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O.R. Applications

A multicriteria accreditation system for information technology skills and qualifications

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Abstract

Employees must acquire new competences and qualifications throughout their lives, in order to be able to deal with the multiple changes in the labour market. The specific knowledge and competences, acquired either formally or non-formally, must be recognized so that they can be transferred and utilized. The existing titles of studies and accreditation mechanisms do not generally cover this need. This paper aims to propose an integrated approach for the evaluation of information technology knowledge and skills, regardless of where and how they have been acquired, so as to apply a continuous education and training policy. The proposed multicriteria methodology for the evaluation of qualifications and skills concerns candidates wishing to be accredited in an information technology specialization or profession. The methodology refers to the evaluation of the professional experience, studies and vocational training of the candidates for accreditation. It contains the analysis and modelling of the qualitative criteria as well as the implementation of multicriteria aggregation–disaggregation techniques attributing value to each criterion. Then, the candidates are classified in categories of professionals using the Electre Tri method, accepting as input data the multicriteria assessments on each criterion. The proposed evaluation approach has been adapted to the Greek educational system and is applied to a specific example of candidate.

Keywords: Multiple criteria analysis; Education; OR in manpower planning; Accreditation of qualifications and skills

1. Introduction

The developments in the labour market, in the content and state of employment, as well as the technical and organizational changes require the intense mobility of the employees. They must necessarily acquire new competences and qualifications throughout their professional lives so as to successfully meet the needs of their job. At the same time, international organizations and many European initiatives seek ways and methods to attribute value to knowledge and skills acquired during the entire lifetime; pioneers in research are the European Council (DG Education and Training, DG Enterprise), the

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Cedefop organization, the Leonardo Da Vinci Programme, the ICT Skills Monitoring Group, the e-Skills Forum, the European e-Skills Certification Consortium, UNESCO and several researchers (Bjørnåvold and Sellin, 1997; Turner, 1999; Bjørnåvold, 2000; UNESCO, 1999). Certain European countries have already enacted some practices for the identification, accreditation and certification of skills acquired through non-formal vocational training. Such initiatives are in France the "Bilan de Compétence" and the system for the Attestation of Professional Experience with a formal vocational training Diploma, in England and Ireland the "Accreditation of Prior Learning" system and in Germany the "Criteria Reference Testing" system (Bjørnåvold, 1997). All the above initiatives aim to attribute *value* to the general and specialized knowledge and skills acquired through non-formal learning.

More specifically, with regard to the general and specialized knowledge and skills in information technology, now useful to almost every employee, action has been taken mainly by private enterprises of the field, offering courses or/and examinations, aiming to provide an accreditation for their products. ECDL is the successful European initiative for the accreditation of general knowledge in information technology. A common feature of the above accreditation procedures is the successful participation in certain examinations; other qualities of the candidates, such as their professional experience, the studies they have completed or any other type of training they might have attended, are not added in. On the other hand, besides the time and cost required by the candidates, this is not always the best method that applies to all ages. Examinations are more suitable for young people and less for those who have been kept away from the educational procedure for years, but who may be successful professionals.

The approach proposed in this paper aims to add in all the qualifications of the candidates for accreditation in information technology, which have been acquired through any type of learning. As a methodology, it incorporates all the possible ways to acquire knowledge, skills and qualifications in a general and pluralistic procedure that deals with the subject from the point of view of a hypothetical accreditation body. It is an original approach for the accreditation of qualifications and skills in information technology, regarded as a multicriteria evaluation problem. For this reason, qualitative criteria have been analyzed and modelled and aggregation–disaggregation techniques have been implemented in order to attribute values to each of them. Finally the Electre Tri multicriteria method has been applied, which is based on the theory of outranking relations (Roy and Bouyssou, 1993; Yu, 1992); Electre Tri accepts the evaluation results as input data in order to classify the candidates in four categories of professionals. The evaluation elements of the candidates derive from their professional experience, their studies, the training programmes they have attended and their personal activity on the subject for which they request accreditation; these elements are collected through interviews, certificates, curriculum vitas, etc. The objective is to attribute *value* to the qualifications of each candidate and to provide a kind of unified "identity" to the interested parties in the field of information technology; this procedure can lead to the award of a certain formal document by a legislated accreditation body.

The particularity of Electre family multicriteria methods is to refuse the possibility of total compensation between the alternative's performance on the criteria and then to accept incomparability and intransitivity. Electre Tri, which is a widely used MCDA sorting method, is chosen firstly because, as a multicriteria assignment method, it sorts alternatives (candidates) by preference-ordered categories (*problematic* β); the ranking of the candidates from the best to the worst is not our case. Furthermore, particularities of the candidates' performance that may result in outstanding performance in some criteria and at the same time low performance in other criteria lead us to apply the Electre Tri method, which manages the above incomparability by proposing pessimistic and optimistic approaches.

The methodological framework and the qualitative criteria making up the problem, are analyzed in Section 2. The evaluation of general and specialized skills is presented in Section 3, while Section 4 deals with the evaluation system of formal studies and non-formal training (an example application is given for the Greek and Dutch educational systems). The methodology for the sorting of the candidates in categories is presented in Section 5. An implementation of the methodology to the Greek educational system is presented in Section 6 while the concluding remarks are included in Section 7.

2. Methodological framework

The procedure for the accreditation of knowledge and skills in information technology as a multicriteria decision problem requires the development of a related methodology and tools to support the decision-making process. Accreditation is a quite complicated issue, because of the qualitative character of the criteria and the insufficient delimitation of knowledge and skills required to practise a specific profession, combined with the absence of an institutional accreditation body. The approaches that have been adopted by certain European countries are not similar, since some of them aim to associate the non-formally acquired knowledge and skills with a formal education diploma, and other with the demands of a profession. The proposed methodology classifies the candidates in four categories of professionals, by examining through their profile the proficiency level of the candidates to practise a specific profession.

The proposed methodology is based on the following principles: (a) the accreditation procedure is carried out in two phases in order to examine at the first phase the proficiency of the candidate in some introductory, essential skills for an ICT specialized job. According to the pyramid of competences (NWCET, 1999) and the three levels of skills as proposed by Anneli Manninen (2004) the *foundation* or *basic* skills are distinguished from the more *specialized – technical* skills and are considered as the basis for every person with knowledge of digital technology. (b) The methodology has to be generally formulated in order to be easily adapted to any modifications either proposed by a legislated national (public) accreditation authority or based on special circumstances prevailing in European countries (e.g. educational particularities). (c) The accreditation procedure is not a self-evaluation task for candidates but is carried out from a *third* authorised body (committee). (d) As a consequence, the candidate has to *entrust* his/her personal achievements to an authorised committee which expresses its opinion for the candidate. (e) The accreditation procedure is not based on oral/

