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Environmental Competency Framework: Development of a Modified 2-Tuple Delphi Approach

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***Abstract*—**Currently, industries endeavor to align their environmental management system with the ISO 14001:2015 international standard, while preserving competitiveness and sustainability. Then, a key driver for these industries is to develop a skilled workforce that is able to implement, continuously improve and audit the environmental management system. The purpose of this paper is to provide an environmental competency framework that aims to identify, rank and categorize the competencies required by both the environmental managers and auditors. This competency framework is expected to be useful during competency assessment, recruitment, and training processes. To achieve this end, a modified 2-tuple Delphi approach is here proposed based on a combination of the modified Delphi approach and the 2-tuple linguistic representation model. The adopted approach is presented as numerous questionnaires that are spread over multiple rounds in order to obtain a consensus among the different Moroccan experts participating to this study.

***Keywords*—**Competency framework, Delphi, environmental competency, 2-tuple.

I. Introduction

THE industrial expansion and the related growing demography resulted in exponentially increasing the environmental pressure and in multiple pollutions impacting the air, the soil and the ground- plus sea-water. The most harmful consequence is by far the global climate warming that is now inducing more frequent drought/inundations, concurrently with the stepwise drop of terrestrial and oceanic bioresources [1].

A right balance between economic plus social demands, and preserving the environment space in use, could mitigate the impacts on the environment, and ensure a sustainable development. This is the mission of the ISO 14001 international standard. The environmental management system enables the organizations to increase their environmental performance, anticipate the environmental regulations, gain the stakeholders' trust, and stand out from competition.

In regard to the importance of the ISO 14001 certification, the organizations must have an effective environmental management system to reduce non-conformances. Accordingly, a more environmentally conscious workforce is needed to implement, incessantly improve and audit the environmental management system. For a best environmental safety in accordance with the economic expectations, these organizations must ensure that the environmental managers and auditors have capabilities to carry out both the managerial tasks and the technical ones. This raises the question of the competencies precisely required by the environmental managers and auditors' positions.

Competency identification is an unavoidable step in the competency management process. Indeed, the ISO 14001:2015 standard developed by the International Organization for Standardization stated as a requirement that an organization must determine the competencies of its working staff that impact the environmental performance. Thus, the identification of the required competencies is very useful, because it provides the organizations with a predictive view in terms of development and recruiting processes. In the literature many methods have been used to identify the required competencies [3]. Among them are the semi-structured and structured interviews, field observation, and Kelly's grid. One of the most effective methods found in the literature is the Delphi method [4]. Accordingly, a modified 2-tuple Delphi study has been carried out in this work, with the purpose to specify the competencies required by the environmental managers and auditors, and then to develop an environmental competency framework.

The present paper is organized as follows: The second section presents a literature review. Section III deals with the modified 2-tuple Delphi method, where the 2-tuple linguistic representation model is introduced, and the stepwise procedure is described. Thereafter, the fourth section presents the environmental competency framework. Finally, some conclusions and perspectives are highlighted in Section V.

II. Literature Review

"Competency" derives from the Latin word "Competere" meaning "to be suitable" [5]. In the literature, several definitions have emerged due to the multidisciplinary dimension of the competency concept. Through analyzing these definitions, it can be noticed that several researchers agree with the fact that individual competency is the combination of diverse skills, namely knowledge, know-how, and know-whom. Moreover, individual competency allows individuals to accomplish a task or mission [6], [7], in a specific context [8]. Some researchers agree that competency results in effective job performance [9], [10]. The latter can also lead to an overall performance of the organization. Indeed, Boucher et al. [11] have positioned the competencies at the heart of performance. Accordingly, the mission of a competent company can no longer be limited to produce specific goods and services, but can also consider the capabilities to adapt to a fast-changing

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environment through involving a multi-skilled and innovative staff. Finally, we can note that competency is also linked to the will to accomplish a task as specified by [12] and [13].

In the industrial engineering field, competency management has been the subject of several research studies. Indeed, Belkadi et al. [14] stated that the competency management process can be summed up as follows: competency identification (i.e., listing the competencies required by a position/job, and those acquired by individuals), competency allocation, competency acquisition, competency mobilization, competency development, competency characterization, and competency evaluation. Furthermore, competency is at the heart of the ISO 14001:2015 standard's requirements. Thus, the ISO 14001:2015 standard requires the organizations to: i) determine the competencies of their working staff that impact the environmental performance, ii) ensure that the collaborators are competent, iii) identify training needs, and iv) undertake actions to acquire the necessary competencies and then evaluate the effectiveness of these actions [2].

Competency identification is considered as the cornerstone of the competency management processes. It leads to the establishment of a competency framework, which is a document that is of major interest during the competency assessment, competency development and recruitment processes. In the literature, several competency identification methods can be found. For instance, the field observation of people achieving their respective tasks remains inadequate to identify the required competencies for high level positions [3]. The interviews and critical incident techniques are both flexible, but the results can be subjective. The Kelly grid is also a flexible method. It is based on the theory of personal constructs [15], but the obtained conception can remain vague and slightly informative in case the answers provided by the experts are not deep and detailed enough. Harzallah and Vernadat [16] proposed a competency identification approach based on the CRAI (Competency Resource Aspect Individual) model. Boumane et al. [17] developed a method based on two different stages. The first one consists of analyzing the company's internal and external context. The second aims to identify the competencies required by the activities. However, it is a complex method that requires the mastery of several methods as investigation methods and process mapping. Sefiani et al. [18] used this methodology to develop a competency identification approach based on the functional approach. Furthermore, several authors have been using Delphi method for competency identification purposes [19]-[22].

