The ERGOMAN Project: designing the new Process Ergo-Designer profile and training model and its validation

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ABSTRACT: In the last twenty years, ergonomics has received great attention from different points of view: the design of products/services, the prevention/reduction of health problems, to face human-machine interaction problems. Training activities and models related to ergonomics often refer to curriculum profiles that are focused on product design rather than process design, but the latter becomes crucial when attention is focussed on the design of production lines or, in general, of workplaces. The challenge is to train students and professionals with adaptive, quick-response, process ergonomics design and evaluation skills for modern flexible manufacturing process to improve quality, productivity and worker health. Trying to meet this challenge, ERGOMAN (a Leonardo project funded by the European Union) has produced some results, presented in this paper: a co mpetence needs analysis made by industries; the definition of a new competence profile for designers of ergonomic production processes and workplaces; and the identification of a suitable training model to train the different targets on the identified needed knowledge areas.

INTRODUCTION

New ergonomics issues, for example, *Ergonomics and Safety of Advanced Manufacturing Systems* and *System Maintenance and Reliability*, reflect not only changes occurring in the workplace and work environment, but also illustrate the need to optimise the ever increasing complexity of human-work systems and work processes. The new and old ergonomic challenges that industry faces today require concentrated efforts of many different professionals and constant updating/improvements of their competence in ergonomics.

Thus, the challenge is to train students, postgraduates and engineers to have adaptive, quick-response, process ergonomics design and evaluation skills, so that modern flexible manufacturing processes can improve the quality, productivity and health of the worker.

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The project's aims are:

- The development of a new professional profile in the field of ergonomics for the design of processes and workplaces. This means the standardisation of professional competence in order to give the same accreditation to different educational systems and countries in Europe.
- To define clearly the steps in which a common framework for uniform competence building will be developed and the steps needed for the development of a transnational training model for competence building. Furthermore, this model will align the competence and skills of teachers and trainers in all European countries.

The main technical goals (and related results) are clearly defined as:

- *Needs analysis*, made through an investigation on large enterprises, and small and medium enterprises (SMEs), with respect of this new profile [2];
- *Competence definition* (for the *Ergo-Designer* professional profile), necessary for the ergonomic design of workplaces, products and processes [3];
- Development of a *Training model*, necessary for the competence building of the aforementioned professionals;
- Set up a *Network of interested parties*, to support the centres of excellence (including the university and training centres), industries and professionals working in the field of ergonomic design.

RESULTS FROM NEEDS ANALYSIS

The actual worldwide situation is pushing more and more into the development of a flexible and proactive system based on effective and efficient design of processes and work methods.

Many factors are influencing these aspects, like the development of new standards and regulations, the requirement for new technologies' implementation, improved productivity of processes and the rapid evolution of production systems. All these aspects lead to the need for radical modification in problem-solving by a multidisciplinary systemic and preventive approach in the design phase for an *Integrated and systematic design application*. For the above reasons, the activities of the ERGOMAN project focused on the identification of industry's major needs as far as ergonomic design of workplaces and the work environment of production processes.
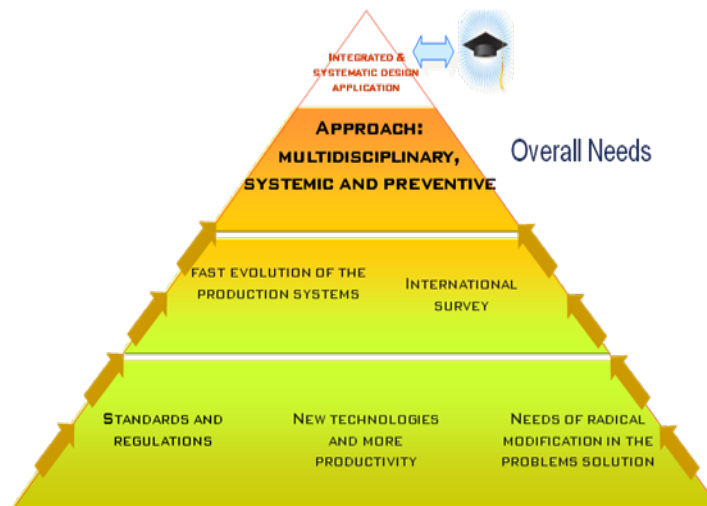

Figure 1: Identification of main needs of industry.