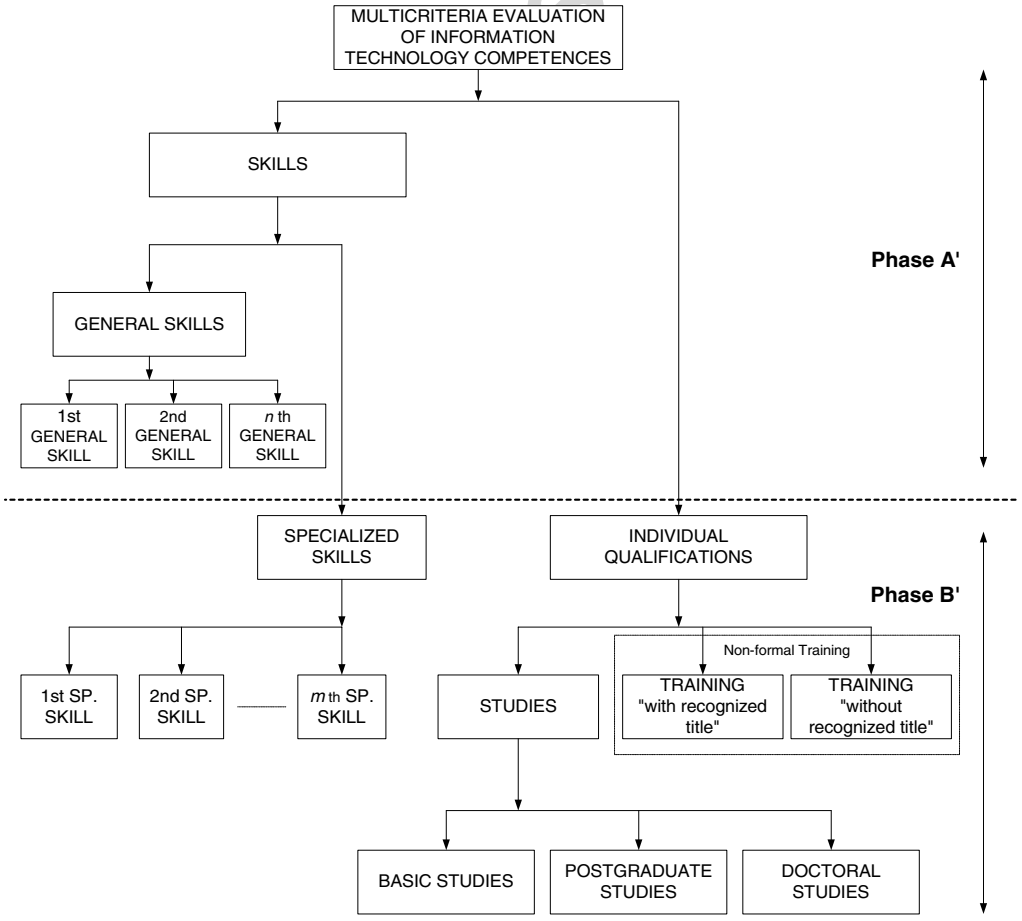

Fig. 1. The general multicriteria evaluation procedure for information technology qualifications.

written examinations but on any valuable information either submitted to the committee or resulting from the interview(s) with the candidate. (f) Participation in such accreditation procedure is voluntary and (g) the whole process is carried out on a profession basis (profession-oriented).

Therefore, if each profession requires n general skills for entry and m specialized skills per speciality, according to the Northwest Center for Emerging Technologies (NWCET, 1999), together with the formal studies and the non-formal training of the candidates, the totality of the evaluation criteria for each candidate is shown in Fig. 1.

The target is to attribute value to each one of the n criteria of the general skills (Phase A′) in order to judge the proficiency of the candidates to be eligible for evaluation in Phase B′. Then, the candidates proceeding to Phase B′ are evaluated on m criteria of the specialized skills required by each profession/speciality, in accomplished studies and in the two criteria of non-formal vocational training; the values to be estimated will become the input entries in the Electre Tri multicriteria table for the classification of the candidates in four homogeneous categories of professionals. The aforementioned methodology is supported by the *Skills Evaluator* decision support system (Anestis et al., under revision).

The procedure is carried out in two phases so as to ensure that the candidates have the general skills to enter the profession and to disqualify from Phase B′ evaluation those who have little relation with the profession to be accredited. Certainly, the extreme case of a candidate receiving a positive evaluation in Phase A′ while he/she has very few qualifications for Phase B′ evaluation, can be practically avoided through the proposed accreditation system, which provides for the evaluation of each candidate by two independent judges and by a third one in case of disagreement between the first two, and the final certification or new evaluation by a legislated Accreditation Committee (see Fig. 2).

The proposed multicriteria accreditation methodology does not substitute the work of the decision-makers; on the contrary, it requires their active participation. In particular, the flexibility of the Electre Tri method and the other multicriteria approaches, together with the possibility to embody the views and preferences of the users, allow the accreditation bodies to make the most of the proposed methodology, providing transparency and scientific documentation of their decisions.

3. The evaluation system for professional skills

According to approaches made by European bodies and educational/research institutions, views converge that for an employee to succeed in the actual working conditions he/she must have certain basic or core skills or key skills, such as the ability to

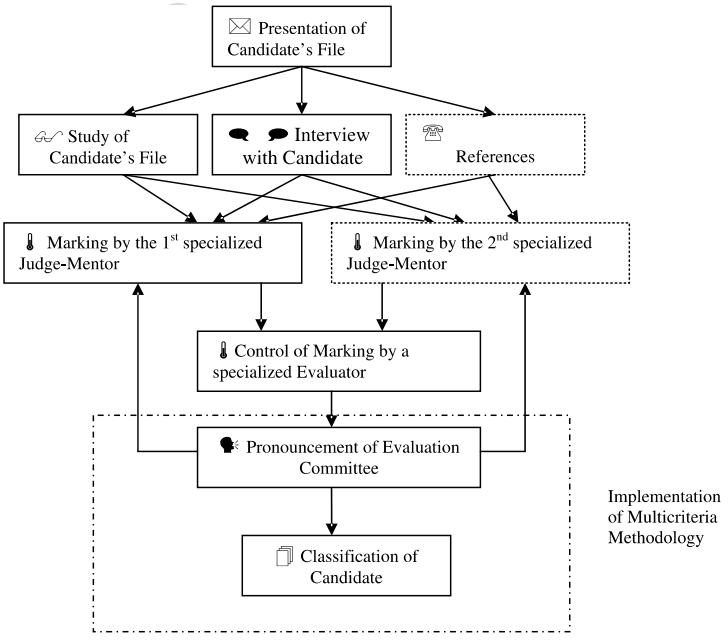

Fig. 2. Accreditation Procedure.

read, write and express themselves verbally, knowledge of arithmetic, critical thinking, sensibility in the detection of problems, etc, (DfEE-Skills Task Force, 2000). Similar proposals are made by US bodies and educational institutions, such as the National Skills Standard Board-NSSB, the Northwest Center for Emerging Technologies (NWCET, 1999) and the US Department of Employment through the O*NET network. In particular, and according to the NWCET other skills are added to the above core skills needed for someone to enter the professional field of information technology, such as: knowledge of database applications, e-mail, internet, network technologies, hardware and software installation, presentation software, spreadsheets, word process, windows and programming. Besides, the practice of a specific profession can be analyzed in separate tasks and sub-tasks, which in their turn require specific technical knowledge and skills. For example, and according to the NWCET proposal, the professions belonging to the group "Technical Support" are analyzed in tasks and sub-tasks, among which is the task "performance of hardware and software installation, configuration and upgrade". This particular task requires, among others, the following skills: knowledge of installation procedures, ability to submit queries in a database, knowledge of hardware and software operation, operating system and networks, multi-users operating systems, etc. Therefore, there is a clear distinction between the general skills that any employee must have and the specialized skills per profession or speciality.

Based on the above point of view, the process for the evaluation of the professional skills unfolds in two phases: in the first one, the n general skills for admission in a specific professional field are evaluated, and in the second phase the m specialized skills for a profession of the field are evaluated.

3.1. Phase A′: Evaluation of general skills

If the general skills constituting the evaluation criteria in Phase A′ are the following:

- *Use of basic s/w & h/w tools* (windows, word processing, spreadsheets, presentation software, databases, programming, hardware and software installation, basic knowledge of networks).
- *Use of Internet services* (e-mail, web browsing, search engines, ftp, etc.).