The Delphi method was first developed by Dalkey and Helmer to obtain and organize the opinions of a group of specialists on military foresight issues [23]. The objective of this method is to obtain a consensus within a group of individuals. The four key characteristics that define the Delphi method [24] are as follows:

1) Anonymity that allows the participants of the study to express their opinions without any social pressure;
2) Iteration of questionnaire for a number of rounds, which helps the participants to refine their points of view;
3) Controlled feedback between questionnaires while informing the participants about their colleagues' opinions;
4) Statistical analysis of the participants' responses

Delphi method has been used in several fields such as psychology, education sciences, social sciences, economics, and industrial engineering. It has been utilized in the context of technological innovations, anticipation of a market or a new trend of consumers, strategic prospecting, participative management, as well as for competency framework development. To identify the required competencies, several studies have been carried out. For instance, Brill et al. [19] conducted a web Delphi study to recognize competencies required by a project manager. Liddell et al. [20] carried out a Delphi study to identify the therapist competencies necessary for the delivery of compassion-focused therapy. However, Johnston et al. [21] proposed a modified Delphi approach with the aim of identifying the core competencies of an undergraduate food safety curriculum. The modified Delphi approach is less restrictive than the conventional one, because it starts with structured items instead with an open-ended questionnaire as recommended in the conventional Delphi method. Furthermore, Horng et al. [22] used a method based on the fuzzy Delphi and Analytical Hierarchy Process (AHP) methods to identify the top managers' competencies in a hotel unit.

In the literature, some authors have been interested in combining the 2-tuple linguistic representation model and Delphi method. The 2-tuple linguistic model as opposed to other fuzzy models, avoids the loss of information while using the qualitative data [25]. Among the authors, we find for instance Ko [26] who proposed a 2-tuple fuzzy Delphi to assess the customers' consensus, as well as Torağay and Arikan [27] who used a 2-tuple Delphi method to determine the weight of criteria. This information has been then used to compare different academic performances of faculty departments.

In this paper, we adopt a modified 2-tuple Delphi method. It results from a combination of the modified Delphi approach and 2-tuple linguistic representation model. The adopted approach is very suitable for developing an environmental competency framework as it will be shown in Section III.

III. The Modified 2-Tuple Delphi Approach

The 2-tuple Modified Delphi approach offers several advantages since it: i) allows the participants to remain anonymous, which gives them the chance to freely express their honest opinions, ii) allows the consensus to be reached among the various experts participating to the study, iii) gives the opportunity to the experts to refine their results through spreading the questionnaire over several rounds, iv) is planned to identify the competencies required by environmental positions, and somewhat v) lightens the process of Delphi method by starting the first round with structured elements. Taking into account that competency is considered as an intangible resource [28], it is difficult to assess its importance through using a quantitative scale. Therefore, it is more appropriate to use linguistic variables as "less important" or "very important". To achieve this, the 2-tuple linguistic representation model is used in this work, as it is proved to be a

reliable computational technique [25], in that the word-bearing information does not result in any data loss.

For a better understanding of the adopted approach, it is appropriate to start with the presentation of the 2-tuple linguistic representation model, and then describe the stepwise procedure of the 2-tuple modified Delphi approach.

A. The 2-Tuple Linguistic Representation Model

The 2-tuple linguistic representation model was first developed by Herrera and Martinez [25]. It is based on the use of 2-tuple linguistic variables expressed as (s_i, α), where: s_i is a linguistic term from the linguistic term set $S = \{s_0, s_1, ..., s_g\}$, and α is a numerical value of the symbolic translation.

According to Chen and Tai [29], a numerical value $\beta \in [0,1]$ can be converted into a 2-tuple linguistic variable (s_i, α) and vice versa by using respectively the Δ function and the reverse function Δ^{-1}, which are expressed respectively in (1) and (2):

$$\Delta : [0,1] \to S \times [-0.5/g, 0.5/g)$$
$$\Delta(\beta) = (s_i, \alpha) \text{ with } \begin{cases} s_i, & i = round(\beta * g) \\ \alpha = \beta - i/g, & \alpha \in [-0.5/g, 0.5/g), \end{cases} \quad (1)$$

$$\Delta^{-1} : S \times [-0.5/g, 0.5/g) \to [0,1]$$
$$\Delta^{-1}(s_i, \alpha) = \beta = i/g + \alpha \quad (2)$$

Example1. Let S = {s_0 = Very Low, s_1 = Low, s_2 = Medium, s_3 = High, s_4 = Very High} be a set of five linguistic terms and $\beta = 0.77$, the equivalent 2-tuple linguistic variable is computed by using the generalized translation function (Δ) presented in (1), which is as follows: $\Delta(0.77) = (s_3, 0.02)$, where $i = \text{round}(\beta * g) = \text{round}(0.77 * 4) = 3$ and $\alpha = \beta - i/g = 0.77 - 3/4 = 0.02$

Let $x = \{(s_1, \alpha_1), (s_2, \alpha_2), ..., (s_n, \alpha_n)\}$ be a set of 2-tuples, the 2-tuple arithmetic mean $\bar{x}$ is formulated as given in (3) [25]:

$$\bar{x} = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\Delta^{-1}(s_i, \alpha_i)\right) = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\beta_i\right) \quad (3)$$

Example2. Let S = {s_0 = Very Low, s_1 = Low, s_2 = Medium, s_3 = High, s_4 = Very High} be a set of five linguistic terms. Suppose that we have five experts $(E_k), k = 5$, each expert is asked to assess the competency level of a candidate. The assigned values of each expert are respectively high, high, medium, and high. Therefore, the arithmetic mean defined in (3) is calculated as:

$$\bar{x} = \Delta\left(\frac{1}{4}\left(\Delta^{-1}(s_3, 0) + \Delta^{-1}(s_3, 0) + \Delta^{-1}(s_2, 0) + \Delta^{-1}(s_3, 0)\right)\right)$$
$$= \Delta\left(\frac{1}{4}\left(\frac{3}{4} + \frac{3}{4} + \frac{2}{4} + \frac{3}{4}\right)\right)$$
$$= \Delta(0.6875) = (s_3, -0.0625)$$

