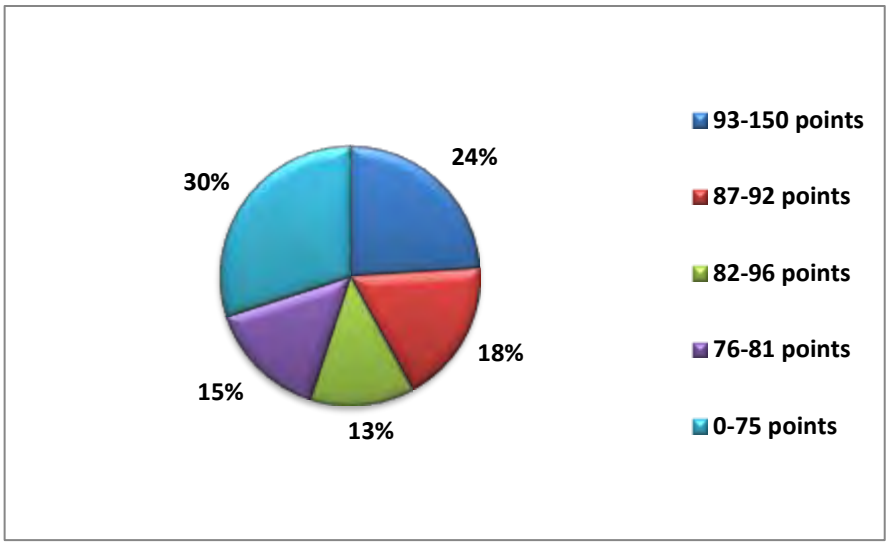


Figure 3.3.1 Students' distribution (by weight) within the five scoring categories

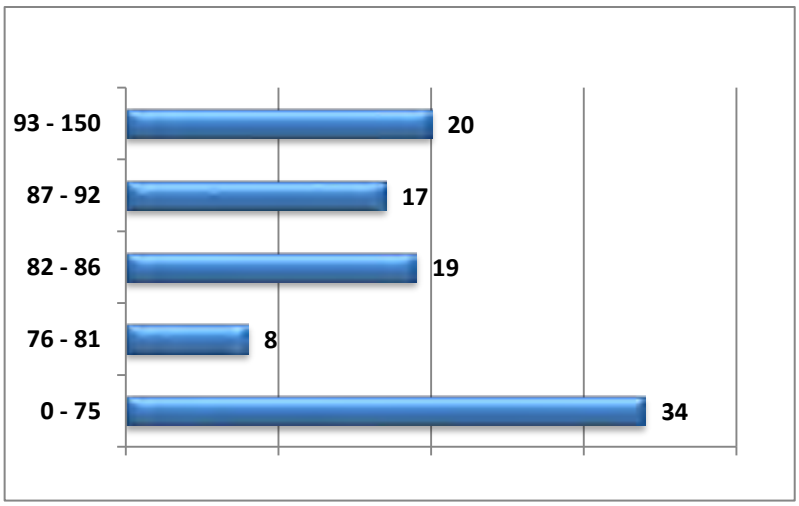


Figure 3.3.2 Distribution of full time students by the reached scores

Thus, the scores reached by the questioned students revealed the prevalence of the last mentioned category showing that most of them (around 30% of total) seem unlikely to succeed as entrepreneurs. The analysis of the results grouped by the type of learning showed some differences between the distribution of full time students and distance-learning students within the five scoring categories (see figures 3.3.2 and 3.3.3).

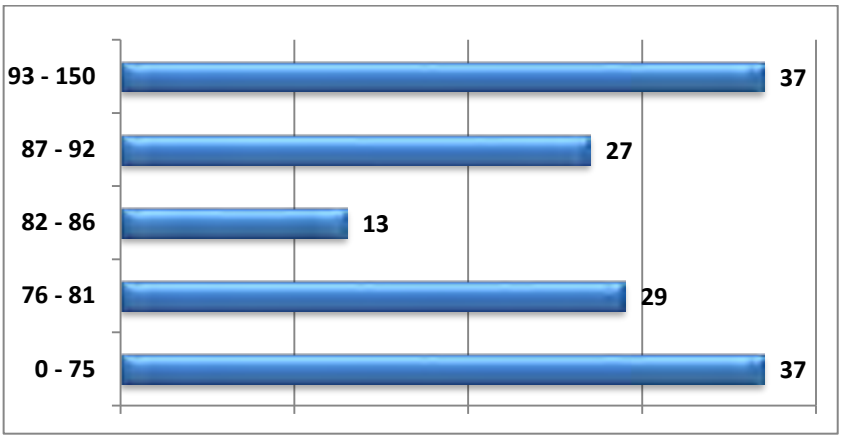


Figure 3.3.3. Distribution of distance-learning students by the reached scores

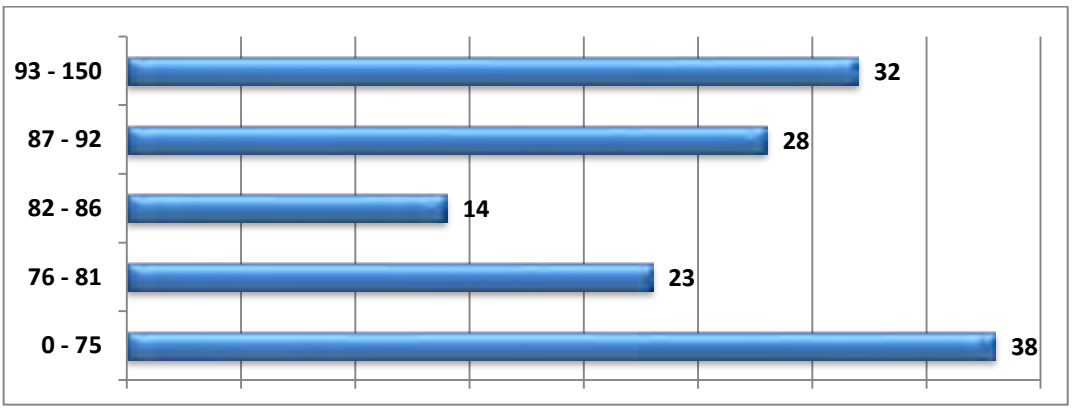


Figure 3.3.4 Distribution of female students by the reached scores

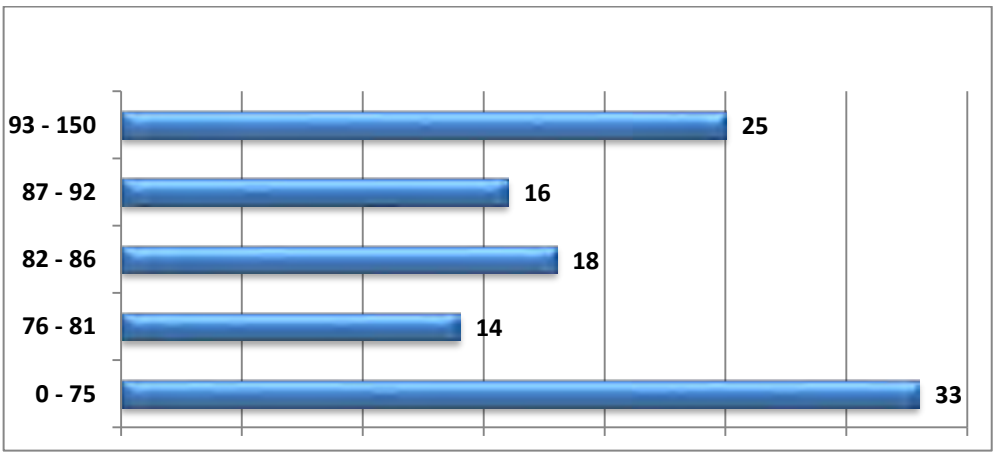


Figure 3.3.5 Distribution of male students by the reached scores

As can observe in the above figures, the gap between the “successful entrepreneurs” category and the one diametrically opposed become higher in the group of full time students (20.4% vs. 34.7% of total group) while is cancel out in the group of distance-learning students (equally weights of 25.9% of total group). The other direction of analysis of our survey’s results that we choose to present in this paper is argued by its relevance to the EU entrepreneurship agenda as for the topic of unlocking the entrepreneurial potential of women, which has yet to be further exploited. Thus, the analysis of the results grouped by the gender (see figures 3.3.4 and 3.3.5) revealed a quite balance situation of female and male students belonging to the „successful entrepreneurs” category (23.7% of total female students vs. 23.6% of total male students).

Moreover, we can consider that the entrepreneurial potential of woman as reflected by the distribution weights of the opposite category (with the minimum chances of success) seems to be sensible more promising (28.1% of total female students vs. 31.1% of total male students belonging to this category).

Entrepreneurship - A Key Competence

The progress report on the implementation of Education & Training 2010 Work Programme (drawing up by the Working Group “Basic skills, entrepreneurship and foreign languages”, 2003) clarified the term ‘*competence*’ as considered to refer to a combination of skills, knowledge, aptitudes and attitudes, and to include disposition to learn as well as know-how. Accordingly, „*key competences* represent a transferable, multifunctional package of knowledge, skills and attitudes that all individuals need for personal fulfilment and development, inclusion and employment. These should have been developed by the end of compulsory school or training, and should act as a foundation for further learning as part of Lifelong Learning*”*.

The definition of the entrepreneurship as a key competences refer to a passive and an active component, meaning that „it comprises both the propensity to induce changes oneself and the ability to welcome, support and adapt to innovation brought about by external factors. Entrepreneurship involves taking responsibility for one’s actions, positive or negative, developing a strategic vision, setting objectives and meeting them and being motivated to succeed”.

Consequently, there is a real need for education and training in order to acquire and develop these entrepreneurship competences.

In February 2006 European Commission (EC) published the Communication "Implementing the Community Lisbon Programme: Fostering Entrepreneurial Mindsets through Education and Learning". According with the above mentioned meanings of the entrepreneurship education and competences, the Communication calls the member states to concert their specific initiatives as a part of a coherent framework and aims to support them in developing a more systematic strategy for entrepreneurship education.

That is one of the purposes of the „EU – Survey on Entrepreneurship in Higher Education in Europe”. In the survey context, entrepreneurship education is defined “as that in which the entrepreneurship courses aim to foster entrepreneurial mind sets, attitudes and skills and can cover a range of aspects such as idea generation, start-up, growth and innovation”.

3.4. Creativity and Gamification – the Link between Discovery and Learning for Educational Innovation

Creativity is considered a resource that "waits" to be discovered. In our work, the students have a high creativity potential. Our goal is not only to teach them, but to help them discover things. There are several previous approaches regarding the relationship between the eLearning systems and the creativity, but only from the point of view of eLearning systems that can stimulate the creativity. We want to complete this relationship adding the use of creativity to improve eLearning. The starting point of our research was the students' satisfaction degree regarding the present eLearning systems from the Romanian universities. In order to achieve a high improvement of the students' perception regarding eLearning there must be changed something regarding the eContent, including elements of creativity and gamification and involving the students in the eContent development process.

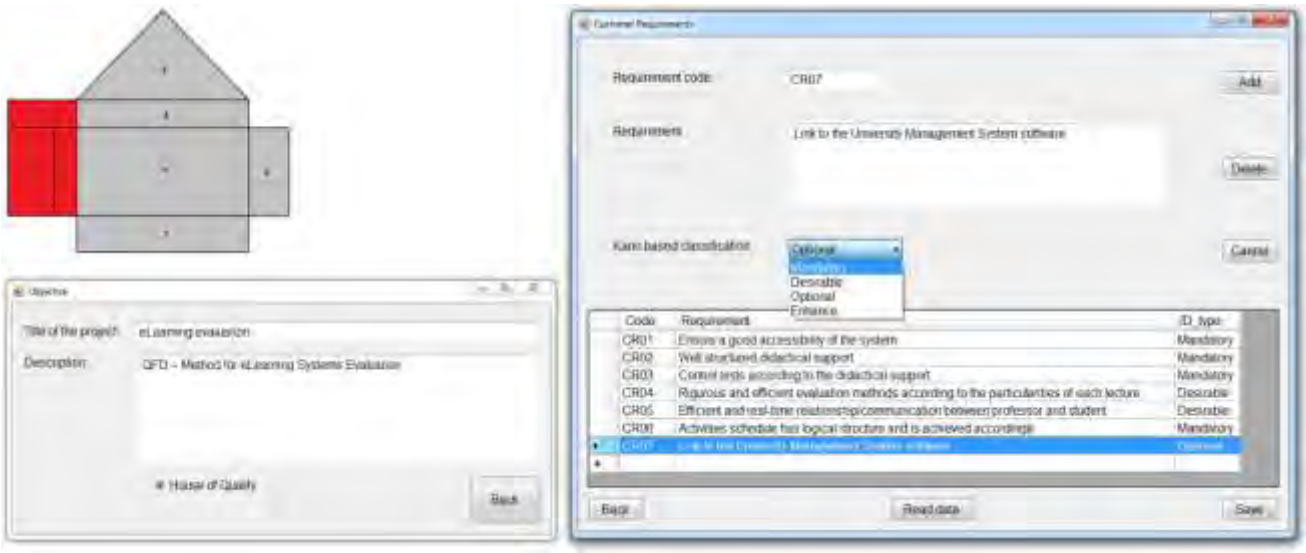


Figure 3.4.1. Customers' requirements

Quality characteristics:

QC01. Pedagogical methods implemented in the system
QC02. Users' security
QC03. Synchronous interactivity (both remote and in situ)
QC04. Asynchronous interactivity
QC05. Forum, chat, email
QC06. Online accessibility
QC07. Scale=200 (number of participants involved simultaneously in a learning activity)
QC08. Ensure the quality of the technical characteristics for the didactical support
QC09. Symmetry of the system (degree of focusing on each participant)
QC10. Interactivity (response time)
QC11. Tools of the system available for learning activities
QC12. Level of cooperation and communication of one student with other students and professors
QC13. Possibility to integrate information from different sources and to represent it in different modes
QC14. Costs of each participant involved in a learning activity
QC15. Time (possibility to browse content at own pace)
QC16. Flexibility of the system for upgrading according to users suggestions

Figure 3.4.2. Quality characteristics

We have evaluated the students' satisfaction degree regarding the eLearning platform from the University of Petrosani. The platform was implemented in the context of the POSDRU project Higher education human resources development in the use of e-Learning system, POSDRU 87 / 1.3 / S / 64273. In order to evaluate the students' level of satisfaction we used the Quality Function Deployment (QFD) method. There was obtained a satisfaction degree of 52.65%.

First there were identified the customers' (lecturers and students) requirements (figure 3.4.1.) and the quality characteristics of the eLearning system (figure 3.4.2.).