Then these may be acquired through professional experience, vocational training, studies and personal activity of the candidate (informal learning).

If U_i expresses the global value given to a candidate in ith general skill, then it results from the sum of the products of the weights of the four sources of skills multiplied by the marginal value of the degree of the candidate's activity (or the relevance of training-studies) with a general skill from each source. This additive value model has the following form:

$$U_i = \sum_{j=1}^{4} w_j U_{ij}, \tag{1}$$

where

i	ith general skill, $i = 1,2$
j	jth source of general skill, $j = 1,2,3,4$
w_j	weight of jth source of general skills
U_{ij}	marginal value of the degree of activity (or relevance of training-studies) with ith general skill from jth source,

under the restrictions:

$$\sum_i w_j = 1$$
$$0 \leqslant U_{ij} \leqslant 1,$$

where each marginal value function U_{ij}, should quantify on a four-degree qualitative scale and this for every source j, as follows:

- High degree of activity (or high relevance of training-studies).
- Medium degree of activity (or medium relevance of training-studies).
- Low degree of activity (or low relevance of training-studies).
- No activity (or no relevance of training-studies).

For the needs of Phase A′ of evaluation of the candidates' general skills, all the necessary information can be taken into account, resulting through titles (certificates, attestations, etc.) submitted to the Committee and through a personal interview with the candidates in order to identify their personal experiences. This procedure aims to point out both to the Committee and the candidate all the general skills considered to be introductory for the information technology professions and specialities, regardless of how they have been acquired, formally – non-formally – informally.

In order to evaluate the global value of *i*th general skill, the UTA* aggregation–disaggregation technique has been implemented (Jacquet-Lagrèze and Siskos, 2001; Beuthe and Scannella, 2001). The set of criteria consisted of the four sources for acquisition of the general skill while the set of alternatives, taken into account as a reference set, was made up of 10 fictitious candidates. The marginal value functions and the weights of the sources, as shown in Tables 1 and 2, have been inferred by analysing rankings of the reference set of candidates given by information technology experts, academics in the field (see ERGASYA, 2001; Krassadaki, 2001; Krassadaki et al., 2004).

According to the estimated values and weights, the adequate candidate is the one who receives on the criterion "Use of basic s/w & h/w tools" a global value of at least 0.60 and at the same time on the criterion "Use of Internet services" a global value of at least 0.55. The specified minimum limits that a candidate must meet on both criteria, obtained with the help of experts in the field, allow each candidate to continue to the next stage-Phase B′ of the evaluation. The specific procedure works as a safety valve, so as to promote to Phase B′ of the evaluation the candidates who have a minimum profile of technical knowledge.

3.2. Phase B′: Evaluation of specialized skills

Specialized skills vary per profession or speciality and often per workplace. In this case we explore the specialized skills that are common per profession/speciality; this does not mean that the proposed

Table 1
Marginal values and weights of sources for the acquisition of the general skill "Use of basic s/w & h/w tools"

Sources for the acquisition of the general skill "Use of basic s/w & h/w tools"	Professional experience (*Weight: 29%*)	No activity	0
		Low activity	0.39
		Medium activity	0.70
		High activity	1
	Vocational training (*Weight: 16%*)	No relevance	0
		Low relevance	0.31
		Medium relevance	0.46
		High relevance	1
	Studies (*Weight: 21%*)	No relevance	0
		Low relevance	0.76
		Medium relevance	0.76
		High relevance	1
	Personal activity (*Weight: 34%*)	No activity	0
		Low activity	0.30
		Medium activity	0.78
		High activity	1

Table 2
Marginal values and weights of sources for the acquisition of the general skill "Use of Internet services"

Sources for the acquisition of the general skill "Use of Internet services"	Professional experience (*Weight: 35%*)	No activity	0
		Low activity	0.29
		Medium activity	0.57
		High activity	1
	Vocational training (*Weight: 25%*)	No relevance	0
		Low relevance	0.50
		Medium relevance	1
		High relevance	1
	Studies (*Weight: 37%*)	No relevance	0
		Low relevance	0.13
		Medium relevance	0.20
		High relevance	1
	Personal activity (*Weight: 3%*)	No activity	0
		Low activity	1
		Medium activity	1
		High activity	1

methodology cannot be adapted even per workplace, where the required skills are adjusted to the specific requirements. Given that the present research is not carried out for account of a certain company, the information technology professions/specialities have been examined in the way they are proposed by research and state bodies on a national and international level in order to identify the skills that describe them. Therefore, related initiatives taken have been recorded and several discrepancies have been identified in the determination of the information technology specialities and in some cases of analysis of the specialized skills required for a profession. More information regarding the specialities-professions of information technology and the analysis of skills, as proposed by the official Greek State according to the ranking by STEP-92 and NACE, the Greek Computer Society, the Northwest Center for Emerging Technologies and the O*Net organization of the US Department of Employment, are given in Krassadaki (2001) and ERGASYA (2001).

According to the above, eight specialized skills are proposed, generally formulated, which, as evaluation criteria, can be accordingly adapted to each information technology profession/speciality. In particular, two of the eight qualitative criteria concern general skills for all professions, while from the other six those connected to a specific profession for accreditation can been used in the evaluation (Fig. 3).

If we accept that the specialized skills are the result of professional experience, then the professional experience of each candidate is evaluated through the analysis of each profession/speciality in the required skills.

Therefore for ith skill, where $i = 1, \ldots, 8$ is sought the value of i skill of each candidate, U_i, which is the sum of the product of the value of i skill from j job, U_{ij}, multiplied by the degree of activity (or relevance of activity) with i skill in j job, R_{ij}. Namely:

$$U_i = \sum_{j=1}^{n} U_{ij} R_{ij}, \tag{2}$$

where

i	index of skill, $i = 1, \ldots, 8$
j	index of job, $j = 1, \ldots, n$
U_i	value of i skill

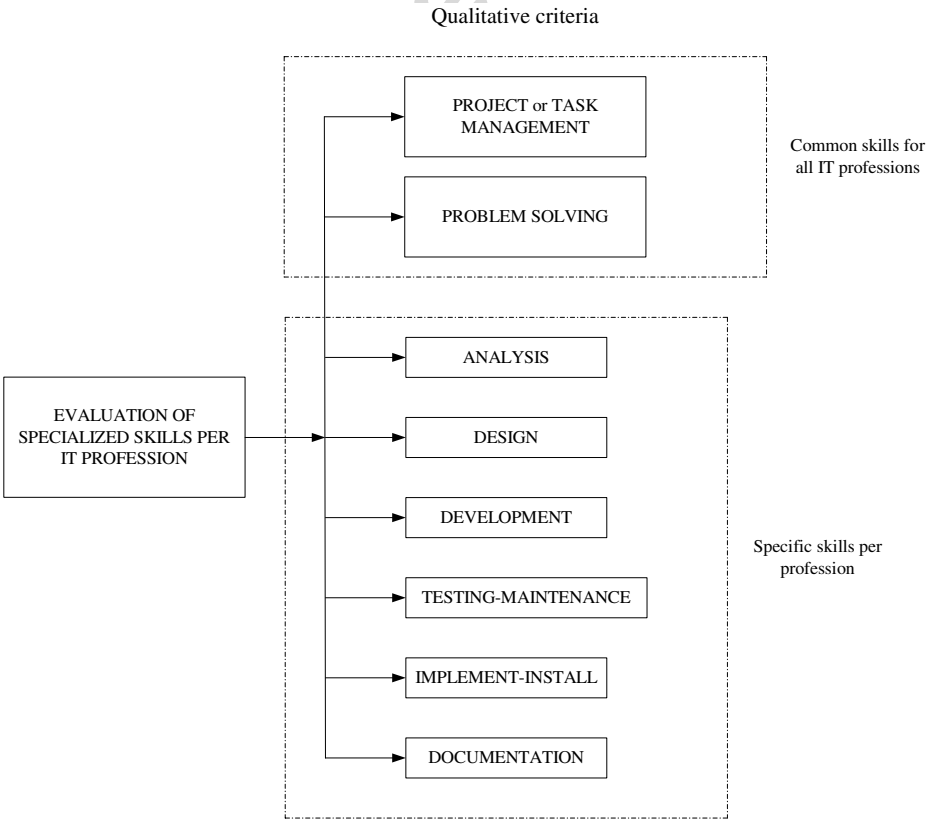

Fig. 3. Specialized Information Technology Skills.