The situation has been analysed with the support of the universities involved in the project, focusing on Europe, but paying particular attention to the Italian, German, Irish and Slovenian circumstances. For large enterprises, the investigation was carried out on Italian and German side; for SMEs, on the Slovenian and Irish side.

The needs analysis aims to orient the educational model toward the application of ergonomic design for production processes in a more effective way than today [2].

The investigation was conducted through observation, interviews and questionnaires with the people working in ergonomics and focus groups from a range of companies.

The major results obtained from the analysis are summarised for each of the two different target groups (large enterprises and SME) as follows:

- Major needs (for an ergonomist role in a **large enterprise**) are concerning the following application fields:

  - Ergonomics tools and methods of evaluation (for ergonomic verification in phase of manufacturing process design);
  - Technical design and technological engineering (for problems solutions on the process/equipment compatible with ergonomics rules/guidelines);
  - Software simulation and CAD-CAE methodologies (for detailed simulations of work activity and ergonomics analysis);
  - Legislation and standards application (to guarantee the compliance with the ergonomic standards for the suppliers);
  - Engineering and design, and procedures for product design (for product analysis, product review and proposal of technical solution for assembly);
  - Work analysis and work methods definition (for planning of work activity and processes and methods evaluation);
  - Human machine interface (for tools and equipment development, and usability evaluation);
  - Communication and interrelationship of personnel (for training and problem management).

- Main needs (or *desired competence* for an ergonomist role **in an SME**) are concerned with the following application fields:

  - Design the workplace (for fast and safe movement of workers between machines to save time);

- Check for health hazards (for checking any potential threats to workers that could compromise their health);
- Set the machines (so the workers can easily access them);
- Check of work environment (for environment evaluation);
- Safety of the workers (for evaluation any dangerous moving parts of the machines that can hurt workers).

It is also possible to show the situation concerning the *needs perceived* by **managers** in different countries (Italy, Ireland, Slovenia) as far as the three main areas of investigation (workplace design, workplace on production floor, organisation), are concerned.

Needs are focused on biomechanical aspects (*development of ergonomic plans for new and existing workstations*), but an *ergonomic management programme*, as well as improvement of *workers' skills about innovative aspects* are also very important. The needs analysis carried out aimed at the development of an educational model that should consider the following aspects:

- The educational model should be inspired by existing realities in which ergonomics aspects are already a strong added value;
- Different levels of knowledge, and a wide range of available competencies and roles could represent a valid diversification for the creation of different types of ergonomics expert to be moulded within the educational model;
- The more one wants ergonomics effects to be noticed, the more the educational model should be modelled and focused on the study of ergonomics aspects into the earlier phase of design and manufacturing.

THE NEW ERGODESIGNER PROFILE OF COMPETENCES

The definition of a competence profile for Ergodesigners is one of the main results of the ERGOMAN project [3]. It has been worked out through the following main steps:

- Analysis of the existing reference standards (HETPEP model for European Ergonomists [4], IEA Code of Conduct for Ergonomists [5], REFA Industrial Engineering (SIE) - Human Factor [6];
- Investigation of **competence** levels required (see needs analysis), also through the organisation of workshops with representatives from large companies and SMEs, and discussions concerning the processes and experiences in training of ergonomics there;
- **Gap Analysis** between the results of needs analysis and existing standards;
- Identification of main **knowledge areas** for the profile *ergo-designer for production processes* aimed to design tasks, work places, environments, tools, as well as work organisation and processes.

The identification of the main competence and main knowledge areas needed for the *ergodesigner* profile have been based on the philosophy concerning the *World Class Manufacturing* (WCM) [7], and the *Product Development Processes* (PDP) [8].

Three competence profiles have been indentified for the three target groups of the project (students, professionals in large enterprises and process designers in industry).