In the following, let $A: (s_i, \alpha_1)$ and $B: (s_j, \alpha_2)$ be two 2-tuples, then the distance between A and B can be formulated in (4):

$$d(A, B) = \left|\left(\frac{i}{g} + \alpha_1\right) - \left(\frac{j}{g} + \alpha_2\right)\right| \quad (4)$$

Theorem1. For any 2-tuple linguistic variables $A: (s_i, \alpha_1)$, $B: (s_j, \alpha_2)$ and $C: (s_k, \alpha_3)$, the distance $d(A, B)$ between A and B satisfies the following conditions [29]:

1) $A = B \Leftrightarrow d(A, B) = 0$
2) $d(A, B) = d(B, A)$
3) $0 \le d(A, B) \le 1$
4) $d(A, B) + d(B, C) \ge d(A, C)$

Proof. It is evident that $d(A, B)$ defined in (4) satisfies the conditions 1, 2 and 3. To prove that $d(A, B)$ satisfies the condition 4 as well we have:

$$d(A, B) + d(B, C) = \left|\left(\frac{i}{g} + \alpha_1\right) - \left(\frac{j}{g} + \alpha_2\right)\right| + \left|\left(\frac{j}{g} + \alpha_2\right) - \left(\frac{k}{g} + \alpha_3\right)\right|$$
$$\ge \left|\left(\frac{i}{g} + \alpha_1\right) - \left(\frac{j}{g} + \alpha_2\right) + \left(\frac{j}{g} + \alpha_2\right) - \left(\frac{k}{g} + \alpha_3\right)\right|$$
$$\ge \left|\left(\frac{i}{g} + \alpha_1\right) - \left(\frac{k}{g} + \alpha_3\right)\right| = d(A, C)$$

Example3. Let S = {s_0 = Very Low, s_1 = Low, s_2 = Medium, s_3 = High, s_4 = Very High} be a set of five linguistic terms. Suppose that we have two 2-tuple variables, $A = (s_3, 0.05)$ and $B = (s_2, 0.02)$. The distance between *A* and *B* defined in (4) is computed as: $d(A, B) = \left|\left(\frac{3}{4} + 0.05\right) - \left(\frac{2}{4} + 0.02\right)\right| = 0.28$

Let $x = \{(s_1, \alpha_1), (s_2, \alpha_2), ..., (s_n, \alpha_n)\}$ be a set of 2-tuples, and let $\bar{x}$ be the arithmetic mean of these 2-tuples. As stated by Wei and Zhao [31], the standard deviation can be defined as given in (5):

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n} d\left((s_i, \alpha_i), \bar{x}\right)^2} \quad (5)$$

According to Herrera and Martinez [25], the comparison of two 2-tuple linguistic variables (s_i, α_i) and (s_j, α_j) can be done as:

If $i < j$ then (s_i, α_i) is smaller than (s_j, α_j);

If $i = j$ then:

1) If $\alpha_i = \alpha_j$ then (s_i, α_i) is equal to (s_j, α_j);
2) If $\alpha_i < \alpha_j$ then (s_i, α_i) is smaller than (s_j, α_j);
3) If $\alpha_i > \alpha_j$ then (s_i, α_i) is bigger than (s_j, α_j).

Example4. Let $S = \{s_0 = \text{Very Low}, s_1 = \text{Low}, s_2 = \text{Medium}, s_3 = \text{High}, s_4 = \text{Very High}\}$ be a set of five linguistic terms. Suppose that we want to compare two 2-tuple variables *A* and *B* where, $A = (s_3, 0.05)$ and $B = (s_2, 0.02)$. Indeed, we have $2 < 3$ then, *B* is smaller than *A*.

B. The Stepwise Procedure

The 2-tuple modified Delphi approach stepwise procedure is presented in Fig. 1.

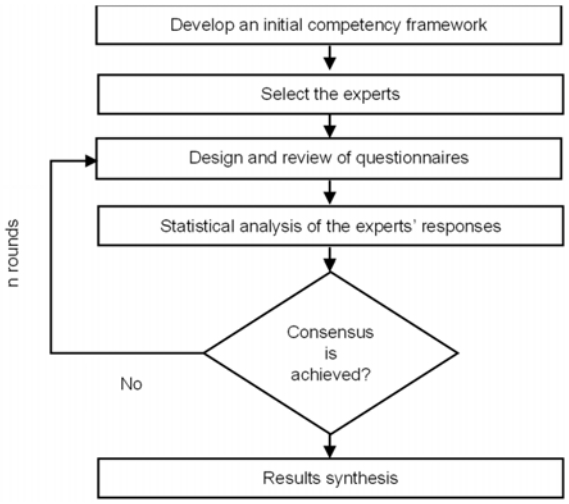

Fig. 1 2-tuple modified Delphi approach

1) Development of an Initial Competency Framework

The aim of this step is to develop an initial competency framework, the objective of which is to name the competencies required for a job or a position. It is expressed as a hierarchical inventory that lists the required competencies according on the category of competencies (knowledge, know-how, and know-whom) and their sub-categories [16] as given in Fig. 2.