U_{ij} value of i skill from j job
R_{ij} degree (or relevance) of activity with i skill in j job

where the value of i skill from j job U_{ij} is estimated as a value function of time in j job, $f(t_j)$. Namely:

$$U_{ij} = f(t_j) \tag{3}$$

and the degree (or relevance) of activity with i skill in j job, R_{ij}, is estimated as the fraction of the total time of activity with i skill in j job (t_{ij}) by the total time in j job (t_j), multiplied by the percentage of activity with i skill in j job (p_{ij}), namely:

$$R_{ij} = \frac{t_{ij}}{t_j} p_{ij}. \tag{4}$$

The main assumptions of the aforementioned model is that the value of a skill depends on the time and degree of activity throughout the professional carrier of a candidate, while at the same time it is an increasing value function of time. These assumptions are mainly based on the principle that most skills result from experience in a particular field (Hanne and Neu, 2004).

For example, if a candidate has totally worked in a j job for 2 years, and has been involved with the specific skill for only 6 months and to a time percentage (or relevance) of 50%, then the degree of activity with j skill is equal to: $R_{ij} = (6/24)0.5 = 0.125$.

The period of time during which the candidate has worked in a certain job (in a company, organization, etc.) is evaluated based on the factor of the years of previous employment, as shown in Table 3. The factor of the years of previous employment refers to the marginal value attributed to i skill from j job, U_{ij}, for a working experience of 1–20 years, taking into consideration that mainly the widely used PCs from the eighties changed rapidly the working environment in the last years. More specifically, the duration of the candidate's professional experience is analyzed in five zones, as it appears in Table 3. These zones represent different growth value rates as proposed by several researchers (Towill, 1984; Yelle, 1979; Edgington and Chen, 2002; Dardan et al., 2006). Also, for the assessment of the analytical form of the value function, a mid-value point technique has been used, based on experts' preferences (Keeney and Raiffa, 1976). The first zone contains the candidates without a professional experience in a certain skill (zero factor of years of previous employment). The second zone includes young employees, with one month to three years of working experience (factor 10% for each year from the 1st to the 3rd year). These people have recently started their careers and therefore the first three-year period of time is an adaptation period in the facts of the job. It is estimated that in this phase the employee acquires skills in a fast rate, in the order of 10%. The third zone concerns candidates with three (completed) to 10 years of employment (factor around 6% for each year from the 4th to the 10th), who have entered the productive phase, but continue to invest in new skills, in a lower rate, around 6%. The acquired skills from the workplace continue to increase although in a lower rate in the fourth zone (3%). The now mature employee, after 10 years of working experience and until 20 years, reaches the maximum of the skills of his/her profession (factor of 20 years of working experience equal to one). Finally, the fifth zone regards candidates with more than 20 years of working experience, who are considered to have acquired a sufficient number of professional skills, and therefore they are given a factor of years of previous employment equal to one. Thus, the value function $U_{ij} = f(t_j)$ has a convex form, although alternative types of

Table 3
Factor of years of previous employment

Years	Factor	
0	0	First zone
1	0.10	Second zone
2	0.20	
3	0.30	
4	0.36	Third zone
5	0.41	
6	0.47	
7	0.53	
8	0.59	
9	0.64	
10	0.70	
11	0.73	Fourth zone
12	0.76	
13	0.79	
14	0.82	
15	0.85	
16	0.88	
17	0.91	
18	0.94	
19	0.97	
20	1	
Over 20	1	Fifth zone

increasing value functions may also be considered without loss of generality.

For all the cases of years of previous employment varying between the intervals of Table 3, is applied the type of linear interpolation.

Thus, as it appears in Fig. 1 and by the relations (2)–(4) a value is attributed to each criterion-specialized skill required by an information technology profession/speciality, while at the same time the professional experience of the candidates is evaluated.

Let us suppose a candidate who has a total professional experience, relevant to the profession to be accredited, of 14 years and 9 months, as follows: 2 years in a company A′, 8 years and 6 months in a company B′ and 4 years and 3 months in an organization A′. Then, for example, for the skill "Project Management" ($i = 1$) from j jobs and the relation (4), he/she is evaluated as shown in Table 4.

Then, according to the relations (3) and (2) he/she receives:

$U_{11}R_{11} = 0.2 \times 0.5 = 0.1$ (see Table 3 for 2 years of previous employment).
$U_{12}R_{12} = 0.515 \times 0.1 = 0.0515$ (application of linear interpolation formula for eight and 1/2 years of previous employment).
$U_{13}R_{13} = 0.1275 \times 0.25 = 0.0318$ (application of linear interpolation formula for 4 years and 3 months).

Therefore, the global value of the first skill from the total professional experience of the candidate's three jobs for the specific information technology profession is:

$$U_1 = \sum_{j=1}^{3} U_{1j}R_{1j} = 0.1 + 0.0515 + 0.0318 = 0.1833 \cong 0.18.$$

The candidate must be evaluated in a similar way on the other specialized skills-criteria required by the information technology profession in which he/she wants to be accredited.

4. Evaluation of studies and non-formal vocational training

Phase B′ also includes the evaluation of studies and non-formal vocational training programmes attended by the candidates (see Krassadaki et al., 2002). The target is to attribute value to the criterion of studies and to the two criteria of non-formal vocational training "with a recognized" and "without a recognized" title.

For the evaluation of studies, the Greek educational system is analyzed as an example and a multicriteria model is proposed, taking into account three subcriteria; the basic, postgraduate and doctoral studies of each candidate. An equivalent adaptation can be made to any educational system, like in this case in the Netherlands. In particular, the evaluation of basic studies regards the studies accomplished after the compulsory and up to the tertiary education. The evaluation is performed through a multiplicative value function that takes into account the title awarded by the candidate, the grade of the title and the relevance of the title with the information technology profession in which the candidate asks for accreditation. For the attribution of value to all the combinations of titles, grades and relevance is applied a disaggregation approach which aims to estimate a value for each combination and a value for each type of title, grade and relevance, through the initial preferential prearrangement of the total possible combinations, performed by experts in the field of education. For the example of the Greek educational system, the values for each type of studies, marking and relevance are shown in Table 5 while the corresponding adaptation for the Dutch educational system is presented in Table 6. The evaluation of postgraduate and doctoral studies examines the existence of a corresponding title and the relevance of the title with a specific information technology