According to the needs analysis carried out in the project, the main competence and knowledge areas were defined for professionals in industry. They should have competence and knowledge about:

1. *National, international* (and company) *standards* related to ergonomics;
2. *Safety rule* and *procedures;*
3. Aspect related to *quality of production processes;*
4. *Logistic* and *work organisation;*
5. *Environment and microclimate* aspect related to the indoor production;
6. *MTM methodologies.*

Based on this competence, the *ergo-designer* profile has been created. This competence profile includes 28 competence items subdivided into six groups, collected in a *Ergodesigner cross-matrix* in order to be easily readable:

1. *Four* competence items in *Background* (Anatomy/Biomechanics/Work Physiology and Psychology (see Figure 2);
2. *Five* competence items in *Design process and problem-solving*;
3. *Eleven* competence items in *Ergonomic guidelines*;
4. *Two* competence items in *Work environment* (physical environment, indoor climate);
5. *Two* competence items in *Work measurement*;
6. *Four* competence items in *Implementing design.*

All competence items are subdivided into three levels: Level 1: Low; Level 2: Medium; and Level 3: High. The first competence group developed in the Ergodesigner **cross matrix** is shown in Figure 2.

	DEFINITION	Competency Level 1 (low)	Competency Level 2 (medium)	Competency level 3 (high)
Part 1 Background				
	To understand basic principles of **human anatomy and motor function** relative to **human interaction with hand tools and machinery**	To remember the important muscle groups and their function	To be able to analyse the muscle groups and their forces required to perform a set of work actions	To be able to understand, analyse and evaluate the muscle function and kinesiology involved in performing a human movement
	To understand **basic biomechanics**. How forces are generated and exerted externally and internally, and to appreciate the relationship between stress and tollerance of internal loads	To understand how internal and external forces are generated and exerted	To be able to perform a biomechanics analysis to determine the internal forces for hand, shoulder or lower back exertions	To be able to analyse and evaluate the acceptability of internal forces in the body due to external exertions
	To understand basic principles of **work physiology** and to appreciate the effects of energy availability on muscle and the cardiovascular system.	To know how energy is liberated in the body and how physiological loads impact on the cardiovascular system	To be able to measure or estimate the physiolocal cost involved in perform a task	To be able to perform, interpret and evaluate the physiological cost involved in performing a task
	To understand **basic principles of ergonomics psychology**: to appreciate the importance of design in **accomodating human abilities**, and to understand the sources of human limits	To know the psychology principles of memory, perception and cognitive loading	To be able to estimate the cogntitive loading involved in a given scenarios	To be able to evaluate the cognitive loading in a scenario and determine its acceptability relative to human limits

(Left vertical labels: Anatomy for ergonomics · Biomechanics for ergonomics · Work physiology for ergonomics · Ergonomics Psychology principles for ergonomics)

Figure 2: Three levels of competence for *ergodesigner* - Group 1 - *background*.

According to the project work programme, the next phase of consortium activity will be addressed to an extended validation of the competence profile *ergodesigner*.

THE ERGOMAN TRAINING MODEL

Another major result of the ERGOMAN project will be the development of a t raining model properly designed, according to the different target profiles of the project (students, professionals and process designers in industry) and to the different knowledge areas/competence items to train [9]. The finalisation of the training model is expected by in a few months.

More specifically, the training model will exploit the approach for each level of each competence reported in the cross matrix, developed on the basis of industrial skills needs and also in reflection of syllabi recommendations in ergonomics from both the International Ergonomics Association [5] and the Centre for Registration of European Ergonomists [4].

The training model will be portrayed by way of concept maps, one for each of the six separate competence parts of the cross-matrix: input and output training level and detailed topics for each cell of the matrix will be exploited. In addition, beside the concept maps, the model will give indications for appropriate pedagogical approaches, training methodologies and technologies.

VALIDATION OF THE PROFILE AND THE TRAINING MODEL

An extensive validation programme is necessary in order to obtain the best possible results from the project, and to see, if the profile and training model can perform in praxis with real teachers and trainers and real students.

The first step of validation will be focused on the comparison of the competence profile against the needs defined in previous work-packages and on the real application field of the competence profile (Figure 3). The problem is the adaptation of the competence profile in order to satisfy the possible needs of industry in the field of ergonomics/safety, applied to production processes and workplace design. To face this problem the competence profile must be valued through the real ability of implementation of criteria and rules for a good and effective design of ergonomic production processes and workplaces.

In order to validate learning methodology, in the second stage, outside experts in the field of ergonomics will be invited to present their opinion on the proposed solutions.