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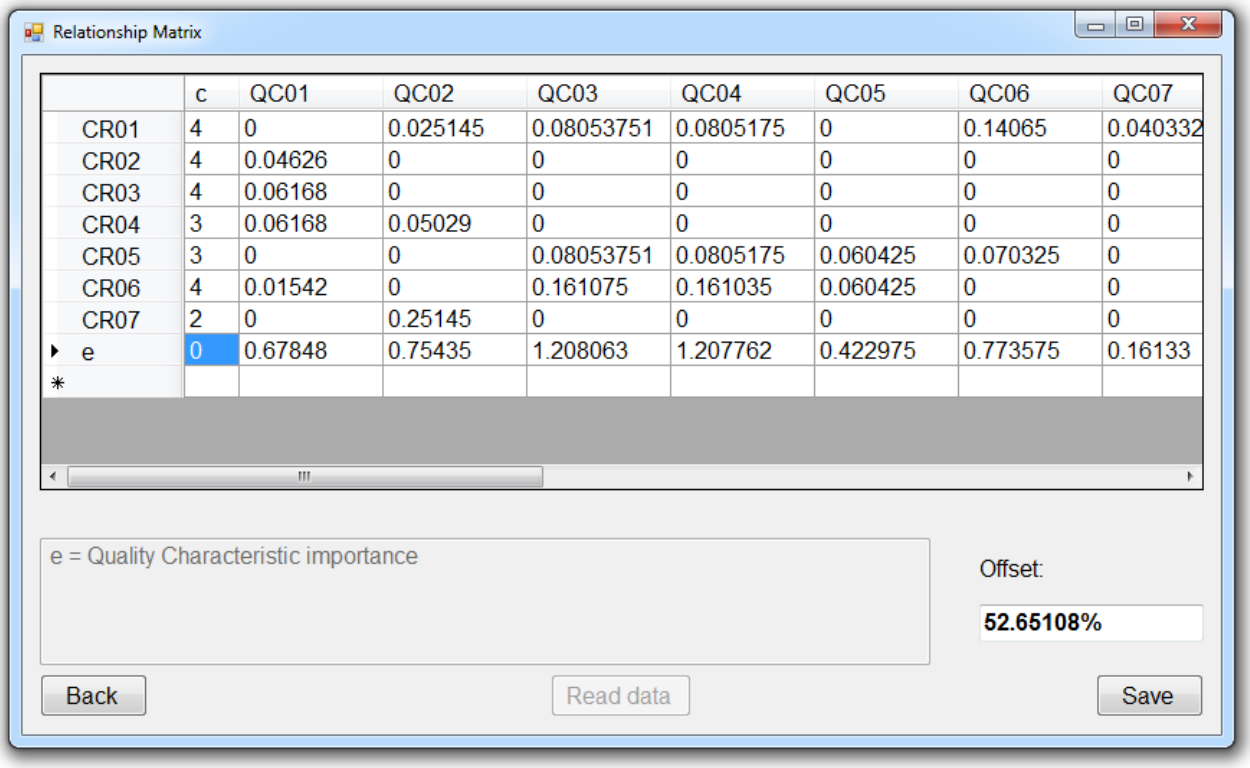

Relationship Matrix

	c	QC01	QC02	QC03	QC04	QC05	QC06	QC07
CR01	4	0	0.025145	0.08053751	0.0805175	0	0.14065	0.040332
CR02	4	0.04626	0	0	0	0	0	0
CR03	4	0.06168	0	0	0	0	0	0
CR04	3	0.06168	0.05029	0	0	0	0	0
CR05	3	0	0	0.08053751	0.0805175	0.060425	0.070325	0
CR06	4	0.01542	0	0.161075	0.161035	0.060425	0	0
CR07	2	0	0.25145	0	0	0	0	0
e	0	0.67848	0.75435	1.208063	1.207762	0.422975	0.773575	0.16133

e = Quality Characteristic importance

Offset:

52.65108%

Back Read data Save

Figure 3.4.3. Offset value based on students eLearning system evaluation

In order to achieve a high improvement of the students' perception regarding eLearning system there must be changed something. We believe that creativity would be the key ingredient of this change. The result: professors and students working together to create and develop an attractive and useful eContent. The students must be motivated in order to consider an eContent as attractive and useful. The motivation can be intrinsic or/and extrinsic. The extrinsic motivation is related to the obtained results that are different kind of rewards. The intrinsic motivation is the path towards these rewards. This path means the use of creativity techniques and self-directed learning (SDL) techniques joint by gamification.

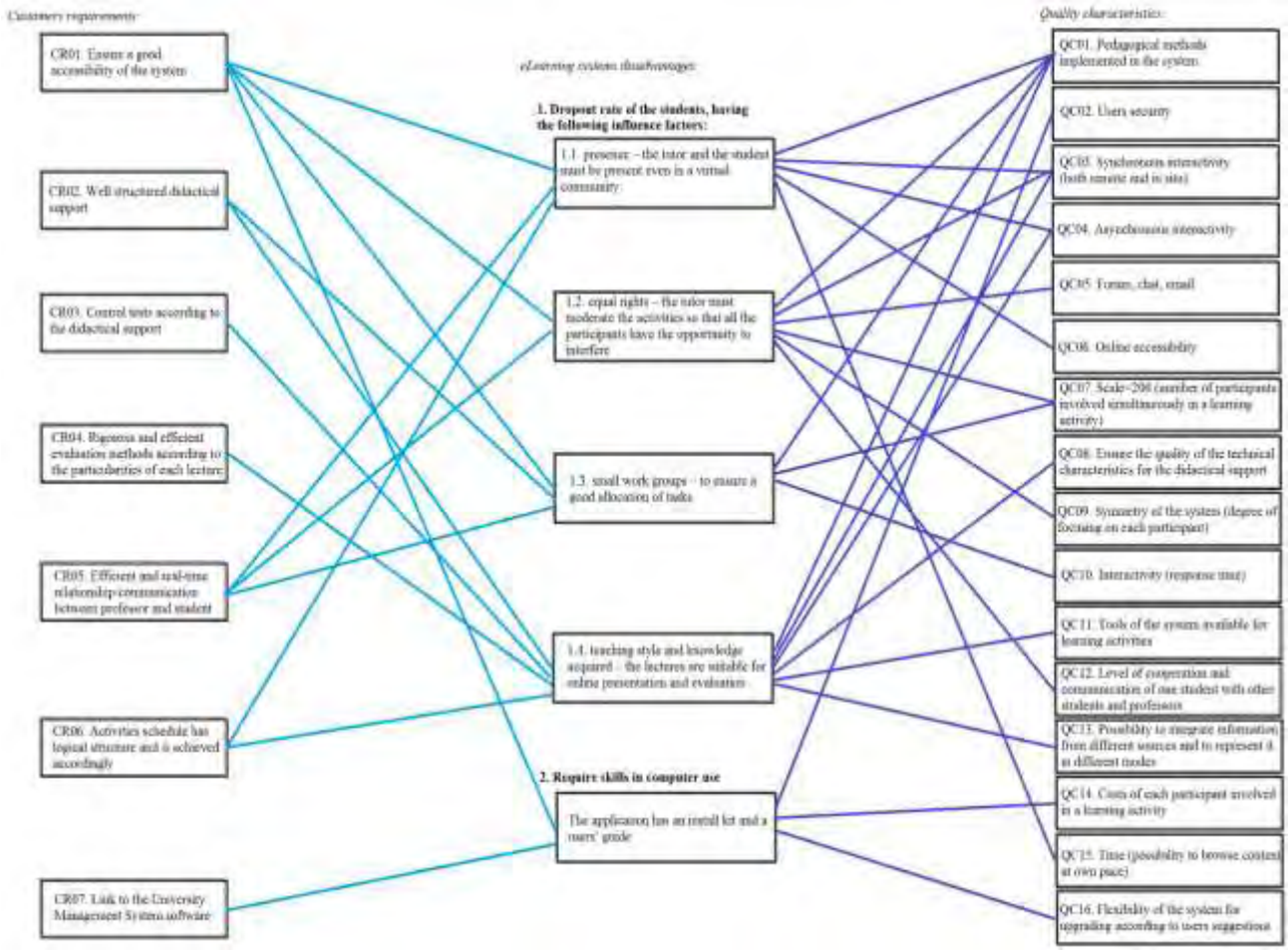

Figure 3.4.4. Customer requirements – Disadvantages of the system – Quality characteristics

So, the eLearning system uses above techniques in order to keep the intrinsic motivation of the students and to add extrinsic motivation making all the learning process fun. This way the students create their own meanings from the creativity embedded eContent. The extrinsic motivation is actually a reward for creating own meanings.

The objective of the research was to create the bases for designing an attractive eContent. This represents the center of figure 3.4.5. around which gravitate all the other elements and techniques described above.

Next, we will present the elements, the links between them and their contribution to eContent development. The final target is mainly related to students and consists in “creating own meanings”.

Usually the eContent is developed only by the professor. But, we considered that it would be helpful mostly for the students to somehow involve them in the eContent development process. This way the students can suggest what and how it should/could be changed.

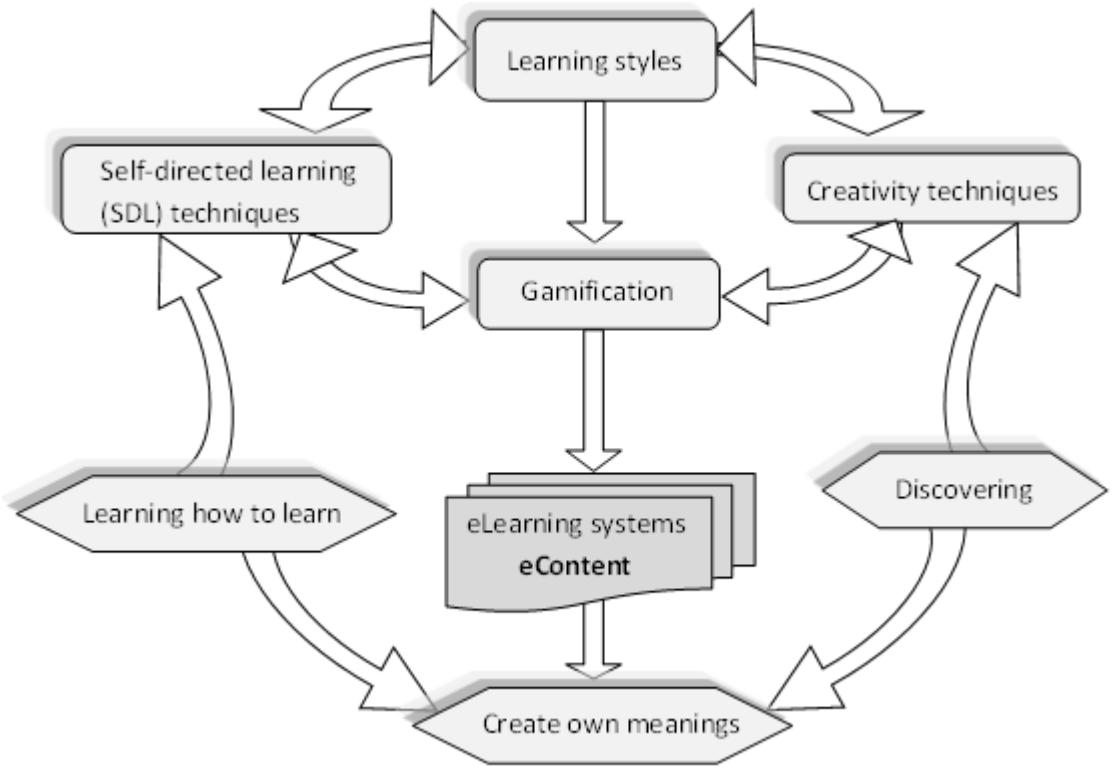

Figure 3.4.5.The main ingredients of discovering and learning for educational innovation

Our research on SDL perception showed that most of the students (93.33% of students from distance learning, 91.66% of students from training adults program, 82.74% of students in day courses and 75% of Master students) have considered very important the SDL.

The next very important elements from our research path are the creativity and gamification. The creativity techniques considered important in eContent development are: automatic drawing and writing, map drawing, show and tell, storytelling types of creativity techniques.

Gamification is the link between SDL and creativity. Moreover, the gamification significantly contributes to the intrinsic and extrinsic students' motivation making the eContent attractive and useful. The creative gamification techniques considered important in eContent development are: exploratory play, construction play, role play and PBL (Points, Badges, Leader boards).

The use of gamification in eContent development proved to be useful as: the resulting learning system allows differentiation as students can progress at their own pace, allows self-directed learning and help students better manage their time, students are motivated by seeing their mates' progress as well as by the rewards they gain for themselves, students retain more information by playing then by reading the same printed content.

Through the creative application of gamification, beyond badges and video games, the final result is the learner empowerment that lead to creation of own meanings and finally to academic success.

The first identified input was related to the students' learning styles. There were considered four learning style types: activist, reflector, theoretician and pragmatic. The selected students sample

was tested using specific tools regarding the learning style and they were distributed in the four above learning style types as presented in figure 3.4.6.

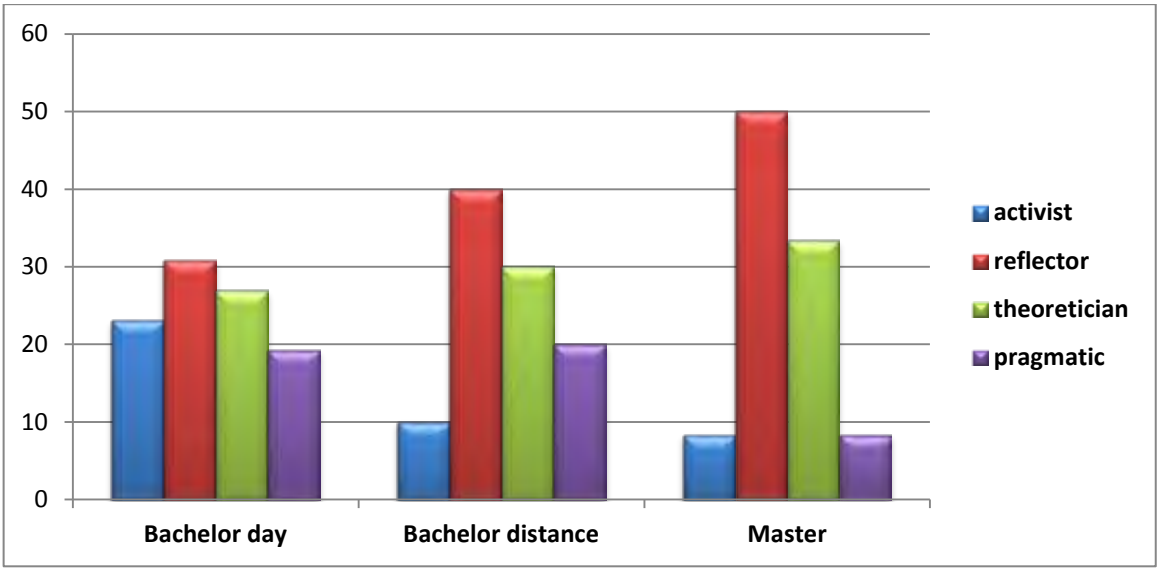

Figure 3.4.6.

The selected sample consists of bachelor (regular and distance learning) and master students from both economic and engineering fields. The research was carried out in the period December 2011-March 2012, and the selected sample was 73 students.

The results of our study proved that all the learning styles are useful for this purpose. Each type of student can be valuable in certain phases of eContent development.

In order to prove the usability of this idea, there were identified the correlations between the eContent development phases, learning styles, creativity techniques and gamification elements (Table 3.4.).

Table 3.4.

eContent development phase	Learning style	Creativity technique	Gamification element
1. Identify the eContent components (Keywords)	Activist	Automatic drawing / writing	Dynamics (big picture)
2. Logical sequence (Map of content)	Theoretician	Map drawing	Mechanics (processes that drive action forward)
3. Case studies	Pragmatic	Show and tell	Components
4. Analysis & evaluation	Reflector	Storytelling types of creativity techniques	Results (PBL)

In Romania there are used a series of norms and standards for the higher education system evaluation. These can evaluate the state of the system, but do not capture the essence of “student

centered learning" that is the need and possibility to actively involve the students in the teaching-learning process, in order to use their entire potential, by means of creativity and gamification.

In our research we identified the ingredients of discovering and learning for educational innovation for the case of the creativity embedded eContent designing elements, but this is only a first step in a wider research that will determine how this new type of eContent will reflect in students' grades, knowledge and how much the students are prepared for a life of continuous learning.