Table 4
Example of evaluation of a specialized skill

Company A′	2 years	Degree of activity = $(12/24) \times 100\% = 0.5$	The first year he/she did not work on Project Management, as opposed to the second year
Company B′	8 years and 6 months	Degree of activity = $(102/102) \times 10\% = 0.1$	His/her activity was constant but low in the order of 10%
Organization A′	4 years and 3 months	Degree of activity = $(51/51) \times 25\% = 0.25$	His/her activity was constant but low in the order of 25%

Table 5
Marginal value functions for basic studies (Greek paradigm)

Variables	Value of the types of basic studies	Variables	Value of the types of marking	Variables	Value of the types of relevance
Us_1 (A: AEI)	1	Uv_1 (Excellent)	1	Ur_1 (High)	1
Us_2 (B: TEI)	0.88	Uv_2 (Very Good)	0.95	Ur_2 (Medium)	0.64
Us_3 (C: IEK)	0.50	Uv_3 (Good)	0.89	Ur_3 (None)	0
Us_4 (D: TEE B, etc.)	0.39	Uv_4 (Pass)	0.84		
Us_5 (E: TEE A, etc.)	0.31				
Us_6 (F: IEK1)	0.04				

Table 6
Marginal value functions for basic studies (Dutch paradigm)

Variables	Value of the types of basic studies	Variables	Value of the types of marking	Variables	Value of the types of relevance
Us_1 (A: WO)	1	Uv_1 (Excellent)	1	Ur_1 (High)	1
Us_2 (B: HBO)	0.74	Uv_2 (Very Good)	0.95	Ur_2 (Medium)	0.63
Us_3 (C: VBO)	0.39	Uv_3 (Good)	0.90	Ur_3 (None)	0
Us_4 (D: VWO)	0.32	Uv_4 (Pass)	0.85		
Us_5 (E: HAVO)	0.25				

profession. Finally, the global value given to the criterion of studies results from the aggregation of the three evaluations and varies in the interval $[0, 1]$.

In addition, the non-formal training programmes attended by the candidates have to be evaluated. Taking as a rule that non-formal training can be divided in the one which provides similar titles in each country (e.g. ECDL and Microsoft implement the same examinational procedures worldwide and award titles through a concrete and strictly specified written test) and the one which is offered without the above precondition (e.g. training programmes organized by companies, chambers or private schools), non-formal training is separated in two independent criteria. In particular, the global value of training "with a recognized title" results from the evaluation of all the corresponding programmes that the candidate may have attended; each time is examined the relevance of the title with the information technology profession for which he/she wishes to be accredited. Respectively, the global value of training "without a recognized title" results from the total corresponding programmes that the candidate has attended, by examining each time the relevance of the title with an information technology profession and the duration of each training programme.

5. Sorting of candidates in categories

For the completion of Phase B′ of the evaluation it is chosen to apply the problematic of sorting of candidates in homogeneous well-defined preference-ordered categories. The method used is the Electre Tri (Yu, 1992), which belongs to the family of outranking relation methods proposed by the French school (Roy and Bouyssou, 1993; Vincke, 1992). The limit between two consecutive categories is formalized by what we call a profile. The assignment of an alternative α results from the comparison of α with the profiles, which define the limits of the categories. In general, from a certain set of alternatives, evaluated in quantitative and/or qualitative criteria and from a predetermined set of profiles, the method proposes two different approaches, which allow the classification of the alternatives in the right category. The optimistic and pessimistic approach, proposed by the method, result from the management of the non-comparability of the alternatives. In general, the pessimistic approach is used when it is required to apply a conservative policy or when the available resources are limited, while the optimistic approach is used for problems where the decision-maker wants to give a comparative advantage to certain alternatives (candidates) with a specific interest.

The categories are proposed independently of the set of alternatives and are defined by reference profiles. Reference profiles (or reference candidates) are the theoretical limits between categories and are defined by their values on the criteria. The categories in the accreditation problem have been determined based on the fact that the expert accredited candidates must be adequately distinguished from those of elementary level; therefore, the policy of definition of four categories is chosen, which can be better adapted to the grouping of professionals, as follows:

- Category of elementary level professionals, (G1),
- Category of standard level professionals, (G2),
- Category of master level professionals, (G3),
- Category of expert level professionals, (G4).

Quite clearly, no rejection or uncertain category is proposed, as it happens in many sorting applications in the finance sector (see Slowinski and Zopounidis, 1995; Dimitras et al., 1995; Zopounidis and Doumpos, 1999). In the case of accreditation of candidates in a specific profession, we are interested in *investigating* their personal achievements, if they *pass* or *fail* at Phase A′. Since a candidate has attained such scores at Phase A′, which ensure a minimum knowledge and experience level, he/she is accepted for Phase B′ of evaluation. If his/her professional achievements are either *high* or *low*, the assignment procedure will assign the candidate to a corresponding category.

In particular, in the proposed multicriteria approach, the criteria for the classification of the candidates result from the evaluation criteria of Phase B′, as they have been evaluated and the values have been normalized in the value interval $[0, 1]$ (see previous sections). Thus, the set of criteria consists of: the eight specialized skills (two common for all ICT jobs and the subset of six specialized skills), the criterion of studies and the two criteria of non-formal vocational training. The values of the eleven criteria are the input data-criteria in the multicriteria table of Electre Tri (Fig. 4).

Let us take for example the profession of "Computer Support Specialist". In order to apply the proposed general methodology for the accreditation in a specific job, like in our case the "Computer Support Specialist", some modifications can be applied for those criteria-specialized skills which better *describe* this job. In this sense the eight criteria-specialized skills, initially proposed, can be reduced/renamed/modified. Taking into account that the project management and problem solving

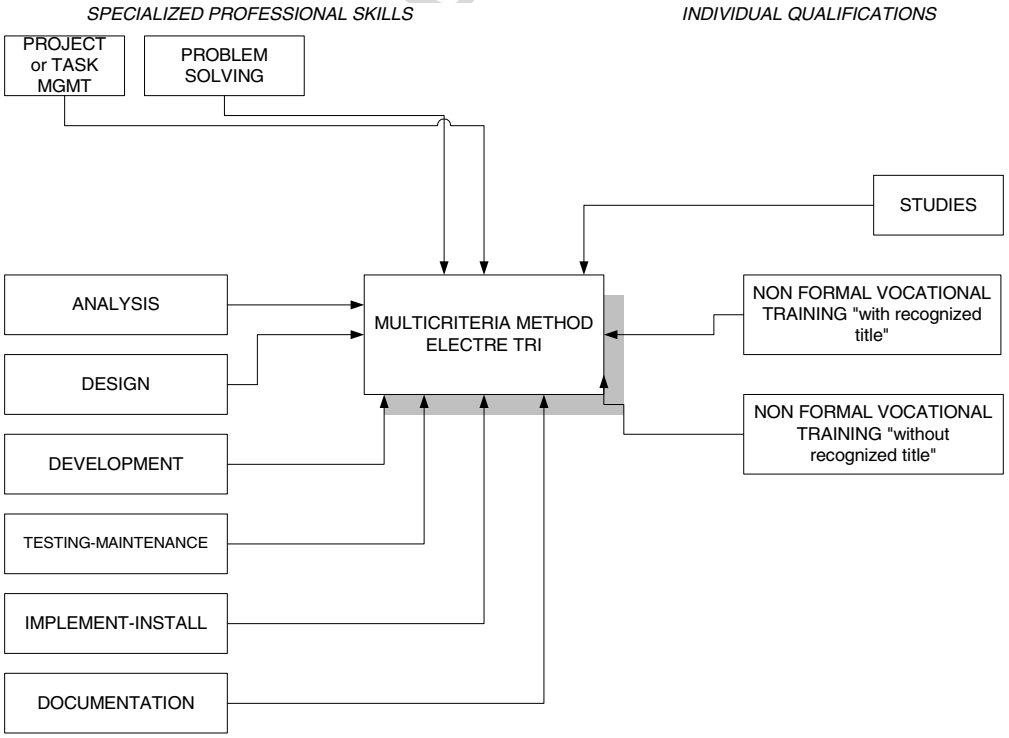

Fig. 4. Electre-Tri method criteria.

