Implantation of a Methodology based on Standard Supplements applied in Engineering Education

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Abstract— **This paper present a model for the integration for the standardization integration inside the technical teaching in university context, taking into account the established requirements by the European Higher Education Area (EHEA). This methodology is based on the development of a new typology of document named as "standard supplement". The proposed methodology serves to identify the set of documents witch are necessaries in a specific subject, the knowledge, abilities and attitudes to identify with the academic competences, previously defined, and a guide for the development of the contents of each "standard supplement". The proposal structure of "standard supplement" is appropriate to different level of complexity and could be used as a link between enterprises and engineering education.**

Keywords: Standardization, EHEA, Engineering Education

I. INTRODUCTION

The EHEA shows an important change in the traditional methodology implemented at the universities. Nowadays, Master class is the most used pedagogical practice in the university. It consists of an expositive method where teacher explains a subject and student take a passive attitude. In this case, teacher has all the responsibility to prepare the subject.

Obviously, to make a change from this teaching method, which is based on the traditional expositive method, with low student participation, into a new teaching method with high level of student participation, is very difficult. This change is impossible to achieve if is based only on a methodological aspect. In order to allow an active implication of the students in their learning, their effectiveness depends on a high level in their personal work. For this reason, the didactical material plays an important roll if it is structured to influence in their attitude.

Actually, the use of standards and standardization field is lower that it could be desired in engineering education, perhaps its high interest in technical learning. For this reason, the main objective of this work is to develop and to introduce a methodology for the integration of standardization in technical education [1, 2].

Technical teaching can not be understood without a constant allusion to standards that, in most cases, establish conditions or restrictions related to a specific topic. The incorporation of additional viewpoints in the contents of standards could be considered as an important advance in the present proposal. This paper can offer a continued flow of updated knowledge, transforming the current pure normative feature in another in which coexists the normative one with the pedagogical one.

This methodology is based on the development of a new typology of document named as "standard supplement" [3]. The incorporation of standard supplement should be understood from the perspective of the educational innovation, to increase the presence of the standardization in technical teaching and documents, by means of the elaboration of documents with all the necessary requirements established for the conformation of an European Higher Education Area (EHEA) [4–7].

The election of the subject of Internal Combustion Engine (ICE), among lots of subjects in technical teaching (electricity, electronics, machine tools or automobile fields) is based on the high number of implicated knowledge fields.

II. METHODOLOGY

The methodology proposed can be divided into three phases. The first one will characterize the necessary standard supplements for the development of the specific matter; second phase identifies academic competences that should be included in standard supplements; at last, third phase shows a guide to develop the content of standard supplements.

A. Characterization

The characterization of standard set to the development of a specific matter is carried out by means of a classification of the different elements to standardize. This classification depends on every matter and should show the relationship among elements (material composition, position, functionality, manufacture) or other technical criteria, and it should help to give an hierarchical structure, being useful to relate the function that every element has in its set and establishing the interrelation among their different systems.

There are different ways to classify the elements of an ICE. The engine is an important part of a vehicle, being formed by great number of elements and auxiliary systems. This proposal

is based on a functional and positional classification of elements, according to technical criteria.

Positional relationship establishes a distribution of elements according to physical position of every element in engine, establishing distinction between external and internal elements.

In one hand, basic external elements shape the structural base, being used profusely as a support for the fixation of auxiliary systems and other elements. Cylinder head and the engine block are significant examples of these elements. On the other hand, internal elements are usually hidden, for example, cog-saft and connecting rod.

Functional relationship is established according to the relative movement of connection among elements, classifying them in “active” elements, if there is a relative movement, and “passive” elements, when there is no relative movement between them.

Main active elements transform thermal power of the fuel in mechanical power. They are situated inside the engine, so they can not be identified to simple view; for example: piston, connecting rod and crankshaft.

They are several series of auxiliary systems in an ICE. Some systems are essential for engine operation, as cooling system, whereas other systems help to optimize their operation, as variable admission system. The most of the elements of auxiliary systems can be included in one of the precedent groups, establishing the positional or functional relationship between engine elements and auxiliary system elements.

The creation of the fourth group is necessary to include other elements not mentioned in precedent classification, as pulley check, cylinder head gasket or plain bushings.

Previous considerations lead us to the need of creation of the next four groups:

- Group I. Active elements

- Group II. External elements

- Group III. Auxiliary systems elements

- Group IV. Other elements

Fig. 1 show positional and functional relationship, that is, the interrelationships established among elements belonging to the same group and among different groups' elements. The identified classification is generated associating concentric way identities. The functional or positional relationship is reflected by means of the union segments among elements. For this way, active elements (group I) have been represented inside the internal circle (green color); external elements (group II) are inside the second circle (blue color); finally, auxiliary systems elements (group III) are outside circle (orange color).