Conclusions and further enhancements

In this chapter were presented the researches achievements from the period 2008-2014 concerning the quality approach in the Student Support Services. I started my researches in the SSS area by identifying the existing premises of the Mentor-mentee (M-m) partnership. It turned out that the M-m partnership is a necessity in the student-centered higher education. For this partnership the point is in its input elements for obtaining success. Creativity and gamification bring motivation on both sides. Intrinsic and extrinsic motivation is essential, especially for students. The importance and necessity of the M-m partnership stems from the fact that students are guided to successful outcomes by mentors. As we said, we have to find the best suited dosage between the partnership input elements, and also the techniques to be used for its proper functioning. This relationship generally difficult to quantify, was evaluated by a proposed method that determines a global index as a measure of the degree to which the requirements are met by the relationship characteristics. A future enhancement of this research will be an expert system that uses game elements to match mentors with mentees based on different personality tests. Even if at first glance it would seem that there are incompatibilities between certain types of mentors and mentees, by using such an expert system we will find all the possible compatibilities and choose the best suited dosage between the partnership input elements.

SDL proved to be also an interesting subject to be approached in the SSS context. The results of the researches reflected the interest shown by respondents to the research topic of SDL in general and SDL in the quality field in special. So, the categories of respondents having in common "quality management" (students in day courses and distance learning that have "Quality management" courses in the academic curricula, Master students in "Management and Quality Assurance", students in the adult training program "Quality manager in the construction field") have rated their own interest in SDL with high scores suggesting that it is perceived as an important issue by many of the students (93.33% of students from distance learning, 91.66% of students from training adults program, 82.74% of students in day courses and 75% of Master students).

The results regarding the SDL were the starting point for some ambitious projects on MOOC type platforms development, and also were an essential ingredient for innovation in education together with creativity and gamification.

In an eEra that embedded from year to year new eElements, like eCommerce, eGovernment, eLearning and recently eLab, it has passed the novelty appeal period and there is a need for renewing by motivating the users. This could be the role of gamification that proved to be successful in many different application fields. So, in order to get the best experience for learners we should leverage the best elements of games to create well-designed games embedded learning. ("Once again, games can and do teach!").

MOOGE (Massive Online Open Game-based Education) is an innovative idea presented at the EDEN Synergy Workshop, Budapesta, 2013 and will be the subject of an international research project for the design and development of a new modern educational platform based on MOOC and gamification principles

The entrepreneurship issue was related with the last step in a student lifecycle, namely employment. The results revealed the prevalence of the last mentioned category (respondents with the minimum chances of success) showing that most of them (around 30% of total) seem unlikely to succeed as entrepreneurs. Beyond these results, our research pointed out a real need for education and training in order to acquire and develop entrepreneurship competences required to start-up and successfully run a business.

The quality management specific tool was integrated in this direction researches both for the quality evaluation of the Mentor-mentee (M-m) relationship (the model that integrates the best elements of SERVQUAL and QFD methods) and for the evaluation of the satisfaction level for the students' using modern teaching-learning systems (the QFD based software tool for evaluation).

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4.

CREATIVITY AND INNOVATION IN NEW PRODUCT DEVELOPMENT

Introduction and Conceptual Background

This research direction integrates the previously addressed researchs and focuses on themes developed in the past years (2012-2015) opening new perspectives for future research following the current trend towards inter-, multi-, trans- disciplinary approaches, having the quality as link between all the other fields.

The integration with the other directions was achieved by scientific papers, proposed research projects and a patent. The topics of these includ new concepts as creativity, gamification, TRIZ principles and innovative products development. These concepts have been used both in correlation with the didactical activities, but also in research activities for new products development.

In this research activity I approached the relationship between quality and innovation in education through the scientific paper *Breaking the Boundaries of eLearning Systems through Creativity*, plenary presented at the International Conference in Vouliagmeni, Greece, 2013 and use of gamification in research and learning activities with students [13_08_C]. The integration of previously addressed research fields (software engineering, quality tools, support services for students) I made it through the scientific papers *Software Engineering 3D Lifecycle Based on Quality Tools and Gamification for eLearning Systems Design* at the conference "Sixth International Conference on Intelligent Computing and Information Systems ", Cairo, Egypt, 2013.

In the context of new product development I presented the plenary paper *Product Innovation Methodology Based on QFD and TRIZ* at the International Conference in Tenerife, Spain, 2014.

The TRIZ creativity techniques have been explored for the development of new products [14_02_C], the undertaken research resulting in the patent no. A 2014 00167 / 27.02.2014 "Method for relevant medical information storage based on biometric identification" [14_01_C]. The invention aims at the development of a storage system based on biometric identification for medical use, that performs a promptly, easy and safe identification of people in need of emergency medical services [14_08_C] [14_10_C]. This patent was awarded with Golden Medal and Diploma of Excellence at the International Inventions Showroom PRO INVENT 2015, Cluj-Napoca, Romania.

Research is the source of innovation. Research in any field requires creativity and motivation for innovative ideas to emerge. Gamification, together with the related serious games and simulations, forms up a powerful toolkit that should be seriously taken into account in research and development (R&D). The present state evaluations show that gamification, serious games and simulations were successfully applied in different fields, usually separately.

We present a way of using these together, emphasising the specific characteristics of each of them and the links between them. For this reason, we represent these three concepts in an Euler type diagram as in figure 4.1.

Figure 4.1. Euler diagram

We will treat each concept from the diagram in figure 4.1. from two points of view: general meaning and educational context.

- General meaning of gamification:

Gamification is the use of game thinking and game mechanics in a non-game context to engage users and solve problems. Gamification is used in applications and processes to improve user engagement, the return on investment, data quality, timeliness, and learning.

The essence of gamification is to provide rewards for players who accomplish tasks. Rewards have the form of points, badges, leader-boards (PBL) and virtual goods. Making the rewards for accomplishing tasks visible to other players by leader boards encourage players to compete. The gamification makes the existing tasks feel more like games. For this reason there are used meaningful choices, on-boarding with a tutorial, increasing challenge, and adding narrative.

- Education context for gamification:

Education and training are areas where there has been a lot of interest in gamification in the last years. Microsoft has released the game Ribbon Hero 2 as an add-on to their Office productivity suite to help train people to use it effectively. SAP has used games to educate their employees on sustainability. The Khan Academy is an example of the use of gamification techniques in online education.

- General meaning of serious games:

A serious game or applied game is understood as a game designed for a primary purpose other than pure entertainment. The "serious" adjective refers to products used by industries like defence, education, scientific exploration, health care, emergency management, city planning, engineering, religion, and politics.

- Education context for serious games:

Serious games are representations of real-world events or processes designed for the purpose of solving a problem. Although serious games can be entertaining, their main purpose is to train or educate users, though it may have other purposes, such as marketing or advertisement. Serious game will sometimes deliberately sacrifice fun and entertainment in order to achieve a desired progress by the player. Serious games are not a sort of game but a category of games with

different purposes. Serious games are primarily focused on an audience outside of primary or secondary education.

- General meaning of simulations:

The general definition of simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviours/functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time. Simulation is used in many contexts, such as simulation of technology for performance optimization, testing, training, education, and video games. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning. Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply not exist.

- Education context for simulations:

Simulation is extensively used for educational purposes. It is frequently used by way of adaptive hypermedia. Simulation is often used in the training of engineers. This usually occurs when it is prohibitively expensive or simply too dangerous to allow trainees to use the real equipment in the real world. In such situations they will spend time learning valuable lessons in a "safe" virtual environment yet living a close to lifelike experience. Often the convenience is to permit mistakes during training for a safety-critical system.

Training simulations typically come in one of three categories:

- "live" simulation (where actual players use genuine systems in a real environment);
- "virtual" simulation (where actual players use simulated systems in a synthetic environment);
- "constructive" simulation (where simulated players use simulated systems in a synthetic environment). Constructive simulation is often referred to as "war gaming" since it bears some resemblance to table-top war games in which players command armies of soldiers and equipment that move around a board.

Simulations in education are somewhat like training simulations. They focus on specific tasks. The term “micro world” is used to refer to educational simulations which model some abstract concept rather than simulating a realistic object or environment or in some cases model a real world environment in a simplistic way so as to help a learner develop an understanding of the key concepts. Normally, a user can create some sort of construction within the micro world that will behave in a way consistent with the concepts being modelled.

In the Euler diagram we have intersections between any two of the concepts and also an intersection between all of them. These intersections will be discussed briefly from education point of view.

The intersection between gamification and serious games is related to the use of rewards.

The main benefit is that the "retention increases when using computer games compared to other teaching" [36]. The use of reward, specific to gamification, in a motivational way is a powerful tool in serious games "the video game will ask a question and the player will answer. When students link the question and the answer enough times, reinforced by a reward, learning will occur" [35].

The intersection between simulations and gamification means the use of motivational PBL to reward problem solved in a simulation environment. From the educational point of view it means to solve laboratory tasks and get points for the proposed solution.

The intersection between serious games and simulations leads to virtual reality applications. In this virtual reality the part that defines the graphics and physics of the virtual world belongs to the serious game and the part that means problem solving belongs to the simulation.

The intrinsic motivation, brought by gamification, for the combination of serious games and simulations in education is based on four characteristics that are provided by all of these "challenge, curiosity, control and the imagination / imaginary (fantasy)" [13]. These four characteristics create a particular advantage "in an educational context the game is likely to make the learning process interesting in itself to obtain the greatest motivation in the learner" [13].

Concepts change, enrich or sometimes even disappear, but the essentials usually remain, that are how and where to apply them.

This was our goal, to give value to these approaches by integrating them into an application designed for training and self-assessment / evaluation of medical students.

The R&D is and will certainly be for many years to come the main source of innovation.

Innovation has existed as long as the human has. Entrepreneurs, scientists, and other innovators in business have always considered that creativity and innovation are key elements to succeed and advance in a continuously changing business world. Innovations are seen as an opportunity to sustain business development and its market success in the long term (Okon-Horodynska *et al.*, 2011, p.357) [32].

In time, innovation had different forms. At the beginning, it was considered an innovation to develop a new product based on new knowledge. Nowadays innovation is more complex and it represents a systemic approach on product development. That is because it arises from complex interactions between many individuals, technologies, organizations and their operating environment. Firms which are successful in realizing the full returns from their technologies and innovations are able to match their technological developments with complementary expertise in other areas of their business, such as manufacturing, distribution, human resources, marketing, and customer service.

Due to the complexity of the interactions from the innovation approach the development of a cross-functional management that manages business processes across the traditional boundaries of the functional areas was necessary. The research in this field is concerned with building a better system for achieving cross-functional goals, like innovation, quality, cost, and delivery. The Total Quality Management (TQM), by its specific methods, like QFD, promotes the use of cross functional teams in order to improve existing products or develop new innovative ones.

We proposed a methodology that integrates the Quality Function Deployment (QFD) and the Theory of Inventive Problem Solving (TRIZ) methods, from general to particular by applying on a specific product development life cycle, in the product development life cycle.

The QFD design and development approach shows *what* to solve but not always *how* to solve the technology problems that can appear. One technique, the Reviewed Dendrogram, relies on the experience of designers and may be limited to certain areas of expertise. But, if the problem to be solved exceeds the limited area of expertise, using TRIZ, the designers would be able to explore design solutions in fields other than their own.

For example, an American company faced a problem like this. They were competing with a Japanese company over the design of brakes for a golf cart. Both competitors were in the automotive field, so they were trying to redesign an automobile brake system taking smaller components. In TRIZ, the search for solutions only in one's field is called "psychological inertia" because it is natural for people to rely on their own experience and not think outside their specialty. Using TRIZ, the solution was found easily by redesigning a bicycle brake system by larger components. The result was a part reduction from twelve to four parts and cost savings of 50%. (Mazur, 1995) [28].

TRIZ is an acronym for the Russian words translated as "the theory of inventive problem solving". From its roots in patent analysis in the 1950s, TRIZ has grown and is today an impressive and useful method that is being applied by leading organizations from all over the world.

TRIZ is a method to solve a problem by analyzing the problem and identifying the contradictions, then adopting different solutions under their physical or technical contradictions. The most famous and practical tools of TRIZ include 39 problem parameters, a contradiction matrix, and 40 innovative TRIZ principles (Altshuller *et al.*, 1999, p.52; Silverstein *et al.*, 2008, p.215). TRIZ tools are used to reach a general solution for lots of TRIZ problems, and that general solution is transformed into a solution applicable to engineering technology (Kim, 2005 [23]; Li *et al.*, 2007 [26], p.213; Hsao, 2011, p.342[17]).

4.1. Gamification & Research – Partnership for Innovation

Gamification and Research were treated like a partnership for innovation in the research work and in the teaching activities with the students creating a link with the third research direction Quality in SSS. Our research tries to identify the components of the innovative partnership gamification and research, as addressed also by Connor (2012) [9]. In other words, how can each element influence the efficiency of this partnership and how gamification with its principles and techniques can increase the research outcomes. Gamification could be seen as a means of motivation in order to generate innovative ideas, to develop and implement them.

We've called it a partnership because each element is important and contributes to the achievement of the innovative products. This partnership can be looked at from both points of view:

- We start from "playing" and do research. In this approach, the research can be fueled by gamification for the emergence of innovative ideas.

- We start from an existing research activity, which at some point needs "something" to break down routine barriers by stimulating and motivating those who participate.

The research method involved in our study consisted in engaging master students teams in research activities and using their creativity potential. The students study in the field of Information Systems and Technologies. First, the research theme was established and announced and then the teams were formed up. The proposed theme was related to 3D virtual environment design. The gamification principles were applied in guiding and motivating the teams as previously applied by McGonigal Read (2011) [29], Newstrom and Scannell (1980) [31]. (figure 4.1.1).

Figure 4.1.1. Gamification in research

After announcing the theme, each student has formulated ideas on how to solve it. Based on these ideas we drew the affinity diagram, and on this basis we have established the teams. For this case resulted three teams with 7-9 members each. Each team received a form consisting in the previously formulated ideas that led to the current structure of the team. Discussions within the team led to common ground ideas, assume roles, pick a name and establish specific objectives for the software developed by the team. This step results in the release of version 0.0 of the product. Based on general objective and specific objectives, each team had available a group of 50 clients (students from other specializations) to capture requirements for developing the prototype. The prototype represents the version 0.1 of the product, which was the subject of a first evaluation made by the customer group, by scoring 1 to 10 points for meeting the previously formulated customer requirements, for presentation of the product utility and the vote of confidence, following the guidelines by Werbach and Hunter (2012) [44], Werbach, (2013) [43].

In this way each team gathered a score, visible in a Leaderboard dedicated to the prototype phase. This Leaderboard reflects an objective and independent assessment of the current version of the products. To stimulate competition between teams, has been organized a presentation of the developed prototypes as an open public participation event. During the event participants were able to give points to the three projects, this time after a comparison between them. Also, each participant could make additional requirements for applications that have been analyzed and sent back to the teams under the form of Challenges. The solutions proposed for these Challenges led to awarding points and Virtual Goods. The Virtual Goods can be exchanged for assistance in one of the stages to come. There were awarded Badges that were related to the creativity of the proposed solution. The Creativity Badge will be displayed in the user interface of the application.

Currently this project consists of three developed prototypes and a Leaderboard. The teams are now working on improving each prototype after solving the Challenges.

The obtained results implied the use of gamification techniques. This is why gamification and research relationship can be considered a partnership in which each component has a significant contribution to innovation. The students' teams work resulted in a software system (figure 4.1.2), with user requirements specifications from Table 4.1, project implementation visible through quality characteristics from Table 4.2, implementation code and software test reports.