are two specialized skills required for every job, adaptation of the remaining six specialized skills is needed. Thus, the criteria 'design, development and implementation' are excluded and the other three are adapted to the needs of the specific profession. The criterion 'analysis' refers to the analysis of technical problems while the criterion 'testing-maintenance' is modified as 'control-maintenance of electronic equipment' and finally the criterion 'documentation' refers to the documentation of technical solutions. In total, the classification criteria of candidates for the profession of "Computer Support Specialist" are proposed as follows:

Criterion g_1: Project management
Criterion g_2: Problem solving
Criterion g_3: Analysis of technical problems
Criterion g_4: Control-maintenance of electronic equipment
Criterion g_5: Documentation of technical solutions
Criterion g_6: Studies
Criterion g_7: Non-formal training "with a recognized title"
Criterion g_8: Non-formal training "without a recognized title"

The parameters of Electre Tri have been assessed based on the preferences of IT specialists, while taking into account the chosen sorting categories G1, G2, G3 and G4, which are the profiles-standards of professionals (r_i) dividing the four categories from worst to best, the indifference thresholds (q_i), the preference thresholds (p_i) and veto thresholds (v_i). The r_1 profile corresponds to the minimum values of the criteria that a candidate must receive in order to consider that he/she belongs to the elementary level G1. The r_2 profile corresponds to the values of the criteria that a candidate must receive minimum in order to enter the standard level professionals category (G2) but not belong to the category G1 or G3, while the profile r_3 separates category G3 (master level) from category G4 (expert level). The values of the parameters, that is the indifference, preference and veto thresholds for each profile and criterion (in the way the criteria have been adapted to the specific profession), have been made to a reference set of 30 candidates. In the present phase of the study and according to the opinion of information technology experts (academics), the criteria weights are considered equal to each other. This simplification has not seemed to alter significantly the results, although different weights could be used. Recent research results proposed by Dias et al. (2002), Mousseau et al. (2001) and Mousseau and Slowinski (1998) address the problem for decision-makers to infer preferential parameters of Electre Tri such as profiles, weights, thresholds and cutting levels.

In this practical decision situation, information technology experts spent a lot of hours and carried out many experiments using trial and error test on the reference set, in order to determine Electre Tri parameters. The values of the thresholds were determined by 'interactive' use of the software Electre Tri in order to minimize the "false" assignments. Although the sample of 30 candidates cannot be considered as sufficiently representative to provide general conclusions, the sample and categories defined in this study are typical cases faced by the specific decision-makers. So, the construction of any model and the relative conclusions are, mainly, important for the decision-makers and results should be evaluated under this limitation.

The values of the parameters for the three profiles (standard professionals) are shown in Tables 7–9, which *describe* particular qualitative characteristics. For example, the elementary level category (G1), according to criterion g_1, includes candidates with professional experience of less than or equal to three years and degree of activity/relevance with the skill of no more than 40%. Additionally, in the

Table 7
Parameters of the profile-standard professional r_1

	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8
r_1	0.12	0.15	0.11	0.18	0.08	0.30	0.20	0.02
q	0	0	0.01	0.01	0	0	0.20	0.02
p	0.03	0.04	0.02	0.02	0.02	0.03	0.20	0.02
v	0.04	0.05	0.07	0.06	0.05	0.08	0.20	0.02

Table 8
Parameters of the profile-standard professional r_2

	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8
r_2	0.42	0.42	0.35	0.49	0.35	0.50	0.33	0.13
q	0	0	0	0	0.01	0	0.01	0
p	0.03	0.03	0.03	0.02	0.03	0.06	0.03	0.11
v	0.07	0.04	0.11	0.12	0.14	0.16	0.13	0.11

Table 9
Parameters of the profile-standard professional r_3

	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8
r_3	0.68	0.77	0.68	0.77	0.64	0.67	0.53	0.35
q	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
p	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03
v	0.05	0.06	0.05	0.14	0.20	0.14	0.20	0.22

same category and in relation to criterion g_6 candidates must have completed studies at IEK (Vocational Training Institutes-post secondary level, after Lyceum) or lower level with a title which has high relevance to the information technology profession to be accredited. For more information on the qualitative meaning of parameters, see Appendix.

6. Implementation to the greek educational system

For implementation purposes of the proposed methodology, two universities, one in Greece and another in the Netherlands applied the method. Academics and researchers, in the role of decision-makers constituting the proposed committee, and independent evaluators have evaluated employees in the profession of Computer Support Specialist, who offered voluntarily to participate in this effort. For the implementation of the methodology in the Netherlands an adaptation was made according to the Dutch educational system. The whole process was supported by the decision support system *Skills Evaluator*, which brings into effect the aforementioned methodology (see Anestis et al., under revision).

Let us take a candidate who has submitted an application for evaluation to the Greek Committee in order to be accredited in the profession of "Computer Support Specialist". According to the data resulting from the candidature file (curriculum vitae, letters of recommendation, certificates of previous employment, titles of studies, certificates of attendance to seminars, etc.) and the interviews given to the evaluators, the following arise:

- Employee in a company for 6 years as a Computer Support Technician at the Maintenance Department, with everyday use of personal computer and related applications for the drafting of reports, etc.
- He/she communicates everyday with other users – members of the company and clients forwarding information to them mainly via e-mail.
- He/she uses the Internet to fulfil the needs of his/her work and to find useful information on technical and other issues through web pages and databases.
- He/she is a graduate of a Unified Lyceum with certificate mark Very Good. His/her contact with information technology during his/her studies was very limited according to the teaching schedule of this type of schools.
- He/she has no "recognized" vocational training title.
- He/she has attended seminars organized by the company to update the knowledge of its employees beyond working hours, as follows: 200 hours Unix, 150 hours Win NT Administration, 40 hours Firewall, 24 hours Web Admin and 200 hours Networks.
- He/she has a computer at home and spends 2–3 h everyday especially on the Internet.

Based on the above characteristics of the candidate, the system provides the evaluations (global values) shown in Tables 10 and 11. It thereby results that the candidate passes to Phase B′ of the evaluation since he/she has received a score above the two limits of 0.60 and 0.55 per criterion respectively.

Table 10
Phase A′ – evaluation of first general skill

Sources for acquisition of skill	Evaluation	Value	Weight	Global value (value × weight)
General skill: use of basic s/w & h/w tools				
Professional experience	High	1	0.29	0.29
Vocational training	High	1	0.16	0.16
Studies	None	0	0.21	0
Personal activity	Medium	0.78	0.34	0.27
Global value				*0.72*

Table 11
Phase A′ – evaluation of second general skill

Sources for acquisition of skill	Evaluation	Value	Weight	Global value (value × weight)
General skill: use of Internet services				
Professional experience	High	1	0.35	0.35
Vocational training	Medium	1	0.25	0.25
Studies	None	0	0.37	0
Personal activity	High	1	0.03	0.03
Global value				0.63

In particular, for Phase B′ of the evaluation, after the interviews of the candidate with the evaluators and the suggestions of the evaluators to the Committee, the Accreditation Committee has come to the results of Table 12. The specific candidate has worked in one job. These results provide an analytical documentation of the marks given to the candidate for each criterion, which can be announced and justify the classification of the candidate, resulting based on the values per criterion. Finally, the multicriteria Electre-Tri method is applied, which based on the values of the evaluation criteria, the defined parameters and the profiles, has classified the candidate using the optimistic approach in the master level professionals-G3, and using the pessimistic approach in the elementary level professionals-G1, (linear representation in Fig. 5).

