Abstract— The aim of this paper is to provide a possibility to gather new knowledge and skills through solving of the new production launch situations in continuously changing global environment as is e.g. relocation of the production from one country to another. Common target is modeling and simulation of related risks using educational web based environment of Quality Management Role Play Simulation SIMPRO-Q. In the paper is presented method for gathering of new abilities and skills in engineering education using SIMPRO-Q. Players make both quantitative and qualitative decisions as they manage a critical situation during relocation of production.

Keywords: production relocation, project quality management system, project failure mode effect analysis, modeling, simulation

I. INTRODUCTION

Relocation or the transfer (also known as ‘off-shoring’ or ‘delocalization’) of a production by multinational companies of production activities from one country to another has become an important issue in industrial relations across Europe [1]. Transitions also occur when the production operation undergoes a shift, which may be due, for example, to start-up operations or product changes. Product quality often suffers during such transition periods [2].

Each production relocating involves also risks that are becoming more pronounced with complexity of the production, and their anticipation and effective management presents a principal element of successful project management. Proper risk identification, analysis and management can assist the project manager to mitigate against both known and unanticipated risks on projects of all kinds [3]. Correspondingly, any relocation project entails also concerns of the interested parties about the change and, hence, the need to motivate them. Failure to perform effective risk management can cause projects to exceed budget, fall behind schedule, miss critical performance targets, or exhibit any combination of these troubles [3].

From our literature survey it follows that existent are organizations focusing solely on relocating productions (such as e.g. Flatworld [4], though we have found only very few papers that were scientifically investigating the issue of mitigating risks at relocating productions, mostly applying the Failure Mode Effect Analysis (FMEA) method. One of the most frequently quoted authors in this field has proven to be Carbone, T. A. Having effective methods for identification and modeling, analyzing and evaluation, and simulation a project risk with tools to overcome the change associated concerns is crucial for the project manager to mitigate against both anticipated and unanticipated risks on projects of all kinds. Modeling and simulation are disciplines for developing a level of understanding of the interaction of the parts of a system, and of the system as a whole [5]. Simulation of actions of people as representatives of either entire organizations or parts thereof by playing roles is being successfully used in research, teaching and in designing socio-technical systems for several decades [6], [7] and [8].

The aim of the present paper is to allow the interested parties to arrive at fresh pieces of knowledge that would enable them to successfully resolve the production relocation issues. The paper is based on the recent knowledge in teaching Industrial Engineering and Quality Engineering and Management at universities, and also on the knowledge and experience of the authors in educating whilst applying the Quality Management System Role Play Simulation (SIMPRO-Q) at varying Higher Education Institutions (HEI) and organizations throughout a number of European countries. Presented in the paper are risk mitigating and motivating methods and tools at utilizing modeling and simulating with use of Project Quality Management System Role Play Simulation (P-SIMPRO-Q) educational tool, of analyzing possible project failures and their effects – Project Failure Mode Effect Analysis (PFMEA), of management of both anticipated and unforeseeable project risks in accordance with ISO 31000:2010 [9] and the project quality management further to ISO 10006:2003 [10]. The paper is primarily intended for teachers of and students taking courses in Quality Management System, New Product Development and Project Management though it will be of help also for professionals acting within teams specializing in moving productions from a country to another one.
II. PRINCIPLES AND CONCEPTS OF THE PRODUCTION RELOCATING PROJECTS

The production relocating principles and concepts are based on the premise that proper identification of risks, their modeling, analyzing and assessing, as well as effective project quality management and targeted education can be of help at alleviating both anticipated and un-anticipated risks at all types of projects.

Understood under the term “production” is the process and result of the target-oriented activities of be it individuals of organizations, i.e. production processes and products.

Production relocation usually occurs when the organization intends to increase profitability of their business operations assuming they would do better in a new environment. Considered are possibilities and needs to change processes (quality, productivity, effectiveness), to change the product (new, updated quality requirements of the customer), as well as change in the entrepreneurial environment. At relocating production, especially carefully considered are basic elements of the new business and cultural environment and discussed and proposed are necessary changes. The new environment is analyzed in detail as to the differences identified against the existing one.