Knowledge is acquired through formal education and trainings as vocational education. This category can be subdivided into three sub-categories as mentioned in Fig. 2: (1) the theoretical knowledge, which refers to a set of general information that makes it possible to explain a situation and guide decisions, for instance, *to know the requirements of the ISO 14001:2015 standard*, (2) the knowledge on what exists, being related to the context in which a competency is performed, for instance, *to know the organization's environmental policy*, (3) the procedural knowledge, intended to describe "how it should be done". It includes procedures and methods, e.g., *to know the company strategic analysis methods (e.g., SWOT, PESTEL).*

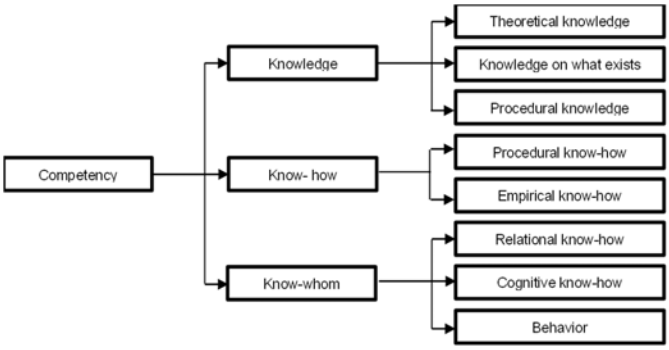

Fig. 2 Competency categories and sub-categories [16]

Know-how is generally related to workplace experience. This category comprises: (1) the procedural know-how, made up of procedural knowledge, with its practical application being mastered, for example, *to ensure an environmental regulatory watch*, (2) the empirical know-how, based on experience, including tricks and rule of thumbs, e.g., *identification of the necessary resources as human, financial, and technical material to achieve the expected results*.

Know-whom is "an individual characteristic, which allows to adopt some specific behavior to maintain good working conditions, or to resolve unexpectedly arising relational situations" [16]. This category covers: (1) the "relational know-how" that refers to the ability to decide how to behave in a particular professional context as, *to know how to cooperate*, (2) the "cognitive know-how" that concerns intellectual capabilities needed for solving problems at time, or projects implementation and decision making [32], e.g. *To know how to instantly make a rational analyze and to shorten the critical path of the decision-making process* (3) the "behavior" includes all other qualities expected in the workplace; for instance, *to have a sense of continuous improvement.*

2) Experts' Selection

The aim of this step is to select the experts willing to participate to the study. To this end, a preliminary list of potential participants of the study has been established. Thereafter, we prioritized the Moroccan experts that have several years of experience, while considering those operating in different business lines. The number of experts varies from one study to another. However, Chtioui [33] considers that the minimum threshold for the number of experts in a Delphi study is 5 to 7.

3) Designing the Questionnaire

Based on the competencies identified in the first step, a questionnaire has been designed. The aim of the questionnaire is to collect general information about the experts namely, the email, number of years' experience, business line, and their opinion about the level of the identified competencies. Moreover, the questionnaire provides the opportunity for experts to leave comments in case they intended to add other

competencies or justifications to their assessment.

To assess the importance of each competency, the experts are asked to use a set of five linguistic expressions $S' = \{s'_0, s'_1, s'_2, s'_3, s'_4\}$ as presented in Table I.

TABLE I
LINGUISTIC TERM SETS

Linguistic label	Linguistic term
s'_4	Extremely Important (EI)
s'_3	Very Important (VI)
s'_2	Moderately Important (MI)
s'_1	Somewhat Important (SI)
s'_0	Not Important (NI)

The questionnaire was written in French in order to make it understandable to the experts, and then designed online. Its link was sent via email or via professional networks to all the experts

4) Statistical Analysis of the Experts' Responses

After receiving the responses from experts, the whole data are submitted to statistical analysis. The statistical analysis includes computations of the percentage of response rates, the arithmetic mean and the standard deviation of the assessments given by experts. Therefore, let n be the number of competencies $C_i (i = 1, 2, \ldots, n)$, and K be the number of experts $E_k (k = 1, 2, \ldots, K)$. Suppose that r_{ik} is the rating given by the expert E_k on the competency C_i, where $r_{ik} \in S'$. S is the linguistic term set (Table I).

The arithmetic mean value of the experts' rating is given in (6):

$$\bar{x}_i = (s'_i, \alpha_i) = \Delta\left(\frac{1}{K}\sum_{k=1}^{K} \Delta^{-1}(r_{ik}, 0)\right), i = 1, 2, \ldots, n \quad (6)$$

where, $s'_i \in S'$ and $\alpha \in [-0.125, 0.125)$

The standard deviation is computed as given in (7):

$$\sigma_i = \sqrt{\frac{1}{K}\sum_{i=1}^{K} d\left((r_{ik}, 0), (s'_i, \alpha_i)\right)^2}, i = 1, 2, \ldots, n \quad (7)$$

where, $d\left((r_{ik}, 0), (s'_i, \alpha_i)\right)$ is the distance between $(r_{ik}, 0)$ and the arithmetic mean value (s'_i, α_i). The distance is defined in (4).

The following step consists of checking whether the consensus has been reached or not. As stated by Torağay and Arikan [27], if all coefficients of variation CV values are less or equal to 50%, then the consensus is reached and no supplementary round is required. The coefficient of variation is the ratio of standard deviation to the mean as formulated in (8):

$$CV_i(\%) = \frac{\sigma_i}{\bar{x}_i} \times 100 \quad (8)$$

If the consensus is not reached, then a second round is performed. The questionnaire is therefore reviewed. Thus, it allows the experts to refine their assessments, by showing them the group responses and their own response. Thereafter, the results are analyzed to check whether or not the consensus has been achieved. This procedure is repeated until the consensus is achieved or a saturation is observed. Once the consensus is achieved, the result synthesis is performed.

5) Results' Synthesis

In this step, the competencies, where the consensus is achieved, are grouped together to form the final competency framework. The obtained document lists, ranks, and categorizes the required competencies. Furthermore, it is very useful in other competency management processes as competency assessment, recruitment, and task allocation.