This particular case, reflects a professional who practise a profession without having accomplished the corresponding formal studies (in other professions they are referred to as empirics). In this particular or in a similar case, when a candidate is classified in a different category of professionals with the optimistic and the pessimistic approach, the Accreditation Committee can proceed to the following:

Table 12
Phase B′ of candidate evaluation

Criterion g_1. Project management	6 years. Relevance of work 70%. $\Rightarrow 0.47 \times 70\% = 0.33$
Criterion g_2. Problem solving	6 years. Relevance of work 60%. $\Rightarrow 0.47 \times 60\% = 0.28$
Criterion g_3. Analysis of technical problems	6 years. Relevance of work 80%. $\Rightarrow 0.47 \times 80\% = 0.38$
Criterion g_4. Control-maintenance of electronic equipment	6 years. Relevance of work 80%. $\Rightarrow 0.47 \times 80\% = 0.38$
Criterion g_5. Documentation of technical solutions	6 years. Relevance of work 60%. $\Rightarrow 0.47 \times 60\% = 0.28$
Criterion g_6. Studies	Unified Lyceum, Grade Very Good, No relevance of title with the profession. $\Rightarrow 0.39 \times 0.95 \times 0 \times 0.6 = 0$
Criterion g_7. Non-formal training "with a recognized title"	Not available. $\Rightarrow$ Value of criterion = 0
Criterion g_8. Non-formal training "without a recognized title"	Evaluation of seminars: 200 h Unix (high relevance) $= 1 \times 1 = 1$ 150 h Win NT (high relevance) $= 0.7 \times 1 = 0.7$ 40 h Firewall (high relevance) $= 0.08 \times 1 = 0.08$ 24 h Web Admin (high relevance) $= 0.04 \times 1 = 0.04$ 200 h Networks (high relevance) $= 1 \times 1 = 1$ $\Rightarrow 2.82/6 = 0.47$

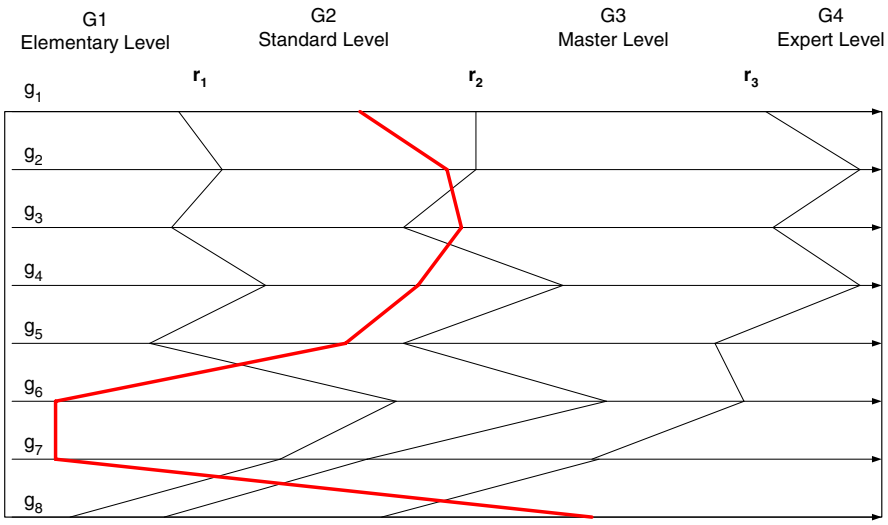

Fig. 5. Evaluation of the candidate in the criteria (grey colour line).

- Decide which one of the two approaches is most appropriate (pessimistic or optimistic) and continue to the accreditation in the respective category.
- Decide on the pessimistic or optimistic evaluation of the candidate and continue to the accreditation with one index on uncertainty.
- Invite the candidate for further research of his/her qualifications, especially as far as the evaluation of his/her professional skills is concerned (criteria g_1 to g_5).
- Ask for some kind of examination of the candidate, oral or written.
- And particularly for the case of the specific candidate, classify him/her in the intermediary category, G2, that is the standard level professionals.

With the specific candidate, the Committee proceeds to the last choice, from those proposed above, and concludes that his achievements are closer to the intermediary category G2 of standard level professionals. It is understood of course that the method cannot replace the work of the Committee; on the contrary, it can become a support tool for the decision-making.

7. Concluding remarks

The purpose of this paper is twofold. The first is to stimulate an interest in modelling the accreditation problem and the second is to show that multicriteria decision aid theory could be a useful tool for the accreditation of skills and competences, an issue which is still in the agenda of top-level consultations in the European Union. The value of the study may lie as much in what it did not achieve as in what it did achieve. The effort was limited, mainly, because of the absence of a real decision-maker, an accreditation authority, and the lack of job profiles for information technology professions. Restrictions of lower importance were the size of the samples-reference sets of professionals, which were very small either in Phase A or B (10–30 maximum), and the unavailability of a *real* sample of accredited (somehow) candidates to validate the results. On the other hand, difficulties arise when a decision-maker expresses his/her preference in qualitative characteristics. However, there may be several general results and conclusions obtained in this study, which are valuable despite the limitations of the research.

The proposed approach recognizes that the technical knowledge for the practice of an information technology profession can stem both from the workplace and the learning field, as two systems complementary to one another. At the same time, the presented research takes into account that non-formal or informal learning generates professional skills, which under the spirit of the specific modelling, can be evaluated for the sorting of candidates to a group. Furthermore, a *value* can be attributed to the personal qualifications (studies, non-formal training "with a recognized title" or/and "without a recognized title") when accompanied or not by professional skills, for the sorting of candidates through an objective approach; which attributes the maximum value in the cases of high individual qualifications and considerable professional experience.