The below possible differences should be as well considered so to be taken for significant project success factors:

- Differences in production processes
- Differences in products
- Differences in the business, working and cultural environment

Basic situations of influence upon relocating the production expressed by use of differences in principal factors: (-) insignificantly differing, (+) significantly differing from the original status are presented in Tab. 1.

| No | Proc | Prod | Env | Brief description of possible situation |
|----|------|------|-----|----------------------------------------|
| 1  | (-)  | (-)  | (-) | Relocation to similar environment with min changes in processes and products. |
| 2  | (+)  | (-)  | (-) | Relocation to similar environment with changes in processes. |
| 3  | (-)  | (+)  | (-) | Relocation to similar environment with changes in products. |
| 4  | (+)  | (+)  | (-) | Relocation to similar environment w/ changes in both processes and products. |
| 5  | (-)  | (-)  | (+) | Relocation to significantly different environment w/ min changes to processes and products. |
| 6  | (+)  | (-)  | (+) | Relocation to significantly different environment with changes in processes. |
| 7  | (-)  | (+)  | (+) | Relocation to significantly different environment with changes in products. |
| 8  | (+)  | (+)  | (+) | Relocation to significantly different environment w/ changes in both processes and products |

Each of the above cases has its particularities; in our paper modeled example pertains to situation under seq. no. 4 and to these pertaining simulated typical issues.

That the arduous tasks were at relocating a production successfully dealt with identified, analyzed and assessed in advance must be the risks and these should be also allowed for within the project quality management processes.

The concept of production relocation modeling and simulating utilizes the project quality management model according to ISO 10006:2011, risk management model according to ISO 31000:2010, tool FMEA adjusted for the project, and the existing educational tool SIMPRO-Q customized for the project.

A. Project Quality Management

The project quality management centres are processes covered by ISO 10006:2010. Project is defined as a unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constraints of time, cost and resources. Understood under the project management is: planning, organizing, monitoring, controlling and reporting of all aspects of a project and the motivation specifying what is necessary to meet the objective(s) of the project. Project processes are those processes that are necessary for managing the project as well as those that are necessary to realize the project’s product. It may be one or several units of product and may be tangible or intangible. The project’s organization is normally temporary and established for the lifetime of the project. The project life cycle breaks down to these sections: concept, development, realization and completion, and the possibility of their controlling. Involved in by us simulated and modeled case are 13 project quality management sub-processes, and the process product is production of auto components.

B. Risk Management

We believe the risk identification is the process of finding, recognizing and describing risks. Risk analysis is a process to comprehend the nature of risk and to determine the level of risk, that is – magnitude of a risk or combination of risks expressed in terms of the combination of consequences and their likelihood. Risk analysis provides the basis for risk evaluation and decisions about risk treatment. Risk evaluation: process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude are acceptable or tolerable (ISO 31000:2010).

The risk management tool is the Failure Mode Effect Analysis.

The FMEA technique dates back to the United States military procedure MIL-P-1629: 1949. FMEA presents team-wise analysis of the possibility of occurrence of risks in the proposal being considered, evaluation of the risk and adoption of the measures ensuring improvements in quality [11]. Pritchard [12] first identified the FMEA technique as an advanced format capable of capturing project risks.
For the Project Failure Mode Effect Analysis (PFMEA), detection techniques or methods are defined as, “the ability to detect the risk event with enough time to plan for a contingency and act upon the risk” [3]. If the team cannot be reasonably assured that the risk can be detected because it is, in a sense, sneaky or has subtle symptoms, the detection number must be assigned as a 10 at initial planning. If the risk is, as Pritchard [10] noted, “like a freight train that can be heard for miles,” then the detection value will be smaller because the team has adequate time to plan a workaround or mitigate the risk once the symptoms are identified. The detection value helps to further rank risks in order to deal with those that require attention immediately [3].