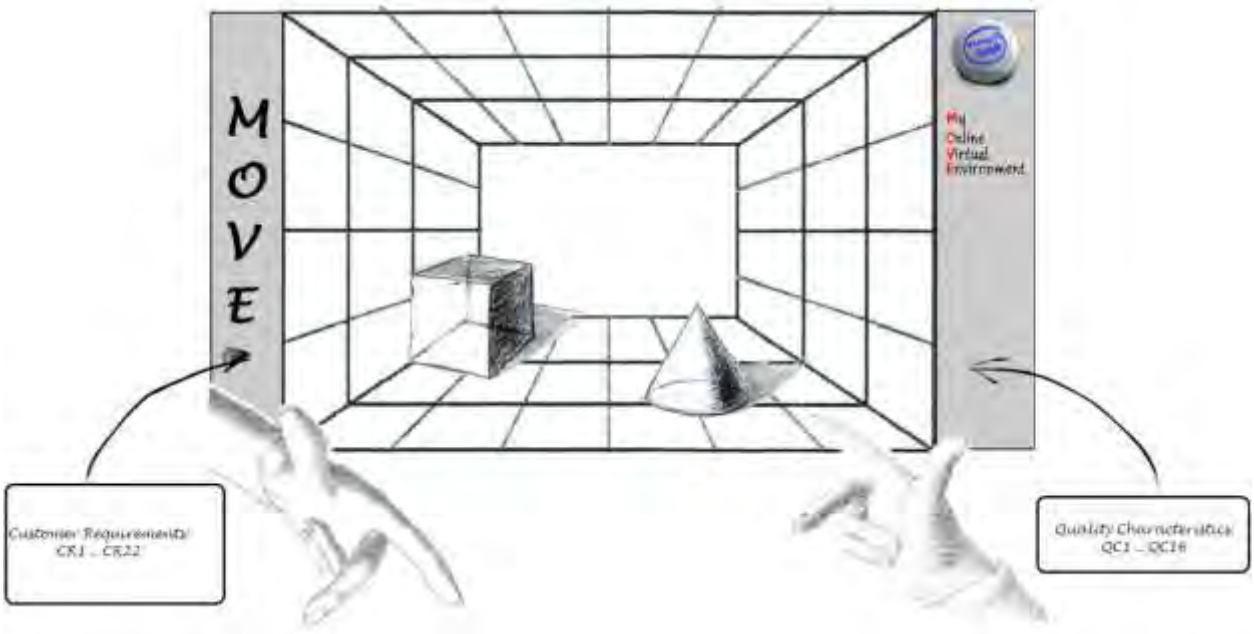


Figure 4.1.2. MOVE application project design

Table 4.1. Customer Requirements.

Code	Customer Requirement
CR1	Complex virtual environment user interface consisting in multiple instances
CR2	Interactive calibration (user request)
CR3	Easy user-application interactivity using accessible equipment (special 3D glasses, finger marker)

CR4	Positioning and movement of the objects on the entire screen
CR5	Messages display of the possible options in a dedicated space on screen
CR6	3D image display according to the user position
CR7	3D suggestive image that can support the best position estimation
CR8	Interaction possibility by repositioning the objects
CR9	Visual and audio feedback at the object “touch” moment
CR10	Appropriate audio background with the possibility to turn it on/off
CR11	The use of different general 3D object forms particularized for the virtual environment
CR12	The use of different specific 3D object forms particularized for the virtual environment
CR13	Interactivity with other users
CR14	Vocal control
CR15	Fast loading of the virtual environment
CR16	User’s position identification
CR17	Accurate object repositioning according to the interaction marker
CR18	Fast feedback at object “touch”
CR19	Synchronized audio background
CR20	Warning and current state messages display in the exact moment of the event
CR21	Web page type application
CR22	Open-source project

Table 4.2. Quality Characteristics.

Code	Characteristic
QC1	3D objects real dimensions displayed by initial calibration by exact dimensions of screen specifications (cm)
QC2	Active window space on screen (for 3D objects representation and movement) (%)
QC3	Time of vibration on the object when “touched” (s)
QC4	Sound level (dB)
QC5	Number of synchronous users on page
QC6	Loading time of the virtual environment (s)
QC7	Time of position identification (s)
QC8	Position identification error (%, mm)
QC9	Delay between the marker movement and the object movement (s)
QC10	3 landmarks (one on the surface of the screen, one in front and one behind the screen) in order to estimate the 3D object position
QC11	Delay between action and sound (s)
QC12	Delay between the event and the message display (s)
QC13	Silverlight Plug-in
QC14	Public webpage
QC15	Quality characteristics regarding the hardware interface elements for the application: red-cyan 3D glasses, red marker, 2 identical web cams (800x600 resolution)
QC16	Identification of the user position in the field of 10cm to 1m from the screen

The above two table and figure present the current development phase of the top project from the leaderboard, the project that received the Creativity badge, visible on the top left side of figure 4.1.2. This side will be filled with all the badges gathered along the project development phases.

The results of gamification techniques application in research activities led to the premises that a research methodology based on the principles of gamification could be useful both as a guide of the entire research activity and as motivational means in certain stages of it.

The “3D virtual environment design” theme proposed at the beginning of our study is intended as the first step in developing open platforms for game based learning and edutainment.

4.2. Educational Software based on Gamification Techniques for Medical Students

Our application is intended for the training of medical students in the field of anatomy and computed tomography images, using elements of gamification, simulation and serious games.

The main ideas behind the design of this application related to the three concepts: gamification, simulations and serious games are presented in fig. 4.2.1.

Figure 4.2.1. Application concept block diagram

he application development is based on the requirements that are usually classified in four categories: mandatory, desirable, optional and future enhancements. Figure 4.2.2. presents the first two classes of requirements, the resulted educational software application and the results that can be obtained from this application, in this case a leader board.

After analyzing the requirements results the primary design of the application, consisting in the following steps:

First, there is defined the user/student profile, including an Avatar and a Status, that starts from Beginner and goes through different forms towards Advanced.

Then, there is offered access to basic structures consisting in manual segmentation tools with minimal assistance and a number of CT / MRI with different degrees of segmentation difficulty. All of these offer a simulation environment for the real-organs.

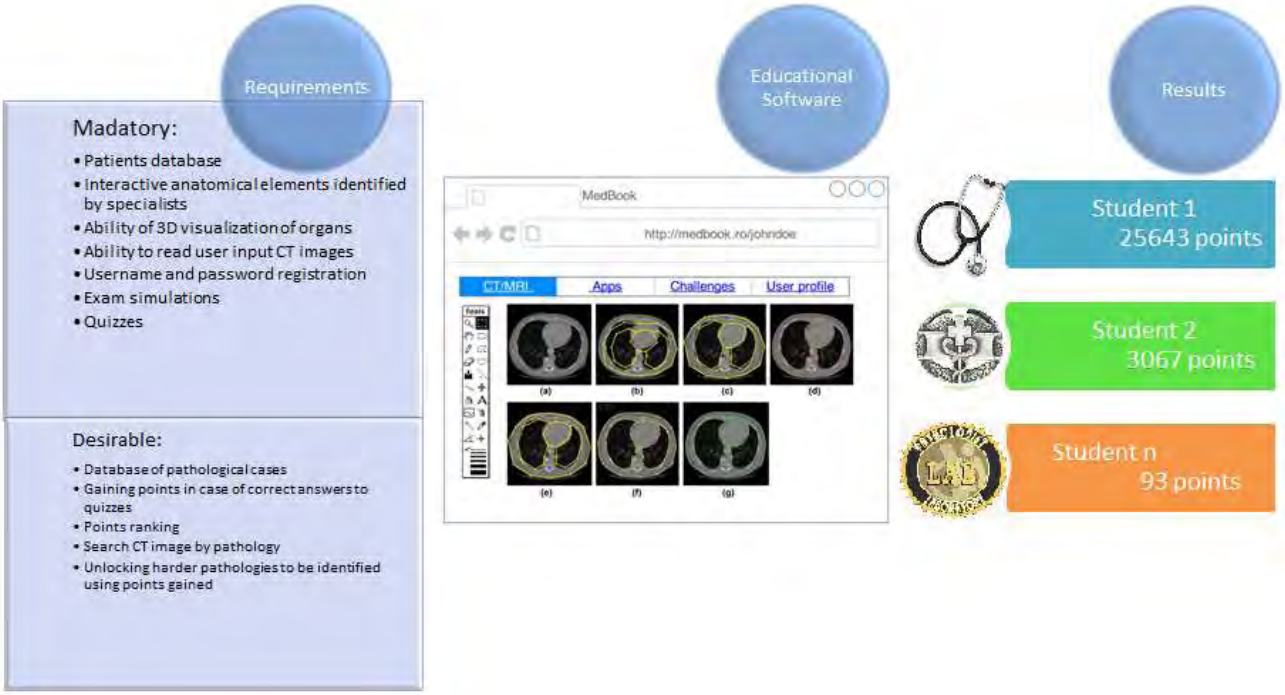


Figure 4.2.2. Application development from the requirements to the results

The student can choose the type of organs available for his particular level (Status) to segment manually (with minimal assistance) in order to tag the components. Each image will have an index of difficulty that will weigh the obtained score. It points to the correct segmentation of each slice and complete identification of the organs and the components. Points are cumulative up to a threshold value for the transition to a higher level (another Status). For this stage of the application will be used as reference a database of CT / MRI images with tags identified by experts in the field. An example of such tagged image is presented in fig. 4.2.3.

Each new Status means releasing new features such as:

- New tools for manual segmentation complex with more help from the computer (e.g. Magic Wand tool, 3D representation of the elements segmented and others) that may be acquired in exchange for virtual goods received during steps resolved (for example, correct segmentation of particular region may lead to the "discovery" of a "key" that can be acquired alone or together with other keys).

- Opportunity to participate in a serious game on the identification of certain pathologies, each with a specific difficulty index which will be reflected in the score obtained for successful recognition. In the application there can also be proposed the identification of pathologies for unsolved cases. This could lead to a polling type evaluation throughout all the gathered solutions.

- The ability to write a script in a language or meta-language for student's own algorithm in order to automate a portion of particular organ segmentation and even for automated tagging. For a functional script the student gets a badge that is worth points and "virtual goods".

There is also a Leader Board with scores of students that use the application, which reflects the results that can be used in an evaluation of the student in comparison with others. From the Leader Board the top students may receive mentor rights for the new entrants. Any proved useful "advice" worth points for the mentor in order to motivate him and also to energize new entrants to seek help when they need it and to forestall the early abandonment of the application. The mentor may also propose a "challenge" in order to win points (e.g., if he noticed something unusual on a particular image, he may propose a finding contest of what it represents and even provide points to the person who win).

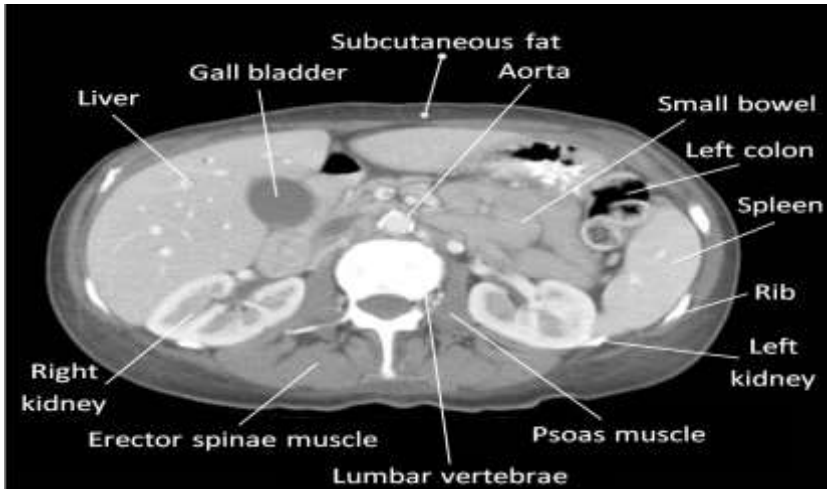


Figure 4.2.3. Tagged imageAll the above steps are iterative and the application evolves by adding new items based on the contribution of all the participants.

These "rules of the game" need to be known from the beginning by all the users.

Computed tomography has become a reference medical examination. Its usefulness in diagnosis is widely recognized and evidence is represented by the exponential growth in the use of this type of medical examination in almost all medical specialties. Regarding current trends in global medicine, computed tomography is to be done very often and therefore we believe it is important to train medical students in interpreting these precious data.

The proposed application offers some obvious advantages, like:

- Training / self-training in medical Imagistics, in anatomy and anatomical topography;
- A web platform to cooperate with others interested in these topics;
- Possibility to engage in competitions proposed inside this application;
- Opportunity to gather ideas regarding segmentation algorithms for both individual cases and for certain organs in general, which can lead to innovative solutions for automatic segmentation;

- This application is constantly refreshed with new tools, new ideas brought by users involved;
- The existence of a general Leader Board throughout the lifetime of the application is a challenge to overcome the maximum score at the moment.

Our proposal can prove to be a solution for some more modern and more practical methods of examination. Therefore, examination of students based on real cases, we believe it would be preferred both by students and by teachers.

The research idea was integrated in the proposed project: “Enabled Archiving, Management and Diagnosis Assistance System for Medical Images” ARMANDIAS (PN-II-PT-PCCA-2013-4 - University of Medicine and Pharmacy "Iuliu Haţieganu" Cluj-Napoca (UMFCN)-leader and University of Petrosani and SC Intuitive Software SRL- partners).

4.3. QFD and TRIZ in Product Development Lifecycle

The “life” of a business starting from its birth time passing through the growing period and reaching maturity is strongly related with the course of its products, also known as product development life cycle (PDL). The research represents an approach that integrates in PDL the Quality Function Deployment (QFD) and the Theory of Inventive Problem Solving (TRIZ) methods, as a tool that can help companies to successfully develop new products or to improve the existing ones through a series of innovation-related steps, starting from the process of idea generation and ending at the launch of the product into the market. In order to validate the research results we present a case study that explores the application of our methodology on a programmable controller for the mining extraction machine. The conclusions emphasize the applicability of the proposed methodology, a useful tool in business innovation for adapting to the current competitive market.

In order to apply our methodology we introduced methods and concepts from different fields. From quality management we used the concept of quality spiral, Juran’s improvement, and the techniques and tools based on the QFD method, as the best suited to transform the customers’ needs in technical characteristics of a product. From business we used the product development life cycle spiral model. From engineering we used the TRIZ method for finding innovative solutions to technical problems in product development processes.