IV. Results and Discussion

The results obtained through developing the modified 2-tuple Dephi approach correspond to competencies that are discussed here below depending on their requiring environment:

A. Competencies Required by Environmental Managers

ISO 14001 is an international standard that has been adopted by several organizations across the world. According to a recent ISO survey [34], there are 348 473 valid certifications at the global level. Indeed, the adoption of ISO 14001 standard offers several benefits, for instance: to improve the environmental performance, contribute to sustainable development, improve the organization's brand image, and stand out from the competition. Tarí et al. [35] conducted a literature review that presents the benefits derived from the ISO 14001 standard. Furthermore, Nguyen and Hens [36] carried out a study in 56 cement plants in Vietnam, and the results showed that the certified plants have significant improvement on the selected environmental indicators compared to non-certified plants. Sadik and Rigar [37] performed a study at the level of 14 listed Moroccan organizations, and their results revealed that the financial performance has increased following their ISO 14001 certification. In addition, Boiral et al. [38] carried out a systematic review of the studies published between 1996 and 2015. Based on this review, it can be deduced that the ISO 14001: 2015 standard has gained a significant interest, mostly at the level of industries. The environmental manager these industries generally hire accomplishes henceforth the mission to implement, manage, and continuously improve an environmental management system. To carry out their missions, several competencies are required. Regarding its importance, the ISO 14001:2015 standard has been considered as the main reference to develop the initial competency framework. In addition to the ISO 14001:2015, we used other sources, namely: the ISO 14004 [39], some books as [40], [41] as well as some job sheets.

The initial competency framework included 98 competencies subdivided into 3 main categories (knowledge, know-how, and know-whom), and 8 sub-categories as illustrated in Fig. 2. The distribution of the 98 identified competencies by categories and

sub-categories is given in Fig. 3.

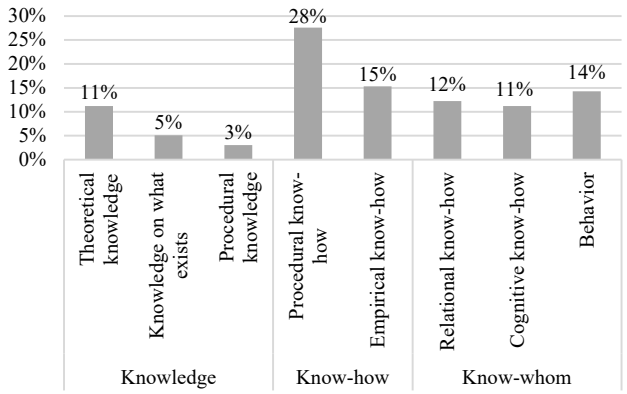

Fig. 3 Distribution of the identified competencies by competency categories and sub-categories – environmental managers

As shown in Fig. 3, the know-how and know-whom categories recorded the highest percentages, which are respectively 43% and 38%. It can be noticed that the sub-category procedural know-how has the highest percentage of all sub-categories (28%), and that of the procedural knowledge represents the lowest one (3%). It is true that to know-how to follow a procedure, we should first know this procedure. Therefore, the two sub-categories: procedural knowledge and procedural know-how, should have the same percentages. However, for the sake of efficiency and in order to avoid a very long competency framework, we preferred to include these competencies in the procedural know-how sub-category.

The second step consists of selecting experts who will participate to the study. Indeed, 20 Moroccan experts agreed to anonymously answer our questionnaire. These experts are operating in various business lines as training, automotive, consulting, and sanitation. 75% of the participants had more than 10 years of experience in the field.

The questionnaire included a description of the study, general questions about the experts, the competencies identified in the initial competency framework, and the importance scale given in Table I that allows the experts to assess the importance of each competency. Moreover, the experts were able to leave comments in case they intended to add additional competencies or justifications to their answers. The questionnaire was designed online and the link was sent to the experts via email or professional social networks. Based on the statistical analysis of the responses as explained in Section III, it can be deduced that all the 98 competencies range between moderately and extremely important. Furthermore, all the coefficients of variation were less than 50%, which indicates that the consensus has been achieved. The experts did not add any competencies. Therefore, we assume that the competencies list is exhaustive and includes all the important competencies. However, a second round of questionnaires has been carried out. The latter questionnaire is designed to open an additional new opportunity for the experts to refine their first response. For this, a specific questionnaire has been elaborated for each expert, and includes: i) the different competencies, ii) the expert's answers, and iii) the percentages obtained by each importance degree. In the latter case, through discovering the different responses forwarded by the other experts, each expert can freely decide to maintain or make changes to their initial responses. The round 2 questionnaires have been sent to the different experts. Their responses are then analyzed, and the corresponding top 3 competencies are presented in Table II.

TABLE II
TOP 3 COMPETENCIES REQUIRED BY ENVIRONMENTAL MANAGERS

Rank	Competencies	Mean	Coefficient of variation	Competency sub-category
1	To know the organization's environmental policy	$\Delta^{-1}(s'_4,0)$	0%	Knowledge on what exists
1	To know how to identify potential emergency situations	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To know how to define the emergency response means	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To know how to review, revise, test emergency response procedures, and provide feedback	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To know how to implement an emergency plan	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
2	To know the ISO 14001 standard requirements	$\Delta^{-1}(s'_4,-0.01)$	6%	Theoretical knowledge
2	To know the regional, national, and international environmental regulations	$\Delta^{-1}(s'_4,-0.01)$	6%	Theoretical knowledge
2	To know how to identify the organization's internal and external issues	$\Delta^{-1}(s'_4,-0.01)$	6%	Empirical know-how
2	To know how to determine compliance obligations	$\Delta^{-1}(s'_4,-0.01)$	6%	Procedural know-how
2	To have listening skills	$\Delta^{-1}(s'_4,-0.01)$	6%	Cognitive know-how
3	To know how to conduct an environmental analysis from a life cycle perspective taking into account Normal, Abnormal, and Emergency Situations	$\Delta^{-1}(s'_4,-0.02)$	8%	Procedural know-how
3	To know how to identify the operational control processes that are necessary to carry out the tasks with respect to the preservation and protection of the environment	$\Delta^{-1}(s'_4,-0.02)$	8%	Procedural know-how
3	To know how to examine non-conformities, determine the causes and take corrective action to prevent their recurrence	$\Delta^{-1}(s'_4,-0.02)$	8%	Empirical know-how
3	Diplomacy (showing tact in dealing with others)	$\Delta^{-1}(s'_4,-0.02)$	8%	Relational know-how
3	Leadership	$\Delta^{-1}(s'_4,-0.02)$	8%	Relational know-how
3	Ability to solve problems	$\Delta^{-1}(s'_4,-0.02)$	8%	Cognitive know-how
3	Stress management	$\Delta^{-1}(s'_4,-0.02)$	8%	Behavior
3	To know how to demonstrate transparency during audits	$\Delta^{-1}(s'_4,-0.02)$	8%	Behavior