The PFMEA is introduced during a team planning meeting utilizing the template form modified as needed for the specific project.

C. SIMPRO-Q Web-Based Educational Tool

SIMPRO-Q or Quality Management System Role Play Simulation educational tool was developed in 1989 [13] at the Technical University in Kosice.

The role-play simulation basis is a team-wise experimenting with in advance prepared quality management system (QMS). Included in the team are individuals that are being educated in the quality management at HEI or real managers of any organization.

Nature, objectives and phases of SIMPRO-Q have been maintained also in the P-SIMPRO-Q, and changed were only the quality management processes so that they were defined and modeled in compliance with ISO 10006:2003 along with the risk management processes per ISO 31000:2010 as follows:

- Strategic process;
- Resource-related processes and personnel-related processes;
- Interdependency-related processes, scope-related processes, time-related processes, cost-related processes, communication-related processes, risk-related processes, purchasing-related processes;
- Improvement-related processes, processes of measurement and analysis, and processes of continual improvement.

III. SIMULATION ROLE-PLAY: QUALITY MANAGEMENT IN THE PRODUCTION RELOCATION PROJECT

The basis of the production relocating simulation and modeling is to arrive at prognostication of future tasks of the project quality management using role-plays.

Identification, modeling, analyzing and evaluation of in advance anticipated risks and behavior of personnel, designed to curb them with the purpose to successfully relocate the production.

Once the play has been prepared the presenter explains to the players that they are going to take on roles of partial design team managers and that their task would be to establish the project quality management system matching a previously selected model. Next, the players will be, under guidance of the presenter, passing individual simulation role-play stages whilst performing assigned tasks. They may help themselves by discussing some issues with the presenter, through mutual discussions or by studying on-line documents and other complementary materials. Attained this way are being in advance postulated educational goals and in time emerging are necessary documents.

Production relocating sub-processes are illustrated in Fig. 1.

![Production relocating sub-processes](adopted from Flatworld, 2011)

A project risk is defined as “an uncertain event or condition that, if it occurs, has a positive or negative effect on a project’s objectives” Project Management Institute [14].

PFMEA is a living document created and then updated throughout the project stages.

In doing the analysis, the system behavior is evaluated for every potential failure mode of every system component. This unacceptable failure effects occur, design changes are made to mitigate those effects. The criticality part of the analysis prioritizes the failures for corrective action based on the probability of the item’s failure mode and the severity of its effects. It uses linguistic terms to rank the probability of the failure mode occurrence, the severity of its failure effect and the probability of the failure being detected on a numeric scale from 1 to 10. These rankings are then multiplied to give the Risk Priority Number. Failure modes having a high RPN are assumed to be more important and given a higher priority than those having a lower RPN [15].

An example of filled-out form for analyzing and evaluating risks using the PFMEA method is presented in Tab.2.

| Mode | Effect | Severity | Likelihood | Occurrence | Risk B | Preventive Action 1 | Preventive Action 2 | Preventive Action 3 | RPN | Recommendations | Control Action | Target Expenditure | Actual Expenditure | Corrected RPN | Risk Priority Number |
|------|--------|----------|------------|------------|--------|---------------------|---------------------|---------------------|-----|-----------------|-----------------|------------------|---------------|--------------|----------------------|
| Fault | Low risk | S | M | R | 2 | S | S | S | 10 | S | S | S | 20 | 10 | 20 |

![TABLE II. PARTIALLY FILLED-OUT FORM FOR THE PFMEA EXAMPLE](adopted from Table 2)
S – Severity (Impact). It is ranked according to seriousness of the failure mode effect on the project objectives if the risk event occurs.

O – Occurrence (Likelihood). It is ranked according to the failure probability, which represents the relative number of failures anticipated during the project life of the item.

D – Detectability (Detection). It is the ability to detect the risk event with enough time to plan for a contingency and act upon the risk.