In order to determine the offset, a mathematical model was developed. The variables and their signification are presented below:

n = number of customer requirements

m = number of quality characteristics

c_1 = value for Mandatory requirement; c_2 = value for Desirable requirement; c_3 = value for Optional requirement; c_4 = value for future Enhancement requirement

$CR(i)_{i=\overline{1,n}}$ = customer requirements classified according to Kano model: $CR(i) \in \{c_1, c_2, c_3, c_4\}$

$QC(j)_{j=\overline{1,m}}$ = quality characteristics distribution functions according to the difficulty level

cor_1 = value for strong positive correlation; cor_2 = value for strong correlation; cor_3 = value for neutral correlation; cor_4 = value for strong negative correlation; cor_5 = value for negative correlation;

$TQC(i,j)_{i,j=\overline{1,m}}$ = correlation matrix of quality characteristic *i* by the quality characteristic *j*: $TQC(i,j) \in \{cor_1, cor_2, cor_3, cor_4, cor_5\}$

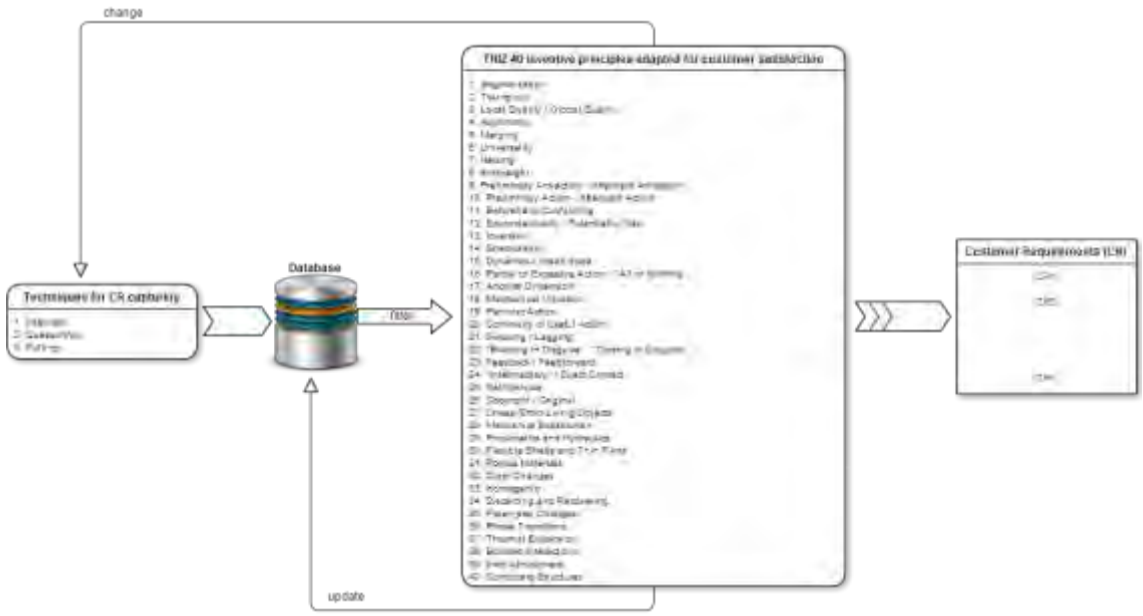
$ICQ(i,j)_{i=\overline{1,n},\, j=\overline{1,m}}$ = influences matrix or how much of the customer requirement i is assigned to the quality characteristic *j*: $ICQ(i,j) \in [0,1]$

$AQ(j)_{j=\overline{1,m}}$ = achievement matrix of the quality characteristics: $AQ(j) \in [0,1]$

$RCQ(i,j)_{i=\overline{1,n},\, j=\overline{1,m}}$ = relationship matrix or how much of the customer requirement *i* is achieved by the quality characteristic *j*: $RCQ(i,j) \in [0,1]$

offset = the degree of customer requirements achievement by the quality characteristics

The first phase from the QFD method consists in objectives definition, customer requirements (CR) capture and CR classification based on Kano model. We have considered four priorities related ranking levels: mandatory, desirable, optional and future enhancement.



4.3.1. Phase 1 in Product Development Lifecycle

In Figure 4.3.1. the CR capture diagram is presented. For the case of product development lifecycle there are specific techniques for customer requirements capture, like: interview, questioners and polling, used. Results of a customer requirements report that there is the basis for filling in a database (DB) containing captured requirements with all relevant details. The data from

DB are filtered according to the TRIZ 40 inventive principles adapted to customer satisfaction. After the captured requirements filtration by the 40 TRIZ inventive principles adapted for customer satisfaction one or both of the following cases can occur: the need to more accurately formulate some requirements that lead to the DB update; the need to reformulate some requirements that lead to the change of the techniques or the application of these techniques for requirements capture. These loops result in a refinement of the CR. The end result of this phase is the CR matrix of size *n*, where *n* is the number of requirements expressed by customer.

The second phase contains the following activities from the QFD method: quality characteristics (QC), also called technical characteristics, identification and technical correlations matrix establishment. For each quality characteristic we have defined a level of achievement difficulty, ranked from hard, medium to easy, and an improvement direction that could be “maximize”, “minimize” or “maintain”. Usually, in the system evaluation the level of achievement difficulty of the quality characteristics is not taken into account. In our model, we have considered different distribution functions for each difficulty level, like quadratic functions for hard and easy levels and linear function for medium level. Under the features being evaluated the best suited distribution functions for the difficulty levels can be chosen. If the difficulty levels are not considered relevant, the distribution functions will all be linear.

In Figure 4.3.2. the practical achievement of the second phase consisting in extracting from the DB the customer requirements obtained in the first phase is presented. These requirements are further filtered by the 40 TRIZ principles adapted for quality management in order to get a draft design of the product containing the quality characteristics that suit the customer requirements. This phase also involves a feedback loop to update the customer requirements referring to technical limitations. Results the QC matrix of size *m*, where *m* is the number of quality characteristics identified by the team.

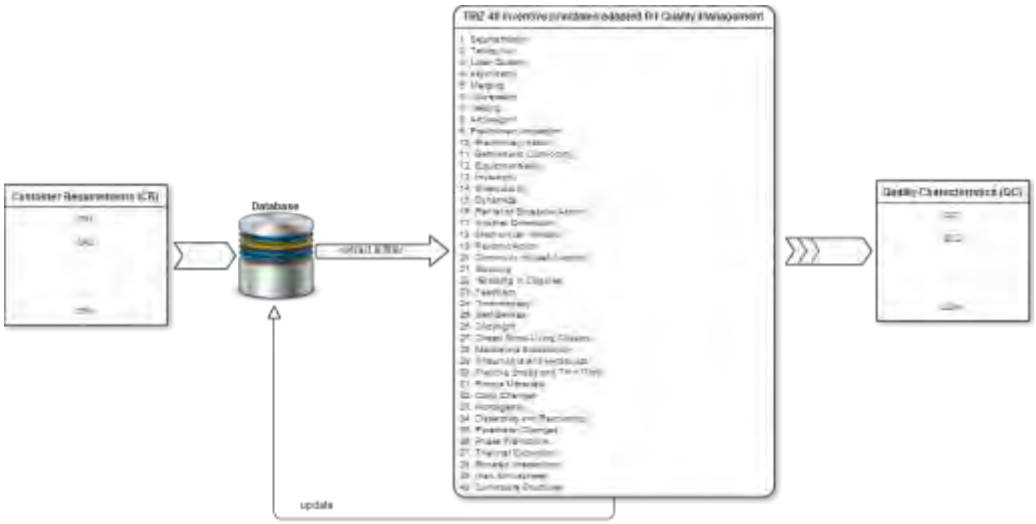


Figure 4.3.2. Phase 2 in Product Development Lifecycle

The technical correlations matrix is valuable for product evaluation providing a means to both estimate the influences and integrate the interdependencies between the quality characteristics. For some products there are cases of non bi-univocal dependencies between the quality characteristics. So, the technical correlation matrix can be either symmetrical, in the case of bi-univocal dependencies, or asymmetrical, in the case of non bi-univocal dependencies.

The model will deal with five types of dependencies: strong negative, negative, neutral, positive and strong positive. These dependencies are introduced in the mathematical model as rated values reported to a maximum estimated possible influence. This technical correlation matrix represents the contradictions matrix from the TRIZ method. This is obtained by mapping the quality characteristics on 39 TRIZ problem parameters (PP), as presented in Figure 4.3.3. For each quality characteristic there are identified the pairs of TRIZ improving and worsening parameters (Silverstein *et al.*, 2008, p.223) [39]. From the general TRIZ contradictions matrix the corresponding inventive principles for the product's quality characteristics are extracted. Based on these principles the TQC matrix of size *m x m*, where m is the number of quality characteristics, is formed up.

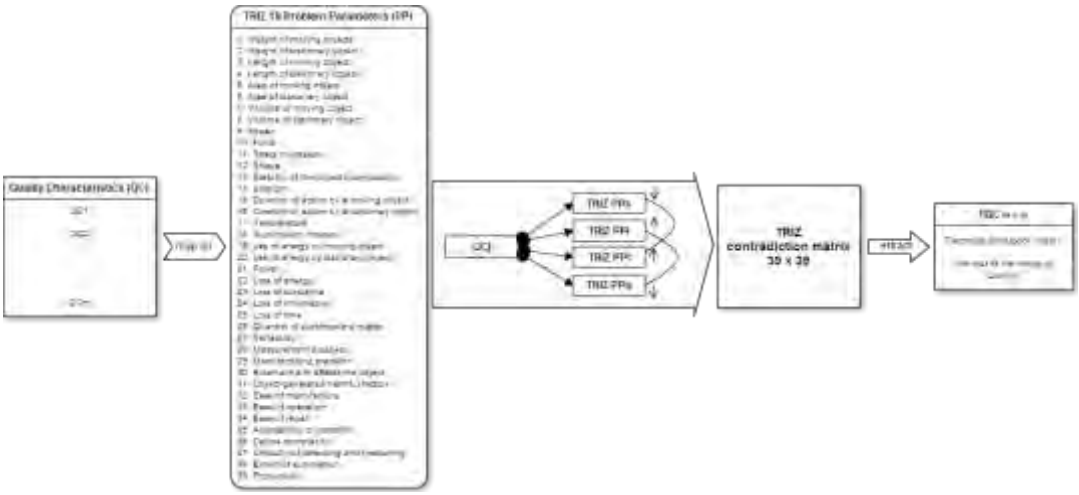


Figure 4.3.3. Phase 3 in Product Development Lifecycle

During the development of a product all the customer requirements are assigned to one or more quality characteristics. These assigned percentages are all quantifiable, because quality characteristics are identified starting from the customers' requirements in such a way that the result is a functional product that satisfies the users' needs. Results the influences matrix ICQ of size *n x m*, where *n* is the number of customer requirements and *m* is the number of quality characteristics. During the evaluation and testing activities the accomplishment degree of each quality characteristic, using known testing tools, is determined. It results into the characteristics achievement matrix AQ_m. The CRs and QCs relationship matrix contains the products between the accomplishment degree of QCs and the assigned percentages of CRs. the relationship matrix $RCQ_{n \times m}$ is the result. The overall evaluation is achieved by computing the offset using the relation:

$$offset = \sum_{j=1}^{m}\sum_{i=1}^{n}\frac{RCQ(i,j)\cdot CR(i)}{\sum_{i=1}^{n}CR(i)}$$

where:

$$RCQ(i,j) = ICQ(i,j)\cdot\frac{QC(j)\cdot\left[AQ(j)+\sum_{i=1}^{n}TQC(i,j)\cdot AQ(j)\right]}{1+\sum_{i=1}^{n}TQC(i,j)}$$

The offset value is a comprehensive quantification for the resulted product of the accomplishment degree of the customers' requirements. The offset could be a comparison basis for different products also useful in the benchmarking analysis.

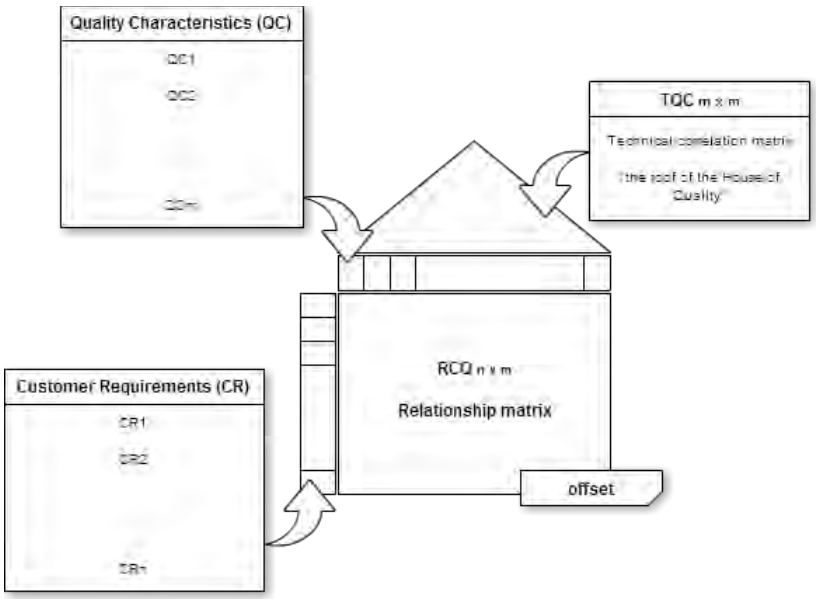


Figure 4.3.4. Phase 4 in Product Development Lifecycle

The next phase, as shown in Figure 4.3.5. is for further improvement of the developed product. In this phase the quality characteristics under their importance in the product development and difficulty to achieve are classified. Then, the best suited two characteristics QC_i and QC_j for improvement are extracted. There is graphically represented the dependency offset=function(QC_i, QC_j) as a surface in order to determine a local optimum. On this surface for a given offset there are more different pairs (QC_i, QC_j). For a target value of the offset a pair of target values for the quality characteristics and are determined the possibilities to achieve these values using the 40 TRIZ inventive principles is chosen. It results into the innovation patterns best fitted for the proposed target and a pattern for the target relationship matrix.

In order to prove the viability of our proposed methodology, the application on a specific product development lifecycle is presented. We have chosen a programmable controller for the mining extraction machine as a product to analyze throughout the development lifecycle.

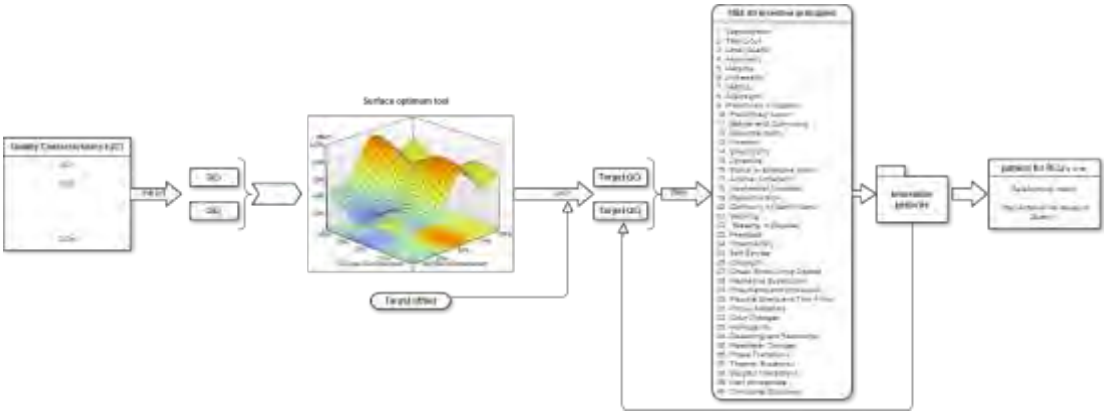


Figure 4.3.5. Phase 5 in Product Development Lifecycle

Applying our methodology a cross functional team, formed up by: mining engineers, mechanical engineers, electrical engineers, control engineers, programmers, quality engineers, economists and product testers was taken.

First, using the interview techniques with key persons involved in the mining sector in our area Jiu Valley, Romania, the customer requirements for this controller were determined. There were obtained initial interview reports that formed the basis for a primary formulation of the customer requirements, subject to filtering by the 40 TRIZ inventive principles adapted for customer satisfaction. This controller is a very complex system that needs to take into account many working conditions, but in order to illustrate the idea of our methodology only the most relevant requirements, which are presented below, were distinguished.

CR1: Choose the direction of movement after receiving a signal from the loading or unloading ramps

CR2: Possibility to stop the installation by two independent means

CR3: Possibility of manual control for maintenance and contingencies with limitations for speed and acceleration

CR4: Achieve an imposed speed profile with a maximum deviation of 10%

CR5: Stop the machine at the end of a running cycle and provide the necessary precision for loading and unloading tasks

CR6: Ensure low speeds of 0.6 ±0.3 m/s for skips when departing and approaching ramps

CR7: Limit acceleration under 1 m/s^2

CR8: Control position of skips inside the mine pit

CR9: Maintain the operating speed regardless of the load on the driving motor

CR10: The ability to maintain the skips at ramps without using mechanical breaking (load “floating”)

CR11: Start the extraction machine in automatic mode only when skips are at ramps

CR12: Provide the required system speed profile

CR13: High energetic and economic indicators of the machine

CR14: Simplicity and operational safety

For example, some of the TRIZ inventive principles that were applied are: *Segmentation* (1) used for splitting the initial requirement: “Ensure low speeds for skips when departing from ramps, limiting acceleration under 1 m/s^2, with the speed slowing down to 0.6 ±0.3 m/s when approaching ramps” in two: CR6 and CR7; and *Beforehand Cushioning* (11) used to reformulate the initial requirement “Possibility of manual control for maintenance and contingencies” as the CR3.