By analyzing the second-round data, we can deduce that all the 98 competencies are still between moderately and extremely important. We can also remark that the averages of the top 3 competencies are very close, and they are near or equal to extremely important. Moreover, it can be noticed that the second-round's coefficients of variation have decreased for most of the competencies compared to the first-round. For instance, the coefficient of variation of "To know the state's environmental aids and subsidies" has dropped from 42% to 34%. If we consider the case of "To know the organization's environmental policy", we can note that its coefficient of variation is equal to "0 %", which means that the consensus has been 100% achieved. For 26% of all competencies, the coefficient of variation remained unchanged. Therefore, it can be concluded that the consensus has been achieved and that all the identified competencies are significant for the environmental managers' position. Indeed, 87,8% of the competencies proved to be placed between very and extremely important. The survey lasted for about two years, and the final environmental managers' competency framework has been developed. This document is an inventory that lists, ranks and categorizes all the required competencies.

B. Competencies Required by Environmental Auditors

The main mission of the environmental auditors is to audit an environmental management system. This audit attempts to detect potential non-conformities, and it enables the organizations to be in adequacy with the ISO 14001 standard's requirements. Therefore, this requires multiple competencies. The ISO 19011: 2018 international standard [42] is the main reference used to develop the auditors' initial competency framework. This standard was developed by the International Organization for Standardization (ISO), and provides, since then, guidelines for auditing management systems.

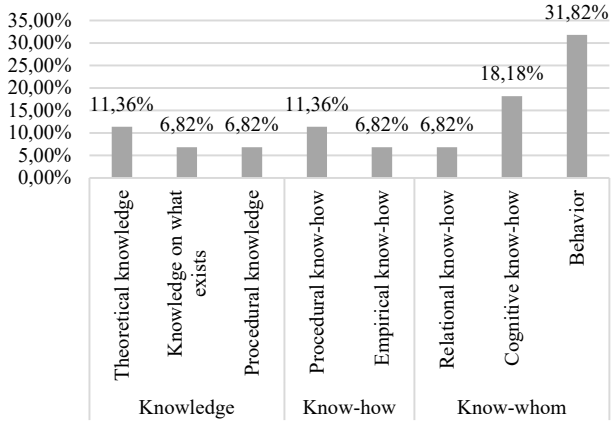

Fig. 4 Distribution of the identified competencies by competency categories and sub-categories – environmental auditors

The initial competency framework included 44 competencies subdivided into 3 main categories (knowledge, know-how, and know-whom), and 8 sub-categories. The distribution of the 44 identified competencies into categories and sub-categories are given in Fig. 4.

According to Fig. 4, the know-whom category represents more of 56% of the competencies. Furthermore, it can be noticed that the behavior sub-category reaches the highest percentage 31.82% and that the following sub-categories: Knowledge on what exists, procedural knowledge, empirical knowledge, and relational know-how recorded near-equal percentages (~6.82%).

A questionnaire has been designed online where all the competencies are included to enable the experts to assess the importance of each of the 44 competencies by using the scale presented in Table I. The questionnaire opens also the possibility to leave complementary comments. Six Moroccan experts accepted to anonymously answer the questionnaire. These experts were very experienced, as they had between 8 to 21 years' experience in the field. Furthermore, they were mainly operating in consulting and auditing offices. The first-round results showed that the consensus has not been achieved for the following competency: "To know how to identify and assess the risks and opportunities of an audit program" where the coefficient of variation was equal to 76%. Two competencies had a coefficient of variation very close to 50% as "To know the relevant access, health and safety, security and emergency provisions of the audited organization; $CV = 49{,}3\%$" and "To have knowledge on project management; $CV = 49\%$". Therefore, a second round proved to be mandatory, and a questionnaire is then designed for each expert. The main objective of the second-round questionnaires was to show to the experts their answers and the group of answers. Consequently, it provides the experts with the opportunity to refine their answers. The second-round answers have been analyzed. The corresponding top 3 competencies are presented in Table III.

This study lasted for about 7 months. Through analyzing the data, it can be noticed that all the coefficients of variation were lower than 50%, which means that the consensus has been achieved. Furthermore, it can be deduced that almost all the competencies range between moderately and extremely important, except for the competency "To have knowledge on project management" that has a mean lower than moderately important. The latter result leads us to remove this competency from the final environmental competency framework. 73% of the competencies ranged between very important and extremely important. Therefore, we deduced that the two rounds are sufficient. The final environmental auditors' competency framework included 43 competencies ranked and categorized according to the categories presented in Fig. 2.

V. Conclusions

Competency identification is an ineluctable step in the competency management process because it helps to define what trainings and recruitments should be made. In this paper, a modified 2-tuple Delphi study has been carried out to identify the competencies required by an environmental manager and auditor. A total of 26 competent Moroccan experts have participated to this study, with the advantage that they are operating in various business lines as training, automotive, consulting, auditing, construction, and sanitation. Furthermore, two rounds were conducted for both positions in order to allow

the experts to refine their answers by showing to them their own answers and the group's answers. As a result, the consensus has been achieved, and an environmental competency framework has been developed. The latter includes 98 competencies for the environmental managers position and 43 competencies for the environmental auditors. It also categorized the competencies and provided their raking. The modified 2-tuple Delphi study is an efficient method that allows us to obtain a consensus. However, the risk of lassitude among experts can be observed, so a major commitment from the experts is required.