RPN – Risk Priority Number. The RPN index is determined by calculating the product of severity, occurrence and detection indexes. \[ RPN = S \times O \times D \]

Phases of the project quality management role-plays

To meet the purpose of role-plays in respect to the P-SIMPRO-Q very nature formulated can be the following phases:

1st phase: Project organization presentation
- familiarization with a project organization; (replication organization structure, replication process, replication of work management process)
- finding the right places for the right people in the project;
- risk identification and modeling
- position acceptance in a project organization.

2nd phase: Experimentation with the processes of the project QMS
- selection from randomly distributed processes;
- acceptance of assigned processes;
- taking responsibility for processes;
- risk analysis and evaluation.

3rd phase: Experimentation with project QMS process inputs and outputs
- buying from randomly distributed processes;
- buying from distributed processes;
- formulation of the comparative effective value.

4th phase: Documentation of a project QMS
- enhanced descriptions of managerial tasks;
- defined and modeled processes of the project QMS;
- responsibility and competence matrixes in the project QMS;
- documented PFMEA plan

5th phase: Experimentation with the functioning of the project QMS
- testing of the modeled situation in a project (falling behind schedule, etc.)
- reason analysis, evaluation the determination of responsibilities;
- ability to alleviate the project risks
- improvements and preventive actions taken.

Results of role-play are in advance prepared and progressively filled in reports on step-by-step meeting of the project partial objectives. Resultant solutions are being attained upon the role-play, using partial indicators, participants’ consensus on the project successfulness. As the simulated project moves forward, the team continuously updates the PFMEA and checks off the completion status of mitigation (alleviation) actions [16].

The quality management role-play benefits are pedagogical, project-wise and/or diagnostic in nature.

IV. P-SIMPRO-Q EDUCATIONAL OBJECTIVES

The summary educational goal of the P-SIMPRO-Q method is to deepen the knowledge, improve skills and foresight of the engineers and managers involved in relocating productions, and to educate them in designing and implementing the project quality management system by mitigating risks so that profitability of the organization would come increased.

Specific partial objectives of educating and training in relocation productions into similar environment due to changes in processes and products:

To learn to foresee and mitigate the production relocation risks
- To know how to identify and model risks accompanying projects of relocating productions and production processes
- To know to analyze and evaluate the production processes relocating project risks
- To come to know how to differentiate among differences of the entrepreneurial, working and cultural environments
- To know how to mitigate the project risks
- To be able to identify the project economical effectiveness.

To learn to design and implement the project quality management system
- To be able to analyze current status of production the organization being relocated
- To know how to analyze the risks from the point of the project quality management system needs using PFMEA.
- To know the project quality management system principle and structure of the production.
- To be able to devise strategy, policy and objectives of the project quality.
To be able to decide on responsibilities and competences within the project quality management system based on flow of information on quality, safety, environment, efficiency and economical effectiveness of the production being relocated.

To be able to decide on that which input information are vital for realizing the project quality management system processes.

To learn to develop the project quality management system documentation (project quality policy, documented phases of the project, quality manual, ...)

V. CONCLUSIONS

Though there is a host of reasons substantiating relocation of a production the core one is profitability of the company attained in a new, more or less differing or similar environment, whilst when the need and arises and the company allows it, changed may be also products and processes as well.

The principle of coming to a solution predominantly depends on proper identification of risks, on their analyzing and assessing, as well as on an effective project quality management and targeted education that can be of help at mitigating both anticipated and unforeseeable risks in all types of projects.

When relocating a production considered should be mainly differences in production processes, products, entrepreneurial and cultural environments, and to have these for features significantly contributing to the project success.

The production relocation project concept has been built on quality management methods pursuant to ISO 10006:2003, on risk management, PFMEA in which represents the principal tool, and also on the new P-SIMPRO-Q method.

Production relocation sub-processes are separated into 3 main stages according to Fig. 1, and presented are on a P-FMEA example (Tab. II.).

The project quality management role-play process breaks down into five phases to attain the below educational and implementing goals of the project:

- To learn how to propose and realize the project quality management system
- To learn how to effectively resolve the project quality, efficiency and economical effectiveness issues.

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

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