It can be noticed the existing functional relationship among active elements, being evident the dependence among them, because all elements are related. Active elements are in the center of the classification because they are considered as essential elements in an ICE.

The situation in the diagram of group II, corresponding to external elements, is justified for the positional relationship among these elements, given that support elements of group I (active elements) and the most of auxiliary systems elements.

Group III is situated in the last level of the diagram. Every auxiliary system is formed by a series of external or internal elements, actives or passives, with a positional relationship with elements of group II.

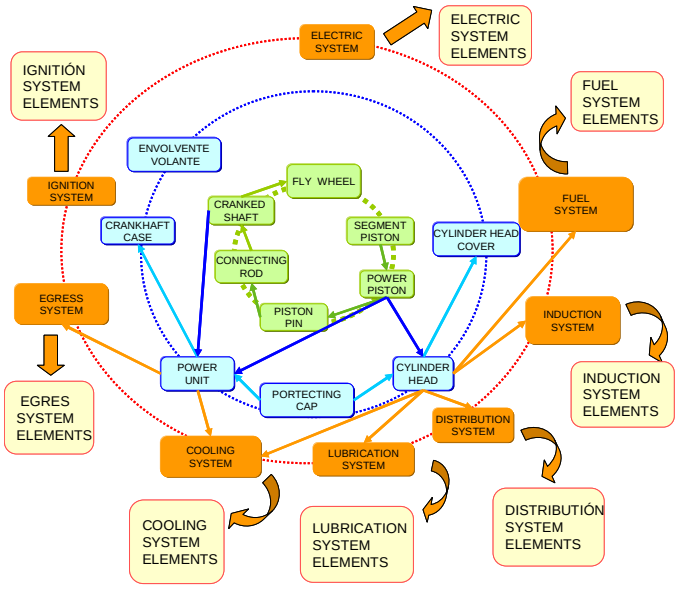

Figure 1. Positional and functional relation

B. *Contents*

Technical document presents, in most cases, references to standards that should be achieve, values that should be established, or allowed limits values. However the use of a standard is reduced, many times, to a simple reference. In the development of this proposed work, it is expected that the standard could be applied in other additional fields, with special attention to teaching context, because it is our point of reference, without underestimating of other possible ones.

The objective of this proposal is not to cancel or to modify the current standard contents, but adding an additional part in the standard supplement, where it is reflected, for each standardized element, the knowledge is considered necessary to be assimilated by an university technical education student, on the EHEA perspective. Due to they can find requirements in the technical educations in different levels, the development of the standard supplement may should have them in consideration, and to do so these requirements are included in this document.

This widening does not only consist of moving knowledge from a determined subject to the corresponding standard. Moreover, it is necessary to move requirements for the new teaching way. To achieve this, it adapts EHEA requirements in the standard content.

The development of aspect as:

- Methodological plurality

- Motivate components of a standard
- Attitudes and abilities acquisition
- Update of contents. University-company relationship
- Standard applicability. Work world relationship
- Relationship with other knowledge areas. Application of the Geometric Product Specification (GPS) philosophy [8]

will establish different bases to carrier out didactic material.

The content of the standardized supplement is developed in a different way if an individual element or set of elements are tried. Two actions are considered in the development of the didactic material so that students can adopts a more active role, which helps them to analyze, synthesize and think in an individual and collective way:

- Elements should be presented dimensionally justified, taking into account design and manufacturing requirements, according to their functional requirements. Functional requirements can be utilized as a guidance to develop a part of standard supplement used as a didactic material.
- Auxiliary systems should be presented to study their function inside the engine set. Therefore, the elaboration of maintenance guide to show possible cause of mistake, from the analysis of element's state, is proposed.

C. Competences

The adaptation of the standardization to technical educations takes into account academic competences that should be acquired. A protocol to show the adaptation process of the standard supplement is proposed in Fig. 2, where the relationship among academic competences and their professional activity is contemplated [9].