TABLE III
TOP 3 COMPETENCIES REQUIRED BY ENVIRONMENTAL AUDITORS

Rank	Competencies	Mean	Coefficient of variation	Competency Sub-category
1	To know the environmental regulations	$\Delta^{-1}(s'_4,0)$	0%	Theoretical knowledge
1	To know the ISO 14001:2015 standard's requirements	$\Delta^{-1}(s'_4,0)$	0%	Theoretical knowledge
1	To know the procedures, techniques, and principles of auditing	$\Delta^{-1}(s'_4,0)$	0%	Procedural knowledge
1	To know how to implement an audit program and plan	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To know how to write an audit report	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To know how to collect and analyze audit evidence	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To know how to develop audit findings	$\Delta^{-1}(s'_4,0)$	0%	Procedural know-how
1	To have observational skills	$\Delta^{-1}(s'_4,0)$	0%	Cognitive know-how
2	Make recommendations to improve the environmental management system	$\Delta^{-1}(s'_4,-0.08)$	13%	Empirical know-how
2	To respect the ethics code	$\Delta^{-1}(s'_4,-0.08)$	13%	Behavior
2	To have the ability to adapt	$\Delta^{-1}(s'_4,-0.08)$	13%	Behavior
3	Independence & autonomy	$\Delta^{-1}(s'_4,-0.12)$	14%	Behavior
3	To have an analytical and synthetic mind	$\Delta^{-1}(s'_4,-0.12)$	14%	Cognitive know-how
3	To be insightful	$\Delta^{-1}(s'_4,-0.12)$	14%	Cognitive know-how
3	Decision-making	$\Delta^{-1}(s'_4,-0.12)$	22%	Cognitive know-how
3	Listening skills	$\Delta^{-1}(s'_4,-0.12)$	14%	Cognitive know-how

It is worthy to note that the experts were satisfied with the final results. As perspectives, we expect to broaden the scope of this study through involving other positions related to the Occupational Health, Safety and Environmental field. These positions are likely to open new avenues to develop competency frameworks adapted to each business line.

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REFERENCES

[1] A. Berger, R. E. Dickenson, and J. W. Kidson, *Understanding Climate Change*. American Geophysical Union, 1989.
[2] *Environmental management systems — Requirements with guidance for use*, ISO 14001:2015, 2015.
[3] C. Lévy-Leboyer, *La gestion des compétences. Éditions d'Organisation.* Groupe Eyrolles, 2009.
[4] Y. K. Sharma, S. K. Mangla, P. P. Patil, and S. Liu, "When challenges impede the process: For circular economy-driven sustainability practices in food supply chain," *Management Decision*, vol. 57, no. 4, pp. 995–1017, Jan. 2019, doi: 10.1108/MD-09-2018-1056.
[5] J. Dorn and M. Pichlmair, "A competence management system for universities," in *15th European Conference on Information Systems (ECIS)*, St. Gallen, Switzerland, 2007.
[6] F. Draganidis and G. Mentzas, "Competency based management: a review of systems and approaches," *Inf. Manag. Comput. Secur.*, vol. 14, no. 1, pp. 51–64, Jan. 2006, doi: 10.1108/09685220610648373.
[7] V. Vathanophas, "Competency requirements for effective job performance in Thai public sector," *Contemp. Manag. Research*, vol. 3, no. 1, Jan. 2007, doi: https://doi.org/10.7903/cmr.49.
[8] G. Berio and M. Harzallah, "Knowledge management for competence management," *J. Univers. Knowl. Manag.*, vol. 0, no. 1, pp. 21–28, June 2005.
[9] R. E. Boyatzis, *The competent manager: A model for effective performance*. John Wiley & Sons, 1982.
[10] A. F. Marrelli, "An introduction to competency analysis and modeling," *Perform. Improv.*, vol. 37, no. 5, pp. 8–17, May-June 1998, doi: 10.1002/pfi.4140370505.
[11] X. Boucher, E. Bonjour, and B. Grabot, "Formalisation and use of competencies for industrial performance optimisation: A survey," *Comput. Ind.*, vol. 58, no. 2, pp. 98–117, Feb. 2007, doi: 10.1016/j.compind.2006.09.004.
[12] J. Burgoyne, "Creating the managerial portfolio: building on competency approaches to management development," *Manag. Educ. Develop.*, vol. 20, no. 1, pp. 56–61, Apr. 1989, doi: https://doi.org/10.1177/135050768902000109.
[13] C. Woodruffe, "What is meant by a competency?," *Leadersh. Organ. Develop. J.*, vol. 14, no. 1, pp. 29–36, Jan. 1993, doi: 10.1108/eb053651.
[14] F. Belkadi, E. Bonjour, and M. Dulmet, "Competency characterisation by means of work situation modelling," *Comput. Ind.*, vol. 58, no. 2, pp. 164–178, Feb. 2007, doi: 10.1016/j.compind.2006.09.005.
[15] G. Kelly, *The psychology of personal constructs*. Oxford, England: W. W. Norton, 1955.
[16] M. Harzallah and F. Vernadat, "IT-based competency modeling and management: from theory to practice in enterprise engineering and operations," *Comput. Ind.*, vol. 48, no. 2, pp. 157–179, Jun. 2002, doi: 10.1016/S0166-3615(02)00003-9.
[17] A. Boumane, A. Talbi, and D. Bouami, "Quelle méthodologie pour identifier les compétences requises ?," in *Congrès Performance et Nouvelles Technologies en Maintenance*, Marrakech, Maroc, 2005.
[18] N. Sefiani, A. Boumane, J. P. Campagne, and D. Bouami, "Démarche d'identification des compétences requises basée sur une approche fonctionnelle," in *9ème congrès international de Génie Industriel (CIGI 2011)*, Saint Sauveur, Canada, 2011.
[19] J. M. Brill, M. J. Bishop, and A. E. Walker, "The competencies and characteristics required of an effective project manager: A web-based Delphi study," *Educ. Technol. Res. Dev.*, vol. 54, no. 2, pp. 115–140, May 2006, doi: https://doi.org/10.1007/s11423-006-8251-y.
[20] A. E. Liddell, S. Allan, and K. Goss, "Therapist competencies necessary for the delivery of compassion-focused therapy: A Delphi study,"

Psychol. Psychother., vol. 90, no. 2, pp. 156–176, June 2017, doi: https://doi.org/10.1111/papt.12105.