The cross functional team established CR with *n=14* requirements each having an assigned importance value according to Kano model. In order to determine the importance value of each requirement was used the polling technique.

The objective of the second phase is to determine the quality characteristics based on the customer requirements. For this reason, our methodology implies the use of 40 TRIZ inventive principles adapted to quality management.

The quality characteristics were grouped in three categories as follows:

Material properties:

QC1: Materials

QC2: Hard environment resistance

QC3: High temperature resistance

QC4: Intrinsic safety

Design properties:

QC5: Programmable device

QC6: Hardware guides at ramps level

QC7: Breaking system

QC8: Ventilation holes

QC9: Construction

QC10: Switching system from manual to automatic and reverse

Function properties:

QC11: Adjustable frequency

QC12: Adjustable modulation index

For example, TRIZ principle 10 *Preliminary action* can be applied to each customer requirement. For CR14 (Simplicity and operational safety), this principle leads to the quality characteristics from the material properties group. The product is highly dedicated to mining industry and the supplier can be only those specific to hard potentially explosive environment

materials and equipment. The suppliers' involvement in this phase, due to the conditions specific to coal mining, has a high impact on the general safety and resistance of the final product.

The cross functional team established the QC with *m=12* characteristics.

Once determined the quality characteristics, there will be applied TRIZ principle (3) *Local Quality*: "Three levels of problem criticality: critical, major, minor". The result of applying this principle will be used in phase 4 to determine the influences matrix ICQ.

The third phase is dedicated to the "roof of the house of quality". First each of 12 quality characteristics are identified corresponding to TRIZ problem parameters from 39 available.

For example, considering the quality characteristic QC11 (Adjustable frequency) we can identify two improving TRIZ problem parameters: (36) *Device complexity* and (38) *Extent of automation* and two worsening TRIZ problem parameters: (32) *Easy to manufacture* and (27) *Reliability*.

The TRIZ contradictions matrix includes all the dependencies between improving and worsening problem parameters and lead to an estimation of interdependencies between these and finally to the correlations between the quality characteristics that include these parameters. The result is the correlations matrix TQC.

			Quality Characteristics											
			Material properties			Design properties							Function properties	
		c	QC1	QC2	QC3	QC4	QC5	QC6	QC7	QC8	QC9	QC10	QC11	QC12
	diff		1	3	1	2	1	1	1	1	1	2	2	3
	AC		0,5	0,6	0,5	0,3	0,4	0,2	0,3	0,2	0,3	0,3	0,35	0,2
Customer Requirements	CR1	1	0	0	0	0	0,2	0	0	0	0,06	0	0,053	0,03
	CR2	3	0	0	0	0	0	0	0,18	0	0	0,12	0	0
	CR3	4	0	0	0	0	0	0,02	0,09	0	0,09	0,09	0	0
	CR4	2	0	0	0	0	0,16	0	0	0	0	0	0,105	0,06
	CR5	3	0	0,12	0	0	0	0,06	0,15	0	0	0	0	0
	CR6	3	0	0	0	0	0	0,04	0	0	0	0	0,14	0,08
	CR7	3	0	0	0	0	0,16	0	0	0	0,18	0	0	0
	CR8	2	0,1	0	0	0	0,16	0	0	0	0,12	0	0	0
	CR9	4	0	0,18	0,1	0	0,08	0	0	0	0	0	0,07	0,02
	CR10	2	0	0	0	0	0,12	0,04	0	0	0	0	0,088	0,05
	CR11	1	0	0	0	0	0,2	0	0,03	0	0,03	0,09	0	0
	CR12	3	0	0	0	0	0,08	0	0,03	0	0	0,03	0,105	0,06
	CR13	4	0,05	0,06	0,05	0,12	0	0	0	0,02	0,06	0	0	0
	CR14	3	0,05	0,06	0,05	0,15	0	0	0	0,02	0,03	0	0	0
			0,55	1,5	0,75	0,93	2,32	0,46	1,47	0,14	1,56	0,9	1,453	0,75
	Offset		0,34											

Figure 4.3.6. House of Quality

The fourth phase forms up the house of quality based on the data collected during the first three phases: the CR matrix with the customer requirements classified, the QC matrix with the quality characteristics, the TQC matrix of quality characteristics correlations and the ICQ matrix of

influences between quality characteristics and customer requirements. The objective of this phase is to determine the global offset that represents the level of customer requirements accomplishment by the quality characteristics of the developed product.

In order to compute this offset according to our methodology based on the above presented mathematical model, there must be determined the achievement matrix AQ. The cross functional team applies specific test methods for the product and establishes the level of each quality characteristic achievement.

The offset determined in this phase can lead to different interpretations of the development process achieved so far. The interpretation that we will take into account in the context of our research deals with the continuous improvement or even innovation of the developed product.

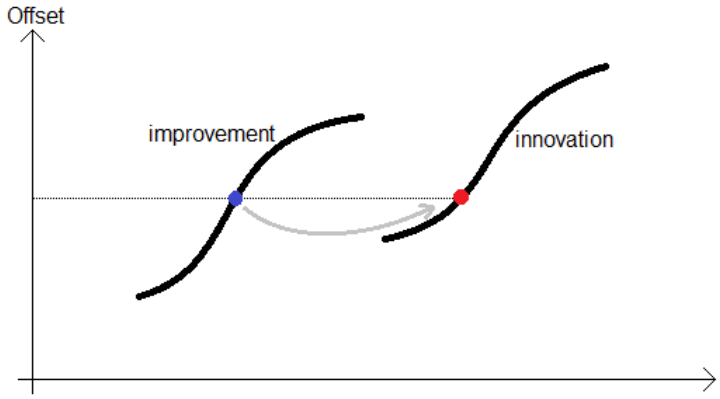


Figure 4.3.7. Improvement versus Innovation Approach in the Product Development Life Cycle

In Figure 4.3.7. we have represented a form of product development lifecycle taking into account the offset as a reference mean. It is the moment when the cross functional team has to decide the path to follow for further development of the product. There are two possibilities. One is the path of continuous improvement, having the advantage of well-known and well-defined steps to follow leading to small improvements with small investments and the disadvantage of limited possibilities to improve the product due to inherent limits of a mature product. The other is the path of innovation, having the advantage of spectacular results and the disadvantage of big investments and major associated risks. In our methodology this is represented by the fifth phase.

Considering our example, the improvement path means to replay the four phases presented above, but the innovation path means to go to the described fifth phase and to use TRIZ inventive principles associated with TRIZ contradiction matrix.

For analysis pair QC4 and QC11 was chosen because these characteristics were determined to have a high value of technical importance, a medium degree of difficulty and a low level of achievement (AQ matrix).

There is graphically represented the function: offset=f(QC4, QC11) as shown in Figure 4.3.8.

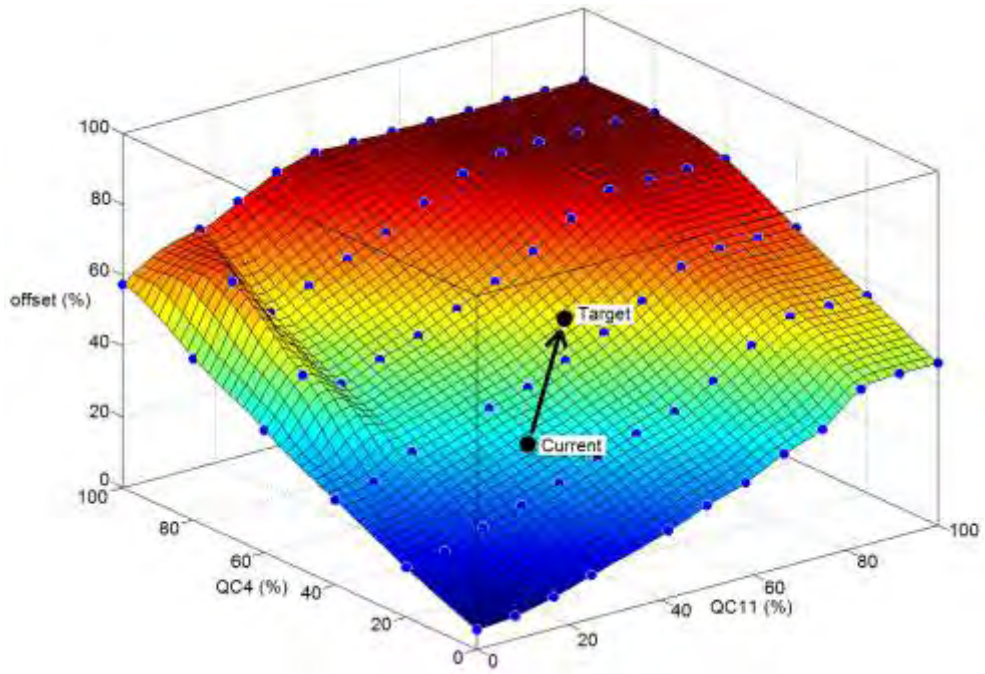


Figure 4.3.8. Offset Dependency on QC4 and QC11

The current offset value after one cycle of product development is 25% and the target value is 45%, as presented in figure *z* by the two black dots. As can be seen in the graphical representation, for the offset value of 34% corresponds the achievement levels of 30% for QC4 and 35% for QC11 while for the target offset value of 50% corresponds levels of 45% for QC4 and 50% for QC11.

In order to illustrate the innovation path for a considered example product and the two quality characteristics: QC4 *Intrinsic safety* and QC11 *Adjustable frequency* with the corresponding TRIZ problem parameters, as presented in Table 4.3. The inventive principles that were selected and applied for the product are presented in italics and bold.

Table 4.3. Quality characteristics-Inventive principles

Quality characteristic	Improving parameter	Worsening parameter	Inventive principle
QC4. Intrinsic safety	27. Reliability	35. Adaptability or versatility	13. “The other way round” 35. Parameter changes ***8. Antiweight*** 24. “Intermediary”
QC11. Adjustable frequency	36. Device complexity	32. Ease of manufacture	27. Cheap short-living object ***26. Copying*** 1. Segmentation 13. “The other way round”
	38. Extent of automation	27. Reliability	***11. Beforehand cushioning*** 27. Cheap short-living object 32. Color changes

Regarding the inventive principle (8) *Antiweight* applied for the innovation of the developed product, the cross functional team came up with the proposition to “integrate most of the electronic part into a dedicated programmable VLSI circuit having implicit intrinsic safety”. Regarding the inventive principle (26) *Copying* for the innovation of the developed product, the cross functional team proposed to “generate by software the frequency of the output control signal”. Regarding the inventive principle (11) *Beforehand cushioning* for the innovation of the developed product, the cross functional team proposed to “anticipate and control the brake system in emergency cases”.

In Table 4.3. it can be noticed that parameter 27 is an improving parameter for QC4 and a worsening parameter for QC11. The offset computed using our methodology emphasizes this situation because the formula contains the correlations between the characteristics (TCQ matrix).

The difference between the current value of the offset and the target offset value is 16%. This increase of the offset is obtained from the analysis of the possibilities of improving of only two quality characteristics, QC4 and QC11, aiming the increase of their achievement level. In order to obtain more spectacular increases of the offset value, other pairs of quality characteristics considered important in product development life cycle will be analyzed.

Previous approaches, carried out in scientific papers and research projects regarding the application of QFD and TRIZ to support systematic innovation within industries, consist in: identifying the potential innovation concepts that have the highest market impact potentials and modelling approach that support the search and usage of external knowledge.

Our methodology is based on an offset determination as a global value for the entire system / product development analysis. The approach that is closest to our methodology is the one developed by Yamashina *et al.* (2002) [46] that consider the mechanism calculated weight for the technical characteristic that most requires innovation from the analysis of customers’ needs. Our methodology additionally provides an indicator that reflects the performance of the product and how changes in customer requirements or/and technical characteristics through TRIZ techniques can be visible in the offset.

The literature in the field of the research presents the application of QFD and TRIZ for different services and industrial products. There are no references regarding the application of QFD and TRIZ methodology for the development of products similar to the one presented in the case study for the mining industry. In our research we have considered the case study of mining industry as in Romania this industry has not benefited from innovative products development in more than 25 years. Nevertheless, this case study does not represent a restriction of the applicability field of our methodology, but it emphasizes the versatility of this approach, being possible to extend it to any innovative industrial product development.

Conclusions and future enhancements

The latest researches results that have been presented in this chapter are oriented towards innovation integrating creativity techniques such as gamification and TRIZ with reference to the educational field and developing new products.

The main results presented concerning the gamification techniques application in research activities and education led to the premises that a research methodology based on the principles of gamification could be useful both as a guide of the entire research activity and as motivational means in certain stages of it.

In this context, the “3D virtual environment design” theme presented at the beginning of this chapter is intended as the first step in developing open platforms for game based learning and edutainment. So, Massive Online Open Game-based Education (MOOGE) is an idea of a project that regards the use of creativity and gamification in an alternative non-formal teaching and learning environment.

The teaching-learning environment consists of two components, that are a visual development environment for the teachers to build up their courses in the non-formal structure based on creativity and gamification elements and a learning platform where the students can access the courses they signed in for and the challenges they qualified for based on their evolution and points gathered and also can interact with other students and teachers.

Another type of users that can get access to the visual development environment are representatives of companies that can propose and design some challenges by which they can gather innovative solutions for their problems and even recruit personnel.

How the platform will work for the students?

First the student can define an avatar and gets a status according to the points gathered by passing through the courses he/she signed in for. After the student reach an intermediate status he/she can participate in challenges proposed by teachers and get extra points, badges and helpful tools according to the found solution. Passing the intermediate level, the student can participate in challenges proposed by companies and solve real-world problems. The solutions to these problems lead to points, a position in the leader-board and possibility to be recruited by the company.

How the platform will work for the teachers?

The teachers have a visual development platform that offers toolboxes in order to achieve an attractive, useful and non-formal form of their courses. Also, they have access to different online tools for sound, image and video processing together with helpful tutorials.

How the platform will work for the companies?

The representatives of the companies have access to some of the visual development platform tools that can be used to design the challenge proposal.

Which are the benefits for the actors involved?

For the students the platform offers an attractive non-formal environment to learn new, interesting and useful stuff and interact with other students. Also, by solving the challenges proposed by the teachers and by companies they can participate in research activities and even be recruited by the companies.

For the teachers the platform offers a visual environment and useful tools to design attractive courses. Also, they have a means to propose challenges in order to find innovative solutions to different research problems.

For the companies the platform offers an environment to get interesting solution for their problems and to recruit personnel.

Concerning the use of gamification in education we proposed also an application for the training of medical students in the field of anatomy and computed tomography images. Our proposal can prove to be a solution for some more modern and more practical methods of examination. Therefore, examination of students based on real cases, we believe it would be preferred both by students and by teachers. The research idea was integrated in the proposed project: "*Enabled Archiving, Management and Diagnosis Assistance or Medical Images" - ARMANDIAS (PN-II-PT-PCCA-2013-4 - University of Medicine and Pharmacy "Iuliu Haţieganu" Cluj-Napoca (UMFCN)-leader and University of Petrosani and SC Intuitive Software SRL- partners.*

The methodology based on QFD and TRIZ for new product development contains many intrinsic elements from the fields of quality management, product development life cycle and innovation. The research results presented are strong connected to the main achievements of the first research direction with reference to a product specific for the Jiu Valley mining area and also to the results of the second research direction related to the 3D spiral model based on QFD for product development life cycle.