The validation of the training model will be done by identifying at least three trainer experts in each participating country in the different competence groups identified in the cross-matrix, of which at least one should belong to the National Ergonomic Association. For each training model (that is the identification of topics, pedagogical model, etc.) related to each competence item in each competence group trainers will be asked for a punctual structured and, therefore, comparable validation. First, they will be contacted by email or telephone and provided with all the relevant documents and a questionnaire needed to conduct an evaluation. Then, they will be visited by the experts in order to conduct a thorough interview concerning their opinion on the weaknesses and strengths of the model.

In the third step, implementation of the model into the educational structures will be validated. Here, final users will be included in the validation process. Partners will conduct training experiments using the Ergoman training model with real users (at least five per category) recruited by three partners: students from the University of Limerick, professionals from Institut für Arbeitswissenschaft Darmstadt and designers from Centro Ricerche Fiat. In this way, the work related to the definition of the training model can focus primarily on this identified competence.
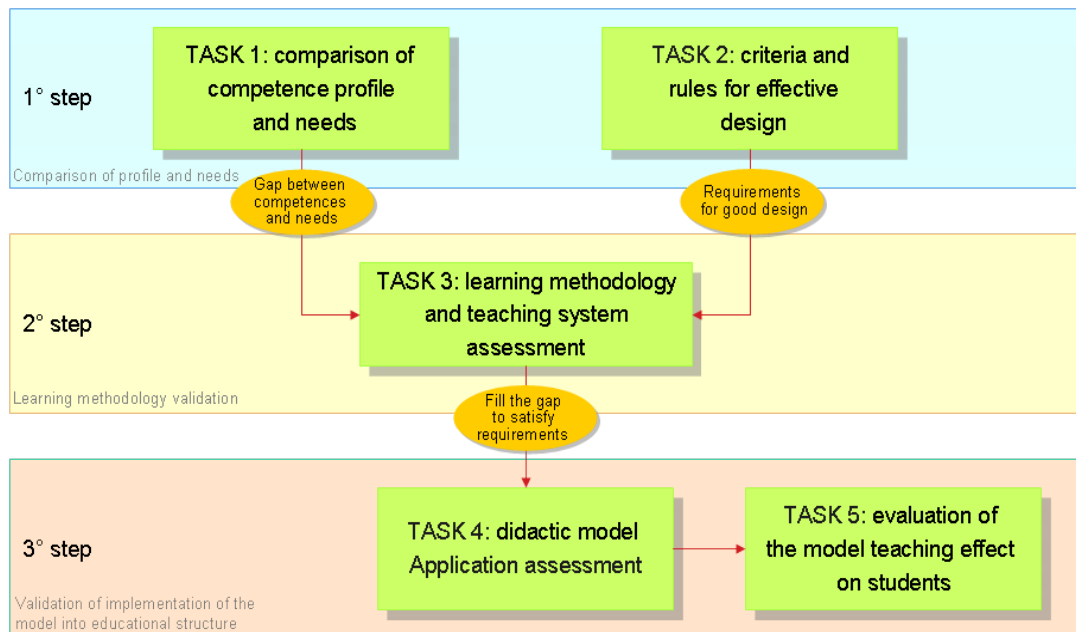

Figure 3: Validation programme.

Validation will provide all the necessary feedback needed to implement the results of the project successfully into praxis enabling organisations/companies and universities to implement project findings quickly into their education programmes.

CONCLUSIONS

Based on the needs analysis led on large enterprises and SMEs, the ERGOMAN project has elaborated the new profile of competence for Process Ergodesigners [3]. This profile, represented in a cross matrix with different competence levels and the related knowledge areas, can be used as a reference framework for the different target of users (students and workers) and for ergonomics centres and companies, networks and universities, both for higher education (single competency to be acquired), then, permanent education.

In particular, the ERGOMAN competence profile will be supported by *guidance material* from the Process Ergodesigner training model [9]. This material will detail how the needs for training in at particular ergonomics competence level can be detected, the related topics to be faced, the recommended technical and pedagogical model to be followed, and the input level of competence that is required. It will recommend how those specific competence items could be delivered to achieve a good quality learning experience for the student or for the worker, and to what level.

The closure of the project is foreseen as being in September 2011. By this date, the training model and the validation, both of the profile and the training model, will be finalised. The results obtained will be useful for organisations/companies and universities, helping them to face this subject in an innovative and more focused way.

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