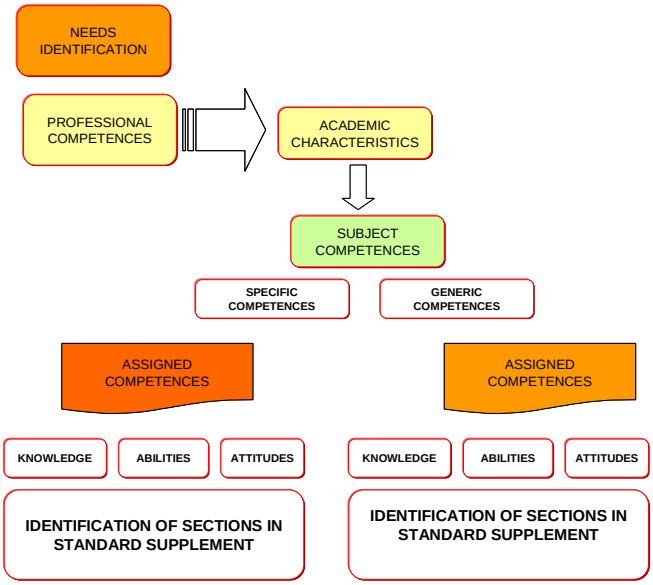

Figure 2. Competences protocol

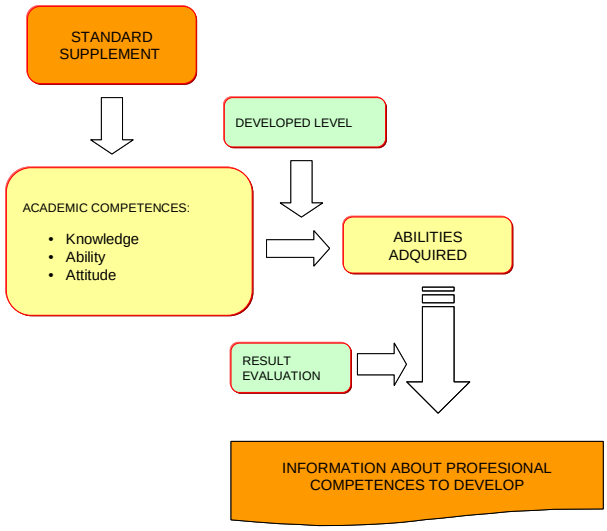

Figure 3. Standard supement generation

The protocol of competences and abilities is used to show a set of documents with a common guidance, which can be used as an aid material for the elaboration of a didactic material according to the capacities and professional necessities that should be acquired. The protocol, divided in two phases, includes:

- Phase I. Identification of society necessities
- Phase II. Development of competences that are implemented in standard supplement

As well, this work is only focused on the second phase.

Phase II contemplates the break down of knowledge, abilities and attitudes that standard supplements can give for established academic competences. These can be generic competences, common to the engineering, or specific competences, common to an engineering specialty.

The generated complexity level in the document should be taken into account, since the result of the acquired capacities should be according to the capacities established in professional competences (Fig. 3).

A matrix, for each of generic or specific competences, is elaborated to establish knowledge, abilities and attitudes [10, 11] that the document contributes and their level. This matrix is used to establish capacities that can be acquired and knowledge that are contributed for a certain competence. Structure of this information is shown in Table I.

TABLE I. STUCTURE OF MATRIX

SUBJECT:		STANDARD SUPLEMENT:		
Competence		*Action*	*Description*	*Level*
GENERIC				
SPECIFIC				

As an example, Fig. 4 shows a standard supplement proposed for an ICE connecting rod.

Some basic aspects of the model to be used in the development of standard supplements are considered:

- Clarification of objectives that should be reached. Academic competences are included in this document and they should be acquired.
- Concepts representation. It is contrasted the importance that represents the incorporation of a high number of figures in the document.
- Document structure. The continuity of document has been considered as a disadvantage to structure it with different levels, having the possibility of a partial use (basic, middle and advanced levels).

Basic level includes the explanation of the elementary knowledge of the connecting rod-crank system, by means of the description of main parts of elements and their function. Finally, available applications for ICE are developed and justified.

Middle level presents the processes and materials used to carry out manufacture of the ICE connecting rod. A short description of employed systems is carried out, justifying their advantages and presenting main characteristics of used materials. A second part of this level develops functional requirements that have influence in the design and manufacture of element.

Finally, advanced level allows of determining the structural resistance of connecting rod, with a previous study of dynamic and kinematic system and forces.

The proposed objective is to establish and to put in order the content of standard supplement according to EHEA requirements and to give a pedagogical features, taking into account the document, which belongs to a standard.

The incorporation of EHEA requirements in each developed document depends on technical and functional characteristics of element. In this case, as it happens in other many ICE elements, functional requirements will be used to develop the knowledge that should be included.

The analysis of different functional requirements gives main and basic characteristics that the element must have. Once the element is characterized, a second analysis allows establishing operating conditions.

Dynamic and kinematic studies are used to determine efforts generated in connecting rod-crank system. Mechanical and structural calculations give the measured of necessary minimum sections.

The study of the element is closed by means of the selection of appropriate materials according to its functions, its solicitations and its manufacturing processes.