The methodology developed forms the basis of a very useful tool in business innovation, mainly in new product development and improvement of the existing ones. For this reason, we have taken the advantage of the spiral model for product development life cycle, the defining elements of the QFD and the unexpected TRIZ principles applicability. In this methodology the product development process follows the spiral model with embedded TRIZ elements for improvement and innovation, all linked together by "glue logic" represented by the QFD method. This methodology can be applied to any type of a product both for ground up development and spectacular improvements.

We have chosen a case study for a product specific for the Jiu Valley mining area as an example. The product is a programmable controller for the mining extraction machine. The need to improve this product came from the customers' requests that wanted a product that might improve coal extraction process. The methodology applied took into account specific conditions of coal mining from Jiu Valley, which is an underground mining with potentially explosive environment. This is why the requirement selected during the methodology case study was related to constructional simplicity and operational safety. The characteristics that led to an improvement in the offset value are related to this requirement and are Intrinsic safety and Adjustable frequency. The first characteristic Intrinsic safety is closely related to the specific coal mining working conditions, that is a potentially explosive environment. The second characteristic Adjustable frequency despite being a common characteristic for this type of equipment should be considered. The application is a hard environment for which the load on the extraction machine is a variable in a wide interval from the weight of a worker to the weight a full coal charge. An offset increase of 16% is notable taking into account that it is related only to these two characteristics, directly and by their influences upon the other characteristics. Another contribution of our methodology is the 3D

spiral model for product development life cycle. Besides the methodological aspects, this model offers a suggestive 3D visual representation of the current stage of the product development process. The case of the programmable controller for the mining extraction machine does not represent a restriction of the applicability field of our methodology, but it emphasizes the versatility of this approach, being possible to extend it to any innovative industrial product development.

In this research direction were included the following ideas for research projects: *Health Care Social Network – MEDBOOK,* Applied Research, Technological Innovation and Entrepreneurship – Proof of Concept Program, ARTIE POC (Romanian American Foundation) and *Development of Innovative Researches in the Field of Human-Machine Interface Oriented to Business And Community Needs* (POSCCE, Priority Axis 2 - Research, Technological Development and Innovation, Key Area of Intervention 2.2 - Investment in R & D infrastructure, Operation 2.2.1: Development of existing CD and creation of new infrastructure (laboratories, research centers)).

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SECTION II

PAST, PRESENT, FUTURE

1.

ACADEMIC, PROFESSIONAL AND SCIENTIFIC ACHIEVEMENTS

The academic, professional and scientific activities interfere all through the 22 years of my university career.

ACADEMIC ACHIEVEMENTS

- PhD. in Industrial Engineering, 2004

"Quality Management System from the Perspective of Constructors and Users of Mining Equipment"

University of Petrosani

- Economist, Accounting and Management Information Systems, 2003

"Study regarding the quality-cost relationship in the Quality Management System context. EM Paroseni case study."

University of Petrosani

- Ingénieur expert en tehnique, economie et gestion de l'entreprise minière, 1998

„Méthodes et outils pour ameliorer la qualité dans l'entreprise roumaine constructrice des machines et outillages miniers (S.C. UMIROM S.A)"

Institute Nationale Politechnique du Lorene, École Nationale Supérieure des Mines de Nancy, France

- Engineer, Electromechanical Engineering, 1992

„Application of intrinsic safety protection for the control circuits from the electrical equipment used in underground mining sites"

University of Petrosani

These form the fundamental basics of my academic achievements, continuously improved through complementary trainings and educational programs (Fig.1).

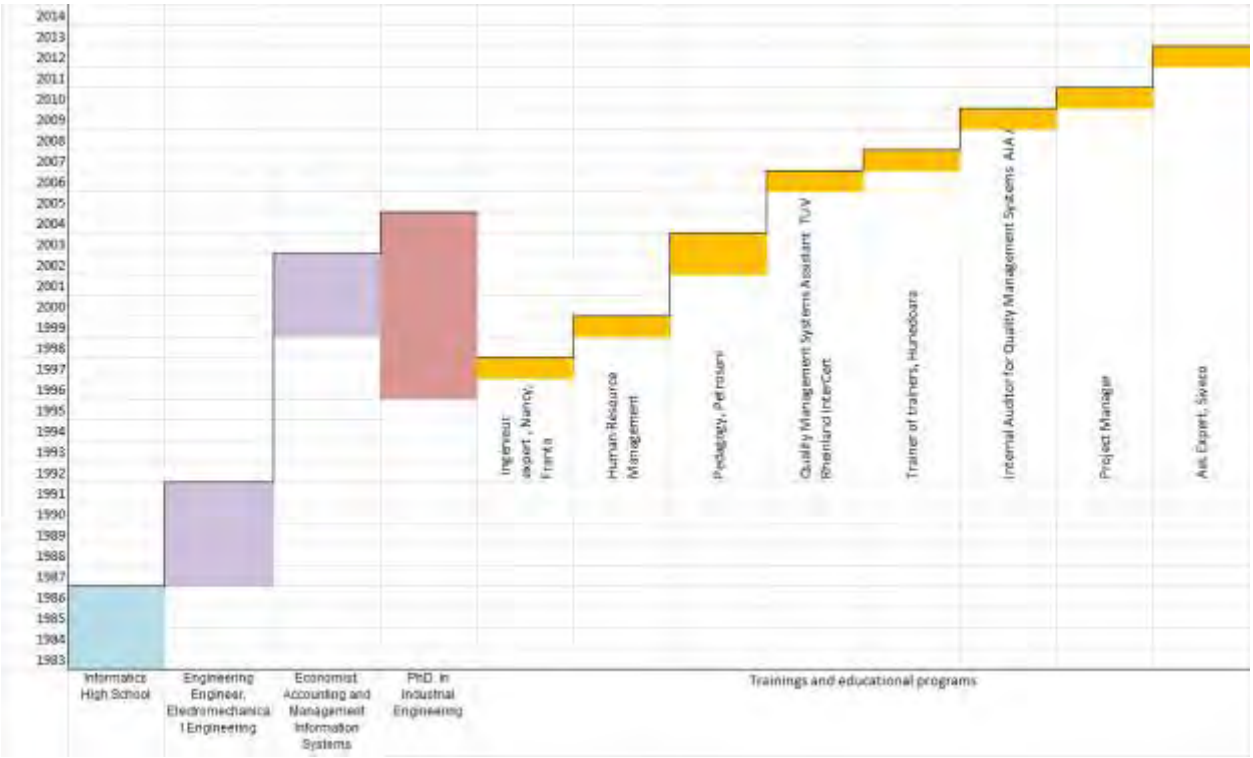


Fig. 1. Academic achievements

Until present, my academic career has developed gradually, from university assistant to university professor.

DIDACTICAL ACHIEVEMENTS

• Teach courses, seminars and laboratories at undergraduate specialization subjects: Quality management, Quality management in the public sector, Quality audit, Production management, Operational management, General management, IT management, Tourism and services management, Database management systems.

• Teach courses and seminars on master specializations subjects: Total Quality Management, Quality Audit, Measurement, inspection and test methods for quality assurance, Methods and techniques for projects' quality management, Information systems for quality management, Project audit, Human implications of reengineering, Business communications, Tourism and services management.

• Coordinate graduation projects and participate as referent member for graduation in the undergraduate area of Industrial Engineering and Management, specializations: Economic Engineering (2000-present), Management (2000-2007).

• Coordinate dissertations and referent member for master specializations: Management and quality assurance (2003-2006), Financial Management (2006), Human Resources Management (2006), Strategic Management and Business (2009).

• Lectures and guidance for postgraduate education - Teach postgraduate courses for qualification of personnel from the National Hard Coal Company (NHCC) Petrosani.

All the published books were related on the main areas of teaching activities for the above mentioned disciplines as follows: *Information systems*, *Services Management* and *Quality Management*.

My professional development is strongly linked to my teaching activity and led to interferences between the three areas from above, resulting in useful teaching materials addressing students from different specializations, as presented in figure below.

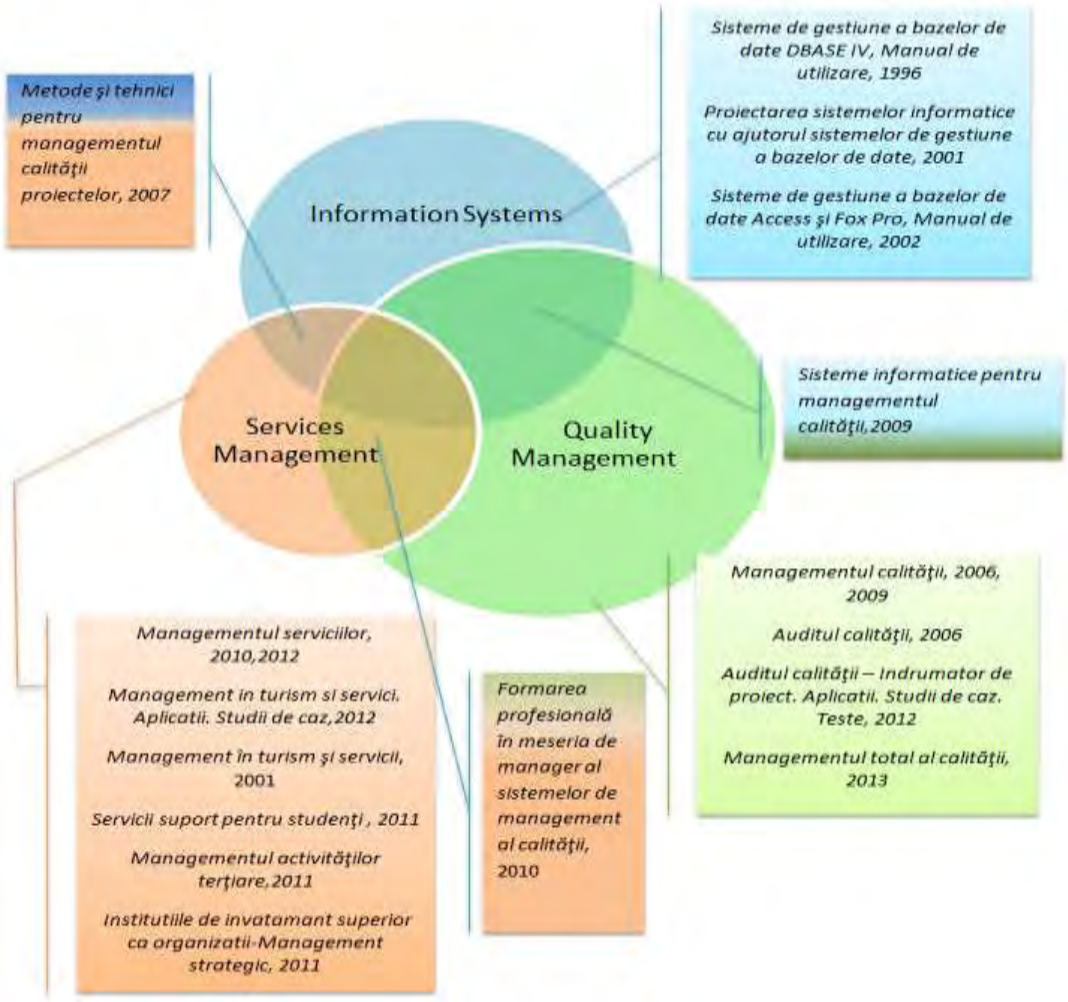


Fig.2. Published books

PROFESSIONAL ACHIEVEMENTS

• At the University of Petrosani, my contributions in developing the field of quality management have resulted in the following: participation in the accreditation process, as responsible of the specialization *Quality Engineering and Management* and the postgraduate course *Products and Services Quality Management*; design and implementation of the Quality

Management System for ISO 9001: 2008 certification of the University of Petrosani as Responsible for Quality Management (RMC) (2010-2013). The particularities of the Quality Management System from the University of Petrosani were presented in the Romania-UK best practices workshop (within the project Improving University Management-IMU) at the Institute of Education, London, by the paper: *Quality Management System at the University of Petrosani* and, also, at the International Conference *Institutional Strategic Quality Management - ISQM 2010*, by the paper: *Some Aspects Concerning Quality Management System (QMS) Implementation at the University of Petrosani (UPET)*.

• Scientific guidance for students: Participation in national scientific symposium - student editions - "Student, Science, Society" held in 2006, 2010, 2014 and national student scientific symposium, "Geoecologia" 2008 as member in the organizing committee and / or coordination of scientific papers presented by students. The topics addressed were related to quality management issues. Among the papers presented the one entitled *Considerations on the implementation of the quality management system to SMEs*, was awarded third place in the National Student Symposium "Science Student Society", eighth edition, section Management, Marketing and Administration, May 2010. Another topic addressed was *Information system for document management within the quality management system at the University of Petrosani*, developed and presented by an interdisciplinary team of students from the specialties of Management and Information Systems Management.

• Participate in the scientific and organization committees, as scientific reviewer and editor at the following international scientific conferences:

- **Recent Techniques in Educational Science**-International Multiconference COSUE '13, CHADE '13, CPED '13Vouliagmeni, Athens, Greece May 14-16, 2013 Educational Technologies Series | 7 ISSN: 2227-4618 ISBN: 978-1-61804-187-6
- **Workshop Intelligent Technologies for e-Learning, iTeL'13 16th** December 2013 In the fram of Sixth International Conference on Intelligent Computing and Information Systems, ICICIS'13 http://net2.shams.edu.eg/icicis/2013/, Chair and Organizer Prof. Dr. Abdel-Badeeh M. Salem, **Ain Shams University, Cairo, Egypt**
- Recent Advances in Computer Engineering Series | 15, ISSN: 1790-5109 ISBN: 978-960-474-317-9, http://www.wseas.us/e-library/conferences/2013/Valencia/CSA/CSA-00.pdf
- Recent Advances in Electrical Engineering Series | 20, ISSN: 1790-5117 ISBN: 978-960-474-318-6, http://www.wseas.us/e-library/conferences/2013/Valencia/ELCS/ELCS-00.pdf
- Mathematics and Computers in Science and Engineering Series | 16, ISSN: 2227-4588, ISBN: 978-960-474-319-3, http://www.wseas.us/e-library/conferences/2013/Valencia/ICCS/ICCS-00.pdf

• Reviewer of scientific articles in international journals

- Universal Journal of Education and General Studies, manuscript numbers: UJEGS-12-030, UJEGS-12-020
- Educational Research, manuscript numbers: ER-12-059, ER-12-049
- Comprehensive Research Journal of Education and General Studies www.crjournal.org, E-learning benchmark and Quality Function Deployment role, manuscript numbers CRJMBS-13-087

• Member in:

- European Distance and e-Learning Network (EDEN)

- General Association of Romanian Engineers (AGIR),
- Association of Managers and Economical Engineers from Romania (AMIER)

SCIENTIFIC ACHIEVEMENTS

In my entire activity I developed 190 papers, from which 91 after the last promotion as follows:

- Articles in ISI Thomson Reuters journals and in ISI Proceedings from the last promotion: **20** articles in ISI Proceedings, **4** journal articles in ISI Thomson Reuters
- Articles in journals and proceedings of scientific conferences indexed in other international databases since the last promotion: **45** papers
- Articles in Journals / Proceedings non-indexed: **94** papers
- Papers plenary presented: **4**
- Unpublished Papers presented at other events: **27**

In published the following didactical books:

- Books and chapters in specialized books: 9 books, from which 4 as first and only author
- Didactic books: 7 textbooks, of which 4 as first author
- Laboratory tutorials / applications: 2 laboratory guides and applications as first author

Inventions:

- 2 OSIM patents registered:
  - Patent no. A 2012 00914 / 11.29.2012, *3D Spiral Life Cycle Model Based on QFD and Spiral Method for Software Development Life Cycle*;
  - Patent no. A 2014 00167 / 27.02.2014, *Method for relevant medical information storage based on biometric identification*.