[21] L. M. Johnston, et al., "Identification of core competencies for an undergraduate food safety curriculum using a modified Delphi approach," *J. Food Sci. Educ.*, vol. 13, no. 1, pp. 12–21, Jan. 2014, doi: https://doi.org/10.1111/1541-4329.12024.

[22] J. S. Horng, H. Hsuan, L. Chih-Hsing, L. Lin, and T. Chang-Yen, "Competency analysis of top managers in the Taiwanese hotel industry," *Int. J. Hosp. Manag.*, vol. 30, no. 4, pp. 1044–1054, Dec. 2011, doi: 10.1016/j.ijhm.2011.03.012.

[23] N. Dalkey and O. Helmer, "An experimental application of the Delphi method to the use of experts," *Manag. sci.*, vol. 9, no. 3, pp. 458–467, Apr. 1963, doi: https://doi.org/10.1287/mnsc.9.3.458.

[24] G. Rowe and G. Wright, "The Delphi technique as a forecasting tool: issues and analysis," *Int. J. forecast.*, vol. 15, no. 4, pp. 353–375, Oct. 1999, doi: https://doi.org/10.1016/S0169-2070(99)00018-7.

[25] F. Herrera and L. Martinez, "A 2-tuple fuzzy linguistic representation model for computing with words," *IEEE Trans. Fuzzy Syst.*, vol. 8, no. 6, pp. 746–752, Dec. 2000, doi: 10.1109/91.890332.

[26] W. C. Ko, "Construction of house of quality for new product planning: A 2-tuple fuzzy linguistic approach," *Comput. Ind.*, vol. 73, pp. 117–127, Oct. 2015, doi: 10.1016/j.compind.2015.07.008.

[27] O. Torağay and M. Arikan, "Performance evaluation of faculty departments by a Delphi method based on 2-tuple fuzzy linguistic representation model and TOPSIS," *Int. J. Basic Appl. Sci.*,vol. 15, no. 05, p. 11, 2015.

[28] K. Laurell-Stenlund and S. A. Hörte, "Competence accounting: methods for measuring and valuing key-competencies," in *European Operations Management Association International Annual Conference, Managing Operations Networks*, 1999.

[29] C. T. Chen and W. S. Tai, "Measuring the intellectual capital performance based on 2-tuple fuzzy linguistic information," in *10th Annual Meeting of, Asia Pacific Region of Decision Sciences Institute (APDSI)*, 2005.

[30] L. Pei-de, "A novel method for hybrid multiple attribute decision making," *Knowl. Based Syst.*, vol. 22, no. 5, pp. 388–391, Jul. 2009, doi: 10.1016/j.knosys.2009.02.001.

[31] G. Wei and X. Zhao, "Some dependent aggregation operators with 2-tuple linguistic information and their application to multiple attribute group decision making," *Expert Syst. Appl.*, vol. 39, no. 5, pp. 5881–5886, Apr. 2012, doi: 10.1016/j.eswa.2011.11.120.

[32] G. Le Boterf, *De la compétence à la navigation professionnelle*. Les Ed. d'organisation. 1998.

[33] T. Chtioui, "Les fondements d'un modèle de mesure de la communication pour le contrôle de gestion : une étude Delphi," in *27ème congrès de l'AFC*, Poitier, France, 2007.

[34] International Organization for Standardization (ISO). "The ISO survey of management system standard certifications 2020." [Online]. Available: https://www.iso.org/the-iso-survey.html. [Accessed: 13-Jan-2022]

[35] J. J. Tarí, J. F. Molina-Azorín, and I. Heras, "Benefits of the ISO 9001 and ISO 14001 standards: A literature review," *J. Ind. Eng. Manag.*, vol. 5, no. 2, pp. 297–322, 2012, doi: 10.3926/jiem.488.

[36] Q. A. Nguyen and L. Hens, "Environmental performance of the cement industry in Vietnam: the influence of ISO 14001 certification," *J. Clean. Prod.*, vol. 96, pp. 362–378, Jun. 2015, doi: 10.1016/j.jclepro.2013.09.032.

[37] A. Sadik and S. M. Rigar, "Performance financière et performance environnementale : (Cas des entreprises cotées certifiées ISO14001)," *RCCA*, vol. 2, no. 3, 2018.

[38] O. Boiral, L. Guillaumie, I. Heras-Saizarbitoria, and C. V. T. Tene, "Adoption and outcomes of ISO 14001: A systematic review," *Int. J. Manag. Rev.*, vol. 20, no. 2, pp. 411–432, 2018, doi: https://doi.org/10.1111/ijmr.12139.

[39] *Environmental management systems — General guidelines on implementation*, ISO 14004: 2016, 2016.

[40] M. P. Grevêche and L. Vaute, *Au coeur de l'ISO 14001:2015 - Le système de management environnemental au centre de la stratégie*. Éditions Afnor, 2015.

[41] F. Gillet-Goinard and C. Monar, *Toute la fonction QSSE - Qualité-Santé-Sécurité-Environnement*. Paris, Dunod, 2013.

[42] *Guidelines for auditing management systems*, ISO 19011:2018, 2018.