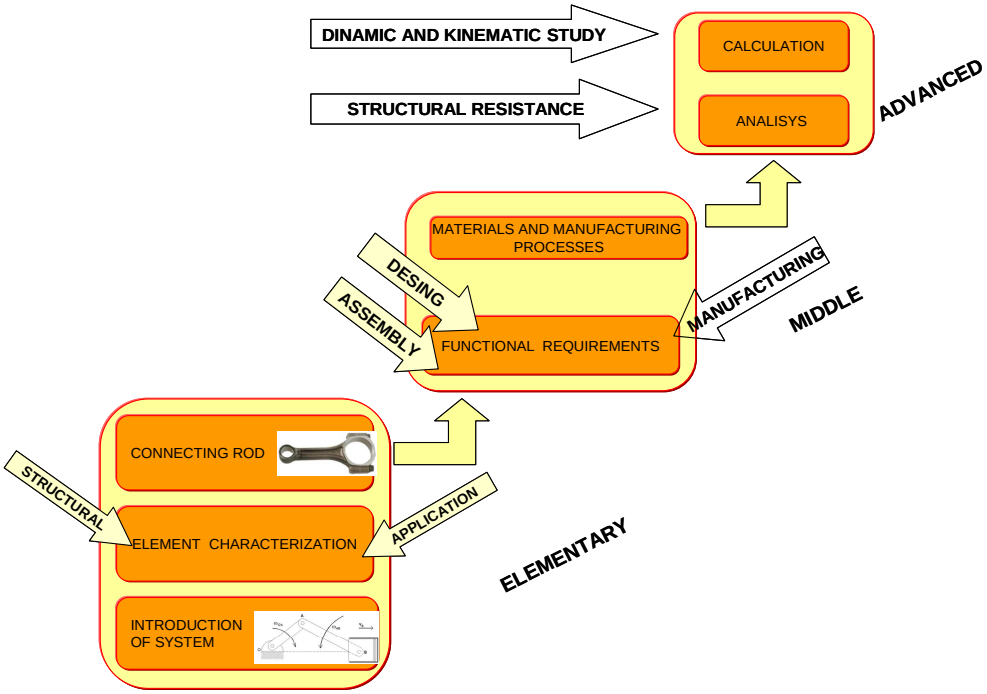

Figure 4. Application to a connecting rod

TABLE II. MATRIX OF COMPETENCES-ATTITUDES

SUBJECT:		**STANDARD SUPLEMENT:**		
Competence		***Action***	***Description***	***Level***
GENERIC	GC.01	Associate	Associating the system and his dynamic and kinematics variables to efforts that are produced in the element	Advanced
	GC.02	Associate	Associating efforts that are produced to the measured and structural calculation of the element	Advanced
	GC…	Compare Contrast	Comparing and to contrast the influence that dimensions of the system have on the set	Advanced
SPECIFIC	EC.01			
	EC.02			
	EC...			

The structure of standard supplement is corresponded with established complexity levels: basic, middle and advanced. However, these three levels do not reflected specifically, although if they are established, due to the continuity that the document should present.

III. CONCLUSIONS

Analysis carries out highlights the importance of standardization in the development of the professional activity, not considered widely in technical educations. Actually, the standard use and standardization field are low. It could be desired in engineering education a deep use, because of its high interest in technical learning. The incorporation of a standard supplement as didactic material can be used in the education so as to help and boost the use of standard documents.

It is necessary to develop a model to fill actual detected voids in some subjects. This development supposes the possibility to generate a non random model, equivalent to Geometric Product Specification philosophy, with a complete structured and coherent body for the ICE elements.

A protocol to evaluate the acquired academic competences has been elaborated. Its conversion to professional competences helps to determine the assimilation level of knowledge, abilities and attitudes. The elaborated protocol should include an evaluation performed by universities, oriented to the certification of academic responsibilities obtained, and an evaluation performed by employers, oriented for the certification of the professional responsibilities recognized.

The standardization can be used as a link between company and university technical educations. Responsible agents for the elaboration of a standard must stimulate existent communication channels, according to recommendation of EHEA.

The elaborated document show significant differences respect to conventional didactic material:

- Structure: standard supplement presents an additional value because of it is structured with different levels and allows to be applied to non university teachings, introducing advantages that standardization can give in other fields.
- Orientation to competences: the development of the oriented document to the acquirement of some academic competences, established in the moment of its elaboration, is useful to different agents on which the process has repercussions (students, graduates, academics and employers), being integrated their priorities in only one proposal.
- Integrative component: the integrative component that should present the elaboration of a standard can be taken into account so as to give the importance of involving the university and the industry as a base of its development.

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