Research projects:

- *Increasing the quality of staff related to vocational guidance* (*ACCESS),* Grant GRU-10-P-LP-151-HD-TR, 2010-2012
- *eQuality Training System* – CC.8/19.04.2013 InterConformity Assessment and Certification Company, Germania
- *Mobile Phone Software Development: Push Notification Framework* - 826/15.07.2009, Omnisource, Italy
- *Information system as educational support for quality audit training* - CC 10/25.06.2013, QS-CERT, Romania
- *InterConformity Academy* - 11/01.05.2014 SC MSC SOLUTIONS SRL Romanian representative of InterConformity GmbH, Germania
- *Integrated information system for monitoring, statistical processing and technical-economical optimization of preparation plants for sustainable valorization of mineral resources containing precious metals, MENER 482 /* 21.09.2004

I participated as management team member or expert in 5 POSDRU projects, 1 PHARE project and 10 research projects with industrial partners.

The visibility and impact of my scientific work is assessed according to citations in journals indexed in ISI and international databases, of which the most current and representative for my research directions are: International Journal of Productivity and Quality, (A Chiarini, 2013); International Journal of Services and Operation Management, Inderscience (A Al-Khalili, K Subari, 2014); Eco-Innovation and the Development of Business Models, Springer (Maria do Rosário Cabrita, Virgílio Cruz-Machado, Florinda Matos, 2014); Artificial Intelligence Review,

Springer (Adil Baykasoglu, 2012); Journal of Business Economics and Management, Taylor & Francis, (A. Krivka, 2014); International Journal of Computer Applications (Gopal Sakarkar, S.P.Deshpande, V. M. Thakare, 2012); Asian Social Science, (Hassan Saleh Al Dhaafri, Rushami Zien Bin Yusoff, Abdullah Kaid Al Swidi, 2014); UTMS Journal of Economics (Pozega, Zeljko, Boris Crnkovic, and Ana Udovicic, 2014). (http://scholar.google.ro/citations?user=x0Sxpa8AAAAJ&hl=ro)

I presented as plenary speaker the following papers from the field of Quality Engineering and Management:

- *QFD in Software Development: a New Perspective.* **Plenary Lecture**, Proceedings of the 14th WSEAS International Conference on Mathematical and Computational Methods in Science and Engineering (MACMESE'12), Sliema, Malta, 7-9 September, 2012, 21-22pp. ISBN 978-1-61804-117-3, ISSN 227-4588, Published by WSEAS Press. http://www.wseas.org/cms.action?id=871
- *Breaking the Boundaries of eLearning Systems through Creativity.* **Plenary Lecture, Recent Techniques in Educational Science,** Vouliagmeni, Athens, Greece, May 14-16, 2013 ISSN: 2227-4618, pp.10-12, ISBN: 978-1-61804-187-6*A* *http://www.wseas.org/cms.action?id=3655*
- *Quality Management Tools Embedded Software Development Lifecycles* **Plenary Lecture,** Recent Advances in Computer Science and Applications,4thInternational Conference on Applied Informatics and Computing Theory (AICT '13), 6-8 august, 2013, VALENCIA, Spania, pp.12, ISBN:978-960-474-317-9, http://naun.org/cms.action?id=5409
- *Product Innovation Methodology Based on QFD and TRIZ.* **Plenary Lecture,** International Conference on Management, Marketing, Tourism, Retail, Finance and Computer Applications, Tenerife, 10-12 January 2014, ISBN 978-960-474-360-5, pp. 10 http://naun.org/wseas/cms.action?id=7306

The main scientific achievements related to the four research directions are addressed in scientific papers and research projects, as follows:

In the first research direction *"Mainstreaming in quality Management*" are concentrated the research results regarding the analysis of QMS and QRM systems implementation possibilities in mining industry, the analysis of possibilities for human factor quality assessment based on a fuzzy logic model for the underground mining working system, the analysis of premises for the preconditions achievement in terms of managerial culture in the context of TQM approach. These researches were conducted as a follow up of the Ph.D. thesis research addressing specific aspects of QMS implementation in mining industry.

The researches were focused on the following areas: integrated management systems; evaluation of the human factor in the underground work system; coordinates of change organizational culture in the context of Total Quality Management approach. Focusing on Total Quality Management (TQM) in this research direction generated generous exploring topics like TQM and Reengineering treated as strategic options for an organization or in the personal life development; TQM and business excellence; assessment tools in the context of TQM; Kaizen strategy in the context of TQM.

The second research direction is dedicated to the quality management tools in general with focus in particularly on developing a methodology to apply the Quality Function Deployment (QFD) method for software quality evaluation introducing a lifecycle model that includes in its representation the quality part. This new lifecycle has a 3D representation made out of

multilevel circles spaced by an offset. The offset value is a comprehensive quantification of the accomplishment degree of the customers' requirements, based on a mathematical model.

In order to demonstrate the viability and applicability of the 3D Spiral Life Cycle Model Based on QFD Method and Spiral Life Cycle for Software Development, that is the subject of a registered patent published by OSIM, I conducted research in the areas of software engineering; renewable energy systems; services (in combination with SERVQUAL model); new product development (NPD).This last area is the link to the development of the fourth research direction, Creativity and innovation in new product development.

The new perspective introduced by the patented model has been the subject of a plenary paper presentation by the title QFD in Software Development: a New Perspective, Plenary Lecture, Malta in 2012.

The project *Mobile Phone Software Development: Push Notification Framework* (CC/826/15.07.2009) was the starting point for achieving this patent, a project within, as responsible for the software quality I achieved the QFD phase implementation in the software development stages.

The researches focused also on a new approach on the EFQM Excellence Model, by creating a mathematical model based on digraph and the design of a software tool for quality self-assessment. The present version of the software tool based on the EFQM model is 1.1 and is integrated in the project *Information system as educational support for training in audit quality field* (CC/10/25.06.2013).

The excellence model is part of the methodological tools that indicate the status, together with the evolution, progress and performance in the framework of organizations approach towards Total Quality Management (TQM). Thus, it is created the link to the first direction of research regarding mainstreaming in quality management.

The research results from this direction were presented in the plenary of the international multi-conference in Valencia in 2013, as subject of the *paper Quality Management Tools Embedded Software Development Lifecycle.*

The many facets of quality, and also the teaching activities carried out, have generated the interest for Student Support Services (SSS) domain exploration in the third research direction. The SSS research aimed topics like mentoring and tutoring in the SSS context; academic counseling role; quality assurance in higher education; role and importance of self-directed learning methods (SDL-Self Directed Learning) in the context of modern learning; entrepreneurship education; use of quality management methods in the evaluation of eLearning systems and the use of innovative and creative methods, like interactive games and gamification; innovation in education; quality management system in the University of Petrosani.

The use of the QFD-based assessment method for modern learning and teaching systems connects to the second research direction, while the innovative methods and techniques is the link to the fourth research direction, creativity and innovation in new product development.

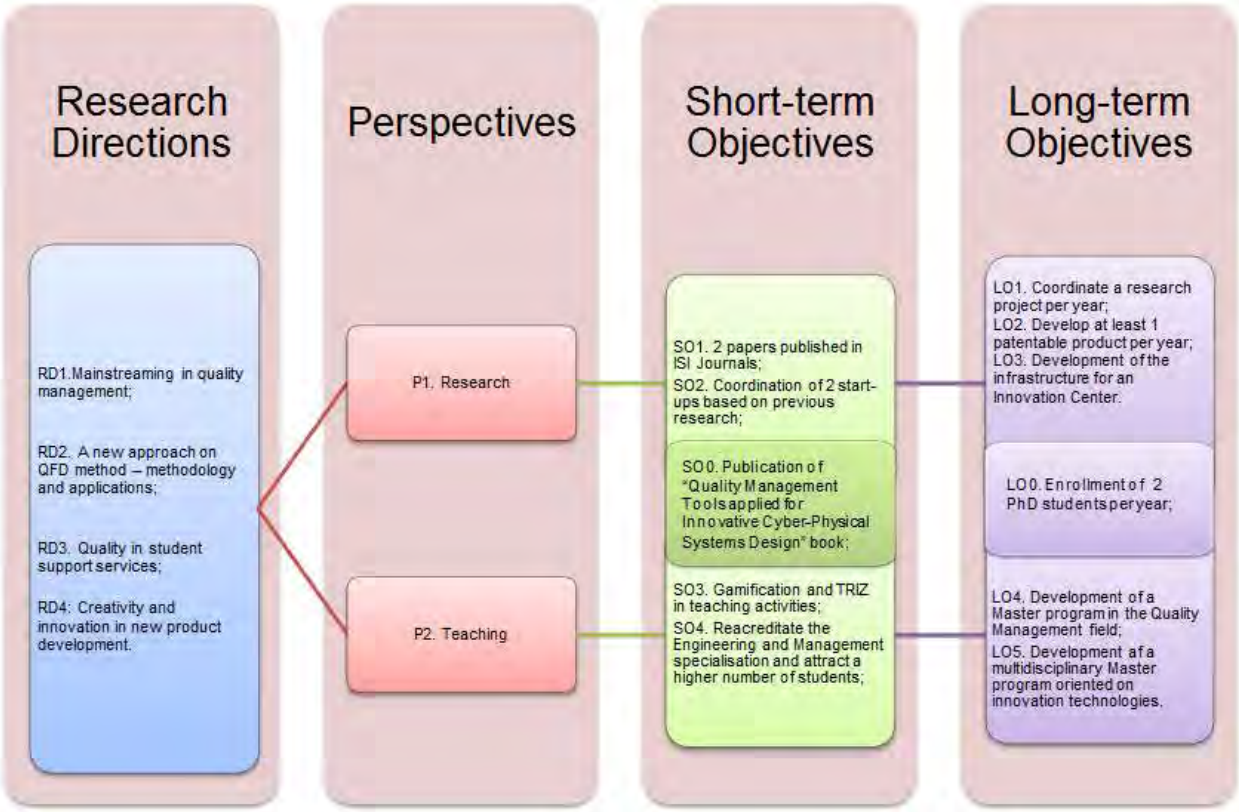
This research direction is related to the research activities from the projects: *Increasing the quality of staff related to vocational guidance* (ACCESS), GRU-10-P-LP-151-HD-TR (vocational

counseling, mentoring and tutoring); Improvement of university management POSDRU / 2 / 1.2 / S / 4 Priority Axis 1 *Education and training in support of economic growth* (improving the quality of university management); *eQuality Trainnig System* CC / 8 / 19.04.2013 and *InterConformity Academy* CC / 11 / 01.05.2014 (development of quality oriented courses in a modern approach based on MOOC, having as starting point the research on Self-Directed Learning SDL); *Training for the job of Quality Manager in the Quality Management Systems - for the line managers from construction companies in the North-East region*, "PHARE project /2006/018-147.04.02 (training in quality management); *Alternative training solutions using information systems - a solution for the conversion of the mining workforc*e, POSDRU 82 / 5.1 / S / 59756, *Higher education human resources development in the use of e-Learning system,* POSDRU 87 / 1.3 / S / 64273 (the use of eLearning systems in training).

2.

DEVELOPMENT PERSPECTIVES

Each chapter, addressing one research direction, contains detailed proposals for further enhancements. Next, I will present perspectives in developing academic, professional and scientific career synthesized in the two components (teaching and research) together with the time horizon of the objectives.



In-work Projects:

- The book "Quality Management Tools applied for Innovative Cyber-Physical Systems Design" (coauthored with Ph.D. Assoc. Prof. Monica Leba), containing the results of inter-,multi-,trans-disciplinary researches on the application of quality management tools and methods in innovative software-hardware systems development.
- The project Massive Online Open Game-based Education (MOOGE) with the objective of designing and implementing a modern educational platform based on MOOC and Gamification. The idea of this project was presented at EDEN Synergy Workshop and the current phase is a partnership with 3 Universities from Hungary, Austria and Germany.

Future Projects:

- Provide continuity with the second cycle of education for students of specialization Quality Engineering and Management by proposing a Master in quality field

- Taking into account that the interdisciplinary research is the current trend, a trend that I followed in my recent years researches, I think it would be appropriate to develop a Master degree or a postgraduate interdisciplinary program containing elements of: project management, innovative soft-hard systems, automotive systems design, quality management.
- Develop an innovation center at the University of Petrosani. This initiative was the subject of a POSCCE project unfunded that will be re-proposed in an improved form in the 2014-2020 funding lines.

The main goal after obtaining the title of habilitation is coordinating the doctoral thesis in the field of Engineering and Management (LO0).

To achieve this currently established long term objective, I considered necessary to achieve other support objectives. Thus, in terms of research, a goal is the creation of the research environment through the development of an Innovation Center (LO3). This center will be available both to Ph.D. students and master students to the specializations in progress and / or newly developed (LO4) but also it will be a basis for the development of a multidisciplinary master oriented on innovation technologies (LO5). The link between university research and industry needs will be addressed through research projects (LO1), because the involvement of an industrial customer or partner leads to a competitive environment that stimulates the innovation. The research-industry collaboration will result in at least one registered patent per year (LO2).

Of course these goals must be supported by short-term, immediate goals, some of them almost reached (SO1), others, such as start-ups (SO2), creating the premises for future development and implementation of the Ph.D. students' innovative ideas.

JV SENSOR VENTURES (www.jvsensorventures.com) is a project which is an initiative started combining teaching with research component through start-ups initiated by students of bachelor and master cycles from the University of Petrosani and continued with prospective PhD students.

In this moment, the following scientific papers are accepted by ISI indexed journals and proceedings and waiting to be published:

Journals:

- **Andreea Ionica**, Monica Leba, *Human Action Quality Evaluation based on Fuzzy Logic*, WORK Journal.
- **Andreea Ionica**, Monica Leba, Remus Dobra, *Successful Mentoring in the GaInCrEd Environment*, TTEM Journal.

Proceedings:

- Monica Leba, **Andreea Ionica**, *3D Spiral Life Cycle Software Model Applied for an Innovative Product Development*, 5th WORLD CONFERENCE on INFORMATION TECHNOLOGY, Dubai, December 2014.
- **Andreea Ionica**, Monica Leba, *EFQM Software Design based on the 3D Spiral Lifecycle Model*, 5th WORLD CONFERENCE on INFORMATION TECHNOLOGY, December 2014.
- Umer Asgher, Monica Leba, **Andreea Ionică**, Roland Iosif Moraru, Riaz Ahmad, *Human Factors in the Context of Excellence Models: European Foundation for Quality Management (EFQM) Excellence Software Model and Cross-Cultural Analysis*, 6th International Conference on Applied

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Having the last years activity oriented on innovation, this will be applied also in teaching activities, using gamification and TRIZ techniques to motivate students, prospective doctoral students, preparing them for a competitive environment (SO3). The doctoral students may come from both “Management” and “Industrial Engineering” specializations which I have and will participate in the reaccreditation (SO4) in a short time, but also from other specializations.

Another important short term objective, useful both for didactical and research activities, is the publication of the book “Quality Management Tools applied for Innovative Cyber-Physical Systems Design” (SO0), result of last years’ inter-, multi-, trans- disciplinary researches.

The previously stated perspectives, even if they are divided on research perspectives (P1) and teaching perspectives (P2), will answer the four research directions (RD1, RD2, RD3, RD4). I considered in this career development plan the timestamps of 6 months to 2 years for short-term objectives and 2 to 5 years for long-term objectives.

SECTION III

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