Appendix. Definition of categories

Criteria	Category G1	Category G2	Category G3	Category G4
Criterion g_1: Task/project management	Professional exper. less or equal 3 years. Relevance no more than 40% (Veto: 2 years, 40% relev. $0.2 \times 40\% = 0.08$) r_1:$0.3 \times 40\% = 0.12$ $v_1(r_1)$:$0.12 - 0.08 = 0.04$	Professional exper. more than 3–10 years. Relevance more than 40% to 60% (Veto: 8 years, 60% relev. $0.59 \times 60\% = 0.35$) r_2:$0.7 \times 60\% = 0.42$ v_1 (r_2):$0.42 - 0.35 = 0.07$	Professional exper. more than 10–15 years. Relevance more than 60% to 80% (Veto: 13 years, 80% relev. $0.79 \times 80\% = 0.63$) r_3:$0.85 \times 80\% = 0.68$ $v_1(r_3)$: $0.68 - 0.63 = 0.05$	Professional exper. over 15 years. Relevance over 80%
Criterion g_2: Problem solving	Professional exper. less or equal 3 years. Relevance no more than 50% (Veto: 2 years, 50% relev. $0.2 \times 50\% = 0.1$) r_1:$0.3 \times 50\% = 0.15$ $v_2(r_1)$:$0.15 - 0.1 = 0.05$	Professional exper. more than 3–10 years. Relevance more than 50% to 60% (Veto: 9 years, 60% relev. $0.64 \times 60\% = 0.38$) r_2: $0.7 \times 60\% = 0.42$ $v_2(r_2)$:$0.42 - 0.38 = 0.04$	Professional exper. more than 10 to 15 years. Relevance more than 60% to 90% (Veto: 13 years, 90% relev. $0.79 \times 90\% = 0.71$) r_3:$0.85 \times 90\% = 0.77$ $v_2(r_3)$: $0.77 - 0.71 = 0.06$	Professional exper. over 15 years. Relevance over 90%
Criterion g_3: Analysis of technical problems	Professional exper. less or equal 3 years. Relevance no more than 35% (Veto:1 year, 35% relev. $0,1 \times 35\% = 0.04$) r_1:$0.3 \times 35\% = 0.11$ $v_3(r_1)$:$0.11 - 0.04 = 0.07$	Professional exper. more than 3–10 years. Relevance more than 35% to 50% (Veto: 6 years, 50% relev. $0.47 \times 50\% = 0.24$) r_2:$0.7 \times 50\% = 0.35$ $v_3(r_2)$:$0.35 - 0.24 = 0.11$	Professional exper. more than 10–15 years. Relevance more than 50% to 80% (Veto: 13 years, 80% relev. $0.79 \times 80\% = 0.63$) r_3:$0.85 \times 80\% = 0.68$ $v_3(r_3)$:$0.68 - 0.63 = 0.05$	Professional exper. over 15 years. Relevance over 80%
Criterion g_4: Control-maintenance of electronic equipment	Professional exper. less or equal 3 years. Relevance no more than 60% (Veto: 2 years, 60% relev. $0.2 \times 60\% = 0.12$) r_1:$0.3 \times 60\% = 0.18$ $v_4(r_1)$: $0.18 - 0.12 = 0.06$	Professional exper. more than 3–10 years. Relevance more than 60% to 70% (Veto: 7 years, 70% relev. $0.53 \times 70\% = 0.37$) r_2:$0.7 \times 70\% = 0.49$ $v_4(r_2)$:$0.49 - 0.37 = 0.12$	Professional exper. more than 10–15 years. Relevance more than 70% to 90% (Veto: 10 years, 90% relev. $0.7 \times 90\% = 0.63$) r_3: $0.85 \times 90\% = 0.77$ $v_4(r_3)$:$0.77 - 0.63 = 0.14$	Professional exper. over 15 years. Relevance over 90%

Criterion g_5: Documentation of technical solutions	Professional exper. less or equal 3 years. Relevance no more than 25% (Veto: 1 year, 25% relev. $0.1 \times 25\% = 0.03$) r_1: $0.3 \times 25\% = 0.08$ $v_5(r_1)$:$0.08 - 0.03 = 0.05$	Professional exper. more than 3–10 years. Relevance more than 25–50% (Veto: 5 years, 50% relev. $0.41 \times 50\% = 0.21$) r_2:$0.7 \times 50\% = 0.35$ $v_5(r_2)$:$0.35 - 0.21 = 0.14$	Professional exper. more than 10–15 years. Relevance more than 50% to 75% (Veto: 11 years, 60% relev. $0.73 \times 60\% = 0.44$) r_3:$0.85 \times 75\% = 0.64$ $v_5(r_3)$: $0.64 - 0.44 = 0.2$	0Professional exper. over 15 years. Relevance over 75%
Criterion g_6: Studies	IEK or lower level with high relevance (Veto: TEE cycle B′–very good–high relev.: $[0.39 \times 0.95 \times 1]0.6 = 0.22$) r_1:$[0.5 \times 1 \times 1] \times 0.6 = 0.3$ $v_6(r_1)$:$0.3 - 0.22 = 0.08$	Higher level than IEK–high–relevance and lower or equal to TEI graduate–very good mark–high relevance (Veto: TEI–excellent grade–medium relev. $[0.88 \times 1 \times 0.64] \times 0.6 = 0.34$) r_2:$[0.88 \times 0.95 \times 1] \times 0.6 = 0.5$ $v_6(r_2)$:$0.5 - 0.34 = 0.16$	Higher level than TEI–very good–high relevance and lower or equal level to AEI–very good–high relevance and postgraduate studies–high relevance (Veto: AEI–good–high relev. $[1 \times 0.89 \times 1] \times 0.6 = 0.53$) v_3:$[1 \times 0.95 \times 1] \times 0.$ 6+$[1 \times 1] \times 0$, $1 = 0.67$ $v_6(r_3)$:$0.67 - 0.53 = 0.14$	Higher than AEI–very good–high relevance and postgraduate studies–high relevance
Criterion g_7: Non-formal training "with recognized title"	No title, max 1 title of medium relevance (Veto: no title) r_1: $(1 \times 0.6)/3 = 0.2$ v_7 (r_1):$0.2 - 0 = 0.2$	At least 1 title–medium relevance to 1 title–high relevance (Veto: 1 title medium relev. $[1 \times 0.6]/3 = 0.2$) r_2:$(1 \times 1)/3 = 0.33$ $v_7(r_2)$:$0.33 - 0.2 = 0.13$	More than 1 title–high relevance to 2 titles (one with high rel. and the other with medium rel.). Veto: 1 title–high relev. $[1 \times 1]/3 = 0.33$ r_3:$(1+0.6)/3 = 0.53$ v_7 (r_3):$0.53 - 0.33 = 0.2$	At least 2 titles (one with high relevance and the other with medium relev.)
Criterion g_8: Non-formal training "without recognized title"	Max. 1 seminar–50 h–high relevance (Veto: no seminar). r_1:$(1 \times 0.1)/6 = 0.02$ v_8 (r_1):$0.02 - 0 = 0.02$	More than 1 seminar–50 h–high relevance to 2 seminars–100 h–high relev. (Veto: 1 seminar–50 h–high relev. $[1 \times 0.1 \times 1]/6 = 0.02$) r_2: $(2 \times 0.4 \times 1)/6 = 0.13$ v_8 (r_2):$0.13 - 0.02 = 0.11$	At least 2 seminars–100 h–high relevance to 3 seminars–150 h–high relev. (Veto: 2 seminars-100 h–high relev. $[2 \times 0.4 \times 1]/6 = 0.13$) r_3:$(3 \times 0.7)/6 = 0.35$ v_8 (r_3):$0.35 - 0.13 = 0.22$	At least 3 seminars–150 h–high relevance

The implementation of the Electre Tri method in this research has responded positively to the needs of the candidate classification, requiring a strict predetermined procedure, which guarantees objectivity and clarity. The classification of candidates in four categories separates elementary level professionals from expert level professionals. The proposed grouping does not provide for any rejection group of candidates since the candidates must have been successfully evaluated in Phase A′. This case does not exclude any person who either has accomplished studies and non-formal training but has no professional experience, or has a professional experience with having completed any studies or non-formal training, or even in case someone has both professional experience and studies and training. Moreover, it does not exclude the possibility for persons who are today unemployed to be evaluated for the professional experience they have acquired in the past and of course for all their other qualifications.

Besides providing answers to important questions regarding the determination of the qualitative criteria for evaluation, their modelling and the process of candidate classification, the issue of accreditation has significant prospects for further research. The principal directions are focused in the following points: (1) exploration of the possibility to combine with alternative methodological approaches proposed in European countries on a pilot or applied level; (2) exploration of similarities and differences with other systems for the identification, accreditation, certification of qualifications, skills and competences acquired through non-formal vocational training; (3) exploration of the proposed evaluation system with the help of a legislated Accreditation Committee in the role of the decision-maker; (4) and finally implementation of a different multicriteria approach and methods and comparison of the results.

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